

Overview of Decision Modeling

Overview of Decision Modeling in R

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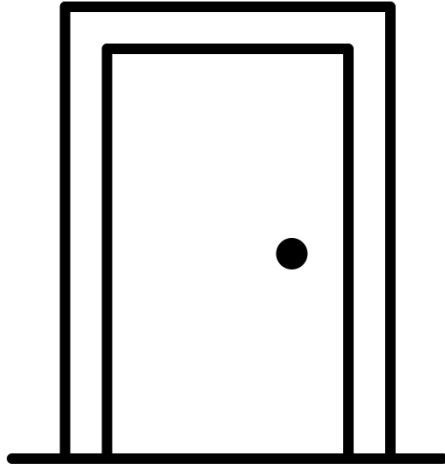
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Decision Analysis

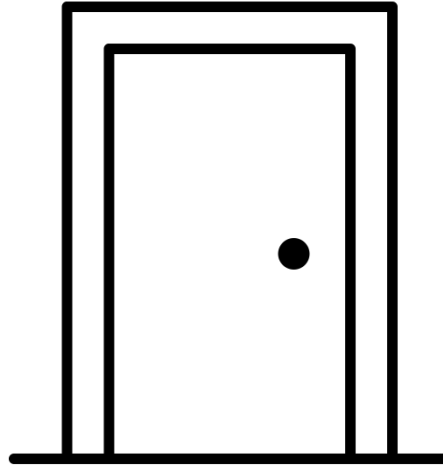
- Explicit, quantitative and systematic approach to decision making under *uncertainty*
- Identify, measure, and value the consequences of decisions as well as the uncertainty that exists when the decision needs to be made
- Help structure the analysts' thinking and facilitate the communication of assumptions
- Provide a structural framework for synthesizing data from disparate sources and allows for *extrapolation*
- Elements are incorporated into a *model* to structure the decision problem over time, and used to compare the outcomes of different options or interventions

Decision Analysis

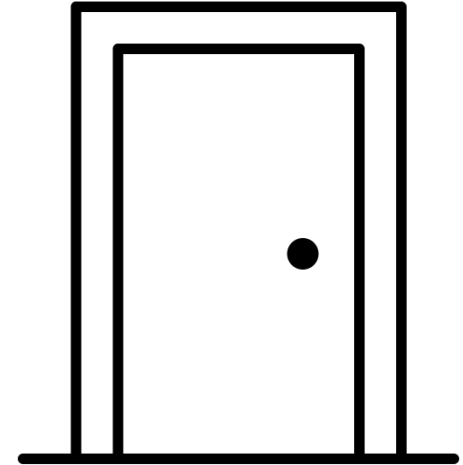
Option 1



Option 2



Option 3



Created by Icons Bazaar
from Noun Project

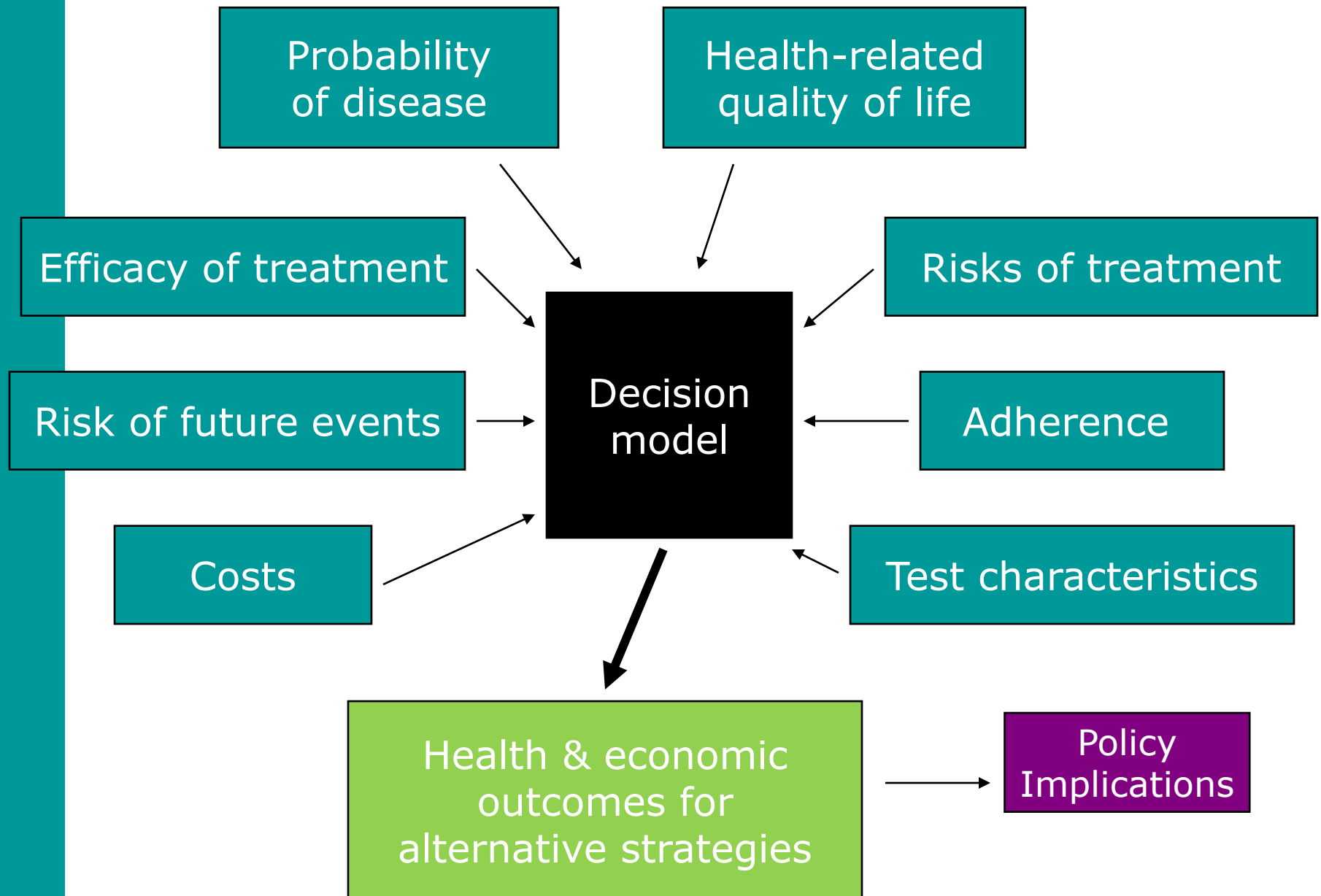
Benefits?



Harms?

Cost?

