A Cost-Effectiveness Analysis of Pre-exposure Prophylaxis (PrEP) for the Prevention of HIV among Men who have Sex with Men (MSM) in Los Angeles County

**Presenter**

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Evidence on Effective HIV/AIDS Prevention Strategies

- Early ART treatment highly efficacious in RCT studies of sero-discordant heterosexual couples (HPTN 052, 2007-2015):
  - 96% and 89% reductions for linked and all HIV transmissions at median follow-up time of 1.7 y \(^1\)
  - 93% and 69% reductions during entire study \(^2\)

2 Figure adapted from Cohen et al. Antiretroviral Therapy for the Prevention of HIV-1 Transmission. *NEJM* 2016; 375(9):830-839.
Evidence on Effective HIV/AIDS Prevention Strategies

- Early ART reduces risk of HIV transmission in observational studies
  - Pooled estimate: 42%
- But much lower efficacy estimates than those from RCTs
- Substantial variations in efficacy rates across studies
  - Bias in studies (e.g. variations in follow-up duration)?
  - Real-world poor adherence effect?

Risk of HIV transmission in sero-discordant couples treated vs untreated with ART in observational studies

<table>
<thead>
<tr>
<th>Study</th>
<th>HIV Cases</th>
<th>Person-Years</th>
<th>HIV Cases</th>
<th>Person-Years</th>
<th>Rate Ratio (95% CI)</th>
<th>Favors Treatment</th>
<th>Favors No Treatment</th>
<th>Weight, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Musicco, 1994</td>
<td>21</td>
<td>481</td>
<td>6</td>
<td>157</td>
<td>0.88 (0.36-2.16)</td>
<td></td>
<td></td>
<td>14.1</td>
</tr>
<tr>
<td>Melo, 2008</td>
<td>6</td>
<td>1272</td>
<td>0</td>
<td>1085</td>
<td>0.10 (0.01-1.67)</td>
<td></td>
<td></td>
<td>2.8</td>
</tr>
<tr>
<td>Sullivan, 2009</td>
<td>171</td>
<td>5038</td>
<td>4</td>
<td>571</td>
<td>0.21 (0.08-0.56)</td>
<td></td>
<td></td>
<td>12.8</td>
</tr>
<tr>
<td>Del Romero, 2010</td>
<td>5</td>
<td>938</td>
<td>0</td>
<td>417</td>
<td>0.21 (0.01-3.75)</td>
<td></td>
<td></td>
<td>2.7</td>
</tr>
<tr>
<td>Lu, 2010b</td>
<td>18</td>
<td>1585</td>
<td>66</td>
<td>3888</td>
<td>1.44 (0.85-2.44)</td>
<td></td>
<td></td>
<td>19.9</td>
</tr>
<tr>
<td>Donnell, 2010</td>
<td>102</td>
<td>4558</td>
<td>1</td>
<td>273</td>
<td>0.08 (0.01-0.57)</td>
<td></td>
<td></td>
<td>5.3</td>
</tr>
<tr>
<td>Reynolds, 2011</td>
<td>32</td>
<td>372</td>
<td>0</td>
<td>25</td>
<td>0.10 (0.01-1.64)</td>
<td></td>
<td></td>
<td>2.9</td>
</tr>
<tr>
<td>Birungi, 2012</td>
<td>8</td>
<td>348</td>
<td>9</td>
<td>440</td>
<td>0.91 (0.38-2.20)</td>
<td></td>
<td></td>
<td>14.4</td>
</tr>
<tr>
<td>Jia, 2012c</td>
<td>696</td>
<td>26758</td>
<td>935</td>
<td>74537</td>
<td>0.74 (0.65-0.84)</td>
<td></td>
<td></td>
<td>25.1</td>
</tr>
<tr>
<td>Total</td>
<td>696</td>
<td>26758</td>
<td>935</td>
<td>74537</td>
<td>0.58 (0.35-0.96)</td>
<td></td>
<td></td>
<td>100.0</td>
</tr>
</tbody>
</table>

