Markov Model in Health Care

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Objectives

• Introduce and familiarize participants with basic Markov modeling for economic evaluation
• Familiarize participants with ‘step by step’ Markov model construction
• Prepare participants to conducting health economic models (Microsoft Excel application)
Introduction

“a health-care evaluation model as an analytic methodology that accounts for events over time and across populations, that is based on data drawn from primary and/or secondary sources, and whose purpose is to estimate the effects of an intervention on valued health consequences and costs” [1]

• Decision analysis: systematic-mathematical approach, informing clinical decisions, uncertainty in decision making

• Decision analytic model have been increasingly applied in health economic evaluation

• Markov modeling for health economic evaluation

Decision Tree: An overview

Which treatment should be chosen?

**Nodes:**
- Decision point between treatment options
- Possible events that patients experienced
- Terminal nodes

*Mutually exclusive for pathway*
*Probability should be 1.0 in the end*
Decision tree

Hint: Expected Cost = probability x cost
Expected utility = probability x utility
Limitations of Decision Tree

- Limited for predicting continuous values
- Expected cost and effect/utility are less visible
- Limited to one output
- Difficulties for regression application and representing long term prognoses
- Difficulties to apply when patients experiencing recurrence events, particularly chronic disease
- Applying discounting and outcome over time become issues.
- Inability to determine when events occur (start and later?)
- Possibly excessive branches
Markov

Markov Process

- Form of stochastic process
- Future event could not be accurately predicted by past event
- Able to look at long sequence
- Memory less assumption

Markov Chains

- Discrete time
- Homogenous transition probabilities
- Statistical model application → real world
- Probability of particular transitions → transition matrix
Steps in Constructing Markov Model

Determine relevant states

- Mutually exclusive
- Representative (clinically and economically)
- Available and consistent evidence of clinical pathway - not contradicted, widely accepted
- Determine cycle length
- Time horizon - long enough

Asymptomatic
Progressive
Death
Steps in Constructing Markov Model

Determine transitions

• Determines relevant transition from each state

• Identify transition probabilities (most representative data)

• Cycle length should be reflective
Steps in Constructing Markov Model

Model parameters

• Outcomes? (Life years, QALYs)
• Determines transition probabilities, utilities, effectiveness and costs related to states
• To understand: transition matrix
Analyzing Markov Model

• Model Parameters

Transition Probabilities:
A to P: 0.105
P to D: 0.411
A to D: 0.202

Costs (progressive state): Rp 12,000,000 (drug A) Rp 9,500,000 (drug B)

Utility (progressive state): 0.70 (drug A) 0.82 (drug B)

Effectiveness: RR: 0.60

Discounting: 3% (both cost and effect)
Analyzing Markov Model

• Transitions Matrix

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<th>Progressive</th>
<th>Death</th>
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Cohort Simulation

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0.693=693
0.693=480
0.202=202
0.105=140
0.105=62
0.411=43
0.105=73
0.202=105
1.00=202
## Analyzing Markov Model

- **Cohort Analysis**

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*No Discounting*
Incremental Cost Effectiveness Ratio

\[
\text{ICER} = \frac{\text{Costs (intervention)} - \text{Costs (comparator)}}{\text{Effect (intervention)} - \text{Effect (comparator)}}
\]
Sensitivity Analysis [2]

“There remains several types of uncertainty related methods in analysis”

“Sensitivity analysis can help the reviewer to determine which parameters are the key drivers of a model’s results”

“By reporting extensive outputs from sensitivity analysis, modellers are able to consider a wide range of scenarios and, as such, can increase the level of confidence that a reviewer will have in the model”

One way sensitivity analysis

- The simplest form of sensitivity analysis
- vary one value in the model by a given amount, and examine the impact that the change has on the model’s results.
- This is known as **one-way sensitivity analysis**, since only one parameter is changed at one time.


[3] Tornado diagram showing results of the one-way sensitivity analyses for the difference (vaccination versus no vaccination) in total cost per vaccinated child. The vertical line indicates where the incremental costs for the vaccine strategy were more than €0. Knoll et al. *Health Economics Review* 2013 3:27 doi:10.1186/2191-1991-3-27
Two way sensitivity analysis

- Assessing the impact of pairs of variables in a CEA by varying them across a plausible range of values and combinations with all other variables constant at their baseline value.

- If varying more than two, it is called multi-way sensitivity analysis'.

Probabilistic sensitivity analysis (PSA)

“A form of sensitivity analysis in which probability distributions are applied to the ranges for a model’s input parameters, and samples from these distributions are drawn at random to generate an empirical distribution of the relevant measure of cost-effectiveness.”


Probabilistic sensitivity analysis (PSA)
Useful Reading Lists


• Philips, Zoe, et al. "Good practice guidelines for decision-analytic modelling in health technology assessment”


Practical

• All the parameters information has already filled
• Move to sheet 3
• Follow the available directions
• Remember that all parameters are named, just put the formula directly and running your model
• If your sum probability is not 1.0 yet...just relax!, try once more time