LIHS Mini Master Class

An introduction to decision modelling

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Key Questions

- Why/when do we use models?
- What is an economic decision model?
- What are the main types of models?
- What are the key strengths and limitations of each type of model?

Why do we use models?

- Should a new health intervention be adopted?
  - Effectiveness
  - Equity
  - **Cost-effectiveness** → **Is the additional cost "worth it"?**
- Required by NICE and increasingly local and international decision makers

=> Economic evaluation

– A comparative analysis of the costs and health benefits of a new intervention compared to current standard care or alternative interventions

Why do we use models?

- If trial data is insufficient
  - Short time horizon
  - Inappropriate comparator/ population/ perspective
  - Missing data
- To combine data from several sources
- To assess & formalise uncertainty
  - Assess need for future research

What is a decision model?

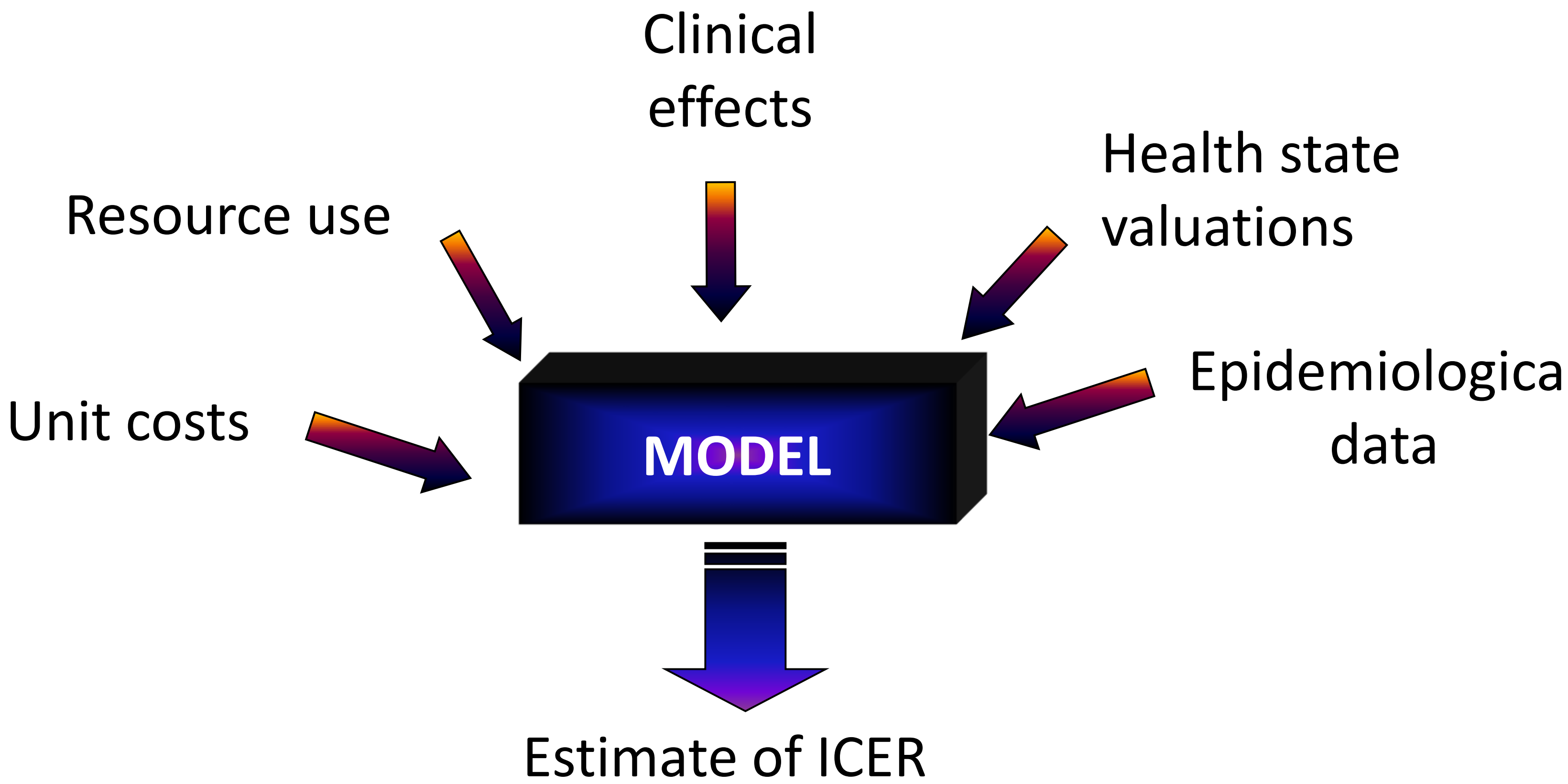
- Decision analytical models: A statistical method used to inform a decision process

More formally…

“a decision analytical model uses mathematical relationships to define a series of possible consequences that would flow from a set of alternative options being evaluated... For a given option, the expected cost (outcome) is the sum of the costs (outcomes) of each consequence weighted by the probability of that consequence.”