Evidence on Effective HIV/AIDS Prevention Strategies

- Early ART efficacious in MSMs (European PARTNER Study):
  - No transmissions through unprotected (“condomless”) sex when HIV+ partner on ART and virally suppressed

Rate of HIV transmission according to sexual behavior reported by the HIV-negative partner

<table>
<thead>
<tr>
<th>Sexual Behavior</th>
<th>Rate of Transmission (per 100 Couple-Years of Follow-up)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any sex</td>
<td>0.84</td>
</tr>
<tr>
<td>Anal sex</td>
<td>0.89</td>
</tr>
<tr>
<td>Insertive anal sex</td>
<td>1.00</td>
</tr>
<tr>
<td>Receptive anal sex with ejaculation</td>
<td>2.70</td>
</tr>
<tr>
<td>Receptive anal sex without ejaculation</td>
<td>1.68</td>
</tr>
</tbody>
</table>

Evidence on Effective HIV/AIDS Prevention Strategies

- Early ART effective at reducing HIV transmission and mortality and delaying progression to AIDS
  - 34% reduction in new infections, 19% reduction in deaths, 39% reduction in AIDS incidence (over 20 years)
- But expensive and could increase resistance to ART
  - 2-fold increase in MDR prevalence (9.06% vs 4.79%)

Evidence on Effective HIV/AIDS Prevention Strategies

- Condoms, medical male circumcision are highly effective strategies
- PrEP is also very effective at reducing HIV transmission
  - But relatively new and costly,
  - Currently indicated only for high-risk individuals (difficult to identify)
  - Real-life adoption, adherence and efficacy data only beginning to emerge

Studies

- Condoms in heterosexuals
- Partners PrEP in discordant couples
- Condoms in US MSM
- TDF in men & women
- Medical male circumcision
- Bangkok PrEP in IDU
- IPREx in MSM
- CAPRISA 004 (1% TDF vaginal gel) in women
- Aspire / MTN 020 (Dapivirine ring)
- FEM-PrEP in women, VOICE (TDF/FTC, TDF vaginal gel), FACTS (TDF gel) in women

Reduction of HIV Transmission

- 80%
- 75%
- 70%
- 63%
- 54%
- 49%
- 44%
- 39%
- 27%

Non significant

Evidence on Effective Prevention Strategies

- PrEP is cost-effective for the U.S. MSMs in high prevalence settings:
  - $32,000/QALY for New York City high-risk MSM \(^1\)
  - $50,000/QALY in high-risk MSM and $172,091/QALY for all MSMs \(^2\)
    - Assumes 20% PrEP coverage and 12.3% HIV prevalence
- But these studies only compare PrEP to no PrEP
  - No comparison with other intervention strategies
    - Testing
    - Test-and-treat
    - Combination strategies

WHAT ARE THE COST AND BENEFIT TRADE-OFFS BETWEEN DIFFERENT HIV PREVENTION STRATEGIES AMONG LOS ANGELES COUNTY MSMs?

- We will compare multiple prevention strategies, including:
  - Status Quo (Test 4.4 y + ART 2.5 y at CD4 \( \leq 500 \))
    - Represents policy in LAC in 2013
  - Expanded HIV testing (“Testing”)
  - Expanded HIV testing + Early treatment with ART (“Test-and-treat”)
  - Initiation of PrEP (“PrEP”)

- We will use a particular Economic Evaluation method
  - Cost-effectiveness Analysis (CEA)
**Economic Evaluation Methods in Health**

- Objective: Maximize outcomes and minimize costs
- Limited resources implies tradeoffs between competing strategies
- CUA is a special form of CEA
  - Effectiveness measure is "Utility" (QALYs)
  - Compares alternatives with different outcomes
  - Useful for assessing both allocative and technical efficiencies

