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

Emine Yaylali[a], Paul G. Farnham[a], Evin Jacobson[a], Benjamin T. Allaire[b], L. Danielle Wagner[b], Katherine A. Hicks[b], Amanda A. Honeycutt[b], and Stephanie L. Sansom[a]

[a]Division of HIV/AIDS Prevention, Centers for Disease Control and Prevention; [b]RTI International

Background

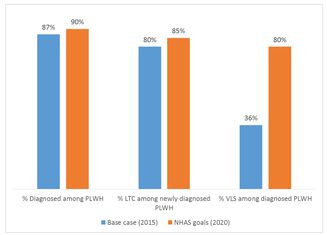
PrEP:

- Pre-exposure prophylaxis (PrEP) with daily oral antiretroviral medication is a new, highly effective intervention that could reduce the number of new HIV infections (*Vital Signs MMWR*, 2015).
- PrEP, designed for persons at high risk for acquiring HIV, may reduce the risk of disease transmission from sexual contact by more than 90% (*Vital Signs*, 2015).

The National HIV/AIDS Strategy (NHAS):

- The National HIV/AIDS Strategy, released in 2010, is a five-year plan that details goals, priorities, and actions to guide the collective national response to HIV in the United States (White House Office of National AIDS Policy).
- In 2015, the strategy was updated to 2020 to reflect changes in prevention and progress toward the goals over the 2010–2015 period.
- NHAS 2020 goals for persons living with HIV (PLWH):
  - 90% to be diagnosed
  - 85% of newly diagnosed to be linked to care (LTC)
  - 80% of diagnosed to achieve viral load suppression (VLS)
- Achieving VLS could reduce HIV transmission by up to 96% (Cohen, 2011).

Figure 1: Comparison of continuum of care; Base Case (2015) and NHAS goals (2020)



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.

Table 1: Scenarios for analysis

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

References

1. Baeten JM, et al. Antiretroviral prophylaxis for HIV prevention in heterosexual men and women. *New England Journal of Medicine* (2012); 367:399–410.
2. CDC. Smith DK., et al. Vital signs: Estimated percentages and numbers of adults with indications for pre-exposure prophylaxis to prevent HIV acquisition — United States, 2015. Morbidity and Mortality Weekly Report (MMWR) 64.46 (2015): 1291–1295.
3. CDC. Vital Signs. "Daily pill can prevent HIV". November 24, 2015. Available at http://www.cdc.gov/vitalsigns/hivprep/ .
4. Choopanya K., et al. Antiretroviral prophylaxis for HIV infection in injecting drug users in Bangkok, Thailand (the Bangkok Tenofovir Study): a randomised, double-blind, placebo-controlled phase 3 trial. *Lancet* (2013): 381:2083–90.
5. Cohen MS., et al. Prevention of HIV-1 infection with early antiretroviral therapy. *New England Journal of Medicine* 365.6 (2011): 493–505.
6. Grant RM., et al. Pre-exposure chemoprophylaxis for HIV prevention in men who have sex with men. *New England Journal of Medicine* (2010): 363:2587–99.
7. Marks, G., et al., Estimating sexual transmission of HIV from persons aware and unaware that they are infected with the virus in the USA. AIDS (2006) 20.10:1447–1450.
8. White House Office of National AIDS Policy: National HIV/AIDS Strategy for the United States. (2015). Available at https://www.whitehouse.gov/administration/eop/onap/nhas .

Methods

Model Summary:

- We developed the HIV Optimization and Prevention Economics (HOPE) Model, a dynamic, compartmental model of HIV transmission and progression for the sexually active United States population.
- We used a Bernoulli process model for HIV transmission from sexual contact and needle sharing.
- Reduction in sexual transmission due to VLS is 96% (Cohen, 2011) and increase in condom use due to diagnosis is 53% (Marks, 2006).
- Individuals ever on antiretroviral therapy (ART) have slower disease progression compared to those never on ART.
- We included high-risk and low-risk groups for heterosexuals (HET) and men who have sex with men (MSM) and we assume all persons who inject drugs (PWID) are high risk. Population is stratified into 195 subpopulations (Table 2).
- Time horizon:
  - 2000–2006 (run-in period)
  - 2006–2010 (calibration period)
  - 2011–after (outcome collection period)
- We calibrated the model to surveillance data on incidence, prevalence, % diagnosed and % VLS in 2006 and 2010, and we validated against deaths among persons with diagnosed PLWH in 2010.

Table 2: Model population stratification

Stratification	Group
Age group	13–17, 18–24, 25–34, 35–44, 45–64
Risk level	Low, high
Transmission group	HET, MSM, PWID
Sex	Female, male
Circumcision status	Uncircumcised, circumcised
Race/ethnicity	Black, Hispanic and others
Total	**195 Subpopulations**

Table 3: Model parameters

Parameter Category	Examples	Sources
Population (aging, birth and death)	Initial population size Non-HIV-related mortality rate HIV-related mortality rate	Census Life tables NA-ACCORD
Continuum of care	Rate of getting tested Rate of linkage to care Rate of ART prescription Rate of becoming VLS after ART prescription Rate of dropping out of care	Surveillance reports and calibration
Infectivity	Transmission probability per unprotected anal intercourse (AI), vaginal intercourse (VI) act, shared needle with infected partner Transmission risk by disease stage Reduction in transmission if circumcised Reduction in transmission if VLS	Literature
Behavior	Annual number of sex and needle sharing partners Number of sex contacts % condomless sex Increase in condom use after diagnosis % of contacts that are AI and VI Mixing: % of partners within subpopulations	NSFG, literature and calibration
HIV disease progression	Duration in each HIV disease stage if not on ART	Literature