Brigg, Claxton and Sculpher, 2007; p6

What is a decision model?



$$\frac{Incremental\ cost\ (\Delta C)}{Incremental\ effect\ (\Delta E)}$$

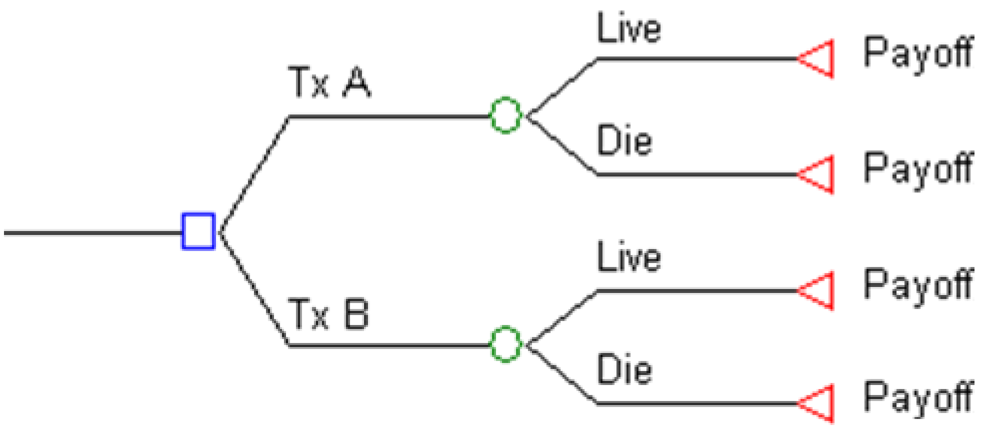
Types of models

LOTS of types of models, but the most common are:

- Decision Trees
- Markov Models
- A combination of both

Decision Tree

- A decision tree utilizes a flow diagram to show the logical structure of the problem



- Think of time flowing from left to right, with each of the branches depicting the possible patient pathways contingent on particular events.

Decision nodes – the square nodes represent a choice for the decision maker

Chance nodes – these circular nodes are used to represent uncertain events, with the branches emanating from the node indicating **all** the various possibilities (probabilities). Each of these chance events has an associated probability and these should sum to 1.0 (100%) for all events associated with a particular chance node

