How should health gains of vaccination strategies be discounted?

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Aim project

- Overview of different discounting methods
- Impact of different discounting methods on the health benefits of HPV-vaccination
Impact discounting on the future health benefits of HPV-vaccination

Undiscounted

Discounted

Brisson et al. Vaccine 2007
Discounting

• Discounting is used to determine the present value of future costs and benefits accounting for time preference
  – Individuals have a time preference for the present, due to:
    • uncertainty about the future
    • the growing (economic) wealth

• Linear discounting model
  – Recommended by guidelines

\[
iCER = \frac{\sum_{0}^{\infty} \left[ C_B(t) - C_A(t) \right] \cdot (1 + r_C)^{-t}}{\sum_{0}^{\infty} \left[ E_B(t) - E_A(t) \right] \cdot (1 + r_E)^{-t}}
\]
Discounting methods

- Different discounting methods have been proposed
  - Linear discounting
  - Proportional discounting
  - Hyperbolic discounting
  - Step-wise discounting
  - Discounting from the moment of risk reduction
Proportional and hyperbolic discounting

• Time preference decreases over time

• Proportional:
  – Proposed by Harvey et al.
    Math of Operations Res 1995

• Hyperbolic:
  – Proposed by Loewenstein and Prelec
    The Quarterly J of Economics 1992

\[
\begin{align*}
  r_E(t) &= \left( \frac{b_E}{b_E + t} \right)^\gamma \\
  r(t) &= \left( \frac{1}{(1 + gt)^{h/g}} \right)
\end{align*}
\]
Estimated discount factor for timepoint ‘t’

- From Cairns et al. *Health econ* 1997 we estimated $\gamma$ and $h$:
  - $\gamma = 1.5$
  - $h = 0.2$
- $g$ and $b$ were estimated by assuming that:
  - AUC constant discount model = AUC prop. or hyper. model

\[
 r_E(t) = \left( \frac{b_E}{b_E + t} \right)^\gamma \\
 r(t) = \left( \frac{1}{(1 + gt)^{h/g}} \right)
\]
Step-wise discounting

- A declining long-term discount rate is prescribed
- UK Treasury

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>0 – 30 years</td>
<td>3.5%</td>
</tr>
<tr>
<td>31 – 75 years</td>
<td>3.0%</td>
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<tr>
<td>76 – 125 years</td>
<td>2.5%</td>
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<tr>
<td>126 – 200 years</td>
<td>2.0%</td>
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<tr>
<td>201 – 300 years</td>
<td>1.5%</td>
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<td>300 – and beyond</td>
<td>1.0%</td>
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<tr>
<td>11 – 20 years</td>
<td>1.5%</td>
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<tr>
<td>21 – and beyond</td>
<td>0%</td>
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<tr>
<td>201 – 300 years</td>
<td>1.5%</td>
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<tr>
<td>300 – and beyond</td>
<td>1.0%</td>
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However, how to estimate the step size?
Alternative approach

- Discounting from moment of risk reduction in stead of moment of QALY gained
  - Proposed by the research group of prof Postma of the University of Groningen.
    - Bos et al. Pharmacoeconomics 2004
    - Model is developed for discounting benefits of vaccines

\[
iCER = \sum_{0}^{\infty} \left[ C_B(t) - C_A(t) \right] \bullet (1 + r_C)^{-t} \\
\frac{\sum_{0}^{\infty} \left[ E_B(t) - E_A(t) \right] \bullet (1 + r_E)^{-t_i}}{\sum_{0}^{\infty} \left[ C_B(t) - C_A(t) \right] \bullet (1 + r_C)^{-t}}
\]

\[t = \text{moment of costs saving}\]
\[t_i = \text{moment of risk reduction}\]
Cervical cancer

- Infection with an oncogenic HPV-type
  - HPV-16 and HPV-18
- Sexual transmitted
- Two highly effective vaccines
- Immunization before sexual debut
Timeline

24y average age of infection
12y immunization

44y average age of CIN and cc development

So, the benefits of preventing CIN and cervical cancer development are on average 32y after initial immunization however this is individual dependent.
Discounting

- As the health benefits of HPV-vaccination occur on average 32 years after the initial immunization, the benefits are undervalued when discounting.

- Estimated ICER of HPV-vaccination is highly sensitive to discounting.
Impact discounting method on the ICER

Discount rate health 1.5%

Costs undiscounted

Incremental costs per QALY gained (€/QALY)

Discounting method
- undiscounted
- constant
- proportional
- hyperbolic
- Postma
Impact discounting method on the ICER

Costs undiscounted

Discount rate health 3.0%

Incremental costs per QALY gained (€/QALY)

Discounting method

- undiscounted
- constant
- proportional
- hyperbolic
- Postma
Step-wise discounting

Costs undiscounted

Incremental costs per QALY gained (€/QALY)

Discounting method

undiscounted
UK treasury
Beutels
Discussion

- Small differences between proportional and hyperbolic discounting
- Hyperbolic and proportional discounting reflects the time preference in the population more accurately
- Empirical studies are needed to estimate $g, h, b$ and $\gamma$ for the Netherlands
- Step-wise discounting represents a less accurate approximation of declined time preference in the future
- Postma’s alternative approach reduces the underestimation of the future health gains of vaccines, but requires more advanced modelling
Conclusion

- Hyperbolic, proportional and the alternative approach of discounting results in an ICER decrease of HPV-vaccination
- For hyperbolic and proportional discounting empirical research is needed to estimate the parameters $b$, $\gamma$, $g$ and $h$
- For the alternative approach more advanced modelling is required
- In general the sensitivity of an ICER for discounting is intervention-dependent; for example, for flu vaccination the benefits are more immediate, so the ICER is less sensitive to discounting
Discount rate health 1.5%

Incremental costs per QALY gained (€/QALY)

Discounting method

- undiscounted
- constant
- proportional
- hyperbolic
- Postma
Discount rate for health 3.0%
Discount rate health 4.0%
Stepwise discounting

- Discount rate costs 0%
- Discount rate costs 1.5%
- Discount rate costs 3.0%
- Discount rate costs 4.0%

![Bar chart showing incremental costs per QALY gained for different discounting methods: undiscounted, UK treasury, Beutels. The chart uses different colors for each discount rate.]