Created by Vectors Point
from Noun Project



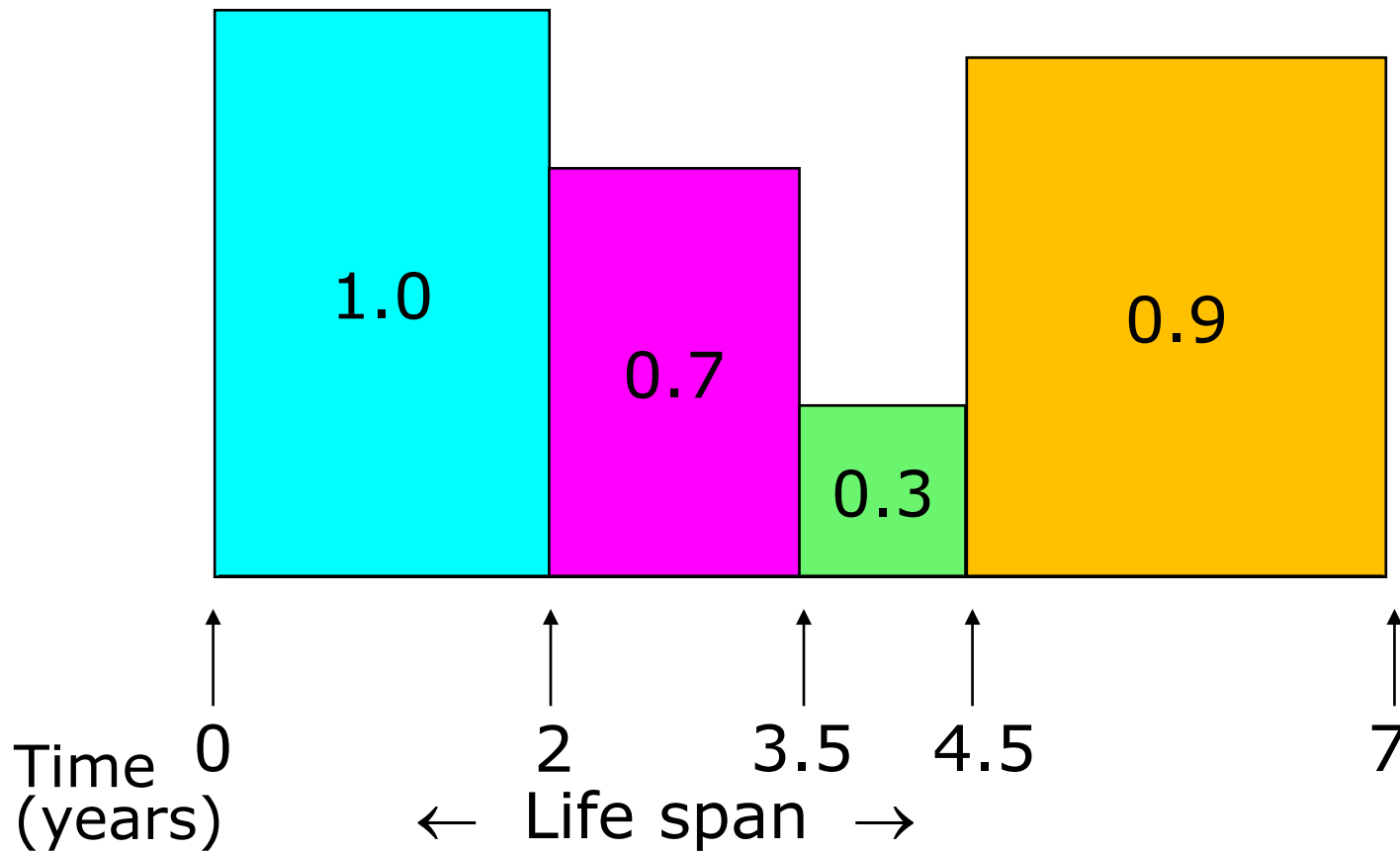
Models Types

- Decision tree
 - Schematic representation of uncertain events/consequences of different alternatives
 - Best for short time horizons
- Cohort state transition model
 - Dynamic model that reflects disease progression and other events
 - Models a cohort
- Microsimulation
 - Stochastic dynamic model
 - Models individuals

Health Outcomes

- Disease-specific
 - Intermediate clinical markers
 - Cases averted
 - Events averted
- Generic
 - Lives saved
 - Life-years gained
 - Quality-adjusted life-years (QALYs) gained

Quality-Adjusted Life-Years



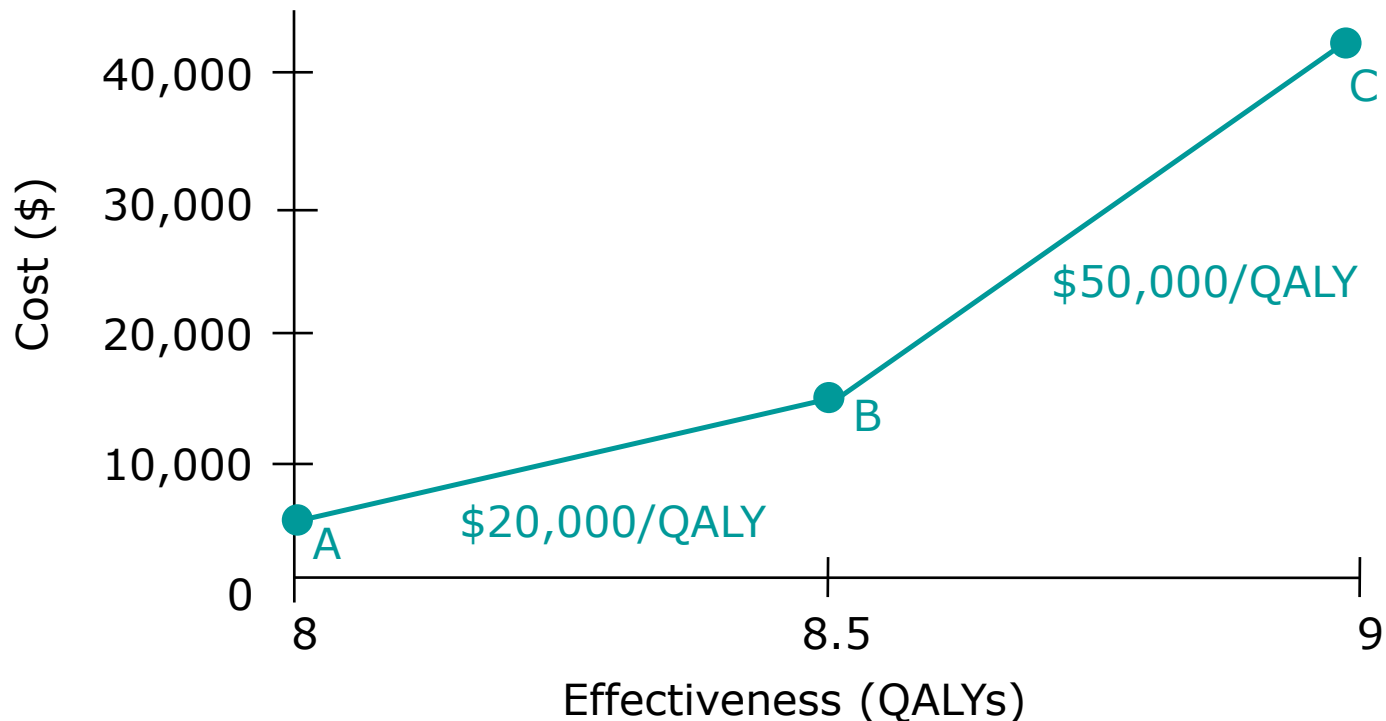
$$\text{QALYs} = (2)(1) + (1.5)(.7) + (1)(.3) + (2.5)(.9) = 5.6$$

Costs

- Formal healthcare sector
 - Facilities and resources
 - Drugs and devices
 - Personnel time
- Informal healthcare sector
 - Patient time
 - Unpaid caregiver time
 - Transportation costs
- Non-healthcare sector
 - Legal or criminal justice
 - Education
 - Housing

Cost-Effectiveness Analysis

- Subset of decision analytic questions where the objective is to balance costs and health benefits
- Defined willingness-to-pay per unit of health benefit (also called cost-effectiveness threshold)



Strengths and Challenges of Decision Modeling

Strengths of Modeling

- Clarifies decision-making
- Can use data from different sources
- Allows explicit and systematic characterization of uncertainty
- Extrapolates short-term observations into long-term outcomes
 - Can translate intermediate endpoints into life-years or QALYs gained
- Encourages “what if” analyses

