Introduction Decision Tree Modelling

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TVEE
TEACHING VACCINE ECONOMICS EVERYWHERE

RECAP - Decision Analytical Models

- Decision analytical models are structured
  - to characterize outcomes of vaccines and alternative options
  - is done in a way that is appropriate for the infectious disease condition and vaccine usage
  - to represent clinical/disease pathways that are pertinent to the infection, or pathways avoided with vaccine use

- Allows the synthesis of evidence from a variety of sources to estimate vaccine costs, safety and effectiveness

- Can allow for events reoccurring over time
  - Reinfection
  - Disease progression
  - Vaccine program completion

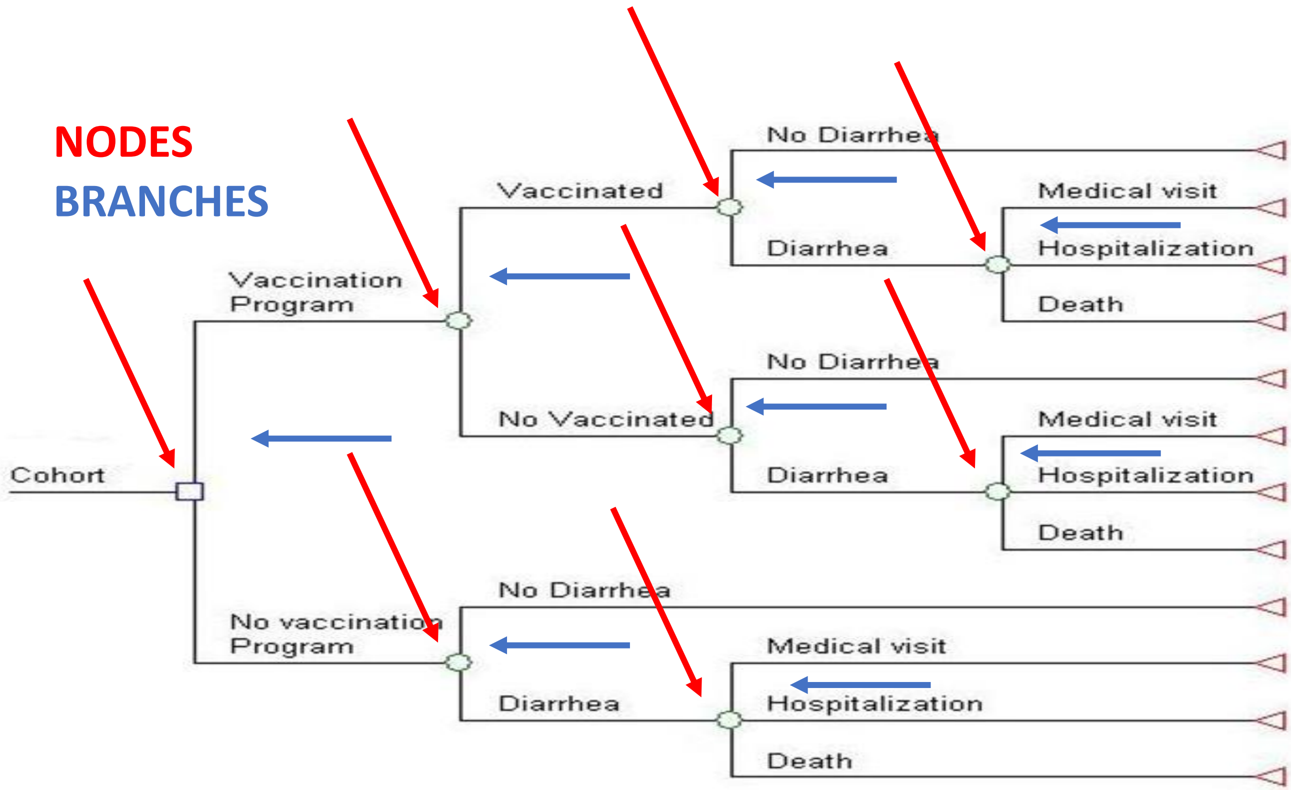
- Allows an assessment of different types of uncertainty
  - Unintended consequences of vaccine use
  - Unknown vaccine effectiveness

Decision Tree Model

- A *decision tree* is a simple model that depicts graphically all of the components of the problem and the corresponding outcomes. It relates actions to consequences.

