Is PrEP for HIV prevention cost-effective in MSM in the UK?

Valentina Cambiano, Alec Miners, David Dunn, Sheena McCormack, KohJun Ong, Noel Gill, Anthony Nardone, Monica Desai, Gus Cairns, Alison Rodger, Andrew Phillips
Background

- Placebo controlled RCTs demonstrated that oral Tenofovir or Truvada in HIV-negative people (Pre-Exposure Prophylaxis) reduces the risk of HIV infection\(^1\)-\(^4\).

- UK PROUD trial showed that PrEP is highly efficacious in the real world (Efficacy 86\%)\(^5\) and the Ipergay trial that “on demand” use has similar efficacy (86\%)\(^6\).

- In the UK it is estimated that HIV incidence among MSM is not decreasing (estimated around 3,000 HIV infections in 2013\(^7\)-\(^8\)).

**Aim:** to evaluate whether the introduction of PrEP among MSM in the UK in 2016 is cost-effective (over an 80 year time horizon).

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HIV Synthesis Model

- Individual based stochastic simulation model. Each time model program runs it simulates a dataset of the experience of the entire adult UK MSM population.

- Variables in simulated data set:

<table>
<thead>
<tr>
<th>Whole adult population</th>
<th>HIV positive people</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>Time of infection</td>
</tr>
<tr>
<td>Condomless sex</td>
<td>CD4 count</td>
</tr>
<tr>
<td>Current STI</td>
<td>Viral load</td>
</tr>
<tr>
<td>HIV testing</td>
<td>Currently on ART</td>
</tr>
<tr>
<td></td>
<td>Specific drugs</td>
</tr>
<tr>
<td></td>
<td>Current adherence level</td>
</tr>
<tr>
<td></td>
<td>Drug resistance mutations, etc.</td>
</tr>
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- incorporates PrEP (taking account of resistance)
PrEP scenarios to be considered

PrEP eligibility criteria:

1. had **condomless sex (CLS)** in past 3 months*
2. had **CLS with ≥1 short-term partner (STP)** in past 3 months
3. had **CLS with ≥5 STP** in a 3 month period in the last year
4. had an **STI** in past 3 months

Assuming:
- PrEP is introduced in 2016
- those willing to use PrEP (50% of men if 1 or 2; 80% of men if 3 or 4) actively seek an HIV test when eligible and, if negative, start PrEP
- 25% of the population have an increased probability of having condomless sex and actively seek an HIV test when eligible and if negative start PrEP (this only applies for 1 and 2).

*except if the only partner they have is a long-term partner who is virologically suppressed on ART.
PrEP scenarios to be considered

PrEP eligibility criteria:

1. had **condomless sex (CLS)***
2. had **CLS with ≥1 short-term partner (STP)**
3. had **CLS with ≥5 STP** in a 3 month period in the last year
4. had an **STI**

Assuming:

- PrEP is introduced in 2016
- those willing to use PrEP (50% if (1) or (2); 80% if (3) or (4)) actively seek an HIV test when eligible and if negative start PrEP
- 25% of the population increase condomless sex (if the option is (1) or (2)) and actively seek an HIV test when eligible and if negative start PrEP

*Except if the only partner they have is a long-term partner who is virologically suppressed on ART. The sexual behaviour refers to the last 3 months if not indicated.
What happens once started on PrEP

If...

Eligible for PrEP (based on sexual behaviour/STIs)

then

Receive PrEP and test for HIV every 3 months

A person becomes HIV positive

At the next test he is diagnosed and PrEP is interrupted

Not longer eligible for PrEP (i.e. no condomless sex)

PrEP is stopped but when having condomless sex again, the person will have a test and re-start PrEP
Number (%) of MSM projected to be on PrEP

By 2096:
128,300 (20%) on PrEP
81,400 (14%) CLS
105,500 (17%) CLS with ≥1 STP
11,800 (2%) CLS with ≥5 STP
6,700 (1%) CLS with STIs
46,400 (7%) CLS (no increase in CLS or testing)
39,200 (6%) CLS (no increase in CLS or testing)
Number of HIV positive MSM seen in HIV care

PrEP in men having:
- CLS
- CLS with ≥1 STP
- CLS with ≥5 STP
- CLS with STIs
- CLS (no increase in CLS or testing)

No PrEP
Number of new HIV infections over 80 years

No PrEP  ▪ PrEP if CLS
▪ PrEP if CLS with 1 STP or more
▪ PrEP if CLS with 5 STP or more
▪ PrEP if current STI
▪ PrEP if CLS - No increase in CLS or testing