Challenges of Modeling

- Validation issues
 - Model may be incorrectly specified (wrong structure)
 - Data to inform input parameter values may be lacking or of poor quality
- Not all decision considerations lend themselves well to modeling
- Communication issues
 - Transparency
 - Trust

Decision Tree Example

Decision Tree (a type of model)

- Schematic representation of all of the important outcomes of a decision (e.g., clinical, economic, non-health sectors)
- Used to combine knowledge about decision problem from many sources
- Computes *average outcomes* (e.g., costs, events, QALYs) from decisions

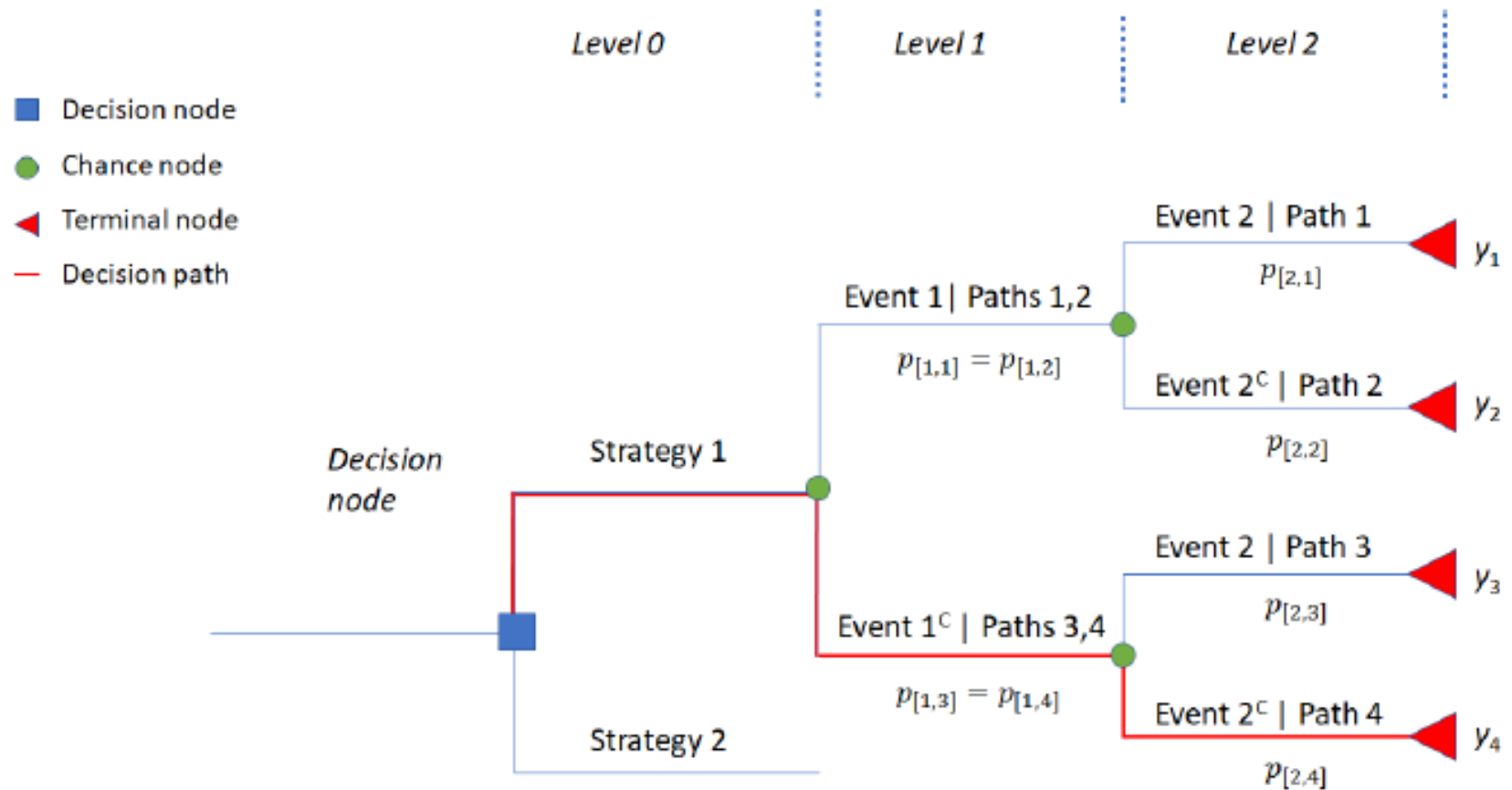
Components of a decision tree

1. The **alternative strategies** of a decision making process
2. The **events** that follow from application of any of these strategies and their **likelihood**
3. The **outcomes** (for an individual, a cohort or a population)

Structure of a decision tree

- A tree consists of 3 different types of *nodes* connected via *branches*:
 1. A decision tree starts with a *decision node*, which represents the choices a decision maker has between mutually exclusive strategies
 2. A *chance node* represents possible events that could occur following a decision or a previous event. We include probabilities of these events in the tree.
 3. A *terminal node* represents end points of each complete branch and the outcome associated with it.

Plot of a sample decision tree



Compute average outcomes

- The expected value (average) of the outcomes (i.e. cost, QALYs) of a strategy in a decision tree can be calculated by using the below steps:
 1. Identify all branches in this strategy
 2. Multiply all conditional probabilities in a branch
 3. The product of all conditional probabilities is then multiplied with the outcome value of that branch
 4. Repeat steps 2 and 3 for each branch
 5. Sum (the product of conditional probabilities x outcome) for all branches under this strategy

Simple Decision Tree

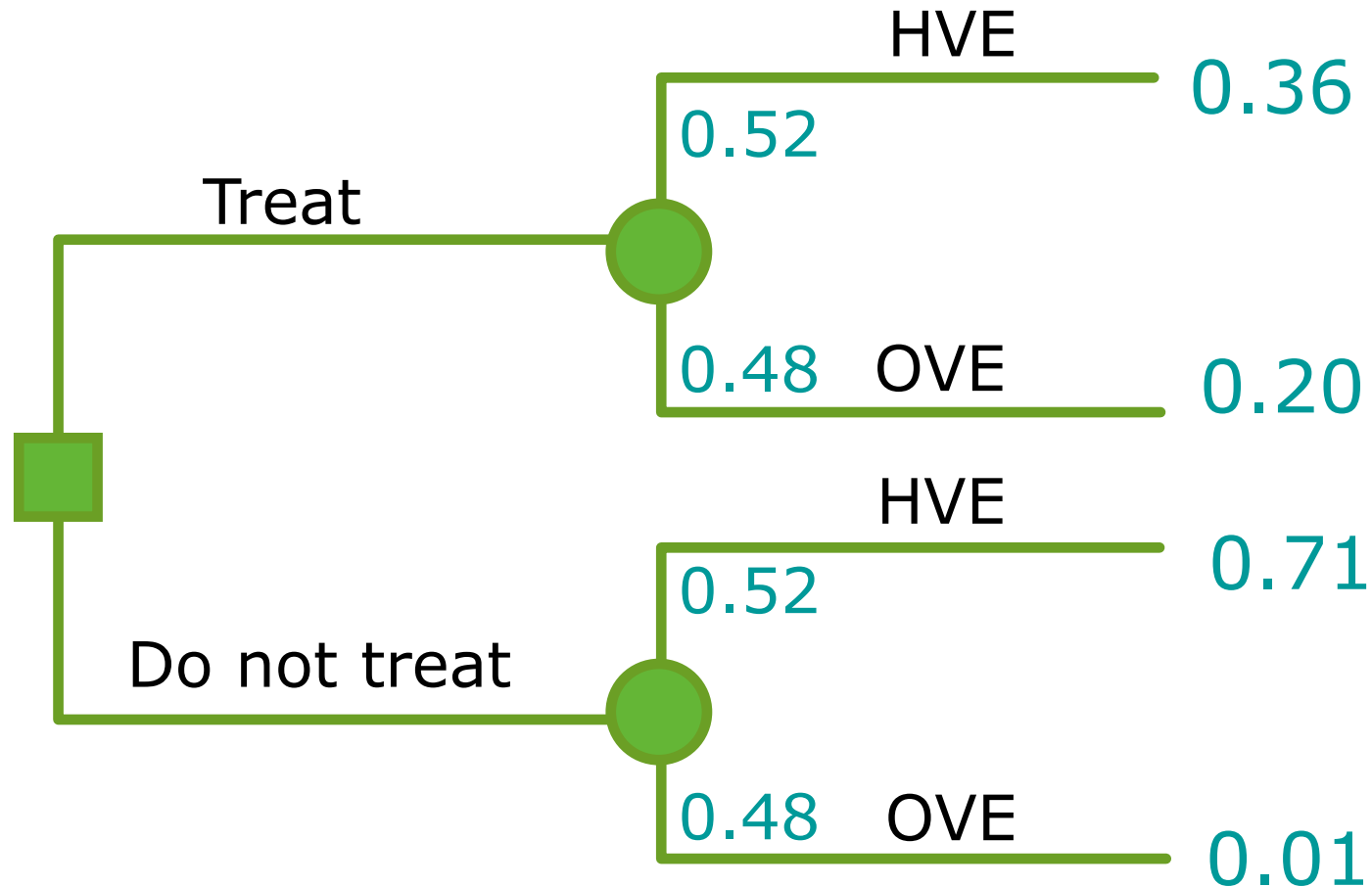
Viral encephalitis can be caused by herpes virus (HVE) or other viruses (OVE); $\text{Pr}(\text{HVE}) = 52\%$.

