Understanding HIV Transmission Dynamics and the Impact of Past HIV Interventions among MSM in Baltimore: a Modelling Study for HPTN 078

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BACKGROUND

- Men who have sex with men (MSM) in the United States are disproportionately infected with HIV.
- Baltimore (Maryland), has one of the highest HIV prevalences among its MSM population, with estimated HIV prevalence of 30% in 2014 from CDC National HIV Behavioural Surveillance (NHBS)*

OBJECTIVES

To estimate 1) the impact of past interventions (condom use and ART) on the HIV epidemic among MSM in Baltimore, and 2) the contribution of different population subgroups to new HIV infections

* Centers for Disease Control and Prevention. HIV Infection Risk, Prevention, and Testing Behaviors among Men Who Have Sex With Men—National HIV Behavioral Surveillance, 20 U.S. Cities, 2014. HIV Surveillance Special Report 15. http://www.cdc.gov/hiv/library/reports/surveillance/#panel2 . Published January 2016.

METHODS

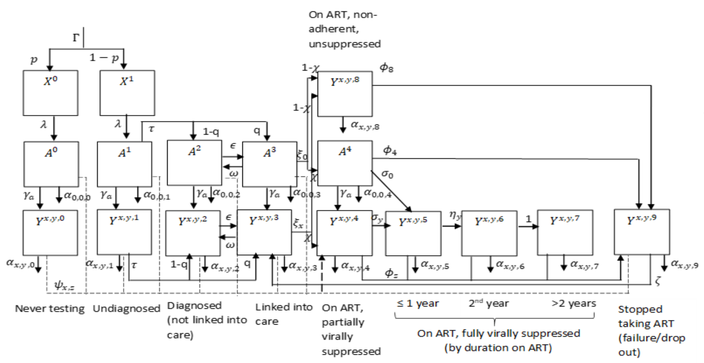
DYNAMIC MODEL OF HIV TRANSMISSION AND TREATMENT AMONG MSM IN BALTIMORE

We developed a deterministic dynamic model of HIV transmission and treatment among the MSM population of Baltimore from 1984 to 2017. MSM are divided by age (18-24 years old (younger), 25+ years old (older)), and race (black, white, >90% of the MSM population in Baltimore).

MSM living with HIV (HIV+ MSM) are also compartmented by CD4 and viral load levels, and care continuum status, reflecting history of HIV testing, diagnosis, linkage to care, ART use, ART adherence and viral suppression (Figure 1).

Demography, sexual activity, sexual mixing by age/race, and condom use parameters were based on NHBS data for Baltimore MSM.

FIGURE 1. Modelled care continuum stages



The size of each of the demographic and care continuum groups, and the HIV prevalence over time was fitted in a Bayesian framework to Baltimore-specific survey and surveillance data (CDC NHBS and Maryland Department of Health data). We simulated a total of 118 different epidemics consistent with the empirical data.

INFECTIONS AVERTED BY INTERVENTIONS, AND ACQUIRED/TRANSMITTED BY GROUPS OVER 2008-2017

We used the 118 fitted simulations to estimate:

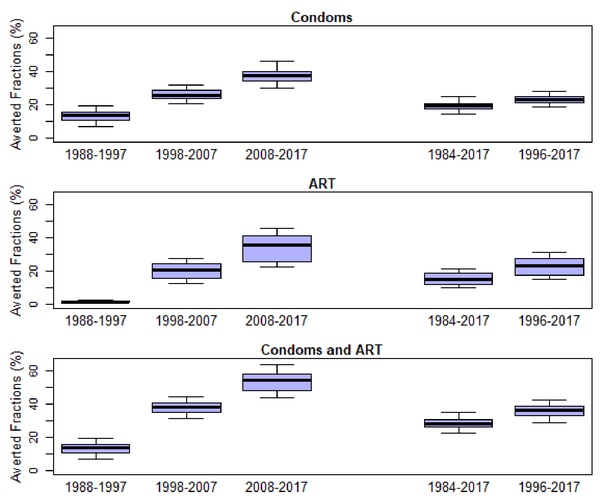
- The averted fraction (AF) = fraction of HIV infections averted by the use of condoms between 1984 and 2017, and by the use of ART between 1996 and 2017, and both combined. The AF was obtained using counterfactual scenarios assuming no intervention during the same period.
- The proportion of infections that were acquired by the different groups between 2008 and 2017.
- The Population Attributable Fraction (PAF) = fraction of HIV infections that were attributable to different demographic (race, age) and care continuum groups between 2008 and 2017. The PAF was obtained using counterfactual scenarios assuming the group could not transmit the disease.

We report median estimates across the 118 fitted simulations, and 95% uncertainty intervals (UI) (2.5th and 97.5th percentiles).

