

Using the HOPE model for Evaluating HIV Interventions in US

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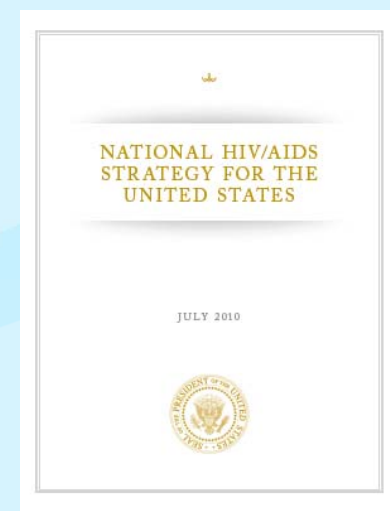


Outline

- **Background/motivation**
- **HOPE model summary**
- **Impact of pre-exposure prophylaxis (PrEP) using HOPE model**
- **Conclusions**

Background

- **1.2 million people living with HIV (PLWH) in US in 2012¹**
- **50,000 people become newly infected with HIV every year²**
- **The National HIV/AIDS Strategy (NHAS) Goals**
 1. Reducing new HIV infections
 2. Increasing access to care and improving health outcomes for people living with HIV
 3. Reducing HIV-related disparities and health inequities
 4. Achieving a more coordinated national response to the HIV epidemic

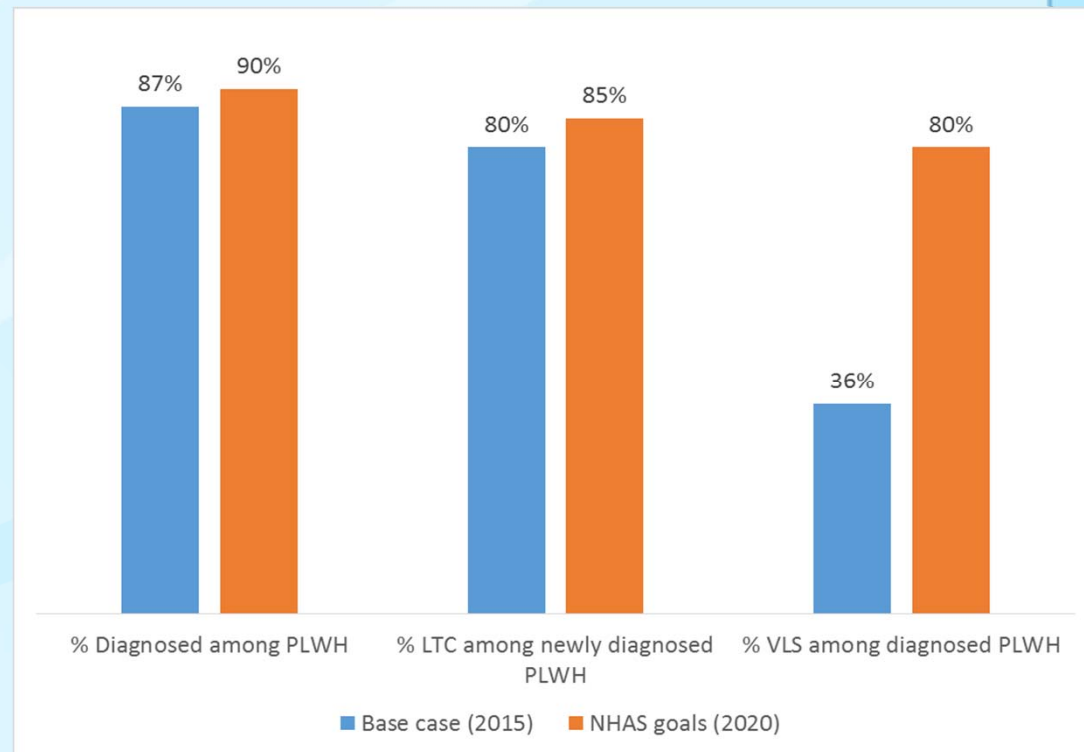


¹ CDC. Monitoring selected national HIV prevention and care objectives by using HIV surveillance data—United States and 6 US dependent areas—2013. HIV Surveillance Supplemental Report 2015; 20(No. 2)

² Hall HI et al. Estimation of HIV incidence in the United States. JAMA 2008; 300 (5): 520-29.