### Are Both Costs and Outcomes of Alternatives Assessed?

<table>
<thead>
<tr>
<th>Comparison of Two or More Alternatives?</th>
<th>Are Both Costs and Outcomes of Alternatives Assessed?</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO</td>
<td>NO Outcomes Only Costs Only Costs and Outcomes</td>
</tr>
<tr>
<td></td>
<td>Partial Evaluation • Outcome Description Partial Evaluation • Cost of Illness Analysis Partial Evaluation • Cost-outcome Description</td>
</tr>
<tr>
<td>YES</td>
<td>YES Partial Evaluation • Efficacy (Outcome) Analysis Partial Evaluation • Cost Analysis <strong>Full Economic Evaluation</strong> • Cost-Consequences Analysis (CCA) • Cost-Minimization Analysis (CMA) • Cost-Effectiveness Analysis (CEA) <strong>Cost-Utility Analysis (CUA)</strong> • Cost-Benefit Analysis (CBA)</td>
</tr>
</tbody>
</table>

General Analytical Approach

▪ **Apply systems science methods to model reality**
  › A model is a simplified representation or abstraction of reality

▪ **Synthesize data from RCTs, natural experiments and “real-world” observational studies**

▪ **Construct a mathematical model of HIV transmission & disease progression**
  › Calculate and compare cost and effectiveness of different strategies
  › Other types modeling approaches used by researchers:
    • Decision-tree models
    • Markov models
    • Microsimulation & Agent-based (extension of microsimulation) models
Methods

- **Model**: Mathematical model of HIV transmission & Economic model
- **Population**: Los Angeles County MSM, aged 15–65 y
- **Evaluation Period**: 2013-2033
- **Perspective**: U.S. societal
- **Time horizon**: Lifetime
- **Comparators**: 623 alternative standalone and combinations strategies
- **Outcomes and measures**:  
  › Cumulative HIV incidence and HIV infections averted  
  › Discounted costs and quality-adjusted life years (QALYs)  
  › Incremental cost-effectiveness ratios (ICERs)
    
    \[
    ICER_{i,j} = \frac{PV(Costs_j) - PV(Costs_i)}{PV(QALYs_j) - PV(QALYs_i)}
    \]

- **Decision criteria**:  
  › ICER < U.S. WTP threshold ($150,000/QALY) deemed cost-effective  
  › Sequential ranking of strategies to trace “Efficient Frontier”  
    • Strategies yielding highest value for defined level of societal WTP
Data

- **Demographic & epidemic data (2000-2010):**
  - RAND California Population and Demographics database
    - 176,971 and 190,699 MSMs in 2000 and 2010
  - LAC HIV Surveillance Reports
    - 17% and 24% HIV prevalence for MSMs in 2000 and 2010

- **Model input parameter values:**
  - Estimated from demographic and epidemic data
  - Extracted from medical clinical literature
  - Informed by expert opinion

- **Cost and health outcomes data:**
  - Economic and medical clinical literature
  - Federal Supply & Clinical Diagnostic Laboratory Fee Schedules
Men enter model through aging and discovery of sexual orientation (rate $\pi$)
Flow Diagram of the HIV Transmission Model

Then can transition between health states, including:

- **Uninfected**
- **Primary**
- **Asymptomatic**
- **Symptomatic**
- **AIDS**
Flow Diagram of the HIV Transmission Model

MSM are also tracked based on their awareness of sero-status through testing, and their treatment status.
Flow Diagram of the HIV Transmission Model

MSM exit the model through death ($\mu$) or mortality from HIV/AIDS complications ($\gamma_{A_k}, \gamma_{AJ_k}$ or $\gamma_{TA_k}$)
Flow Diagram of the HIV Transmission Model

