Modelling and Health Economics

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Conflict of Interests

No conflict of interests to declare.
Outline

- What is (health) economics?
- Types of decisions economic evaluations (EE) inform
- why are EE performed?
- why modelling is needed in most EE?
- Example
What is (health) economics?
Economics is about

- Limited resources
- Unlimited “wants”
- *Choosing* between which ‘wants’ we can ‘afford’ given our resource ‘budget’
Economics is about choice

Good ‘A’

Budget

Good ‘B’
For lunch I could have a…

Whopper meal deal (small)

Tall latte and Chocolate Cherry Muffin (to go)

Roasted falafel & spinach wrap and cracked pepper crisps

Nicaragua filter coffee and chicken club sandwich
Government choice

National Health Service could fund one IVF (US$4,500/ €3,850/ £3,500) course or…

a. 1/3 of a cochlear implant

b. 1 heart bypass operation

c. 11 cataract removals

d. 150 MMR vaccinations

e. 1/1000 of a Challenger 2 tank
Economics is the study of...

“...how society manages its scarce resources” (Mankiw, 2001, p.4)

“[Economics is the] social science that studies the choices that individuals, businesses, governments, and entire societies make as they cope with scarcity” (Bade and Parkin, 2002, p.5)

“...economies, at both the level of individuals and of society as a whole” (Krugman and Wells, 2004, p.2)

“...how human beings coordinate their wants and desires, given the decision-making mechanisms, social customs, and political realities of the society” (Colander, 2006, p.4)

“...human behavior, with a particular focus on human decision making” (Gwartney, Stroup, Sobel, and MacPherson 2006, p.5)
Economics

- NOT just practiced by economists
- NOT (necessarily) concerned with saving money
- Economics IS concerned with…
  - Understanding choices
  - Benefits
  - Costs (resource use)
  - Efficiency
    - ‘do the benefits outweigh the costs?’
What is Health Economics?

“What health economics is the application of economic theory, models and empirical techniques to the analysis of decision-making by individuals, health care providers and governments with respect to health and health care”

(Morris, Devlin and Parkin, 2007)
What is an economic evaluation and what types of decision does it inform?
NHS accused of delaying access to 'highly tolerable' hepatitis C drugs over cost concerns

NHS England claimed Sofosbuvir's cost is prohibitive and not 'affordable'

The NHS has been accused by leading health charities of attempting to “severely limit” the introduction of new drugs to treat hepatitis C because they are too expensive – despite the cost of them being cleared by officials.

Acupuncture for low back pain no longer recommended for NHS patients

New advice represents a u-turn in treatment for back pain, which affects one in 10 people, after evidence review showed acupuncture no better than a placebo.

NHS fights obesity epidemic with fat super-camps

Obese patients will be sent to specialist centres that offer psychological counselling on “comfort” eating, medication to lose weight, fitness training,
What is an economic evaluation?

“The comparative analysis of alternative courses of action in terms of their costs and consequences”

(Drummond et al 2005)

“Based on the common sense notion that a decision to do or not to do something should depend on weighing up the advantages (benefits) and disadvantages (costs)”

(Morris et al 2007)
Economic evaluation

**Purpose:** To inform decisions

**Key input:** Evidence about the effects of alternative courses of action
Economic evaluation

Choice

Option A

Option B

Time
# Types of economic evaluation

<table>
<thead>
<tr>
<th>Type of EE</th>
<th>Costs</th>
<th>Outcomes</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost minimization analysis (CMA)</td>
<td>Money</td>
<td>Identical</td>
<td>Least cost alternative</td>
</tr>
<tr>
<td>Cost effectiveness analysis (CEA)</td>
<td>Money</td>
<td>Single effect of interest common to both alternatives: Life years gained, deaths averted (natural units)</td>
<td>Cost per unit of consequence eg. cost per LY gained.</td>
</tr>
<tr>
<td>Cost utility analysis (CUA)</td>
<td>Money</td>
<td>Single or multiple effects not necessarily common. Valued as “utility” eg. QALY</td>
<td>Cost per unit of consequence eg. cost per QALY.</td>
</tr>
<tr>
<td>Cost benefit analysis (CBA)</td>
<td>Money</td>
<td>valued in money (also can include non-health aspects)</td>
<td>Net £ cost: benefit ratio</td>
</tr>
</tbody>
</table>
Why are economic evaluation performed?
Cost-utility and cost-effectiveness analyses

Limited resources

Budget constrained health care systems
Cost-utility and cost-effectiveness analyses

Many interventions that improve health

Limited resources

Intervention A

Intervention B

Intervention C

Intervention D

Budget constrained health care systems
Cost-utility and cost-effectiveness analyses

New interventions
- Health gained
- Additional Cost

Budget constrained health care systems
Cost-utility and cost-effectiveness analyses

New interventions
- Health gained
- Additional Cost

Budget constrained health care systems

Interventions displaced or foregone
- Health forgone
- Resources released
Cost-utility and cost-effectiveness analyses

**Goal:** maximize health of the population

- **New interventions**
  - Health gained
  - Additional Cost

- **Budget constrained health care systems**

- **Interventions displaced or foregone**
  - Health forgone
  - Resources released
Cost-utility and cost-effectiveness analyses

**Goal:** maximize health of the population

- New interventions
  - Health gained
  - Additional Cost

- Interventions displaced or foregone
  - Health forgone
  - Resources released

Budget constrained health care systems

“Is the new intervention cost-effective?”