Motivation

- Treatment reduces HIV transmission by 96% (HPTN 052 Trial)*
- New prevention method for persons at higher risk of HIV infection: PrEP (pre-exposure prophylaxis)**
- 87% of PLWHs are diagnosed and only 36% of diagnosed PLWHs are estimated to have viral load suppression (VLS)

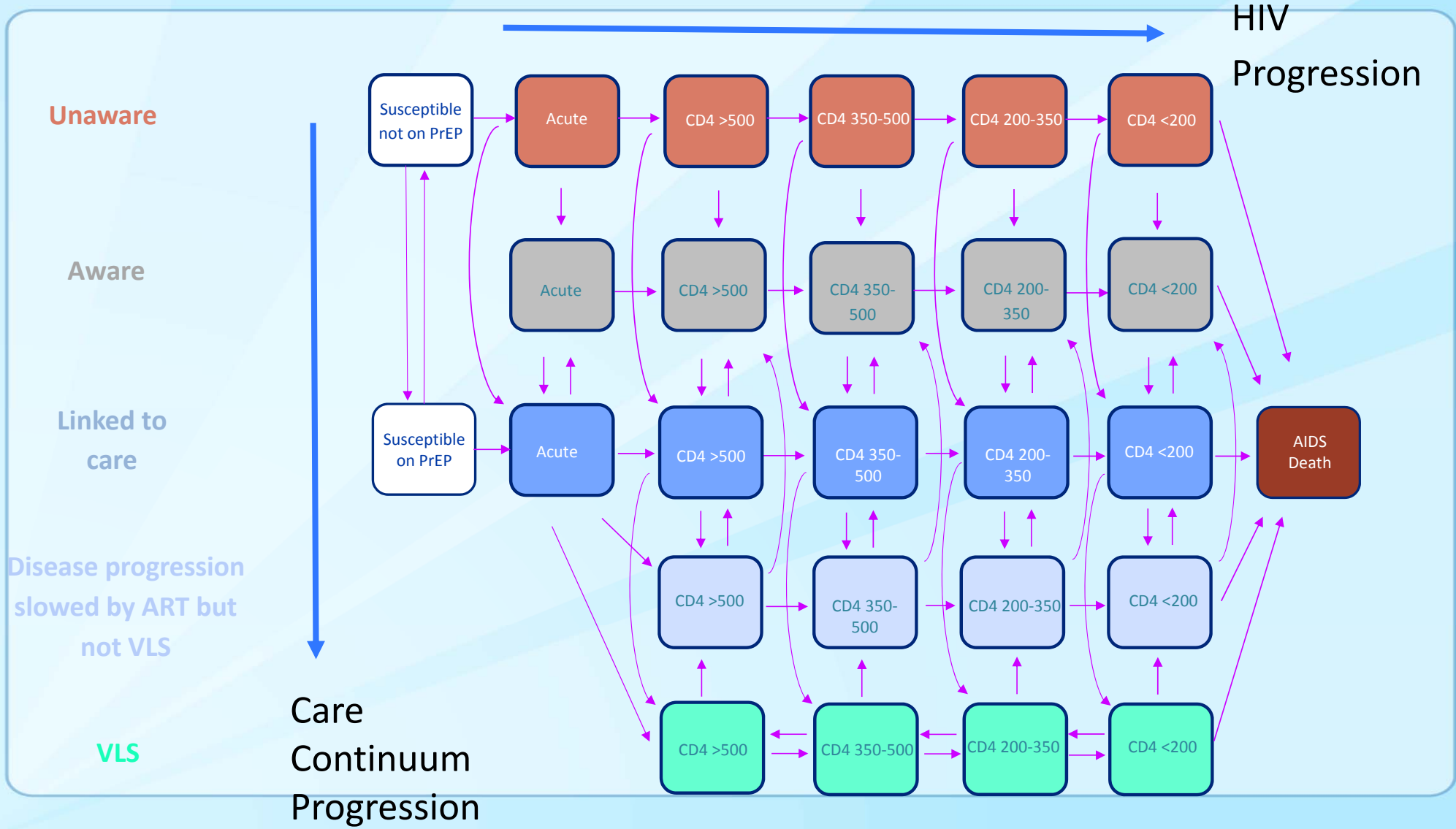


*Cohen et al., N Engl J Med 2016, 375(9):830-9

** Centers for Disease Control and Prevention. Preexposure prophylaxis for the prevention of HIV infection in the United States—2014: a clinical practice guideline, 2014. <http://www.cdc.gov/hiv/pdf/prepguidelines2014.pdf>.

