**Cost-Effectiveness of a Statewide Pre-Exposure Prophylaxis Program for Gay, Bisexual, and Other Men Who Have Sex with Men**

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**ABSTRACT**

Pre-exposure prophylaxis (PrEP) is an effective tool for preventing HIV infection among men who have sex with men (MSM), but its cost-effectiveness has varied across settings. Using an agent-based model, we projected the cost-effectiveness of a statewide PrEP program for MSM in Rhode Island over the next decade. In the absence of PrEP, the model predicted an average of 830 new HIV infections over ten years. Scaling up the existing PrEP program to cover 15% of MSM with ten or more partners each year could reduce the number of new HIV infections by 33.1% at a cost of $184,234 per quality-adjusted life-year (QALY) gained. Expanded PrEP use among MSM at high risk for HIV infection has the potential to prevent a large number of new HIV infections but the high drug-related costs may limit the cost-effectiveness of this intervention.

**KEYWORDS:** HIV pre-exposure prophylaxis, agent-based modeling, cost-effectiveness, men who have sex with men

**BACKGROUND**

Similar to national trends,1 men who have sex with men [MSM] represent the majority of people newly diagnosed and living with HIV infection in Rhode Island.2 Once-daily pre-exposure prophylaxis (PrEP) represents an effective prevention tool that has the potential to decrease the number of new HIV infections occurring among MSM.3

Recent mathematical models have demonstrated that the expansion of PrEP use among MSM may have benefits at the population level in terms of reducing HIV incidence. 3-5 However, many studies have produced mixed results in terms of the cost-effectiveness of scaling up this intervention.5-10 A recent analysis found that PrEP initiation among 20% of MSM in the United States would result in a 13% reduction in new HIV infections over 20 years but would not be considered cost-effective unless those most vulnerable to HIV infection were prioritized for PrEP initiation.10

As many jurisdictions make important decisions about supporting scale-up of PrEP use among MSM, the clinical and economic benefits in local settings must be understood. To date, few studies have expanded the cost-effectiveness of real-world PrEP implementation in specific settings with models parameterized to represent local epidemiologic and behavioral contexts.8,9 In the current study, we simulated HIV transmission using an agent-based model representing all MSM in Rhode Island and considered the cost-effectiveness of various PrEP implementation scenarios.

**METHODS**

All model parameters and processes have been described previously.11 In brief, the agent-based model simulated HIV transmission from 2013 to 2022 among a population of individuals [referred to as agents] representing all MSM in Rhode Island [n = 25,000]. The agents in the model were assigned specific demographic, behavioral, and clinical characteristics with distributions informed by data on MSM in Rhode Island, with estimates from the literature used as needed (Table 1).

The model progressed in a series of discrete time-steps, each representing one calendar month. During each time-step, agents were able to form and dissolve sexual partnerships. In the context of serodiscordant partnerships, agents could

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-exposure prophylaxis (PrEP) use</td>
<td></td>
</tr>
<tr>
<td>Retention in clinical care</td>
<td>54.0%</td>
</tr>
<tr>
<td>6 months post-initiation</td>
<td>15.0%</td>
</tr>
<tr>
<td>Monthly probability of discontinuation (7+ months post-initiation)</td>
<td></td>
</tr>
<tr>
<td>Pill adherence</td>
<td></td>
</tr>
<tr>
<td>4 to 7 doses per week</td>
<td>82.0%</td>
</tr>
<tr>
<td>2 to 3 doses per week</td>
<td>18.0%</td>
</tr>
<tr>
<td>Reduction in risk of HIV acquisition</td>
<td></td>
</tr>
<tr>
<td>4 to 7 doses per week</td>
<td>96.0%</td>
</tr>
<tr>
<td>2 to 3 doses per week</td>
<td>76.0%</td>
</tr>
<tr>
<td>Costs (2015 U.S. dollars)</td>
<td></td>
</tr>
<tr>
<td>Annual cost of PrEP, per patient</td>
<td>$10,664</td>
</tr>
<tr>
<td>Lifetime cost of HIV treatment, per patient</td>
<td>$337,036</td>
</tr>
<tr>
<td>Utility</td>
<td></td>
</tr>
<tr>
<td>Quality-adjusted life-year gained per averted infection</td>
<td>5.83</td>
</tr>
</tbody>
</table>
acquire HIV infection by engaging in condomless anal intercourse. Following infection, an agent could be tested and diagnosed, initiate antiretroviral treatment, or achieve viral suppression. Agents without HIV infection were eligible to initiate PrEP use based on the specific allocation scenario. Those who initiated PrEP could achieve an optimal level of adherence and discontinue PrEP use at any time (Table 1).