Arrows and associated Greek symbols indicate transitions, and associated rates
Subscripts “s” denote drug-sensitive stratum
## Base Case Model Assumptions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Status Quo/Testing/Test-and-Treat</th>
<th>PrEP</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIV testing rate (Frequency)</td>
<td>0.227 (Every 4.4 y)</td>
<td>1.000</td>
</tr>
<tr>
<td></td>
<td>(Annually)</td>
<td>0.500</td>
</tr>
<tr>
<td></td>
<td>(Every 2 y)</td>
<td>0.500</td>
</tr>
<tr>
<td>Blood urea nitrogen concentration, serum creatinine levels, and STI testing frequency</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Every 3 mo</td>
</tr>
<tr>
<td>ART initiation rate at CD4≤500 cells/µL (frequency)</td>
<td>0.404 (Every 2.5 y)</td>
<td>0.404</td>
</tr>
<tr>
<td></td>
<td>(Every 2.5 y)</td>
<td>0.404</td>
</tr>
<tr>
<td></td>
<td>(Every 2.5 y)</td>
<td>0.404</td>
</tr>
<tr>
<td>Early ART initiation rate</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Immediate</td>
</tr>
<tr>
<td>PrEP initiation rate</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.250</td>
</tr>
<tr>
<td></td>
<td>(Every 4 y)</td>
<td></td>
</tr>
<tr>
<td>ART and PrEP adherence rates</td>
<td>0.282 0.282 0.282 0.282</td>
<td>0.282</td>
</tr>
<tr>
<td></td>
<td>(Every 2.5 y)</td>
<td>(Every 2.5 y)</td>
</tr>
<tr>
<td>ART and PrEP discontinuation rates</td>
<td>0.116 0.116 0.116 0.116</td>
<td>0.116</td>
</tr>
<tr>
<td></td>
<td>(Every 2.5 y)</td>
<td>(Every 2.5 y)</td>
</tr>
<tr>
<td>Reduction in risky sexual behavior owing to testing and counseling</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.200</td>
</tr>
<tr>
<td>Reduction sexual infectivity owing to ART</td>
<td>0.900 0.900 0.900 0.900</td>
<td>0.900</td>
</tr>
<tr>
<td></td>
<td>(Every 2.5 y)</td>
<td>(Every 2.5 y)</td>
</tr>
<tr>
<td>Reduction sexual infectivity owing to PrEP</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.920</td>
</tr>
<tr>
<td>Reduction in risk of infection owing to PrEP</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.440</td>
</tr>
</tbody>
</table>
Model Calibration and Validation

- Calibration: Latin-hypercube sampling method and best-fit approach
- Validation: Compare model’s prediction to reported HIV/AIDS prevalence
PrEP and Test-and-Treat are very effective at reducing HIV transmission
But do not eliminate HIV
Key Findings

- PrEP and Test-and-Treat strategies are highly cost-effective
  - $27,863/QALY and $19,302/QALY, respectively (relative to Status Quo)
- Efficient Frontier: Status Quo + 5 Test-and-treat + 7 PrEP strategies
- More aggressive strategies are more costly, but more effective
- Diminishing returns to more aggressive strategies
- The most aggressive strategy (PrEP + Test 3 mo + immediate ART) is highly cost-effective relative to Status Quo ($37,181/QALY)
Efficient Frontier for Resource Allocation

Strategies that yield the highest value (lowest cost per QALY) for a defined level of societal WTP.

Slope of the line between 2 points represents the ICER of these strategies relative to each other.

Steeper slopes mean high ICERs.
Sensitivity Analyses

- One- and multi-way sensitivity analyses
  - Bootstrapping and probabilistic sensitivity analyses
- All ICERs are robust to perturbations of the input parameter values (epidemic, cost and effectiveness parameters)
- Relative effectiveness of PrEP is sensitive to
  - Initial disease prevalence
  - PrEP and ART initiation rates
  - Adherence to PrEP and ART
  - Sexual mixing rates
- All cost-effectiveness profiles improve with ART price reductions
PrEP (TT + Test 6 mo + PrEP 4 y) Relative to Status Quo

Epidemic Parameters

- ICERs sensitive to PrEP & ART coverage rates and rates of adherence

$63,269/QALY
Robustness Analysis

All ICERs are cost-effective at the U.S. average WTP of $150,000/QALY gained.
Robustness Analysis

All cost-effectiveness profiles improve with ART price reductions following patent expiration.
Summary of Key Findings & Discussion