Untreated HVE leads to death or severe sequelae in 71%; for OVE the figure is 1%.

A drug, vidarabine, decreases mortality or severe sequelae due to HVE from 71% down to 36%.

Side effects cause an increase in mortality among OVE patients treated with vidarabine from 1% to 20%.

To treat or not to treat

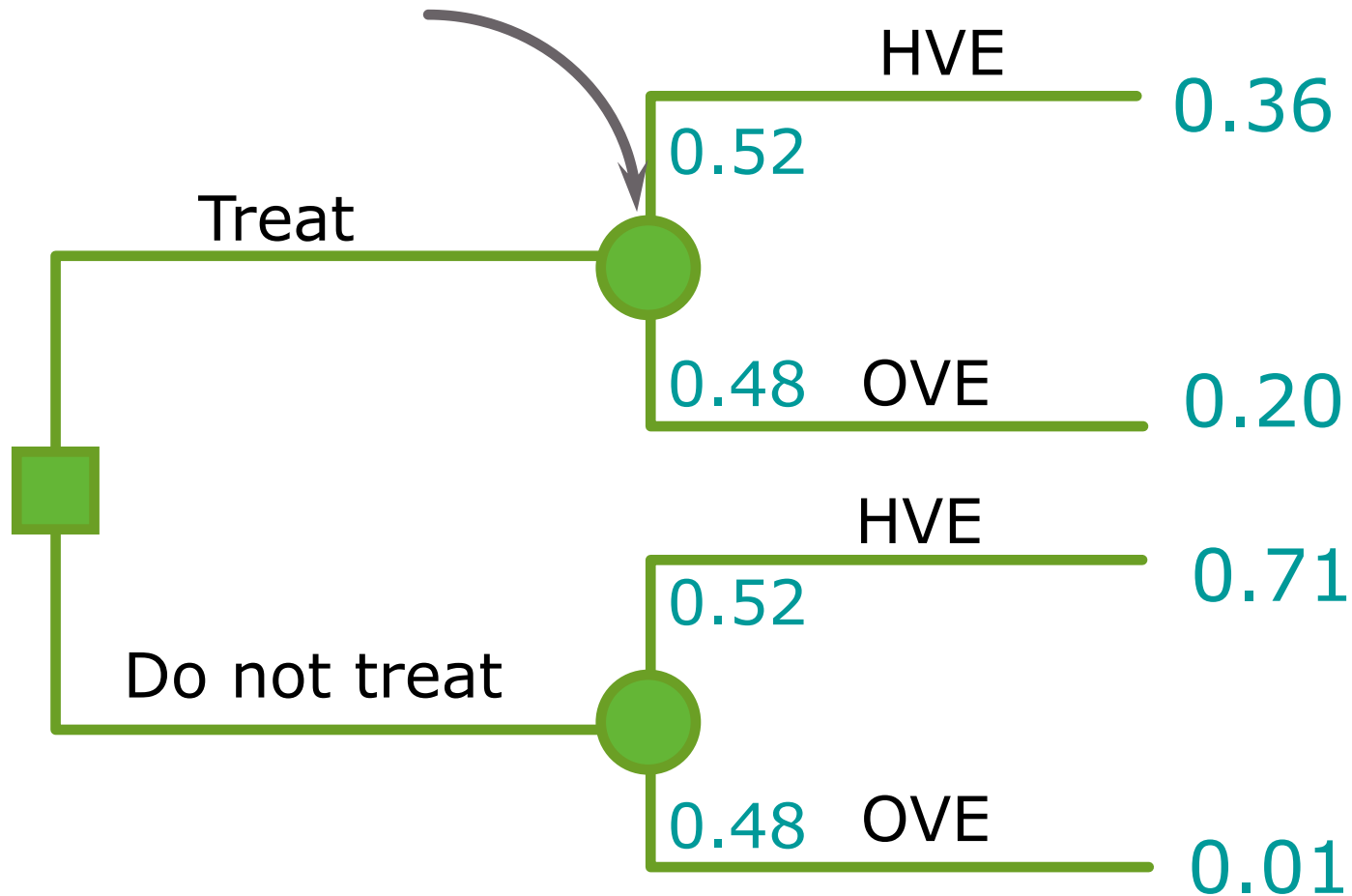


Outcome = $\text{Pr}(\text{mortality or severe sequelae})$

Define Variable Names

Variable	Variable Name in R	Value
Prevalence of HVE	p_HVE	0.52
Probability of complications (death or sequelae) without treatment		
HVE	p_HVE_comp	0.71
OVE	p_OVE_comp	0.01
Probability of complications (death or sequelae) with vidarabine treatment		
HVE	p_HVE_comp_tx	0.36
OVE	p_OVE_comp_tx	0.20

