Improving Statewide Pre-Exposure Prophylaxis Implementation Among Men Who Have Sex with Men

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BACKGROUND

- To date, pre-exposure prophylaxis (PrEP) uptake in most areas remains low among populations at risk of HIV infection,[1] despite PrEP's effectiveness at preventing transmission.
- In 2013, The Miriam Hospital Clinic in Providence, Rhode Island began prescribing PrEP to at-risk patients. The program is believed to monitor a large majority of men who have sex with men (MSM) on PrEP in the state.
- We **sought to identify PrEP allocation criteria** that most efficiently produced a **25% reduction in HIV incidence** over 10 years, using clinical data from the first 241 MSM prescribed PrEP through this program.

METHODS

- We used a discrete-time stochastic **agent-based model** to simulate HIV transmission within a virtual population of agents (*N* = 25,000) representing **MSM in Rhode Island aged 15–74**.
- The model progressed in monthly time steps, during which agents within HIV-serodiscordant sexual partnerships engaged in at-risk sex acts.
- We calibrated the model to match inferred yearly prevalence in Rhode Island from 2009 through 2014, assuming 82% of MSM were diagnosed.[2]

Agent Characteristics

- Agents exhibited **heterogeneous sexual behaviors**, including annual partner number, relationship duration, condomless anal sex, sexual role preference, and assortative mixing by age.
- **HIV-infected agents** were characterized by their diagnosis and viral suppression status, with starting probabilities of 82% and 45%, respectively.[2,3]
- **HIV-uninfected agents** were characterized as on/off PrEP. They initiated and discontinued PrEP stochastically and could be fully (82%) or partially adherent,[4] corresponding to 96% and 76% reductions in per-act risk of HIV acquisition, respectively.[5] HIV testing frequency was based on Rhode Island data.[6]
- These risk factors and behaviors in combination determined the overall per-sex-act transmission probability between two serodiscordant agents.
- Behavioral, demographic, and epidemiologic parameters were derived from publicly available surveillance data,[7–9] the scientific literature,[10–17] and primary clinic data from MSM on PrEP in Rhode Island.[4]

Simulations

- We simulated each scenario 1000 times at stable PrEP coverages ranging from 5 to 30% of the HIV-uninfected population.

Outcomes

- Ten-year **incidence**, number and percentage of **infections averted** (NIA, PIA), and **person-years on PrEP per averted infection** (PYPAI)

PREP ALLOCATION SCENARIOS

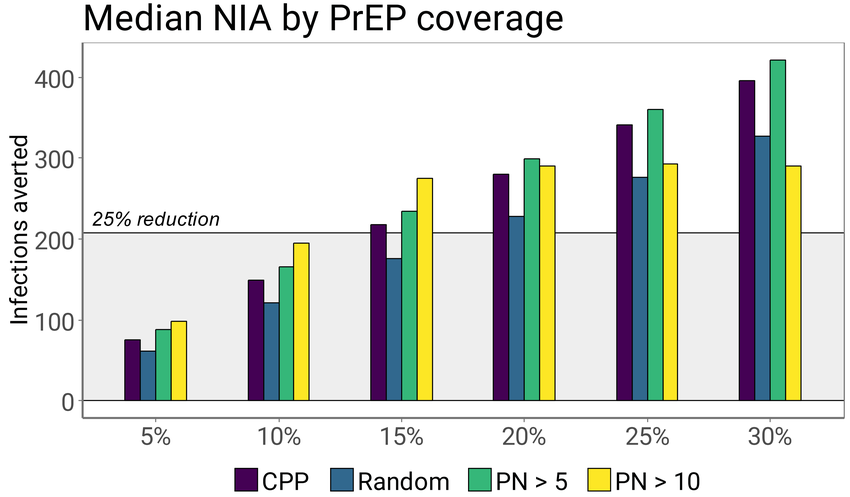
Current Patient Population (CPP) — Selection based on age and partner degree (quartiles) among patients in the Miriam Clinic PrEP program

Random — Random allocation to HIV-uninfected agents

Partner Number (PN) — Annual partner number greater than 5 or 10

RESULTS

- MSM in the PrEP clinic had an annualized median of 8 partners (IQR: 4–17).
- Between 2015 and 2025, the No PrEP model predicted 826 new infections (IR = 3.51 per 1000 person-years), with HIV prevalence rising from 3.5% to 7.4%.
- **Median PIA reached 25% after 3.2, 6.4, and 8.8 years** in the PN > 10, PN > 5, and CPP scenarios, respectively, at 15% PrEP coverage.