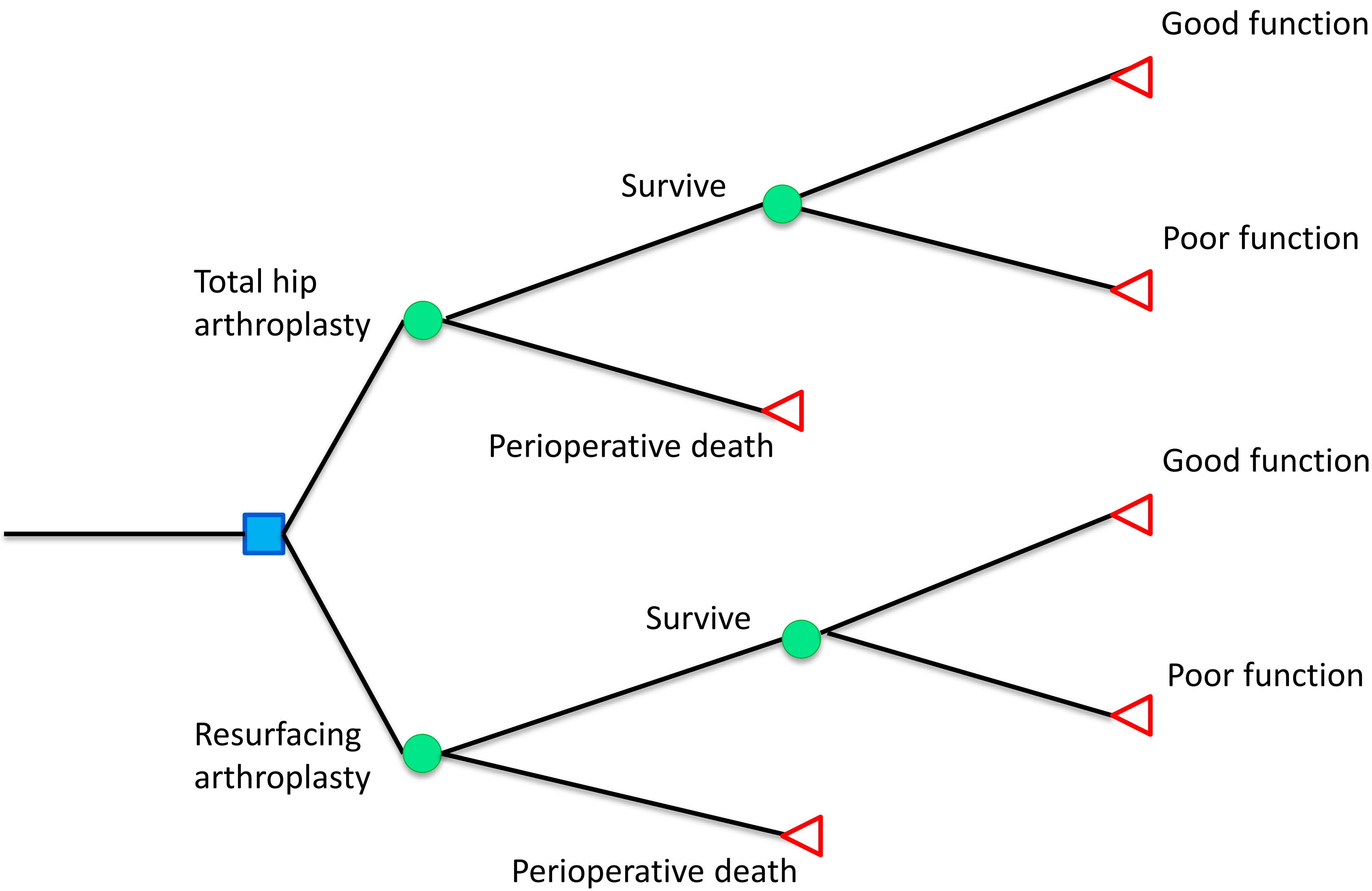
Terminal nodes – these triangular nodes represent the endpoint of the model and are assigned value(s) or *payoff(s)*. These payoff can be utility, costs, or anything