86%↓  86%↓  84%↓  84%↓  72%↓
Number of new HIV infections & deaths over 80 years

- Number of HIV infections:
  - No PrEP: 186,000
  - PrEP if CLS: 86% ↓
  - PrEP if CLS with 1 STP or more: 84% ↓
  - PrEP if CLS with 5 STP or more: 84% ↓
  - PrEP if current STI: 72% ↓

- Number of deaths:
  - No PrEP: 13,000
  - PrEP if CLS: 13% ↓
  - PrEP if CLS with 1 STP or more: 13% ↓
  - PrEP if CLS with 5 STP or more: 12% ↓
  - PrEP if current STI: 10% ↓
  - PrEP if CLS - No increase in CLS or testing: 12% ↓
Budget for HIV

- Healthcare services for HIV+
- CD4 measurements
- ART for HIV+
- VL measurements
- Resistance test
- HIV test
- Post-Exposure Prophylaxis
- 1st PrEP visit
- Extra cost of monitoring PrEP
- PrEP drugs

Cost in million £

2016  2036  2056  2076  2096

No PrEP
Budget for HIV

- Healthcare services for HIV+
- CD4 measurements
- ART for HIV+
- HIV test
- Post-Exposure Prophylaxis
- Resistance test
- PrEP drugs
- Extra cost of monitoring PrEP

**No PrEP**

2016: 800 million £
2036: 600 million £
2056: 400 million £
2076: 200 million £
2096: 100 million £

**PrEP introduced (full listed cost of ARVs)**

2016: 900 million £
2036: 700 million £
2056: 500 million £
2076: 300 million £
2096: 100 million £

**PrEP introduced (50% reduction in ARVs cost)**

2016: 900 million £
2036: 700 million £
2056: 500 million £
2076: 300 million £
2096: 100 million £
Health benefits and costs over 80 years

PrEP in men having:

- CLS

*discounted at 3.5% rate
Health benefits and costs over 80 years

PrEP in men having:

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Health benefits and costs over 80 years

PrEP in men having:
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Health benefits and costs over 80 years

PrEP in men having:

- CLS

£ 6,411 m / 112,195 = £57,145 per QALY gained

*discounted at 3.5% rate
Health benefits and costs over 80 years

PrEP in men having:
- CLS

£57,145 per QALY gained

*discounted at 3.5% rate
Health benefits and costs over 80 years

£39,314

£9,290

£1,522 m saved

PrEP in men having:
- ● CLS
- ● CLS with ≥1 STP
- ● CLS with ≥5 STP
- ● CLS with STIs
- ● CLS (no increase in CLS or testing)

Cost-effectiveness threshold range

*discounted at 3.5% rate
Health benefits and costs over 80 years

**50% reduction in cost of ARVs**

- £23,847
- £13,010
- £471 m saved
- £660 m saved
- £2,097 m saved

**80% reduction in cost of ARVs**

- £299 m saved
- £1,169 m saved
- £1,623 m saved
- £2,426 m saved
- £3,934

PrEP in men having:
- ● CLS
- ● CLS with ≥1 STP
- ● CLS with ≥5 STP
- ● CLS with STIs
- ● CLS (no increase in CLS or testing)

Cost-effectiveness threshold range; *discounted at 3.5% rate
Conclusions

This analysis suggests that the use of PrEP among MSM in the UK is cost-effective when:

- it is targeted to men reporting 5 STP or more in the last year or present with an STI
- the cost of ARVs is assumed 50% lower than current full list prices, once patents expire (which seems realistic based on past experience and may well be an under-estimate)
- when there is no increase in CLS and men do not actively seek an HIV test, as a consequence of PrEP becoming available
Acknowledgements

Fumiyo Nakagawa
Ian Williams
Catherine Mercer

Legion computing cluster (Legion@UCL)

Thank you very much for your attention
Proportion of men having condomless anal sex in past year

Number living with HIV

Number of deaths per year

Proportion of men tested for HIV in the past 5 years

Median CD4 count at diagnosis

Proportion diagnosed in less than 6 months from infection

Number of men diagnosed with HIV per year

Number seen for care per year

Number on ART

Data source: NATSAL

Data source: PHIN/PES

Data source: PRE
HIV epidemic in UK MSM - 2015

~590,000 MSM
~54,000 living with HIV
~25% undiagnosed
~83% of diagnosed men on ART
~96% of ART experienced men are on ART
~92% of men on ART have viral suppression
~58% of HIV positive men have viral suppression

Sources: NATSAL, Public Health England (PHE)
Number of MSM ever on PrEP

By 2096:
298,300 (45%) ever on PrEP

- - Ever on PrEP of those alive

CLS
CLS with ≥1 STP
CLS with ≥5 STP
CLS with STIs
CLS (no increase in CLS or testing)
## Assumptions on costs