$$0.52 \times 0.36 + 0.48 \times 0.20 = 0.2832$$

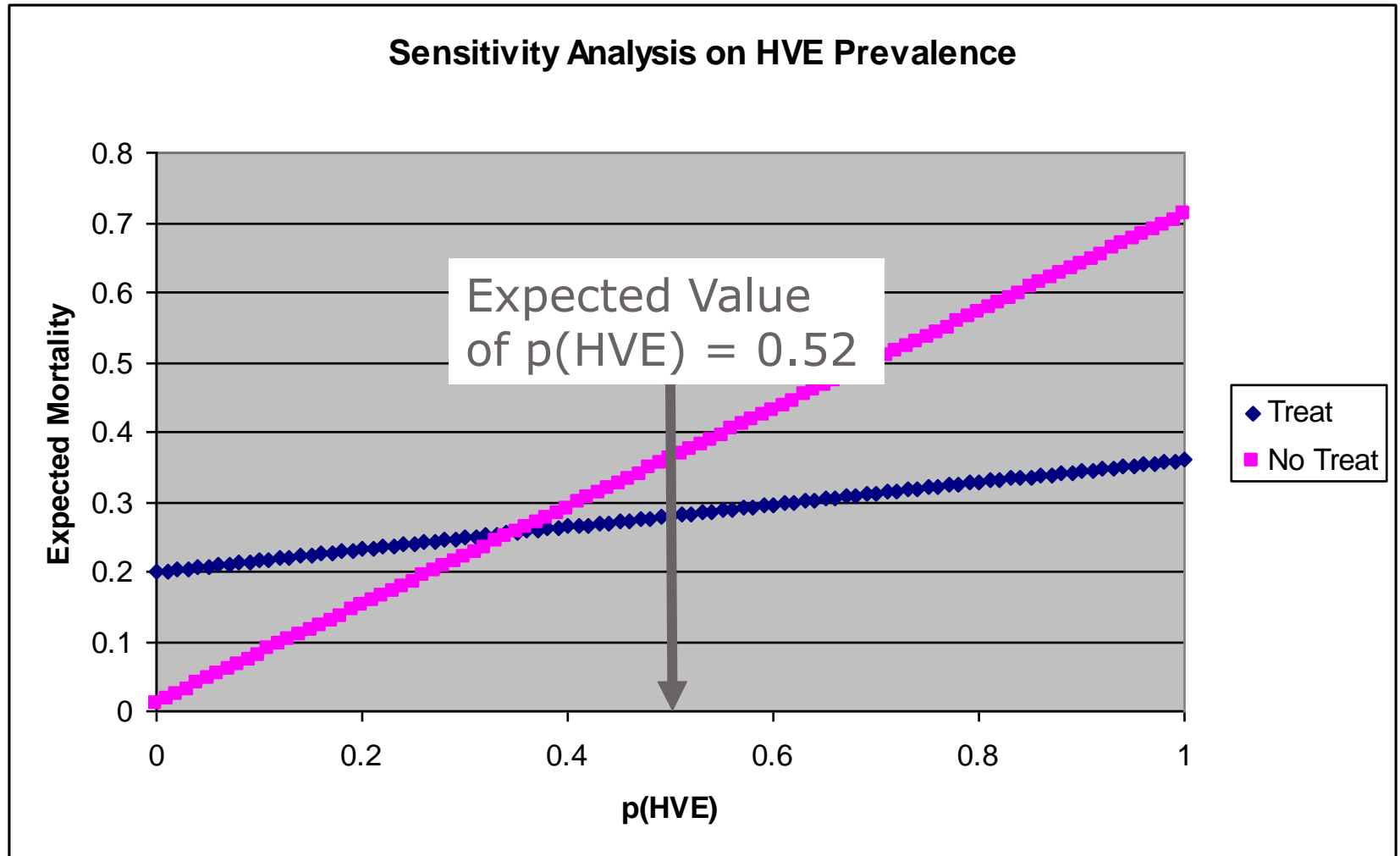


$$0.52 \times 0.36 + 0.48 \times 0.20 = 0.2832$$

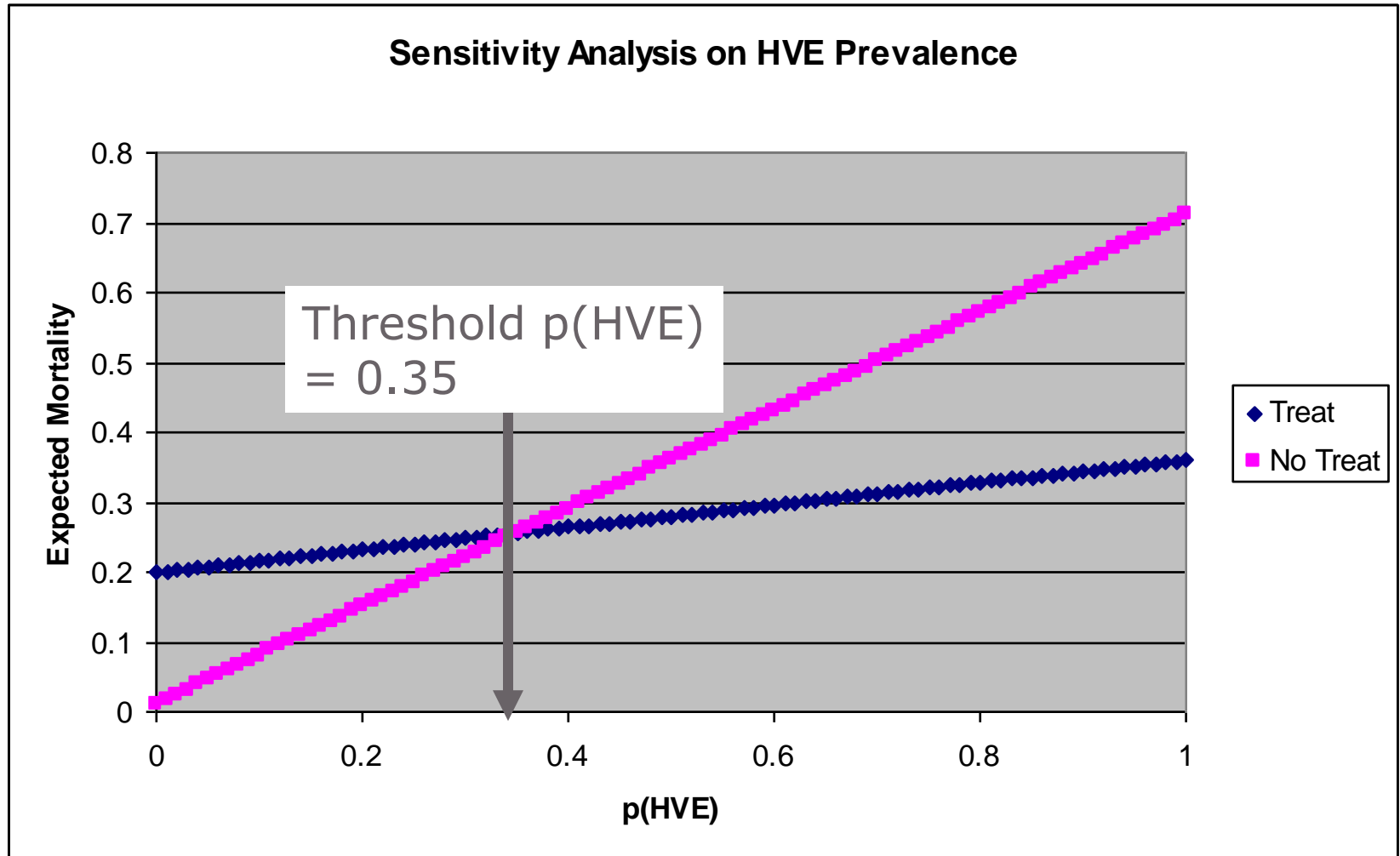