else thought to be a critical outcome for a particular scenario

Example

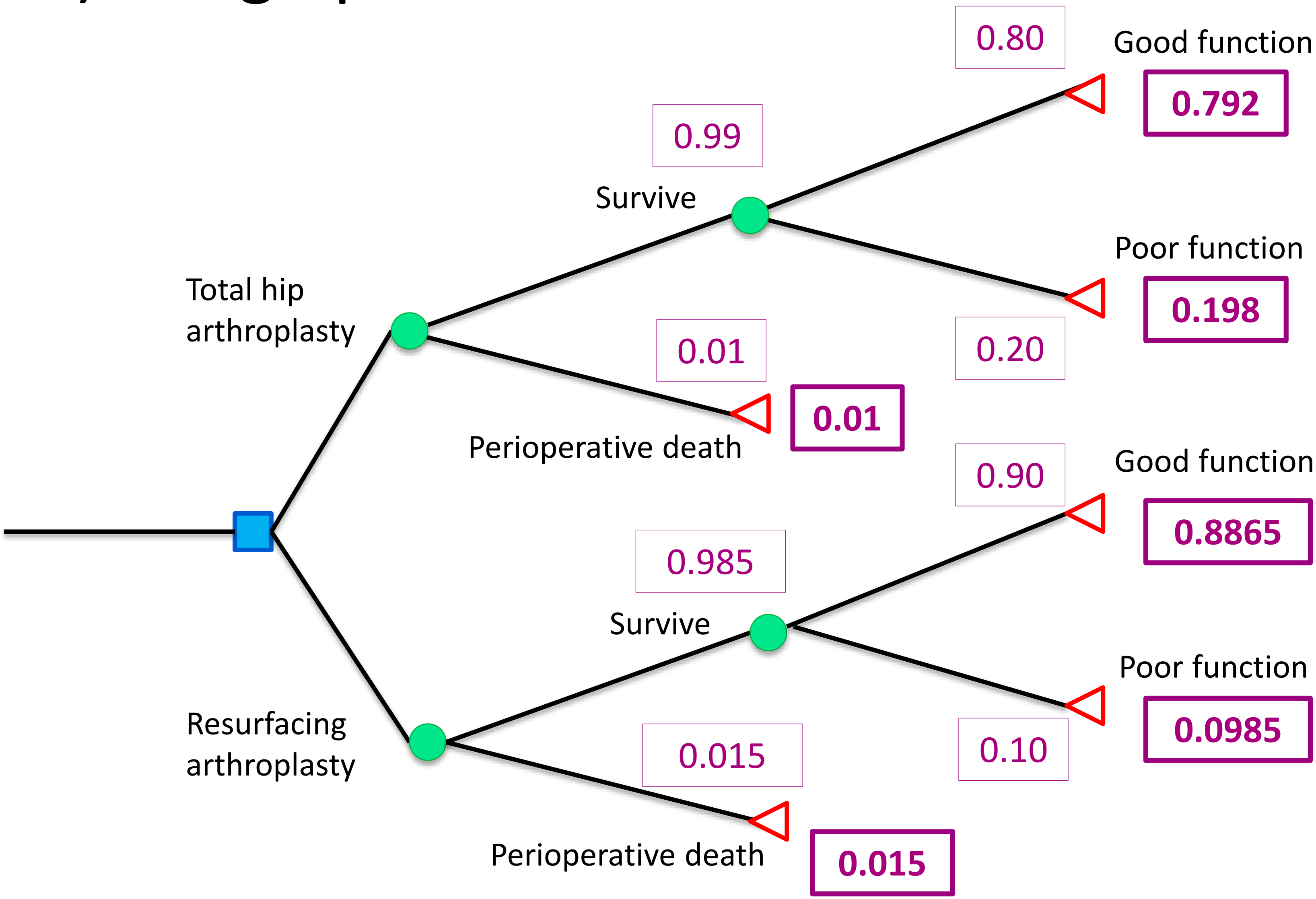
"Which method of operating on arthritic hips in young patients is the most cost-effective?"