Methods (Continued)

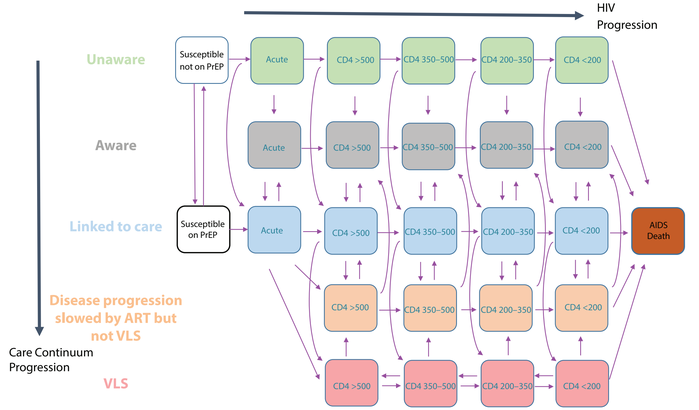
Model Assumptions Related to PrEP

- Uninfected high-risk MSM, high-risk HET (HRH) and PWID were eligible for PrEP.
- In scenarios in which PrEP was implemented, a portion of the eligible population initiated PrEP starting in 2015 and continued through 2020; the number of people participating in PrEP was set so that risk-group-specific coverage levels were reached (Table 4).
- PrEP's effect in the model was a constant reduction in HIV infection rates per person (Table 4).

Table 4: PrEP Parameters

Parameter	Value	Source
PrEP efficacy (reduction in incidence)		
MSM	73%	Grant (2010)
PWID	49%	Choopanya (2013)
HRH	75%	Baeten (2010)
PrEP coverage among eligible HIV-uninfected persons (constant between 2015–2020)		
High-risk MSM	40%	Assumption
PWID	10%	Assumption
HRH	10%	Assumption

Figure 2: Model Flow Diagram



Results

Table 5: The impact of improving diagnosis, care and treatment among PLWH and delivering PrEP to persons at risk of HIV, United States, 2015–2020

	Total Number of New Infections, 2015–2020			
	HET	MSM	PWID	Total
Current continuum of care, No PrEP (Base Case)	72,069	166,448	26,813	265,330
Current continuum of care, PrEP	67,224	124,531	25,354	217,109
HIV infections prevented, n (%)*	4,845 (7%)	41,917 (25%)	1,459 (5%)	48,221 (18%)
Improved continuum of care, No PrEP	45,619	111,509	19,293	176,422
HIV infections prevented, n (%)*	26,450 (37%)	54,938 (33%)	7,520 (28%)	88,908 (34%)
Improved continuum of care, PrEP	42,646	83,539	18,248	144,434
HIV infections prevented, n (%)*	29,423 (41%)	82,909 (50%)	8,565 (32%)	120,896 (46%)
NHAS goals achieved, No PrEP	25,346	59,522	12,331	97,198
HIV infections prevented, n (%)*	46,723 (65%)	106,926 (64%)	14,482 (54%)	168,132 (63%)
NHAS goals achieved, PrEP	23,702	44,906	11,661	80,269
HIV infections prevented, n (%)*	48,367 (67%)	121,541 (73%)	15,152 (57%)	185,060 (70%)

*Compared to base case (current continuum of care, no PrEP)

- Model estimates approximately 44,000 new HIV infections annually in the base case compared with the 2014 CDC Surveillance estimate of new diagnoses 44,073.
- Total HIV infections prevented compared with base case
  - Improved continuum of care alone: 34%
  - NHAS goals achieved alone: 63%
    - HET: 65%
    - MSM: 64%
    - PWID: 54%
- Marginal benefit (additional HIV infections prevented) of adding PrEP
  - Current continuum of care (base case): 18%
  - Improved continuum of care: 12% (= 46%–34%)
  - NHAS goals achieved: 7% (= 70%–63%)
- Additional infections prevented from PrEP among risk populations
  - NHAS goals achieved
    - HET: 2% (= 67%–65%)
    - MSM: 9% (= 73%–64%)
    - PWID: 3% (= 57%–54%)

Conclusions

- In the base case, the annual HIV incidence estimates in the HOPE model were similar to the most recent surveillance data (Diagnoses of HIV infection, 2014).
- Increasing diagnosis, care and treatment of PLWH alone resulted in large decreases in HIV incidence by 2020.
- Improving diagnosis, care, and treatment alone reduced infections among all risk populations with HET and MSM having the largest reductions.
- The marginal benefit of PrEP (additional infections prevented) decreased as diagnosis, care and treatment improved. As more people achieve VLS and have a reduced probability of transmission, there is less overall risk to HIV-negative persons.
- Among risk populations, PrEP reduced MSM infections the most because the coverage of PrEP in MSM was assumed to be highest among all risk populations.
- Although the benefit of PrEP decreased as the percentage of PLWH with VLS increased, PrEP continued to achieve reductions in HIV incidence even at high levels of VLS over 5 years.

National Center for HIV/AIDS, Viral Hepatitis, STD, and TB Prevention
Division of HIV/AIDS Prevention

Visit: www.cdc.gov | Contact CDC at: 1-800-CDC-INFO or www.cdc.gov/info
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.

CS263201-A