$$0.52 \times 0.71 + 0.48 \times 0.01 = 0.3740$$

One-Way Sensitivity Analysis



Threshold Analysis

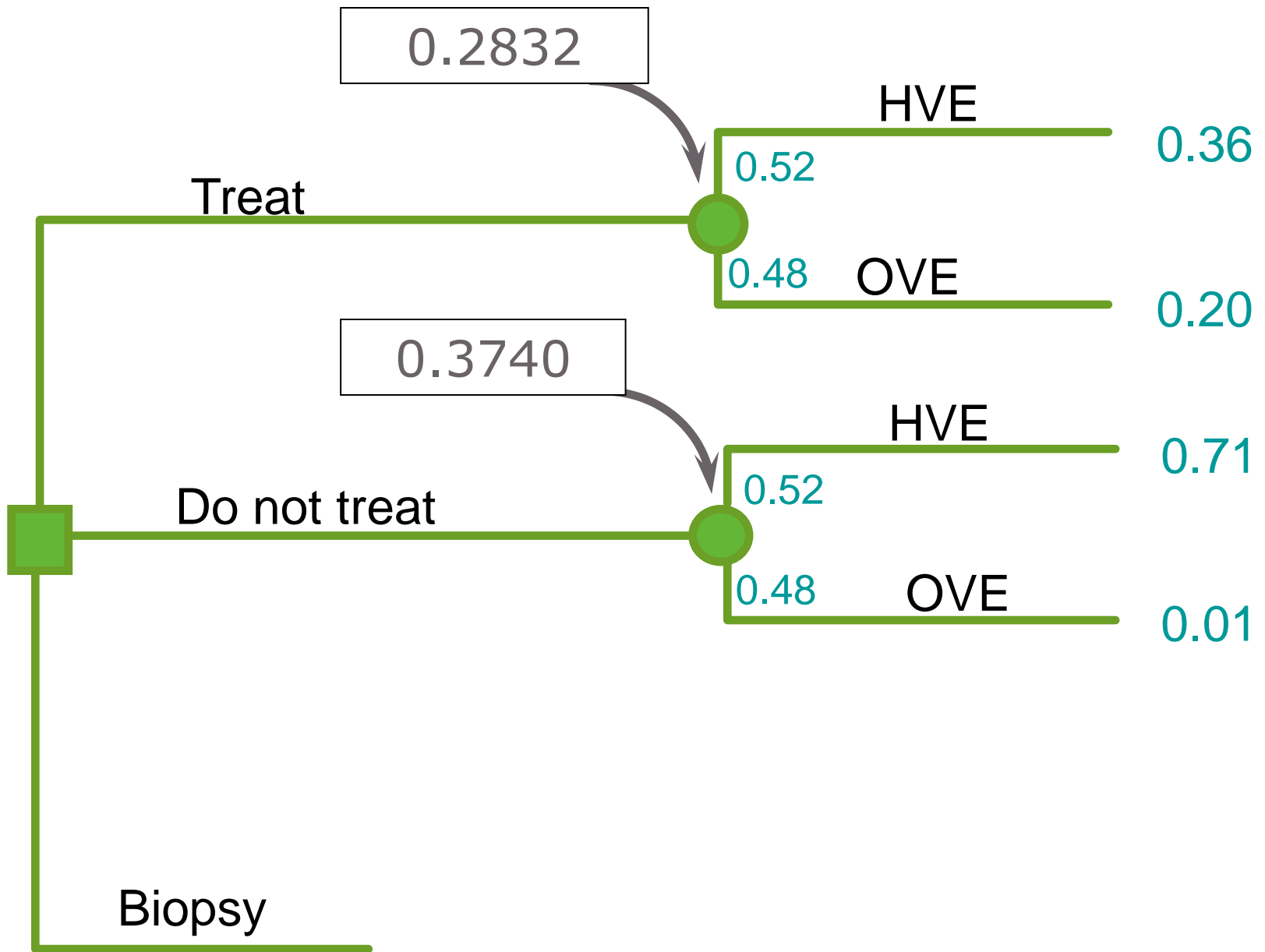


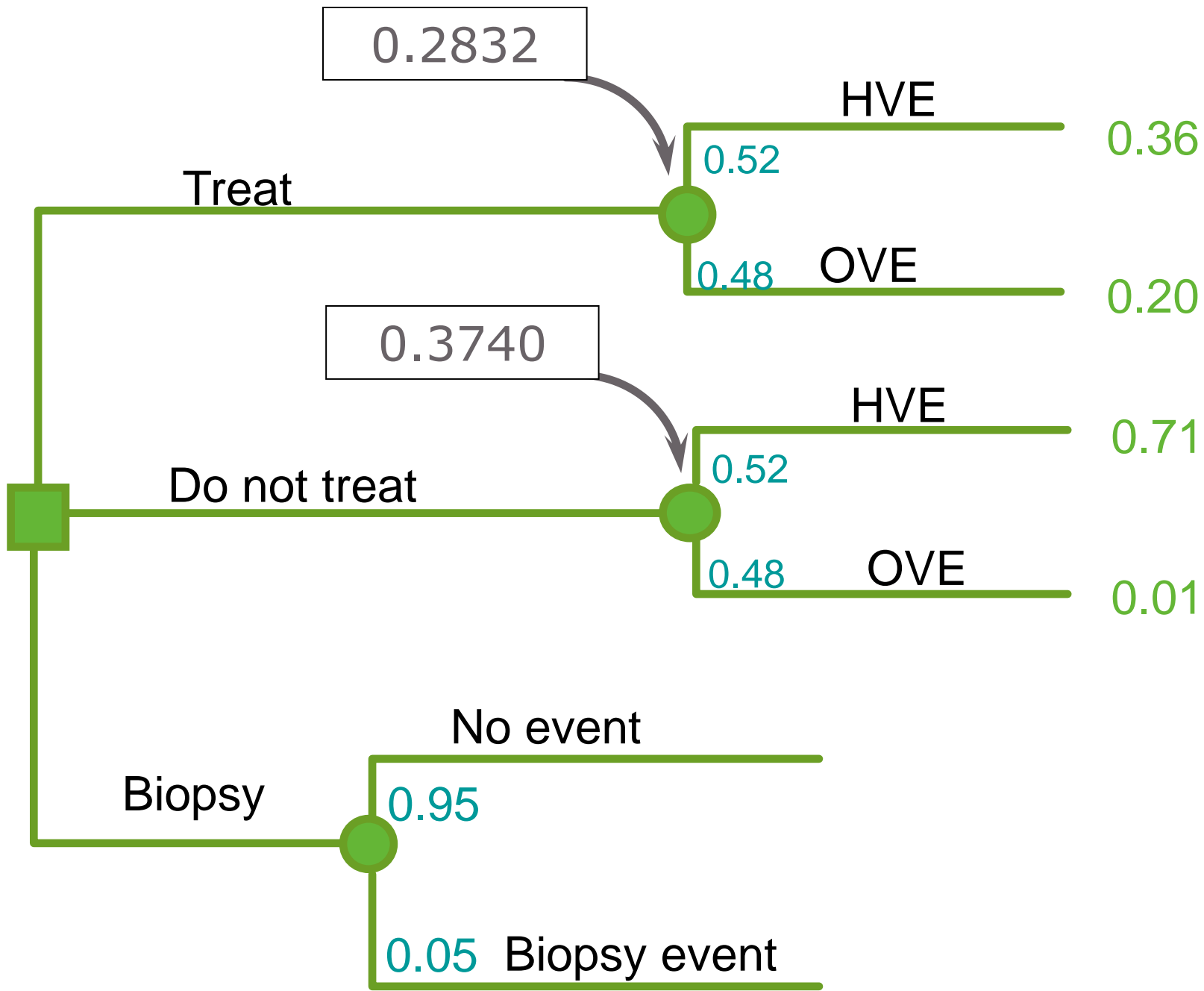
There is a third option