- **Total hip arthroplasty**: replace the whole joint
- **Resurfacing arthroplasty**: replace part of the joint, making a smooth surface to allow more normal hip function

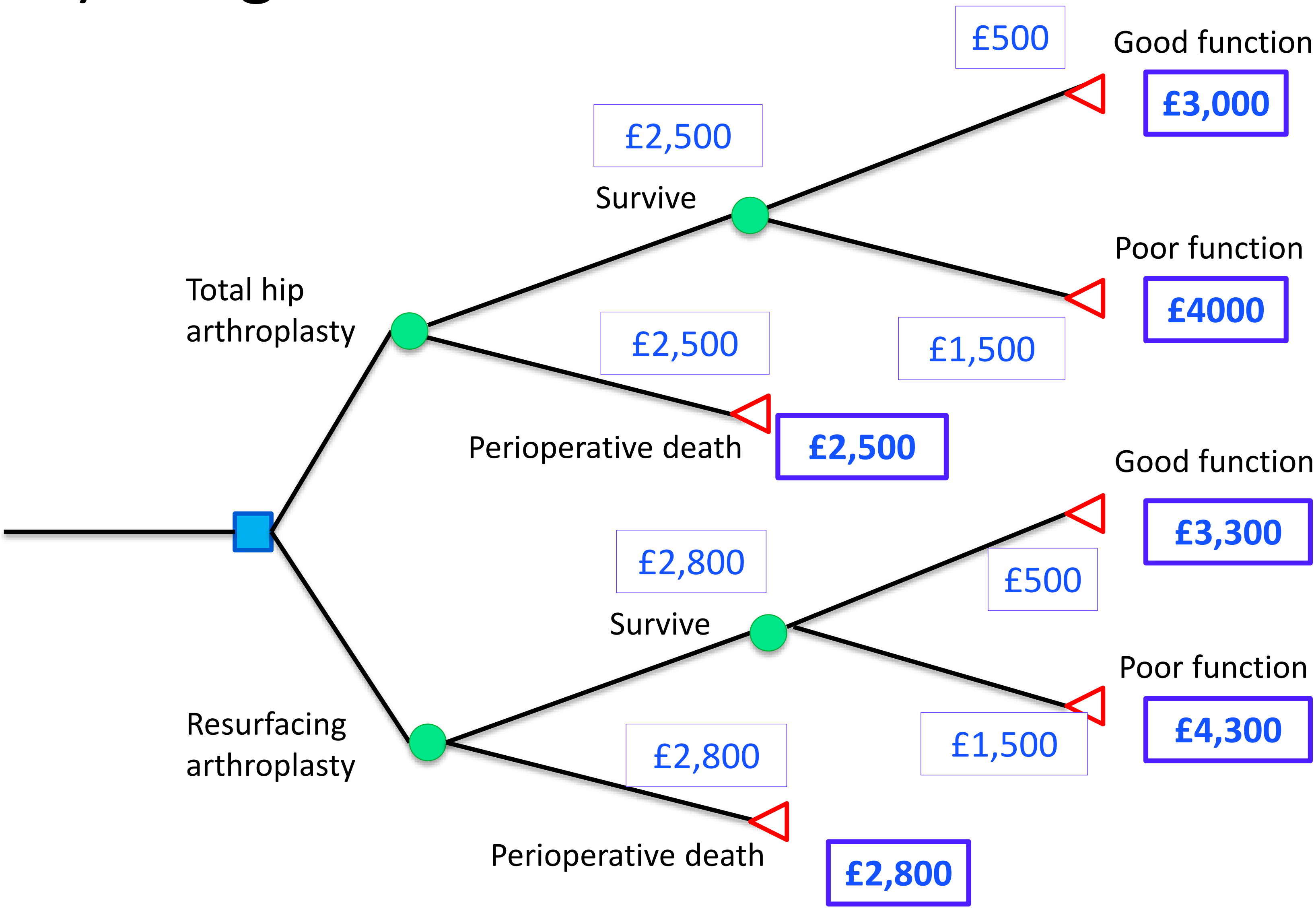
1) Formulate tree structure



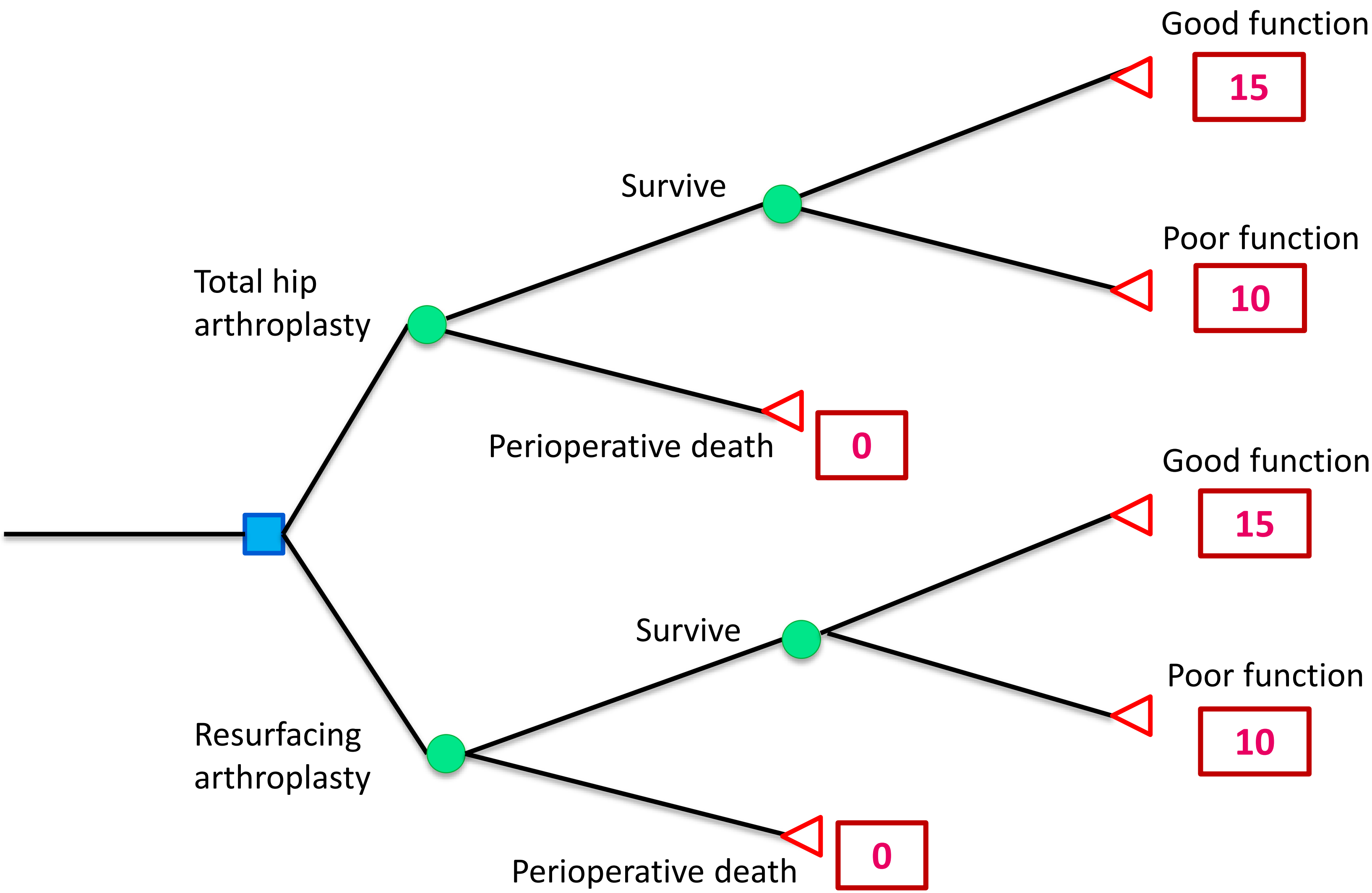
2) Assign probabilities