RESULTS

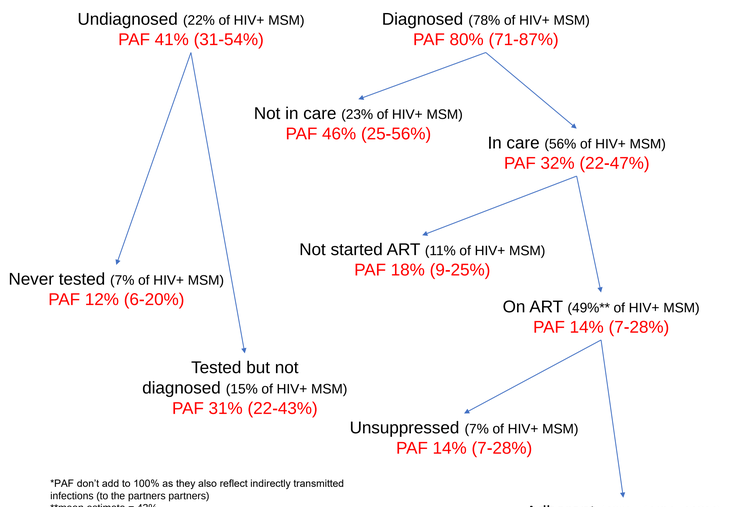
IMPACT OF PAST INTERVENTIONS AGAINST HIV

FIGURE 2. Percentage of new HIV infections among MSM in Baltimore averted by condoms and ART, and both simultaneously, over different time periods.
The model estimated that condom use averted 19% (95% UI: 14-25%) of HIV infections over 1984-2017, and its impact increased over time, to 37% (30-46%) over 2008-2017. ART averted 23% (15-31%) of new infections after its introduction in 1996. This fraction also increased over time as ART coverage increased, reaching 36% (23-46%) over 2008-2017. Condoms and ART together were estimated to have averted 36% (29-43%) of all new infections after 1996, and 54% (42-62%) over 2008-2017.



PAFs OF CARE CONTINUUM GROUPS

FIGURE 3. Median PAF* estimates and 95%UI for HIV+ MSM in the different care continuum groups over 2008-2017 (with median % among all HIV+ MSM).
HIV+ MSM on ART might have contributed to 14% (7-28%) of HIV infections over 2008-2017, while undiagnosed and diagnosed but not in care contributed to 41% (31-54%) and 46% (25-56%) of the new infections (Figure 3). HIV+ MSM adhering to ART only transmitted 3% (1-5%) of new infections, while representing 42% of all HIV+ MSM over 2008-2017.



HIV ACQUISITIONS/TRANSMISSIONS BY RACE AND AGE

TABLE 1. Estimated proportions of new HIV acquisitions and contribution to transmission of different demographic groups over 2008-2017

Demographic Group	Group Size	HIV Acquisitions		HIV Transmissions	
	% all MSM	% susceptible MSM	% acquired infections	% HIV+ MSM	PAF
Black MSM	74.9% (72.1-78.6)	63.4% (58.8-68.4)	93.0% (89.8-95.8)	92.5% (89.4-94.4)	97.1% (95.1-98.2)
White MSM	25.1% (21.4-27.9)	36.6% (31.6-41.2)	7.0% (4.2-10.2)	7.5% (5.64-10.6)	3.7% (2.2-5.9)
Younger MSM	26.9% (23.9-29.3)	32.4% (29.1-36.2)	46.3% (40.7-52.2)	18.5% (15.3-21.1)	35.4% (27.2-49.1)
Older MSM	73.1% (70.7-76.1)	67.6% (63.8-70.9)	53.7% (47.8-59.3)	81.5% (78.9-84.7)	75.4% (66.6-81.0)

We estimated that in Baltimore, black MSM comprise 92% of HIV+ MSM (Table 1). Between 2008 and 2017, black MSM acquired an estimated 93% (90-96%) of new HIV infections despite comprising only 63% (59-68%) of HIV-susceptible MSM during the period, while directly or indirectly contributing to 97% (95-98%) of transmitted infections. White MSM (8% of HIV+ MSM) acquired 7% and contributed to 4% (2-6%) of transmitted infections. An estimated 46% of new infections were acquired by, and 35% (27-49%) attributable to MSM aged 18-24 years old (18% of HIV+ MSM), while 54% (48-59%) were acquired and 75% (67-81%) attributable to 25+ year old MSM (82% of HIV+ MSM).

CONCLUSION

- We estimated that past condom and ART use have had a insufficient effect on the HIV epidemic among MSM in Baltimore to date, preventing about a third of all HIV infections that would have occurred since 1984, and half over 2008-2017.
- Interventions targeting undiagnosed MSM or MSM who are diagnosed but not in care are needed since the majority of new HIV infections have been attributed to these groups, and at higher levels than previously estimated for the US population*. In particular, Black MSM were estimated to be more vulnerable to HIV in Baltimore, and heavily impacted by unmet treatment needs.

*Skarbinski, JAMA Intern Med. 2015

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