R Foundations Workshop DAY 1 | 9 April 2025

R-HTA in LMICs

Increasing accessibility to R for HTA in LMICs

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Modelling Basics: Decision Tree

HTA in LMICs R Foundations Workshop DAY 1

(9 April 2025)

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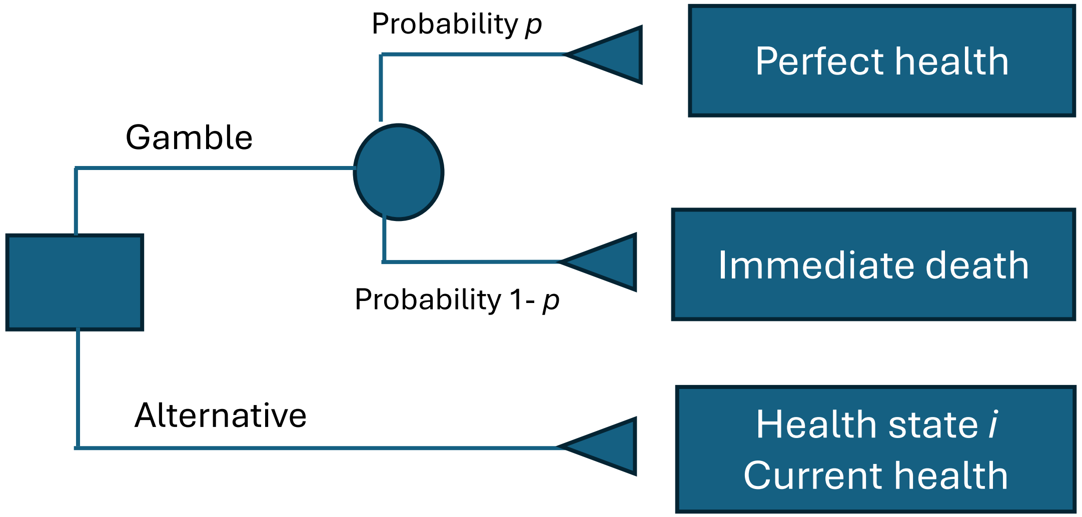
for

Health Technology Assessment

Standard Gamble theory

- The standard gamble is **a method that has its theoretical basis in the von Neumann–Morgenstern axioms of expected utility theory**.
- It aims to measure the 'disutility' of a health state by observing the willingness to accept a certain risk of death in order to avoid the state.
- Typical standard gamble framework, a respondent is asked to consider a choice between two alternatives:
  - **Alternative A:** the person would live with a particular health problem (the one for which the valuation is needed) with certainty, for the remainder of his or her life.
  - **Alternative B (Gamble)** is usually characterised as a risky treatment, with two possible outcomes: life in a state of optimal health, with probability *p*, or immediate death, with probability (1−*p*).
  - The measurement objective for the standard gamble is to identify the probability of optimal health, *p*, at which the respondent is ‘indifferent’ between alternatives A and B, in other words, <u>the point at which the two alternatives seem equally attractive</u>.