- PrEP and Test-and-treat are cost-effective alternatives to Status Quo
  - Consistent with Desai et al. (2008) estimate of $32,000/QALY
  - Also consistent with Juusola et al. (2012):
    - $50,000/QALY in high-risk MSM
    - 20% PrEP coverage; 12.3% HIV prevalence
  - Difference between Juusola et al. (2012) and our results partly due to assumptions about HIV prevalence
- Choice of optimal strategy depends on societal WTP threshold
  - Test-and-treat is optimal with constrained budgets
  - Combination strategies of Test-and-treat and PrEP are optimal with less constrained budgets
- Provides additional evidence on the cost-effectiveness of PrEP
- However, even the most aggressive cost-effective PrEP strategy is unlikely to eliminate the HIV epidemic
Limitations

- Proportional sexual mixing assumption is unrealistic
  - Differences between Blacks and other race groups \(^1\)
  - Better characterized by preferential mixing \(^2\)
- Does not capture heterosexual transmission
- No stratification by risk type (e.g. injection drug-users, sex workers)
- Does not account for geographic and demographic variations
  - Limits applicability of findings for targeted interventions
- HRQOL estimates based on one instrument only (EQ-5D US)
  - QOL estimates are sensitive to instrument used
- Omits other effective biomedical and behavioral interventions:
  - Treatment of other STIs
  - Harm reduction programs
  - Education programs

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Conclusion

- Results help policymakers and public health officials choose optimal HIV prevention strategies adapted to their resources and objectives.
- Can inform policy debate around PrEP use (WHO endorsement, calls for statewide strategies).
- More aggressive strategies on the frontier should be adopted when possible.
- Success of PrEP and Test-and-treat depends particularly on:
  - Uptake of PrEP and ART
  - Adherence to treatment
  - Behavioral responses to PrEP and ART
- PrEP and Test-and-treat be further enhanced by:
  - Behavioral interventions (e.g. incentives, reminders, education, motivation)
  - Innovation (long-acting agents, smart ART delivery systems)
  - Policies that reduce barriers to access to care and treatment (e.g. education, health insurance, price regulation)
- Data critically needed to understand behavioral response to PrEP.
Thank You!
Supplementary Materials
Other Research

HIV/AIDS
- New cross-campus collaboration with UCLA, USC and the LAC office of HIV/AIDS
  - Inform implementation of LAC’s HIV/AIDS Strategic plan for 2020 and Beyond to
    - reduce HIV infections to 500/year,
    - increase the percentage of individuals aware of HIV infection to 90%
    - increase viral suppression among diagnosed to 90%

Cerebrovascular and Neurological Diseases
- Racial/ethnic disparities in Alzheimer’s disease (AD) diagnosis and treatment patterns and their linkages with patient outcomes
- Evaluation of strategies for improving stroke outcomes
- Relationships between Stroke and dementias:
  - How do stroke-prevention interventions affect AD risk and outcomes?
- K-award application

Safety Net Programs
- Linkages between SNAP and chronic disease risk and outcomes
- Unintended consequences of changes in safety-net program participation rules
  - E.g. SNAP work requirement and SSDI participation
  - Section 8 vouchers and neighborhood-related health outcomes

Innovation Policy
- Statistical discrimination
- Rare and neglected diseases
A Conceptual Model of HIV Transmission & Prevention

- **Uninfected (Susceptible)**
- **HIV Transmission**
- **Infected**
  - **HIV Risk Perception**
- **Other STIs**
- **Biology**
- **Behavior**
  - **HIV Risk Perception**
  - **Behavioral Interventions**
    - **Counselling**
    - **Testing & referrals**
    - **Sexual health promotion**
    - **Harm reduction**
    - **Education**
    - **Positive prevention**
  - **Biomedical Interventions**
    - **Highly Effective**
      - Condoms, ART/TASP, PrEP, PEP/nPEP
    - **Other**
      - Treatment of other STIs, Penile circumcision, Microbicides, Vaccines
## Economic Evaluation Methods in Health