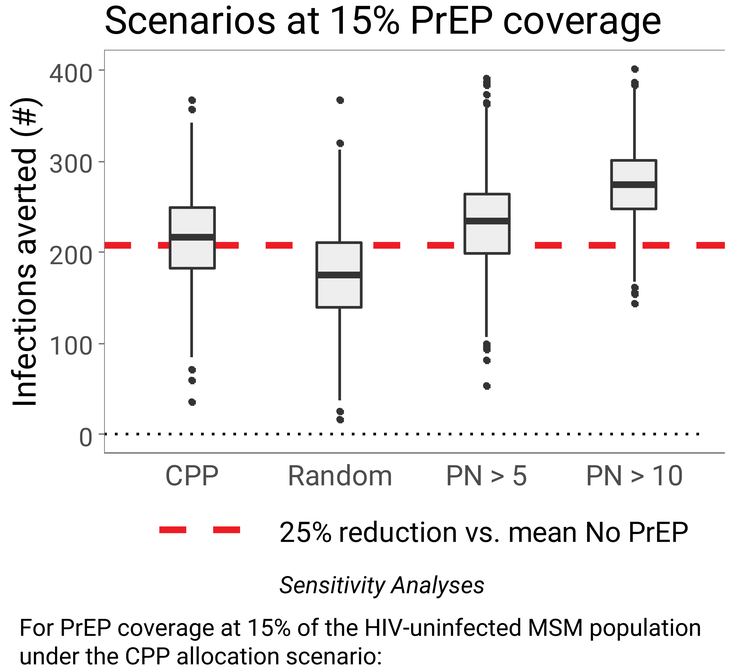


NOTE: PN > 10 scenario achieved a maximum 15% population coverage

TABLE. 10-year HIV outcomes under each allocation scenario at 15% PrEP coverage*

Scenario*	Final HIV (%)	New Infections	Incidence Rate†	Infections Averted (%)	PYPAI
No PrEP	7.4 (6.7, 8.1)	826 (711, 955)	3.51 (3.00, 4.08)	-	-
RI/CDC	6.5 (5.9, 7.2)	612 (523, 709)	2.59 (2.21, 3.02)	26.2 (14.5, 37.0)	161 (115, 289)
Random	6.7 (6.0, 7.4)	654 (546, 756)	2.77 (2.31, 3.22)	21.2 (8.9, 34.2)	199 (124, 474)
PN > 5	6.5 (5.8, 7.1)	595 (499, 691)	2.52 (2.11, 2.94)	28.3 (16.7, 39.9)	150 (107, 252)
PN > 10	6.3 (5.7, 6.9)	555 (478, 639)	2.35 (2.01, 2.71)	33.1 (23.0, 42.4)	128 (100, 184)

**Except No PrEP. †Per 1000 person-years at risk. PYPAI, person-years on PrEP per averted infection. Medians and 95% simulation limits (2.5% and 97.5% quantiles of outcome distributions)*



Sensitivity Analyses

For PrEP coverage at 15% of the HIV-uninfected MSM population under the CPP allocation scenario:

- Scaling the sex frequency distribution by 0.5 and 1.5 resulted in medians of 68 and 520 averted infections, respectively.
- Scaling the annual partner number distribution in the same manner resulted in medians of 89 and 1471 averted infections.
- Changes in age-assortative mixing patterns had relatively modest effects on aggregate HIV transmission measures, as did changes to the proportion of fully adherent PrEP agents.

DISCUSSION

- At consistent 15% population coverage, **most PrEP scenarios succeeded in reducing 10-year HIV incidence by 25%**.
- When population coverage remains low, focusing efforts on MSM with high partner numbers may improve both the impact and efficiency of PrEP implementations.
- Future research should investigate implications for cost-effectiveness across a range of settings and implementations.

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