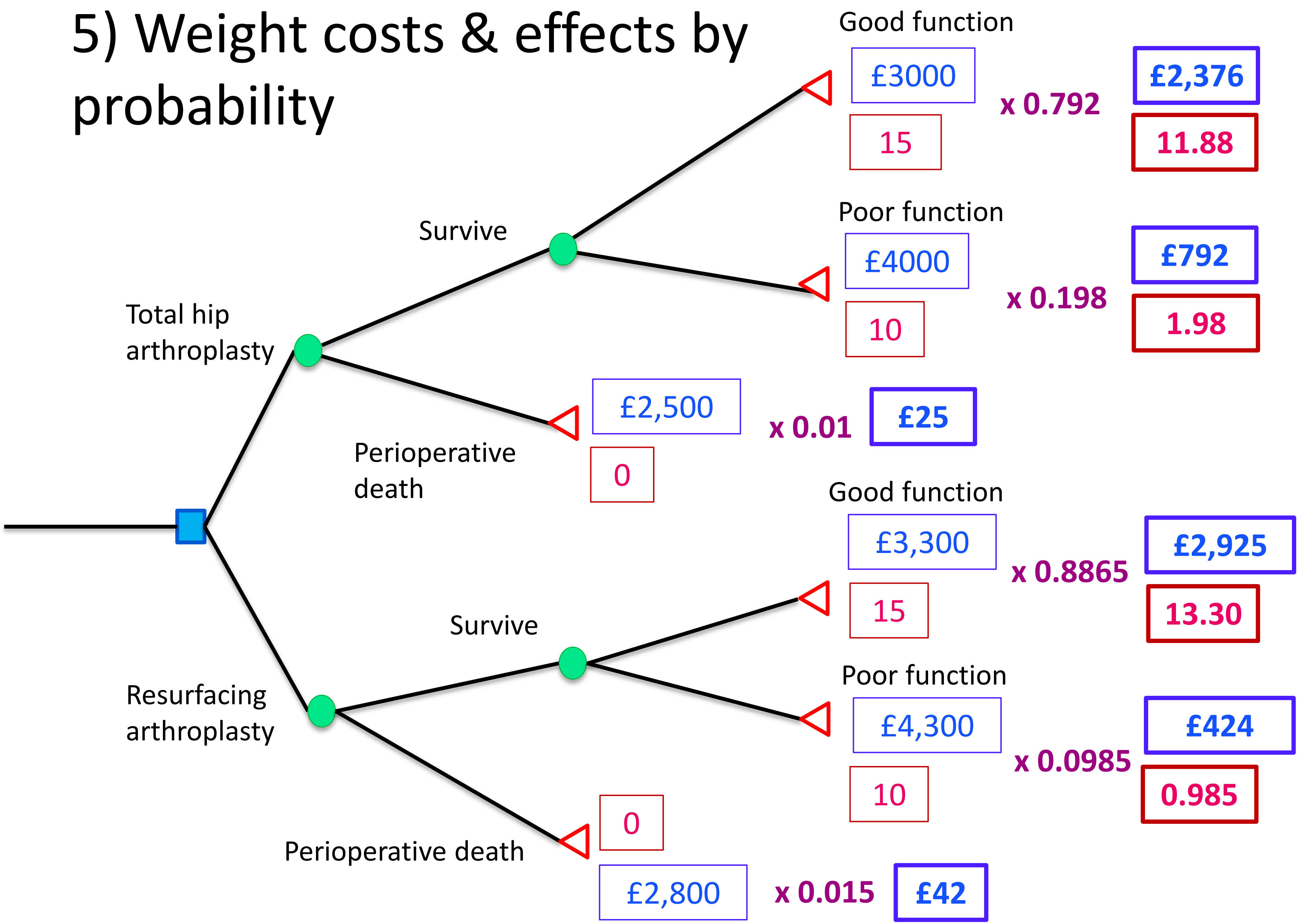
3) Assign costs



4) Assign effects (QALYs)



5) Weight costs & effects by probability



6) Calculate cost-effectiveness

Strategy	Total Cost	Total QALYs	Incremental Cost	Incremental QALY	ICER
Total Hip Anthroplasty	£3,193	13.56			
Resurfacing Anthroplasty	£3,391	14.285	£198	0.755	£262/QALY