Model Scenarios
The model predicted the total number of new HIV infections over ten years under three PrEP allocation scenarios with varying levels of intervention coverage (5% to 25%, in 5% increments). The first set of scenario allocated PrEP to individuals similar to those currently receiving PrEP from the Rhode Island STD Clinic,11 while the two other sets of scenarios allocated PrEP to MSM with at least five or ten sexual partners each year, respectively. Each scenario is simulated for 1,000 iterations. Each scenario summarized as the mean number of HIV infections averted relative to a ‘status quo’ scenario where PrEP implementation does not occur.

Cost and Utility Assumptions
The annual operating cost of providing PrEP to one patient was estimated using a health system perspective (Table 1). Costs were derived from an analysis of the PrEP program at the Rhode Island STD Clinic.12 For each scenario, we calculated the cost per quality-adjusted life-year (QALY) gained relative to the ‘status quo’ scenario. Based on current guidelines, a scenario was considered cost-effective if this value was under a threshold under $100,000 QALY gained. Because drug-related costs represent the primary driver of program costs, we conducted sensitivity analyses where these costs were reduced (10% to 90%, in 10% increments).

RESULTS
In the absence of PrEP use, the model estimated an average of 830 new HIV infections over ten years, corresponding to an incidence rate of 3.5 infections per 1,000 person-years. With all strategies, increasing PrEP use resulted in proportionate reductions in HIV incidence (Figure 1).

If the current patient population served by the PrEP program were to be scaled up to cover 15% of MSM for ten years, the cumulative number of new HIV infections could be reduced by 26.1%. This scenario generated an increment $305 billion in healthcare-related costs and $73 billion in savings on HIV care, corresponding to $260,050 per QALY gained. Although increasing coverage to 25% would reduce the number of new HIV infections by 41.1%, the total cost and incremental cost-effectiveness increased because of the diminished benefits of additional PrEP use (Table 2).

Should 15% of MSM with five or more sexual partners each year use PrEP over the next ten years, the cumulative number of new HIV infections could be reduced by 28.0%. This allocation strategy improved cost-effectiveness, where the cost per QALY gained was reduced to $235,358. An allocation strategy that initiated 15% of MSM with ten or more sexual partners each year to use PrEP over a decade could reduce the number of new HIV infections by 33.1% and further reduce the cost per QALY gained to $184,234. Despite
these reductions in incremental costs, neither of these strategies were considered cost-effective based on a standard threshold of $100,000.

Drug-related costs have considerable effect on the cost-effectiveness of PrEP implementation. Were the annual drug-related costs to be reduced by 40%, for example, the cost per QALY gained when 15% of MSM with five or more partners use PrEP is reduced to $118,085. Under a standard threshold of $100,000, a scenario where 15% of MSM with ten or more partners used PrEP would be considered cost-effective with this reduction in drug-related costs ($87,416 per QALY gained).

**CONCLUSION**

We found that PrEP use among MSM in Rhode Island has the potential to prevent a considerable number of new HIV infections over a decade. However, expanded PrEP use is expensive. PrEP use among MSM at high risk of HIV acquisition provides substantial benefits at a lower cost, although its budgetary impact is still sizable. The high drug-related costs of PrEP are a significant barrier to cost-effective scale-up of PrEP implementation in this context. Drug costs must be reduced for PrEP to become an affordable HIV prevention option.

**Acknowledgments**

We thank Jesse L. Yedinak, MPA, for her administrative assistance. This work was supported by the National Institute of Mental Health (R21MH109360). Mr. Goedel is further supported by the National Institute of Mental Health (R25MH083620). The views expressed herein are those of the authors and do not necessarily reflect the views of the National Institutes of Health.

**References**


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