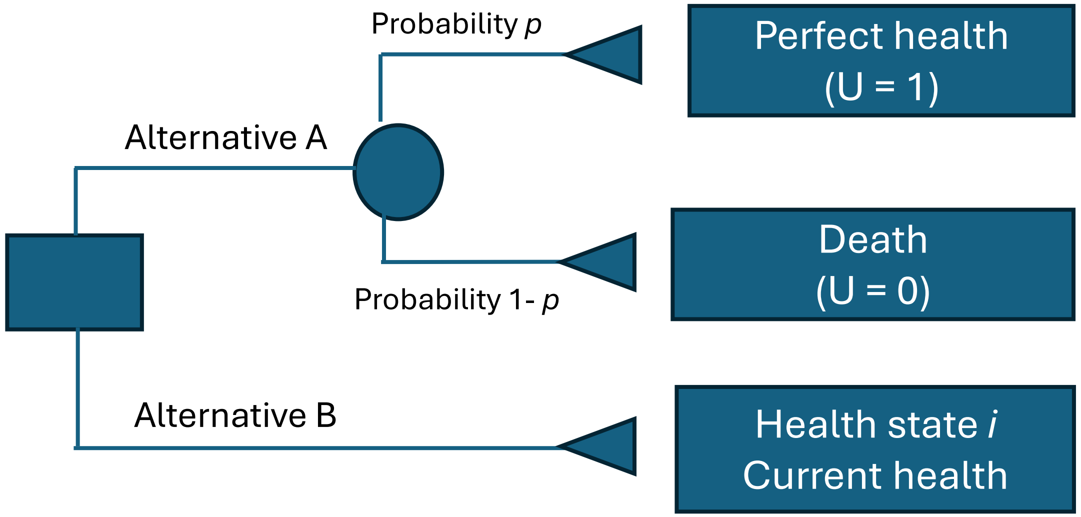
Standard gamble theory

- Once this ‘indifference’ point is identified, a health state valuation for the particular health problem of interest is equal to *p*.

- The logic of this inference derives from setting the utility of optimal health to 1.0 and that of death to 0 and assuming that at the point of indifference, the respondent considers the expected utility of alternatives A and B to be the same.

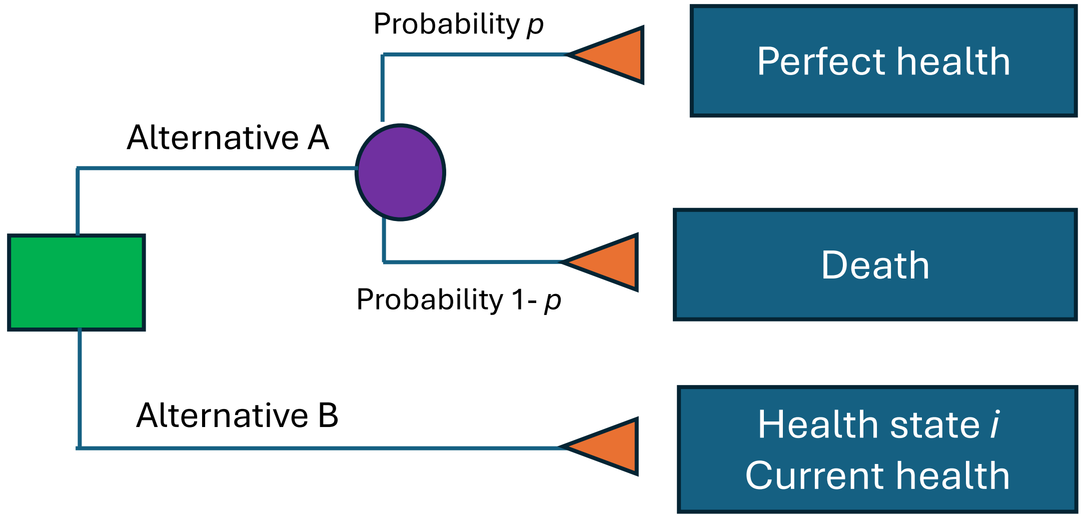
- In mathematical terms, the equality is stated as $p \times U(\text{optimal}) + (1-p) \times U(\text{death}) = U(\text{health outcome})$

- $p \times 1 + (1-p) \times 0 = U(\text{health outcome})$, which simplifies to $p = U(\text{health outcome})$.



Decision Tree: basics

- Simplest form of decision model
- Short time horizon: e.g. 6-12 months
- Perspective: e.g. health system/provider, societal etc
- Pathways
  - Are routes through the decision tree
  - These are a sequence of mutually exclusive events
- Probabilities
  - Show likelihood of a particular event occurring at a chance node
  - Move from left to right
    - 1st probability: shows probability of an event.
    - 2nd probability: conditional or depends on whether an earlier event occurred or did not occur.
  - Pathway joint probability: obtained from multiplying probabilities along a pathway