<table>
<thead>
<tr>
<th>Analytical Method</th>
<th>Measures</th>
<th>Results</th>
<th>Applicability for Assessing</th>
<th>Strength</th>
<th>Weakness</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Options to Achieve a Specific Objective</td>
<td>Options Across Health Sector</td>
<td>Options Inside and Outside Health Sector</td>
</tr>
<tr>
<td></td>
<td>Cost</td>
<td>Outcome</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CCA</td>
<td>$</td>
<td>Multidimensional listing of outcomes (clinical values)</td>
<td>Cost per case</td>
<td>Yes</td>
<td>?</td>
</tr>
<tr>
<td>CME</td>
<td>$</td>
<td>Equivalence demonstrated or assumed in comparative groups</td>
<td></td>
<td>Yes</td>
<td>No</td>
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<tr>
<td>CEA</td>
<td>$</td>
<td>Single “natural” unit outcome measure (Quantity OR Quality of Life): Life-years gained</td>
<td>ICER</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>CUA</td>
<td>$</td>
<td>Multiple outcomes (Quantity + Quality of Life): QALYs, HYE/QAL</td>
<td>ICUR</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>CBA</td>
<td>$</td>
<td>$ (e.g. human capital, WTP)</td>
<td>NB, Benefit to cost ratio, ROI</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

System of ODEs – Example

\begin{align*}
\dot{S} &= (\pi + g_{PP,\text{EP}}SPrEP + \psi SJ) - (\mu + \lambda_s + \lambda_r + \omega_S)S \\
\dot{SJ} &= (\omega_S S + \omega_{SP,\text{EP}}SPrEP) - (\mu + \psi + \lambda_{Js} + \lambda_{Jr} + \sigma_{SP,\text{EP}})SJ \\
SPrEP &= \sigma_{SP,\text{EP}}SJ - (\mu + \lambda_{s,PP,\text{EP}} + \lambda_{r,PP,\text{EP}} + gSPrEP + \omega_{SP,\text{EP}})SPrEP \\
\dot{P}_s &= (\lambda_s S + \lambda_{Js} SJ + g_{PP,\text{EP}}PPrEP)P_s - (\mu + \rho + \sigma_{PP,\text{EP}} + \omega_P)P_s \\
\dot{P}_r &= (\lambda_r S + \lambda_{Jr} SJ + g_{PP,\text{EP}}PPrEP)P_r - (\mu + \rho + \sigma_{PP,\text{EP}} + \omega_P)P_r \\
\dot{P}J_s &= (\omega_P P_s + \omega_{PP,\text{EP}}PPrEP)P_s - (\mu + \rho)PJ_s \\
\dot{P}J_r &= (\omega_P P_r + \omega_{PP,\text{EP}}PPrEP)P_r - (\mu + \rho)PJ_r
\end{align*}
Economic Model Results

Benefits and costs of the “testing”, “test-and-treat”, and “PrEP” strategies over 20 years in the LAC MSM population.

<table>
<thead>
<tr>
<th>Rational Decision</th>
<th>Discounted $^a$</th>
<th>Inc. Values $^b$</th>
<th>Extendedly</th>
</tr>
</thead>
<tbody>
<tr>
<td>(On Efficient Frontier)</td>
<td>Cost, QALYs, M</td>
<td>Costs, QALYs, $/QALY</td>
<td>Dominate Strategies $^c$</td>
</tr>
<tr>
<td>Status Quo (SQ) $^d$</td>
<td>$B$</td>
<td>$B$</td>
<td>$B$</td>
</tr>
<tr>
<td>Test-and-treat, TT</td>
<td>45.18</td>
<td>3.05</td>
<td>1.6</td>
</tr>
<tr>
<td>(SQ + Imm. Early ART) $^d$</td>
<td>48.97</td>
<td>3.23</td>
<td>3.79</td>
</tr>
<tr>
<td>E. TT</td>
<td>50.85</td>
<td>3.31</td>
<td>1.88</td>
</tr>
<tr>
<td>(TT + Test 3 y)</td>
<td>53.32</td>
<td>3.39</td>
<td>2.47</td>
</tr>
<tr>
<td>E. TT</td>
<td>55.22</td>
<td>3.44</td>
<td>1.90</td>
</tr>
</tbody>
</table>

Continued...
Benefits and costs of the “testing”, “test-and-treat”, and “PrEP” strategies over 20 years in the LAC MSM population.