It consists of

- Nodes
- Branches
- Outcomes



- You start with a de
These two options
of the choice you
- The branches exte
branch representi
available at that point

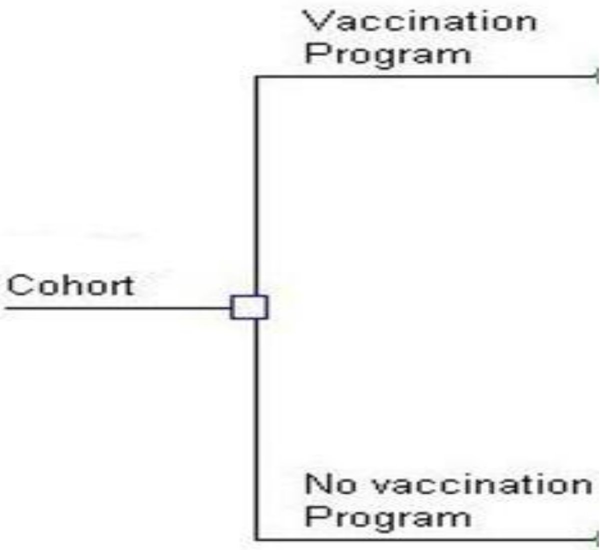
Types of Nodes

- **Decision node**

It is the *first* point of choice in the decision tree and is the focus of the analysis. It is represented in model as a small square.

The node represents the alternatives (comparators) that are chosen for the model.

Regardless of the decision made, the final outcome is determined by a series of chance events.



Types of Nodes

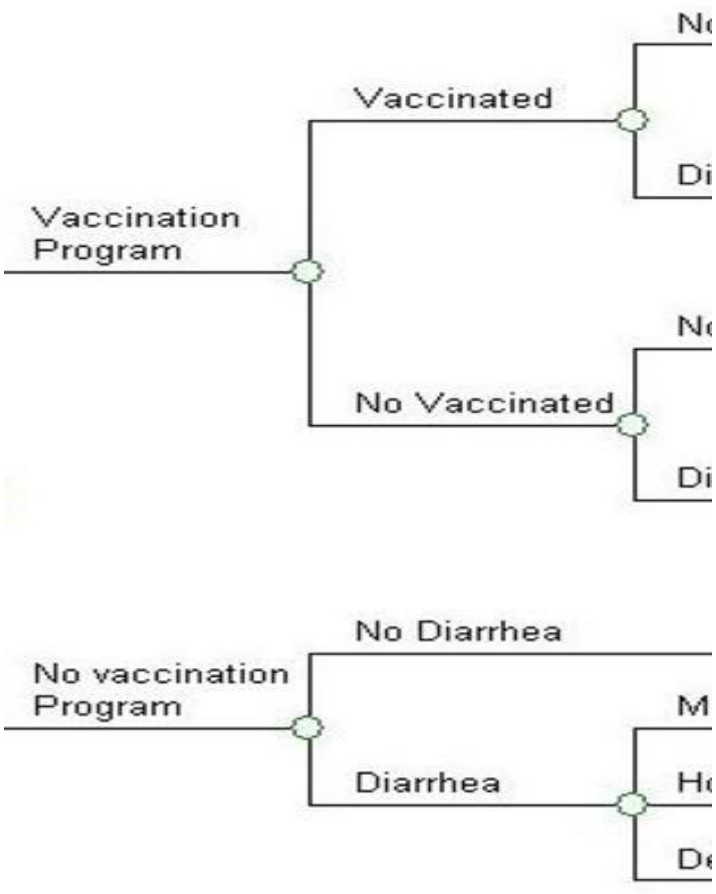
- **Chance node**

It represents a point in time at which chance determines which of the several possible events, that are out of control of the decision maker, may occur.

A line attached to the circle denotes each outcome of a chance event, and each line is labeled with the event.

There is no limit to the branches allowed on a chance node.

REMEMBER: The events at a chance node must be mutually exclusive and collectively exhaustive. Thus, at any given node, the sum of the probabilities of the events must equal 1