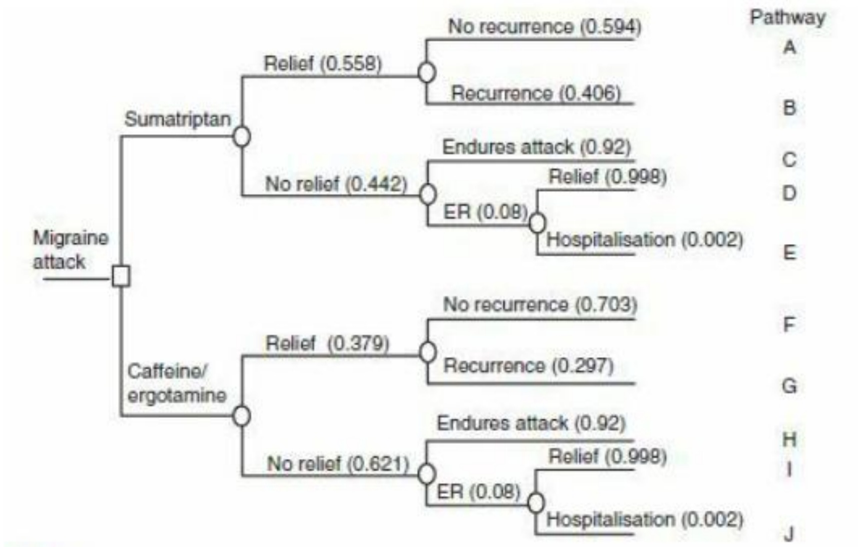


Decision nodes:

- **Square decision Node** (At start of tree):
  - Show decision point between alternative options.
- **Circular chance node** (branches coming out of the node):
  - Show a point where 2 or more alternative events for the patient pathway are possible.
- **Terminal nodes (Leaf node):**
  - Contains records that do not pass through any further decisions

Decision Tree Probabilities

- **Probabilities in decision analysis**: a number indicating a likelihood of an event occurring in future.
- **Joint probability:**
    - The likelihood of 2 events taking place at the same time.
    - Notation = P(A and B)
- **Conditional probability:**
    - Probability of event A, given that event B is known to have taken place.
    - Notation = P(A|B)
- **Independence:**
    - Events A and B are independent if the probability of event A, P(A), is the same as the probability of P(A|B).
    - When the events are independent P(A and B) = P(A) x P(B).
- Relation of joint and conditional probabilities is shown here: P(A and B) = P(A|B) x P(B)



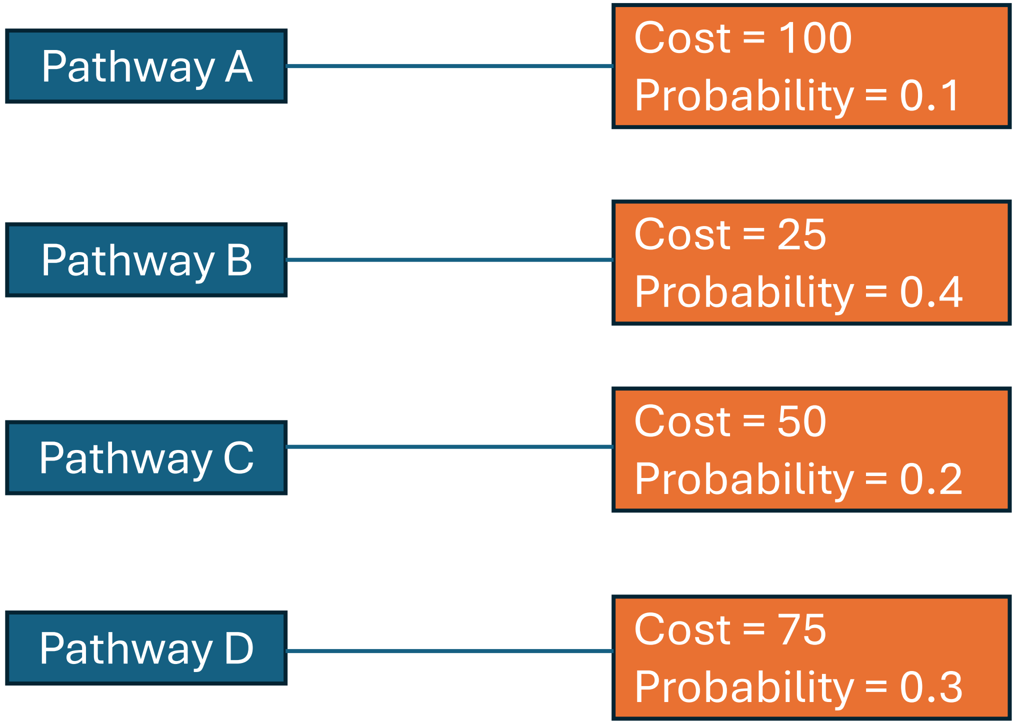
Pathway	Probability	Cost	Expected cost	Utility	Expected utility
Sumatriptan					
A	0.331	16.10	5.34	1.00	0.33
B	0.227	32.20	7.29	0.90	0.20
C	0.407	16.10	6.55	–0.30	–0.12
D	0.035	79.26	2.77	0.10	0.0035
E	0.0001	1172.00	0.11	–0.30	–0.00003
Total	**1.0000**		**22.06**		**0.41**
Caffeine/erogotamine					
F	0.266	1.32	0.35	1.00	0.27
G	0.113	2.64	0.30	0.90	0.10
H	0.571	1.32	0.75	–0.30	–0.17
I	0.050	64.45	3.22	0.10	0.0050
J	0.0001	1157.00	0.11	–0.30	–0.00003
Total	**1.0000**		**4.73**		**0.20**