HOPE Model

- **HIV Optimization and Prevention Economics Model: a comprehensive dynamic compartmental model of HIV progression and transmission in the US**
- **195 subpopulations: age group, risk level, transmission group, sex, circumcision status, race/ethnicity**
- **Time horizon: 2006-2010 (calibration period), 2011- after**



Model Formulation

- A system of differential equations
- Flow in - Flow out for each compartment
- E.g. For acute unaware

$$\frac{dX_p^{c=3}(t)}{dt} = \underbrace{[\lambda_p(t)]}_{\text{Infection}} X_p^{c=1}(t) - \underbrace{[\omega^{c=3}(t) + \tau_p^{c=3}(t)]}_{\text{Disease progression}} + \underbrace{\mu_p}_{\text{Diagnosis}} + \underbrace{\delta_p^-}_{\text{Death}} X_p^{c=3}(t) + \underbrace{[\delta_p^+]}_{\text{Aging out}} X_{p-1}^{c=3}(t)$$

Infection Disease progression Diagnosis Death Aging out Aging

- Solved in Matlab
- Force of infection calculates the transmission rate from infected to uninfected

Parameter Estimation

Parameter Type	Examples	Sources
Population (aging, birth and death)	Initial population size HIV-related mortality rate	Census NA-ACCORD
Continuum of care	Rate of ART prescription Rate of becoming VLS after ART prescription Rate of dropping out of care	Surveillance reports and calibration
Infectivity	Transmission risk by disease stage Reduction in transmission if VLS	Literature
Behavior	Number of sex contacts % unprotected sex Mixing: % of partners within subpopulations	NSFG, literature and calibration
HIV disease progression	Duration in each HIV disease stage if not on ART	Literature
Cost	Intervention costs	Literature

VLS: Viral load suppression

ART: Antiretroviral treatment

NA-ACCORD: North American AIDS Cohort Collaboration on Research and Design

NSFG: National Survey of Family Growth

Calibration

Health outcome	Year	Stratification	Point estimate and range from surveillance data	Base case
% Diagnosed	2006	Overall	79% [73-85%]	79%
	2010	Black	84% [78-90%]	84%
		Hispanic	84% [78-90%]	84%
		Other	87% [81-93%]	87%
% VLS	2006	Overall	19% [15-23%]	19%
	2010	Black	26% [21-31%]	26%
		Hispanic	27% [21-32%]	27%
		Other	30% [24-36%]	30%
Incidence	2010	Heterosexual, Male	4,100 [3,100-5,200]	4,529
		Heterosexual, Female	8,000 [6,700-9,200]	8,012
		Men who have sex with men	30,280 [26,200-34,000]	30,059
		People who inject drugs, Male	3,520 [2,500-5,000]	3,035
		People who inject drugs, Female	1,500 [970-2,000]	1,766
		Overall	47,400 [42,000-53,000]	47,401
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Prevalence	2006	Overall	1,061,100 [1,030,800-1,091,500]	1,070,216
	2010	Overall	1.144.500 [915.600-1.373.400]	1.083.172

Purpose of HOPE model

- **Observe trends in HIV**
- **Evaluate the effectiveness or cost-effectiveness of prevention interventions**
- **Inform policy in HIV prevention**
- **Example use:**

Impact of improving HIV care and treatment and initiating PrEP in the U.S., 2015-2020

The Impact of PrEP Study

- **Research objective:** Estimate the number of new infections prevented in 2015 - 2020 when populations at high risk of acquiring HIV are on PrEP either under the current continuum of care or under an improved continuum of care that results in achievement of the 2020 NHAS goals.
- **Scenarios:**

No PrEP	With PrEP
Current continuum of care - Base Case (87% diagnosed, 80% LTC, and 36% VLS)	Current continuum of care
Improved continuum of care (90% diagnosed, 85% LTC, and 60% VLS)	Improved continuum of care
NHAS goals achieved (90% diagnosed, 85% LTC, and 80% VLS)	NHAS goals achieved

Key assumptions

- **Uninfected high-risk MSM, high-risk HET (HRH) and PWID were eligible for PrEP.**
- **For eligible population PrEP is initiated in 2015 and continued through 2020; the number of people participating in PrEP was set so that risk-group-specific coverage levels were reached.**
- **PrEP's effect in the model was a constant reduction in HIV infection rates per person.**
- **Coverage levels: 40% (MSM), 10% (HRH) and 10% (PWID)**
- **PrEP efficacy: 73% (MSM), 75% (HRH) and 49% (PWID)**