= 

“Is the health gain from the new intervention likely to be greater than the health foregone?”
Incremental cost-effectiveness ratio (ICER)

It is their key (traditional) metrics when conducting an economic evaluation.

It compares costs and health outcomes over time.

\[
ICER = \frac{\text{Mean Cost}_B - \text{Mean Cost}_A}{\text{Mean Effect}_B - \text{Mean Effect}_A}
\]

Additional cost

Health benefit
Cost-effectiveness plane

- Cost difference
- Effect difference

A - reference

B
Cost-effectiveness plane

Cost difference

I

II

Effect difference

A - reference

0

+ -

Intervention (B) is LESS effective and MORE costly than A

Intervention (B) is MORE effective and MORE costly than A

Intervention (B) is LESS effective and LESS costly than A

Intervention (B) is MORE effective and LESS costly than A

Intervention (B) is MORE effective and MORE costly than A

Intervention (B) is LESS effective and MORE costly than A
Cost-effectiveness plane

<table>
<thead>
<tr>
<th>Quadrant</th>
<th>Description</th>
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<tr>
<td>I</td>
<td>Intervention (B) is LESS effective and MORE costly than A</td>
</tr>
<tr>
<td>II</td>
<td>Intervention (B) is MORE effective and MORE costly than A</td>
</tr>
<tr>
<td>III</td>
<td>Intervention (B) is LESS effective and LESS costly than A</td>
</tr>
<tr>
<td>IV</td>
<td>Intervention (B) is MORE effective and LESS costly than A</td>
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- Quadrant I: Intervention (B) is LESS effective and MORE costly than A
- Quadrant II: Intervention (B) is MORE effective and MORE costly than A
- Quadrant III: Intervention (B) is LESS effective and LESS costly than A
- Quadrant IV: Intervention (B) is MORE effective and LESS costly than A
Comparison of the ICER(s) to a cost-effectiveness threshold

- Greater than cost effectiveness threshold
  - Not cost-effective

Cost-effectiveness threshold represents the opportunity cost, the value of the alternative that is foregone. In the UK the threshold is around £20,000/QALY gained.

- Less than cost effectiveness threshold
  - Cost-effective
Concept of cost-effectiveness threshold – ideal scenario

Interventions producing health benefit

Cost
effectiveness threshold

Width of bar indicates total cost of implementing the intervention in a country

Total health care budget

Cost
Example
Example – PrEP among MSM in the UK

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

Valentina Cambiano, Alec Mines, David Dunn, Sheena McCormack, Koh Jun Ong, O'Noel Gil, Anthony Nardone, Monica Desai, Nigel Field, Graham Hart, Valerie Delpech, Gus Cairns, Alison Rodger, Andrew N Phillips

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), averting 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.

Funding National Institute for Health Research.

Introduction Sex between men is the predominant mode of HIV transmission in Europe and other high-income settings. In the UK, HIV incidence among men who have sex with men 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
Aim

To evaluate the **cost-effectiveness** of introducing a PrEP programme with **sexual event-based PrEP** among **MSM in the UK**.

In order to receive the intervention they needed to attend a genitourinary medicine clinics.

We took a health-care perspective (ie, the National Health Service [NHS] in the UK).
Scenarios/Options compared

PrEP is not available

**Sexual event-based** PrEP is introduced in April 2016 for MSM who present for a clinical risk assessment (i.e. GUM clinic) who:

- Have had CLAI in the previous 3 months (unless the only partner they had condomless sex with was a long-term partner virologically suppressed on ART);
- Are anticipated to have CLAI in the next 3 months [in the model they will use PrEP only if actually having CLAI];
- Have had a negative HIV test at PrEP initiation and an additional in the past year.

PrEP programme is interrupted once HIV incidence is below 1/1000 person-years.
Why do we need a mathematical model?