Expected values using costs

For a given option, the likelihood of each prognosis can be quantified using probabilities and their cost implications or health outcomes.

Health outcomes or Payoffs

- Costs would typically be one form of payoff but, on the effects side, a range of outcomes may be defined depending on the type of study.
- Increasingly, quality-adjusted life-years (QALYs) would be one of the payoffs in a decision model for cost-effectiveness analysis, which may or may not be based on utilities elicited using the standard gamble.
- The principle of identifying a preferred option on the basis of a decision analytic model is on the basis of expected values.



Expected costs = Path A + Path B + Path C + Path D
= (100 x 0.1) + (25 +0.4) + (10 X 0.2) + (75 x 0.3)
= 52.50

Calculations

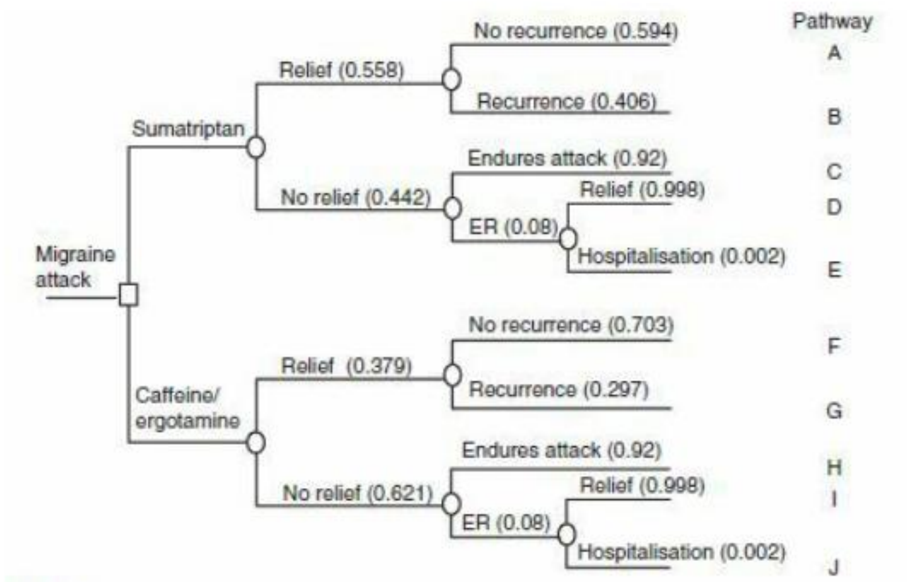
- Pathway A = Prob. of Relief$_A$ x Prob. of NoRecurrence$_A$
  = 0.558 x 0.594
  = 0.331

- Probabilities must equal to 1
  - Pathway probabilities (A+B+C+D+E) = 1

- Expected costs = Probability$_B$ x Cost$_B$
  = 0.227 x 32.30
  = 7.33

- Expected Utility = Probability$_C$ x Utility$_C$
  = 0.407 x -0.30
  = - 0.12

Note: Utilities may be provided in the data (If not, you will find in the published literature)



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(Source: Briggs *et al.*, 2006, pg 46 (Box2.3))

Decision Tree in R: Exercise

Q1. Set the sample size to 300.

Q2. Change the tree model 'type' to 2 or 5. What happens to the structure of the tree?

Q3. Change extra to 101. How many patients are in palliative care (Hint: numerical number)?

Q4. Remove the neat layout of the decision tree (Hint: opposite of TRUE)

Q5: Change the title of the decision tree to 'Decision Tree for Breast Cancer Treatment'

THANK YOU!

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