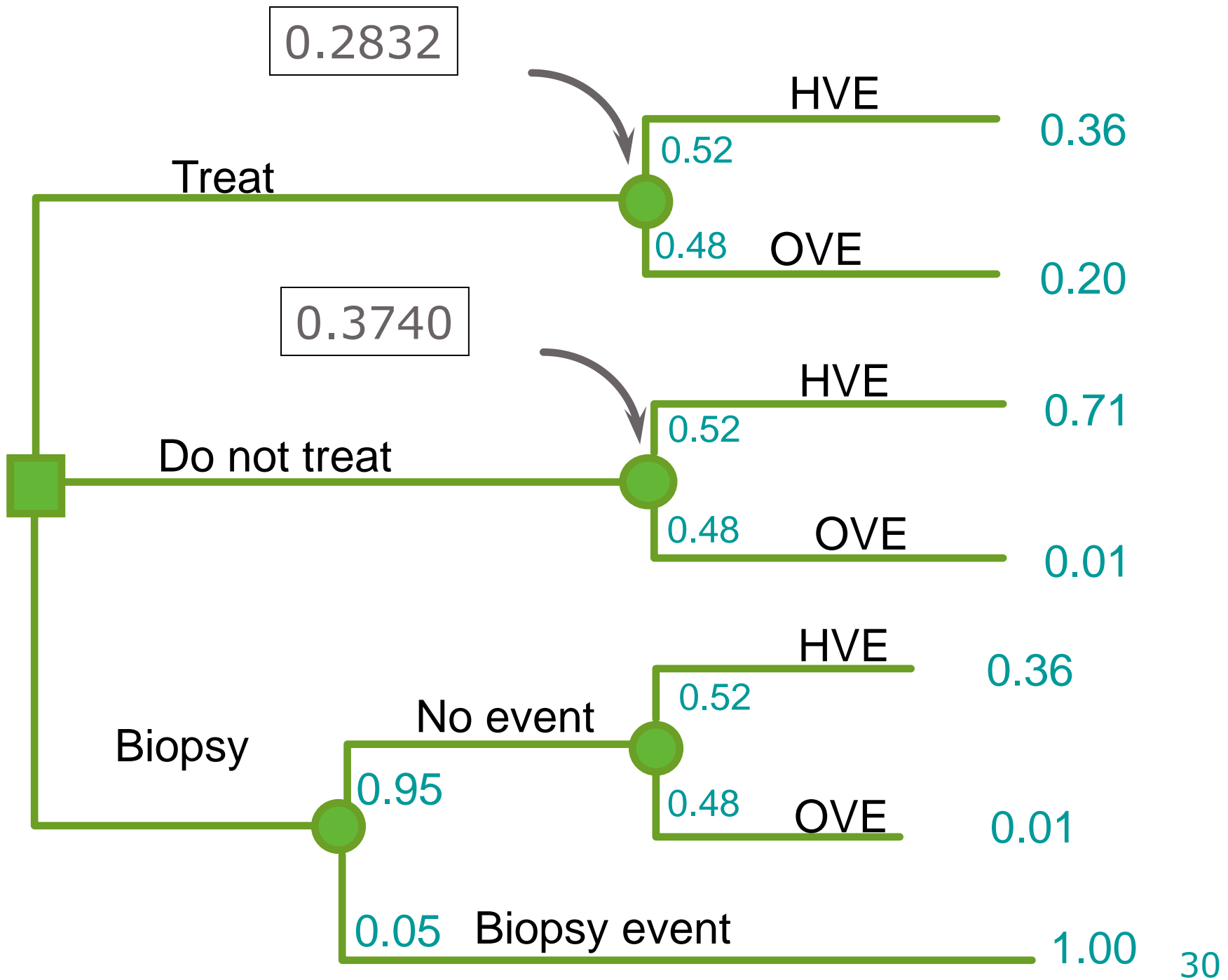
It is possible to obtain a definitive diagnosis by means of brain biopsy, but this procedure itself carries a rate of mortality or severe sequelae of 5%.