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost (£)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIV testing</td>
<td>58 1</td>
</tr>
<tr>
<td>Use of healthcare-centre services in HIV+ (per year)</td>
<td></td>
</tr>
<tr>
<td>- Undiagnosed, In care ART naïve with CD4&gt;200, Not in care ART naïve, Not in care ART experienced with CD4&gt;200</td>
<td>2,499 2</td>
</tr>
<tr>
<td>- In care ART naïve with CD4≤200 cells/mm³, Diagnosed not in care, ART experienced with CD4≤200 cells/mm³</td>
<td>6,135 2</td>
</tr>
<tr>
<td>- On ART - CD4 &gt;200 cells/mm³</td>
<td>4,063 2</td>
</tr>
<tr>
<td>- On ART - CD4 ≤200 cells/mm³</td>
<td>6,550 2</td>
</tr>
<tr>
<td>Antiretrovirals (per year) [e.g. Atripla]</td>
<td>6,488 4</td>
</tr>
<tr>
<td>CD4 measurement</td>
<td>41 3</td>
</tr>
<tr>
<td>VL measurement</td>
<td>69 3</td>
</tr>
<tr>
<td>Resistance test</td>
<td>238 3</td>
</tr>
<tr>
<td>PrEP (cost of drugs + monitoring, per year)</td>
<td>4,615 1,4</td>
</tr>
<tr>
<td>First visit for PrEP</td>
<td>234 1</td>
</tr>
</tbody>
</table>

Overall cost on ART and on PrEP

1 year **on ART** (CD4>200 cells/mm³):

- £6,488 Atripla (BNF 2015)
- £4,063 Healthcare
- £164 (£41x4) CD4 measurements
- £276 (£69x4) VL measurements
- £238 resistance test at ART initiation

~£11,000

1 year **on PrEP**:

- £4,331 Truvada (BNF 2015)
- £234 First visit for PrEP
- £232 (£58x4) HIV tests
- £284 Additional cost of monitoring people on PrEP compared to people at similar risk not on PrEP

~£5,000
## Main assumptions for PrEP

<table>
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<tr>
<th>Assumption</th>
<th>Value</th>
<th>Rationale/Source</th>
</tr>
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<tr>
<td>Efficacy</td>
<td>100% if adherence ≥75%, otherwise same as adherence to PrEP. Reduced in presence of mutations resistant to PrEP.</td>
<td>IPreX trial, PROUD trial</td>
</tr>
<tr>
<td>Adherence to PrEP in those taking PrEP</td>
<td>Median=85%; IQR: 77% - 92%</td>
<td>PROUD trial</td>
</tr>
<tr>
<td>Willingness to use PrEP</td>
<td>50%; 80% when targeting high risk groups (≥5 STP or STIs)</td>
<td>AURAH&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HPA/UCL bar survey 2011&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SIGMA&lt;sup&gt;3&lt;/sup&gt;</td>
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## Sensitivity analyses of PrEP introduction

<table>
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<tr>
<th>Change in cost (£ billion)*</th>
<th>Change in QALYs (1,000s)*</th>
<th>Incremental cost-effectiveness ratio (£)</th>
<th>Full listed cost of ARVs</th>
<th>50% reduction in ARVs cost</th>
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<tr>
<td>Base case</td>
<td>6.4</td>
<td>112</td>
<td>57,000</td>
<td>24,000</td>
</tr>
<tr>
<td>No increase in CLS, no active PrEP seeking</td>
<td>0.7</td>
<td>75</td>
<td>9,000</td>
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<td>PrEP used only in 50% of 3m of CLS</td>
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<tr>
<td>Willingness to use PrEP 80%</td>
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<td>124</td>
<td>75,000</td>
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<td>6m extra of PrEP when not having CLS</td>
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<td>47,000</td>
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<tr>
<td>Increase in CLS while on PrEP</td>
<td>13.0</td>
<td>127</td>
<td>103,000</td>
<td>50,000</td>
</tr>
<tr>
<td>Base case (including HCV cost)</td>
<td>11.1</td>
<td>112</td>
<td>99,000</td>
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*discounted at 3.5% rate, compared to no PrEP; ■ considered cost-effective in the UK; ■ considered not cost-effective in the UK;
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If the cost of ARVs is **reduced by 80%** (from the year after the patent drug expires) the introduction of PrEP is cost-effective in all circumstances, except if an increase in condomless sex occurs as PrEP is introduced and the cost of treating HCV is taken into account.