# Cost-effectiveness of pre-exposure prophylaxis for HIV prevention in men who have sex with men in the UK: a modelling study and health economic evaluation

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## Summary

**Background** **In the UK, HIV incidence among men who have sex with men (MSM) has remained high for several years, despite widespread use of antiretroviral therapy and high rates of virological suppression. Pre-exposure prophylaxis (PrEP) has been shown to be highly effective in preventing further infections in MSM, but its cost-effectiveness is uncertain.**

**Methods** **In this modelling study and economic evaluation, we calibrated a dynamic, individual-based stochastic model, the HIV Synthesis Model, to multiple data sources (surveillance data provided by Public Health England and data from a large, nationally representative survey, Natsal-3) on HIV among MSM in the UK. We did a probabilistic sensitivity analysis (sampling 22 key parameters) along with a range of univariate sensitivity analyses to evaluate the introduction of a PrEP programme with sexual event-based use of emtricitabine and tenofovir for MSM who had condomless anal sexual intercourse in the previous 3 months, a negative HIV test at baseline, and a negative HIV test in the preceding year. The main model outcomes were the number of HIV infections, quality-adjusted life-years (QALYs), and costs.**

**Findings** **Introduction of such a PrEP programme, with around 4000 MSM initiated on PrEP by the end of the first year and almost 40 000 by the end of the 15th year, would result in a total cost saving (£1·0 billion discounted), avert 25% of HIV infections (42% of which would be directly because of PrEP), and lead to a gain of 40 000 discounted QALYs over an 80-year time horizon. This result was particularly sensitive to the time horizon chosen, the cost of antiretroviral drugs (for treatment and PrEP), and the underlying trend in condomless sex.**

**Interpretation** **This analysis suggests that the introduction of a PrEP programme for MSM in the UK is cost-effective and possibly cost-saving in the long term. A reduction in the cost of antiretroviral drugs (including the drugs used for PrEP) would substantially shorten the time for cost savings to be realised.**

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## Introduction

Sex between men is the predominant mode of HIV transmission in Europe and other high-income settings.[1] In the UK, HIV incidence among men who have sex with men (MSM) has remained high, with around 3000 new HIV infections in 2014[2] and 2015,[3,4] despite high levels of antiretroviral treatment (ART) coverage, virological suppression for those on treatment, and an expansion in HIV testing, although reports of numbers of new diagnoses suggest that there might have been recent declines.[5–7] Additional prevention approaches are needed, of which a promising option is pre-exposure prophylaxis (PrEP) based on emtricitabine and tenofovir. This approach involves HIV-negative people taking the drug combination to reduce the risk of HIV infection. PrEP has been shown to be highly efficacious among MSM, whether used daily[8] or in an event-based manner (ie, two pills 2–24 h before a sexual act, one for each consecutive day having condomless sex, for 2 days after the last sexual act),[9] and effective in real-world conditions when used daily.[10]

However, when considering a PrEP programme in the UK for MSM, important questions are whether it is cost-effective from a health-system perspective (ie, the National Health Service [NHS] in the UK) and its budgetary impact. The aim of this study is to evaluate the cost-effectiveness of introducing event-based PrEP among MSM attending genitourinary medicine clinics in the UK in 2016. The choice of offering a sexual event-based PrEP regimen, rather than the daily regimen, was driven by the high efficacy of the event-based regimen reported in the IPERGAY study[9] and its lower cost compared with the daily regimen. In the UK, there is a network of around 200 genitourinary medicine clinics, which offer sexual health advice, testing, treatment for sexually transmitted infections (STIs), and post-exposure prophylaxis (PEP) free of charge and confidentially to anybody. This network is envisaged to be the most pragmatic way of offering PrEP to MSM in the UK.