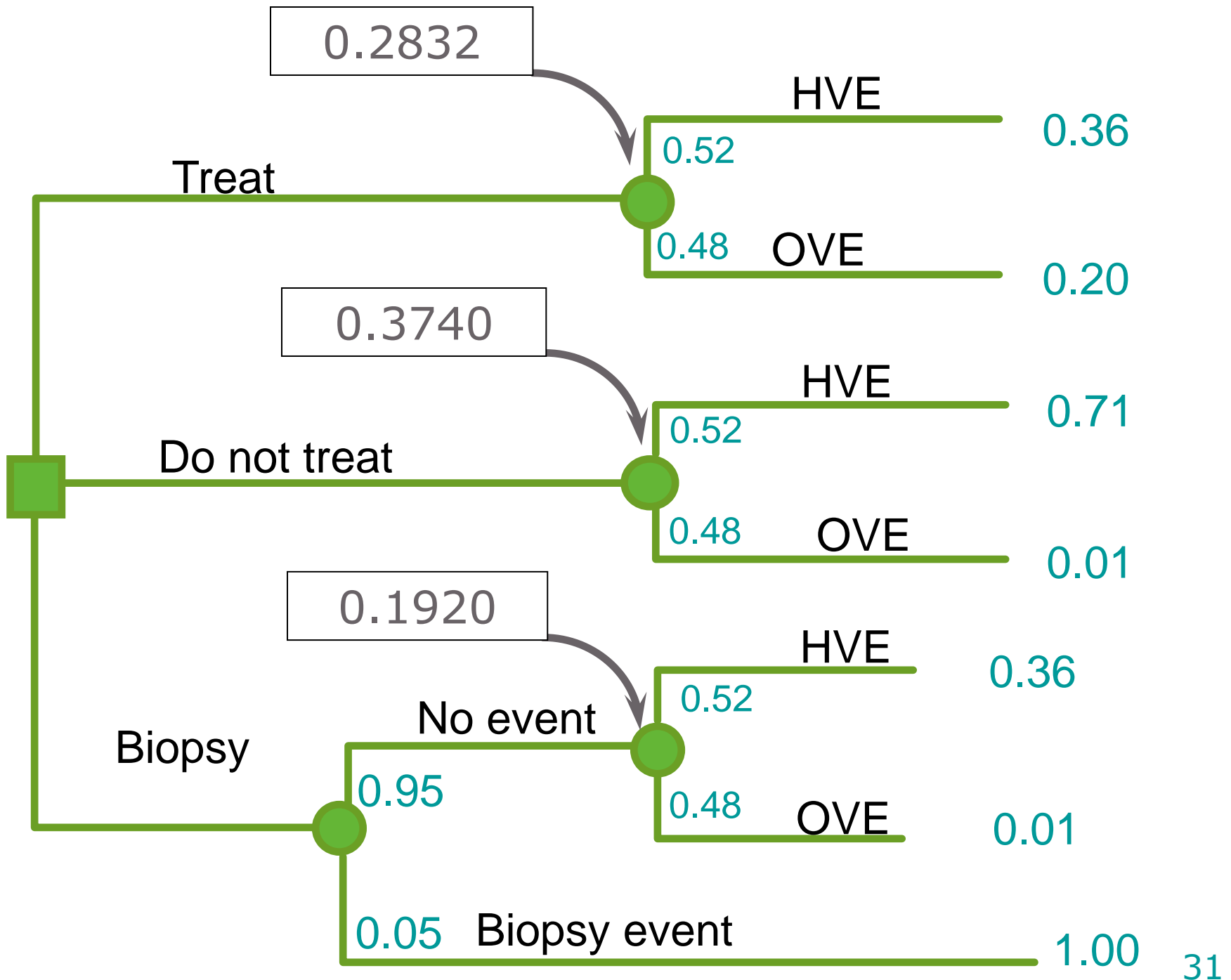
One More Variable Name

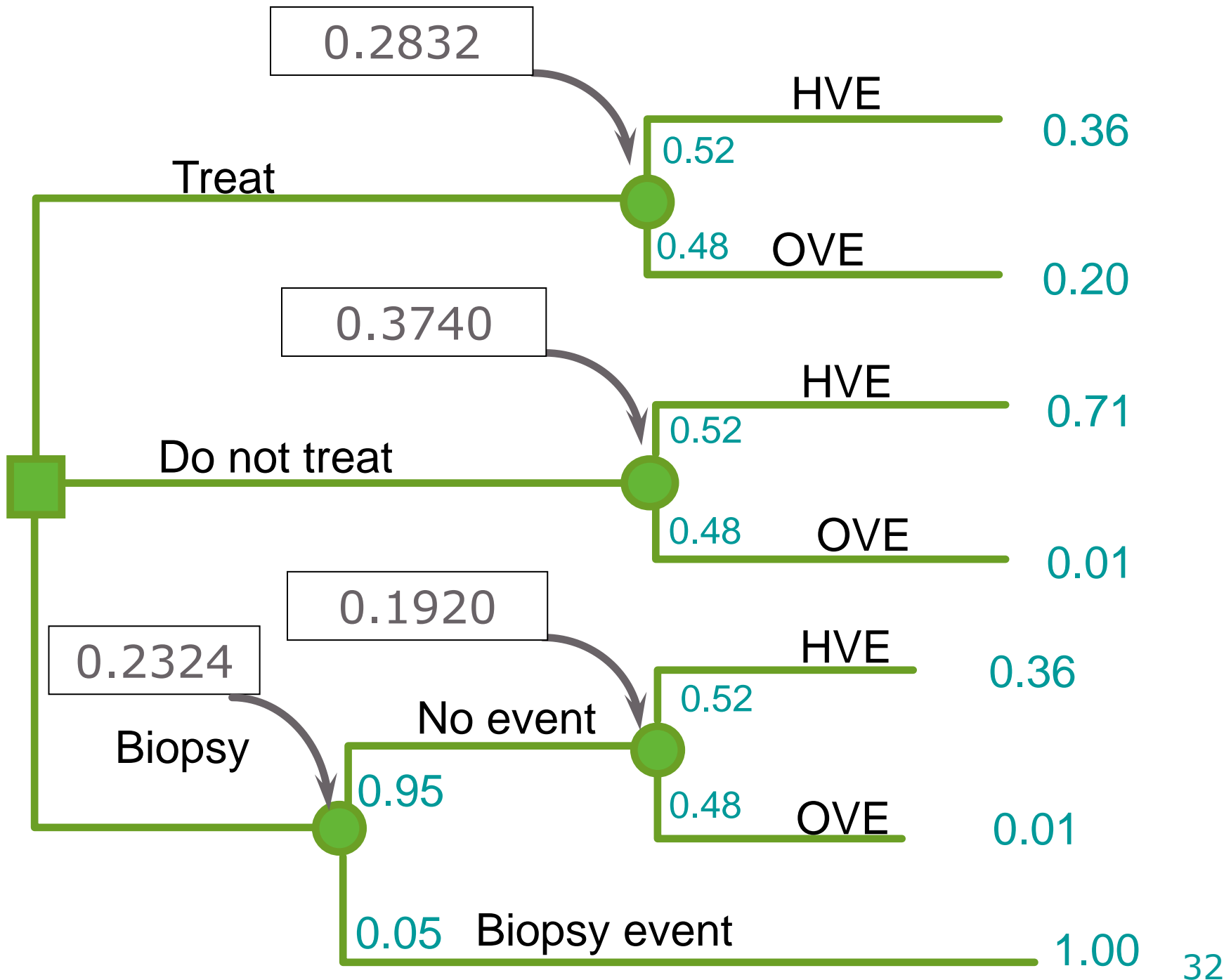
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Probability of complications (death or sequelae) with vidarabine treatment		
HVE	p_HVE_comp_tx	0.36
OVE	p_OVE_comp_tx	0.20
Probability of complications due to brain biopsy	p_biopsy_comp	0.05



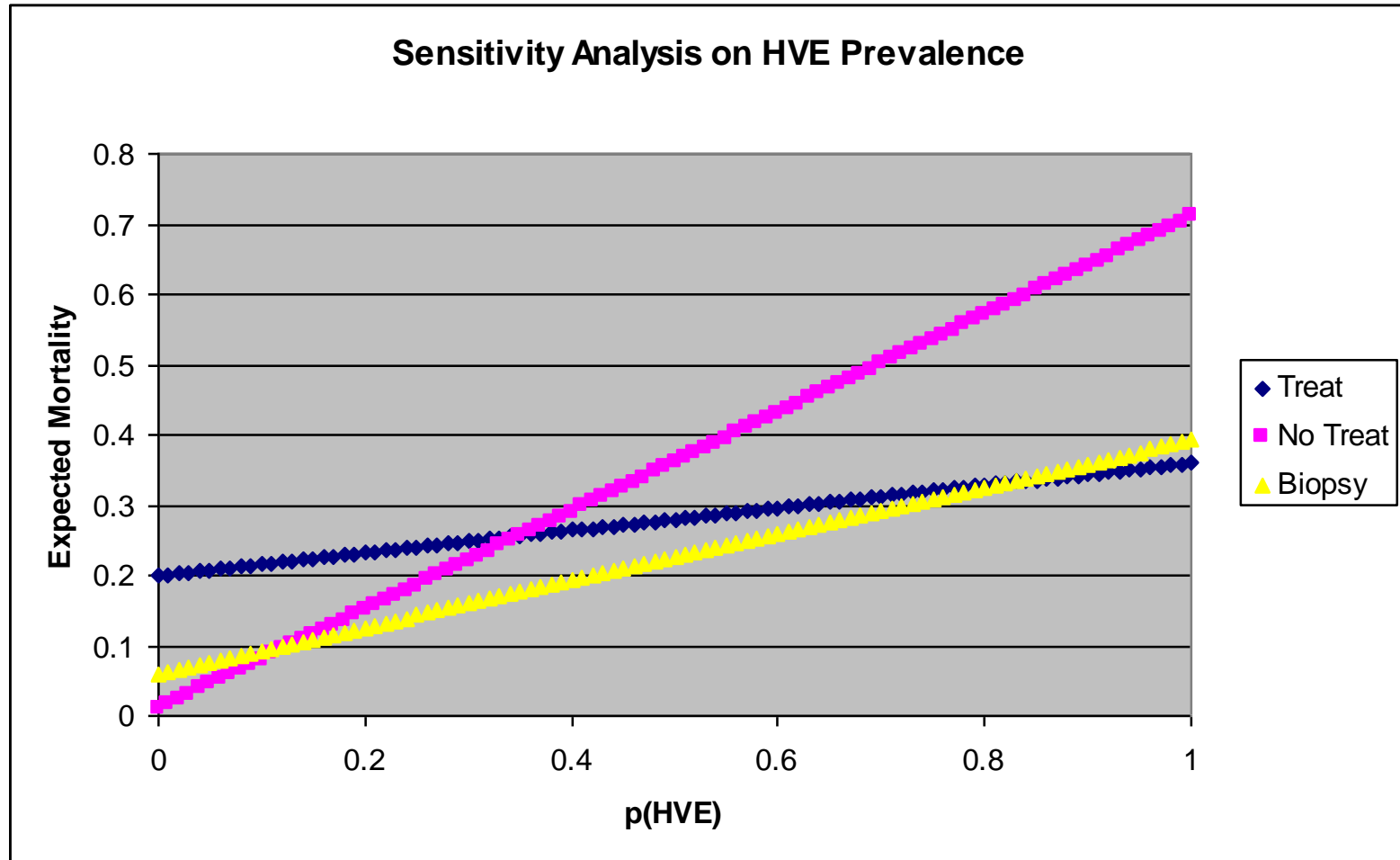








One-Way Sensitivity Analysis



R Session

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