• Think about what needs to be estimated?
• And why a clinical study (randomized controlled trial, RCT) type framework might be limited?
  – Mean costs and benefits of all relevant options
  – Over a relevant time horizon
  – Outcomes expressed in relevant units such as QALYs / DALYs
  – Using all relevant evidence (Other RCTs might already exist)
  – Others …..
Combining modelling with cost data for cost-effective analysis

Combining modelling with cost data for CEA

Data → Statistical analysis of data → Mathematical Model

Economic modelling → Projections of cost → Projections of impact

X

Projections of cost → Cost-effectiveness analysis and policy decision making
<table>
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<th>No PrEP</th>
<th>PrEP introduction</th>
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<tbody>
<tr>
<td>Cumulative mean number of HIV infections</td>
<td>178,900 (81,100 to 323,300)</td>
<td>134,600 (61,700 to 264,300)</td>
</tr>
<tr>
<td>Number of HIV infections averted</td>
<td>...</td>
<td>44,300 (3300 to 97,600)</td>
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<td>Proportion of HIV infections averted (%)</td>
<td>...</td>
<td>25%</td>
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<tr>
<td>QALYs (in 1000s)*</td>
<td>55,590 (55,030 to 55,990)</td>
<td>55,810 (55,290 to 56,120)</td>
</tr>
<tr>
<td>QALYs gained (in 1000s)*</td>
<td>...</td>
<td>220 (20 to 430)</td>
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<td>18,410 (18,330 to 18,490)</td>
<td>18,450 (18,360 to 18,510)</td>
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Mean (90% range) data shown; range across means of simulations with the same combination of probabilistic sensitivity analysis parameter tertiles. MSM = men who have sex with men. PrEP = pre-exposure prophylaxis. QALYs = quality adjusted life-years. *In all MSM (HIV-positive and HIV-negative). †Discounted at 3.5% per year. ‡Considering a cost-effectiveness threshold of £13,000 per QALY gained.

**Table:** Epidemiological impact on HIV infections, QALYs, and cost among MSM in the UK over an 80-year time horizon (2016–96)
Overall cost of ART and on PrEP

1 year on ART (CD4>200 cells/mm³):

£6,288 ART (FOI request)
£4,063 Healthcare
£ 164 (£41x4) CD4 measurements
£ 276 (£69x4) VL measurements
[£ 238 resistance test at ART initiation]

~£10,800

1 year on PrEP (following the first year):

£4,331 Truvada (BNF 2015)
£ 156 (£39x4) HIV tests
£  94 Additional cost of monitoring people on PrEP compared to people at similar risk not on PrEP

~£4,600
Difference in budget impact

Current cost of ARVS for treatment and PrEP

Cost of ARVS for treatment and PrEP reduced by 50%
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<td><strong>Cost (in million £)</strong>*</td>
<td>64 460 (24 070 to 141 890)</td>
<td>56 440 (23 910 to 126 050)</td>
</tr>
<tr>
<td><em><em>Discounted† cost</em> (in million £)</em>*</td>
<td>20 640 (11 080 to 36 220)</td>
<td>19 630 (11 390 to 33 690)</td>
</tr>
<tr>
<td><em><em>Difference in discounted† cost</em> (in million £)</em>*</td>
<td>..</td>
<td><strong>-1000 (-4900 to 1230)</strong></td>
</tr>
<tr>
<td><strong>Net monetary benefit‡ (in million £)</strong></td>
<td>..</td>
<td><strong>1490 (-1360 to 6580)</strong></td>
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**Table:** Epidemiological impact on HIV infections, QALYs, and cost among MSM in the UK over an 80-year time horizon (2016–96)
Example conclusions

- the introduction of event-based PrEP among MSM in the UK with the eligibility criteria proposed is cost-saving and leads to health benefits, caused by a substantial reduction in HIV incidence among MSM.
- Our results are robust to substantial variations in the main assumptions.
- However, there are increases in budget for the first 20 years in our main results and it takes 40 years for the incremental cost-effectiveness ratio to reach less than £13 000 per QALY gained.
What Factors Are Taken Into Account when making a decision?

- Cost-effectiveness
- Additional health benefits
- Extent of uncertainty
- Equity & Diversity legislation
- Social Value Judgements
ABOUT THE PrEP IMPACT TRIAL

We know from previous studies that PrEP can effectively reduce the risk of HIV infection. Several countries have implemented PrEP programmes to provide the drug to individuals at high risk of HIV. To plan a PrEP programme in England, NHS England and Local Authorities need to know how many people need PrEP, how many will want to take it and for how long. In order to find this out, we are conducting this research. This study does not involve a placebo, so everyone who is enrolled in the trial will have access to PrEP.

The PrEP Impact trial will answer three important questions:

1. How many people attending sexual health clinics need PrEP?
2. How many of these start PrEP?
3. How long do they need PrEP for?

10,000 people will be recruited to the trial over three years. HIV negative people attending sexual health clinics in England will have their risk of acquiring HIV checked by the clinic staff. If the clinic staff consider an individual meet the eligibility criteria for the trial, they will give them more information about the trial and ask if they are interested in participating. If they agree, they will be asked to take part in this research.
Thank you
Questions?