Incremental cost-effectiveness ratio (ICER) = $\frac{Incremental\ cost\ (\Delta C)}{Incremental\ effect\ (\Delta E)}$

= 198/ 0.755

= £262 per additional QALY

Decision Tree

Strengths

- Easy to interpret
- Relatively simple to develop

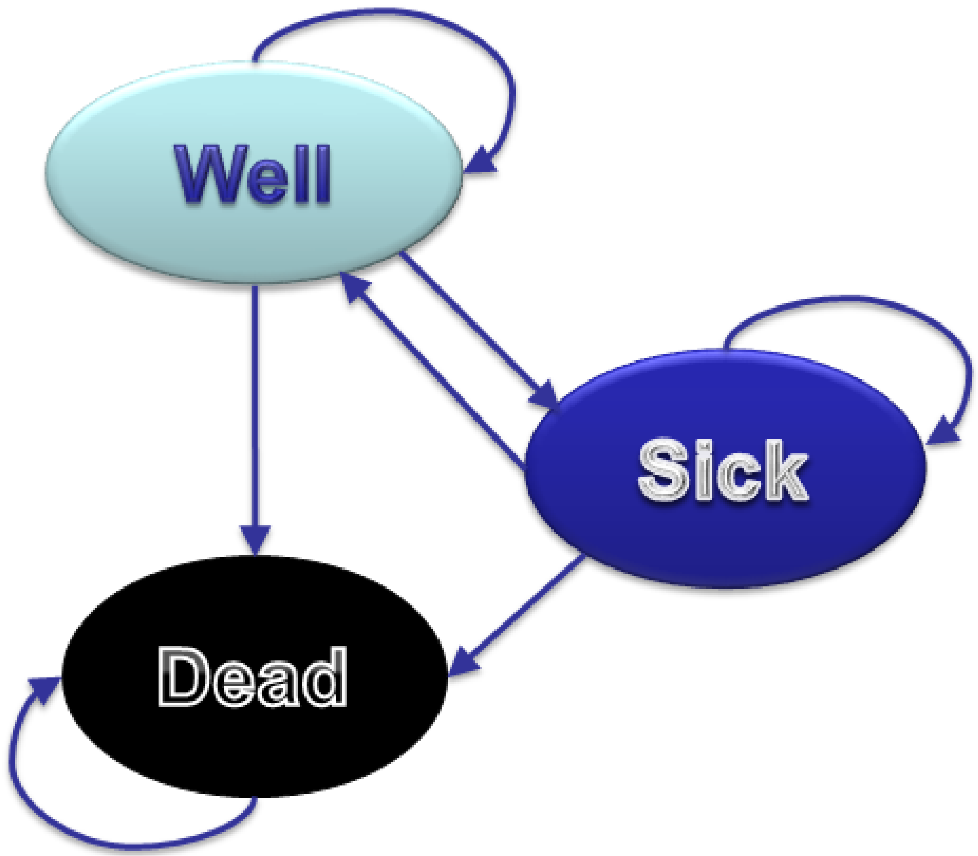
Limitations

- Cannot account for time (dynamic processes)
- Become unwieldy when dealing with reoccurring events (e.g. chronic diseases)