## Methods

### Study design

For this modelling study and health economic evaluation we used a dynamic individual-based simulation model (the HIV Synthesis Model), calibrated to the MSM HIV

## Research in context

### Evidence before this study

Pre-exposure prophylaxis (PrEP) has been shown to be highly efficacious and effective. However, PrEP drugs are expensive in high-income settings, and the cost-effectiveness of offering PrEP as part of universal health-care systems in such settings is unclear. We searched PubMed for English language studies published up to May 31, 2017, that estimated the cost-effectiveness of PrEP programmes, taking into account onward transmission. We combined search terms for PrEP ("pre-exposure prophylaxis", "preexposure prophylaxis", "PREP", and "HIV") with health economic terms ("cost", "cost-effectiveness", "cost effectiveness", "ICER", "cost-benefit", "cost benefit", "cost-utility", "cost utility", "health economics", "economics", and "economic evaluation") and "transmission". We found one report of a cost-effectiveness analysis of a PrEP programme among men who have sex with men (MSM) in the Netherlands. By use of a deterministic compartmental model calibrated to the Netherlands, the authors of this report concluded that the introduction of event-based PrEP in MSM in the Netherlands would be cost-effective at the current cost of emtricitabine and tenofovir over a 40-year time horizon. No such studies were done in the UK setting. The PROUD and IPERGAY trials showed that PrEP is highly efficacious and effective among MSM. We therefore used the effectiveness estimated in PROUD to evaluate the cost-effectiveness of a programme that will be delivered in the same population from which participants in the PROUD trial were recruited, with similar eligibility criteria and assuming the programme will be delivered through the same system (genitourinary medicine clinics).

### Added value of this study

Our study suggests that a PrEP programme offering sexual event-based use of emtricitabine and tenofovir to MSM results in a cost saving and a health benefit when considering an appropriately long time horizon (80 years). The patent protection on drugs used for PrEP expires in Europe in 2017–18 (a supplementary protection certificate for Truvada [Gilead Sciences, Foster City, CA, USA] expires in February, 2020). If the cost of antiretroviral drugs (used for PrEP and HIV treatment) is reduced from 2019 by 80%, introduction of such a PrEP programme would be cost-effective even when considering a 20-year time horizon.

### Implications of all the available evidence

There is no doubt about the effectiveness of PrEP. Our work suggests that introduction of PrEP will—in addition to delivering a substantial health benefit—ultimately lead to a saving in costs, as a result of decreased numbers of men in need of lifelong HIV treatment. As antiretroviral drug patents expire over the next few years, the emergence of generic drugs might result in potentially large cost reductions for PrEP, and these reductions could help to limit the budget impact of PrEP and make it cost-effective over a relatively short time horizon.

See Online for appendix

epidemic in the UK that has previously been described in detail[3,6] (see appendix p 1 for a brief description, pp 18–48 for details about the calibration, and pp 50–114 for full details). Ethical approval was not required for this work. A probabilistic sensitivity analysis was done to produce the main results, by sampling 22 key parameters (see appendix p 1 for the list of parameters sampled). 5965 simulations were done. To reduce the stochastic variability when presenting the main results, we divided each of these parameter distributions into tertiles and calculated the mean across simulations with the same combination of parameter tertiles. When estimating the health benefit we considered the combination of parameters affecting the HIV infections averted (five parameters); when estimating the incremental cost we considered the combination across all 22 parameters sampled in the probabilistic sensitivity analysis. The univariate sensitivity analyses were done by fixing the parameters that were sampled in the probabilistic sensitivity analysis.

### PrEP policy options compared and main assumptions relating to PrEP

Two main scenarios were compared: one in which PrEP was not available and the other assuming that sexual event-based PrEP was introduced in April to June, 2016 (the proportion of pills taken was sampled; the mean corresponded to five pills per week). In both scenarios it was assumed that sexual behaviour, HIV testing behaviour, and the probability of initiating ART would remain at current levels. In the PrEP scenario, it was assumed that MSM were eligible for PrEP if they had a negative HIV test at PrEP initiation; they had reported condomless anal sexual intercourse in the previous 3 months (unless the only partner they had condomless sex with was a long-term partner virologically suppressed on ART[11]); and they had an additional documented negative HIV test in the preceding year, similarly to the eligibility criteria for the PROUD study.[10]

The number of men eligible for PrEP in the UK, based on the above criteria, was estimated to be between 8400 and 12 200 (appendix p 2). This group was characterised (in the model) by an HIV incidence of around 2·0 per 100 person-years (90% range 0·7–4·3 per 100 person-years) in 2016, similar to the HIV incidence observed in repeat testers in genitourinary medicine clinics.[12]

Once PrEP has been started, we assumed that sexual event-based PrEP will be used in any subsequent 3-month period when having condomless sex (unless the only condomless sex partner is a long-term partner who is virologically suppressed on ART), unless there is a decision to interrupt it (mean rate of interruption of 0·1 per year, with wide variability considered; appendix p 128). However, men could restart PrEP with a mean