<table>
<thead>
<tr>
<th>Rational Decision (On Efficient Frontier)</th>
<th>Discounted (^a)</th>
<th>Inc. Values (^b)</th>
<th>Extendedly Dominated Strategies (^c)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PrEP</strong> <em>(TT + T 6 mo + PrEP 4 y)</em></td>
<td>$58.03, 3.48$</td>
<td>$2.81, 44,457$</td>
<td>$63,269$ SQ + T 1 y + Early ART 1 mo + PrEP 3 y TT + T 1 y + PrEP 2 y</td>
</tr>
<tr>
<td><strong>E. PrEP</strong> <em>(PrEP + PrEP 3 y)</em></td>
<td>$58.55, 3.49$</td>
<td>$0.52, 6,111$</td>
<td>$85,117$ SQ + T 3 mo + Early ART 1 mo + PrEP 3 y</td>
</tr>
<tr>
<td><strong>E. PrEP</strong> <em>(PrEP + PrEP 2 y)</em></td>
<td>$59.36, 3.5$</td>
<td>$0.81, 7,707$</td>
<td>$104,788$ SQ + T 6 mo + Early ART 1 mo + PrEP 2 y</td>
</tr>
<tr>
<td><strong>E. PrEP</strong> <em>(PrEP + T 3 mo + PrEP 2 y)</em></td>
<td>$61.01, 3.51$</td>
<td>$0.68, 4,676$</td>
<td>$145,956$ E. PrEP (PrEP + PrEP 1.2 y)</td>
</tr>
</tbody>
</table>
PrEP (TT + Test 6 mo + PrEP 4 y) Relative to Status Quo

Cost Parameters

- Annual health care costs of AIDS (untreated)
- Cost per physician visit
- Annual health care costs of asymptomatic HIV (untreated)
- Annual health care costs of AIDS (treated with ART)
- Cost of HIV diagnosis
- Annual cost of ART
- Cost per test (other sexually transmitted infections)
- Cost per antibody test
- Annual health care costs of symptomatic HIV (treated with ART)
- Annual health care costs of symptomatic HIV (untreated)
- Annual health care costs of acute HIV
- Cost per test (serum BUN and creatinine levels)
- Cost of pretest counseling
- Monthly cost of PrEP
- Cost per HIV RNA test
- Cost per CD4 count test
- Cost per HIV genotype test
- Cost of posttest counseling (HIV-)
- Cost of posttest counseling + linkage to care (HIV+)
PrEP (TT + Test 6 mo + PrEP 4 y) Relative to Status Quo

Effectiveness Parameters

- QOL: Uninfected
- QOL: AIDS (unaware)
- QOL: Symptomatic HIV (aware, untreated)
- Reduction in QOL due to false-positive test (multiplier)
- QOL: AIDS (aware, untreated)
- QOL: Symptomatic HIV (aware, treated with ART)
- QOL: Symptomatic HIV (unaware)
- QOL: Asymptomatic HIV (unaware)
- Reduction in QOL due to drug-resistance
- QOL: Acute HIV (aware)
- QOL: Asymptomatic HIV (aware, treated with ART)
- QOL: AIDS (aware, treated with ART)
- QOL: Asymptomatic HIV, Year 2+ (aware, untreated)
- Reduction in QOL due to ART side effects (multiplier)
- QOL: Asymptomatic HIV, Year 1 (aware, untreated)
- QOL: Acute HIV (treated with ART)
- QOL: Acute HIV (unaware)

Incremental cost-effectiveness ratios (ICERs), 2013 US$ per QALY gained

Stanford University
Sensitivity Analyses

Robustness analysis: Share of cost-effective iterations as a function of societal average willingness to pay (AWTP). ICERS for each strategy are calculated relative to the prior efficient strategy on the efficient frontier. Based on 2,000 simulations; parameters values are drawn from their uncertainty range following a PERT distribution.
Sensitivity Analyses

All cost-effectiveness profiles improve with ART price reductions following patent expiration.
Comparison with Juusola et al. 2012

Assumptions about initial HIV prevalence affect model predictions

Assuming Juusola et al. (2012) HIV prevalence rate of 12.3% in 2013, our model estimates ICERs ranging between $30812 and $45921 per QALY gained.
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