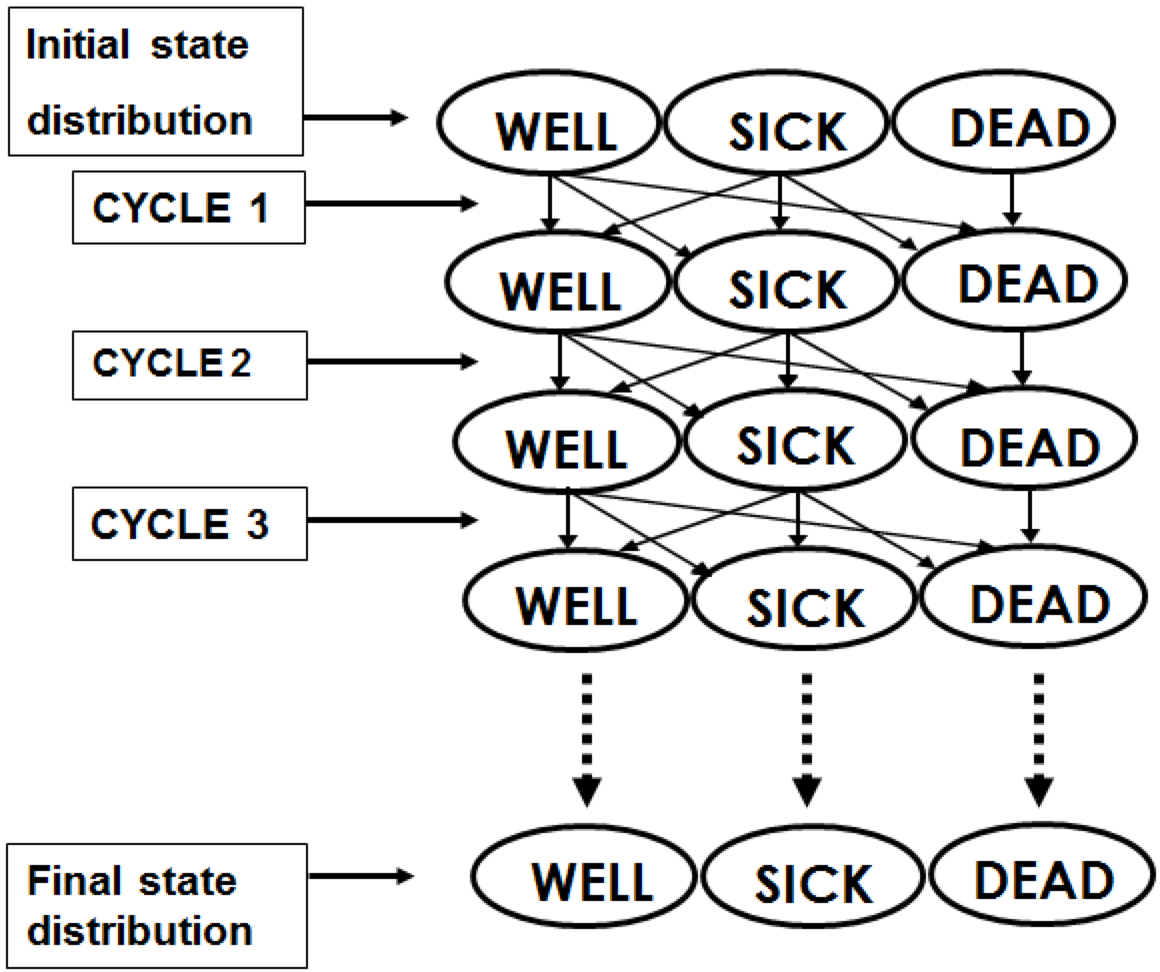
Markov model

- Also called "state-transition models"
  - Time-dependent
  - Consist of a number of mutually exclusive health states
  - At any specific time a patient is assumed to be in one of these health states for a fixed period of time – **one cycle**
  - At the end of each cycle patients move between states (or remain in the current state) according to a fixed set of probabilities

- Example of a Markov model with 3 health states:



- Example of the Markov process:



- A cost and benefit value is assigned to each health state
- At each cycle, the total costs and benefits are determined by the proportion of patients in each health state multiplied by the cost and benefit value associated with that state.
- Assume that the measure of benefit is patient utility, and in the well state utility is 1, in dead is 0, and in sick is 0.5.
- If each cycle is 1 year then 50 QALYs will be accumulated in the first cycle.

Cycle	Well	Sick	Dead	Total	Total utility	Cumulative utility
0	0	100	0	100	50	50
1	10	60	30	100	40	90
2	12	38	50	100	31	121

- A similar procedure would be carried out with costs to generate a cumulative cost column
- The cost-effectiveness is then calculated in a similar way as for the decision tree model

Markov model

Strengths

- Can deal easily with time-dependent, dynamic events
- Can deal with recurrent events
- Easy to use (as long as no. of states is manageable)

Limitations

- The Makovian assumption: The Markov model is 'memoryless' – we do not retain knowledge of which health states individuals come from.

A good decision model should…

- be populated with the most appropriate and good quality clinical data (e.g from meta-analysis)
- reflect a realistic picture of current clinical practice
- use the appropriate comparator(s)
- be run for an appropriate time period
- be valid, transparent and reproducible
- explore uncertainty
- be easily interpreted

“If they [models] were as **complex** and difficult to control as **reality** there would be no advantage in their use. Fortunately we can usually construct models that are **much simpler than reality** and still use them to **predict and explain** phenomena with a very high degree of accuracy. The reason is that although a very high number of variables may be required to predict a phenomenon with great accuracy, a small number of variables will usually account for most of it. The **trick**, of course, is to find the **right variables** and the **correct relationship** between them.”

Ackoff & Sasieni (1968)

Summary

- Models are a useful tool for extending clinical trial data, synthesising data from different sources, and assessing uncertainty
- The two main types of models are the decision tree and the Markov model
- All models are simplified representations of reality
- The ‘robustness’ of model results depends on the reliability of the data used, and the appropriateness of the model assumptions and structure