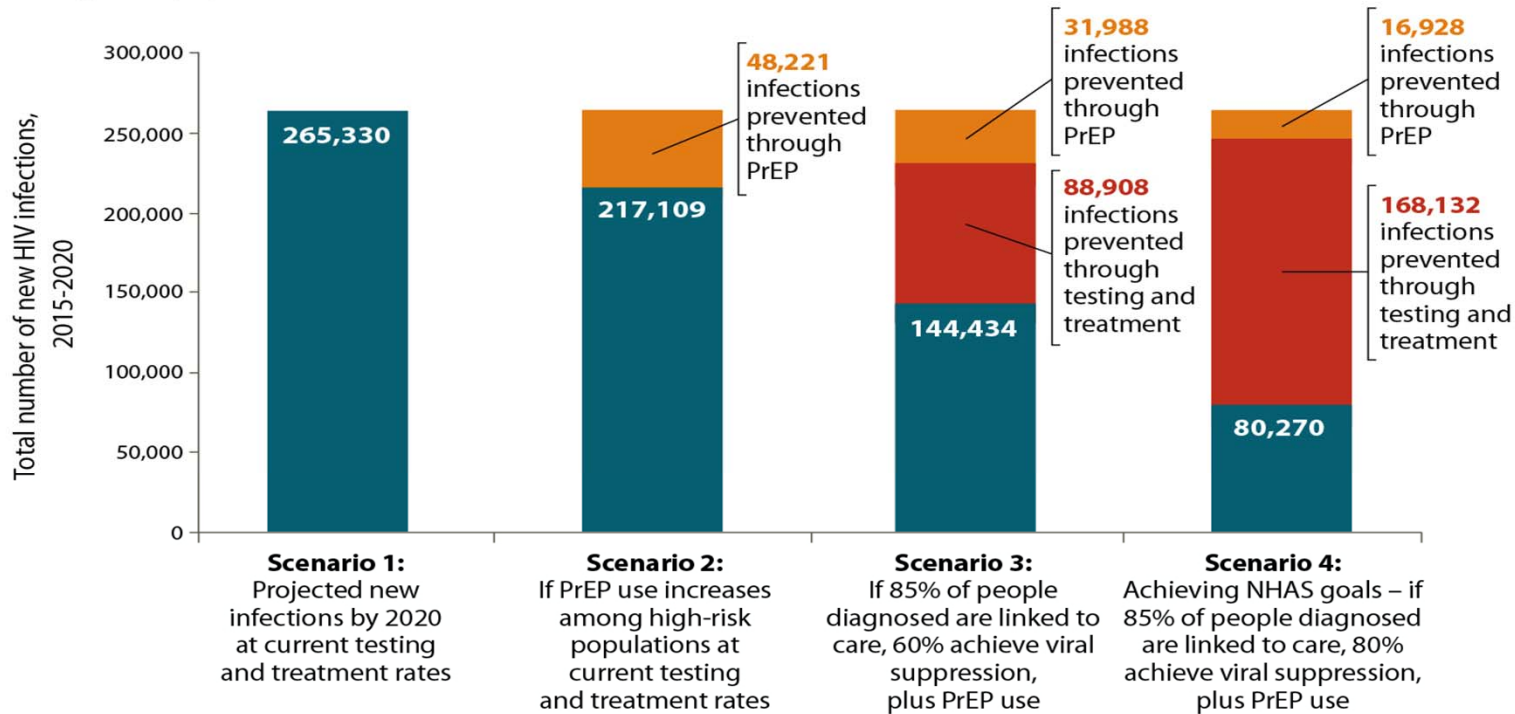
PWID: People who inject drugs

MSM: Gay, bisexual, and other men who have sex with men

HET: Heterosexuals

Four Scenarios of the Potential Impact of Expanded HIV Testing, Treatment and PrEP in the United States, 2015-2020

- New infections
- HIV infections prevented due to expanded testing and treatment
- HIV infections prevented due to PrEP (assumes PrEP use among high-risk populations = 40% MSM; 10% PWID; 10% HET)



Source: Centers for Disease Control and Prevention

Results

Results

- **HIV infections prevented over 5 years compared with base case (% reduction)**
 - Improve continuum: 88,908 (34%)
 - Meet NHAS goals: 168,132 (63%)
- **Marginal benefit of PrEP - additional infections prevented (% reduction)**
 - Over base case: 48,221 (18%)
 - Over improve continuum: 31,988 (12%)
 - Over meet NHAS goals: 16,929 (7%)

Conclusions on PrEP Study

- **We could achieve a 70% reduction in new HIV infections if we reached NHAS HIV care continuum goals and scale up PrEP by 2020.**
- **The marginal benefit of PrEP decreased with improvements in the HIV care continuum.**
- **Even when NHAS care continuum goals are reached, PrEP continued to reduce HIV incidence.**

Limitations

- **The large amount of data required to inform model inputs, and uncertainty in those data, can lead to uncertainty in the estimated outcome of cumulative HIV incidence**
 - We have conducted an uncertainty analysis to illustrate ranges around key outcomes
 - We have conducted broad sensitivity analyses to understand which inputs have the greatest effect on outputs (would be good to have a slide prepared if possible)

Summary

- **We developed a complex model (HOPE) that will examine**
 - Transmission dynamics with/without interventions
 - Health outcomes
 - Effectiveness and economic impact of interventions
 - Current gaps in care and treatment
- **HOPE model could be used to evaluate single/multiple interventions as well as take a comprehensive look at HIV prevention in the US**

Thanks

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The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

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