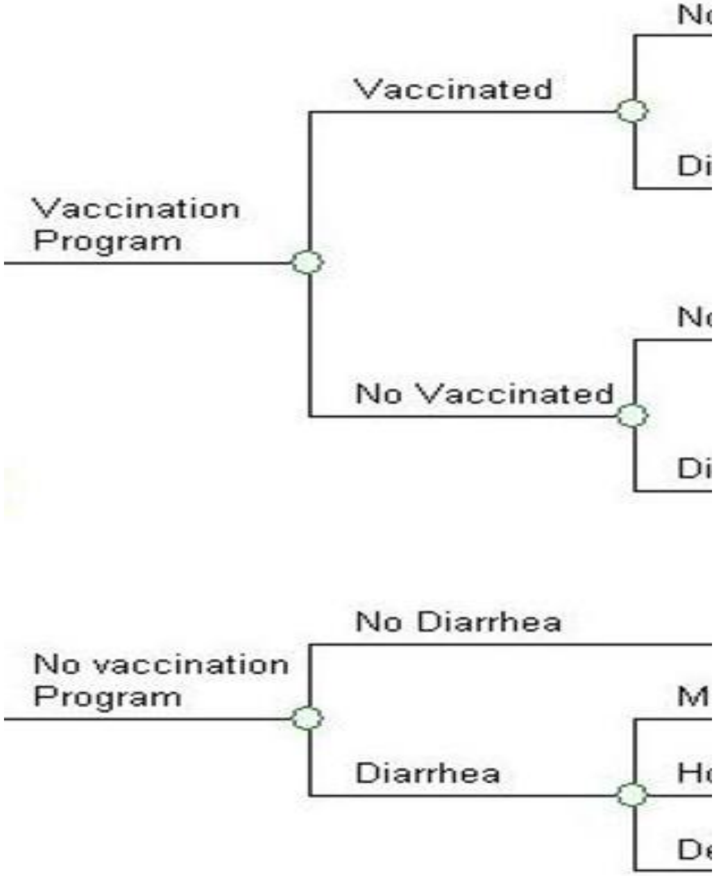


Types of Nodes

- **Chance node**

A decision tree is developed *left to right*, starting with a decision node on the extreme left and moving through chance nodes to reach the final outcomes on the extreme right.

The sequence of chance nodes from left to right usually follows the temporal sequence of events.



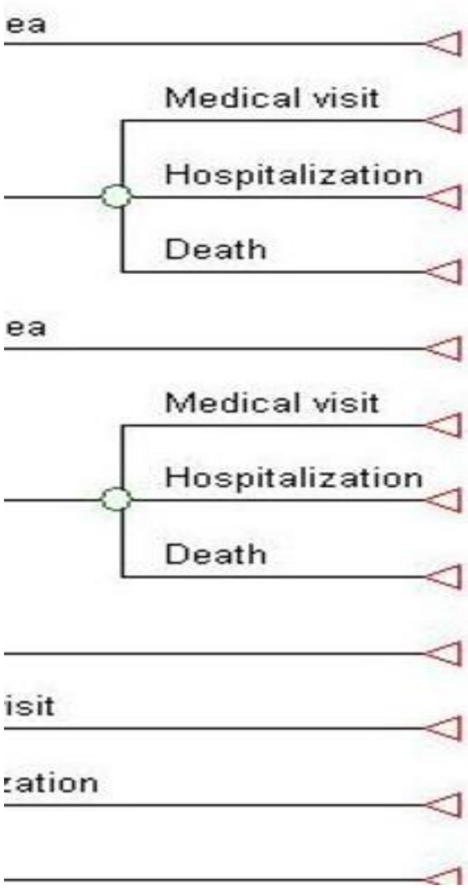
Types of Nodes

- **Terminal node**

It indicates the end point of each sequence of events that takes place in a decision tree.

A terminal node represents the final outcome resulting from that particular pathway.

With the help of terminal nodes, we can calculate the expected outcomes of all the comparators for a single person or a cohort on individuals.



Expected/Weighted Value of Costs and Outcomes

- Costs and outcomes are the consequences of the events represented in the decision tree.

- Given that the probability of occurrence of the final outcome for every pathway is not 100%, we use the **expected or the weighted value.** It is the sum of the products of the estimates of the probability of events and their outcomes.

- Expected(Weighted) Value = Actual Value x Probability of Occurrence

- We can use the expected/weighted value to observe which decision option would provide the highest value.

Averaging Out and Folding Back

- The process of calculating the expected value (costs and outcomes) of a decision tree model. It is all known as the rollback method.
- It starts at the terminal nodes of the tree and works backward to the initial decision node, determining the certain equivalent rollback values for each chance node.

- At a terminal node, the rollback value equals the terminal value.
- At a chance node, the rollback value for a risk neutral decision maker is determined using expected value (probability-weighted average); the branch probability is multiplied times the successor rollback value, and the products are summed.
- At a decision node, the rollback value is set equal to the highest rollback value on the immediate successor nodes.

Averaging Out and Folding Back - Example

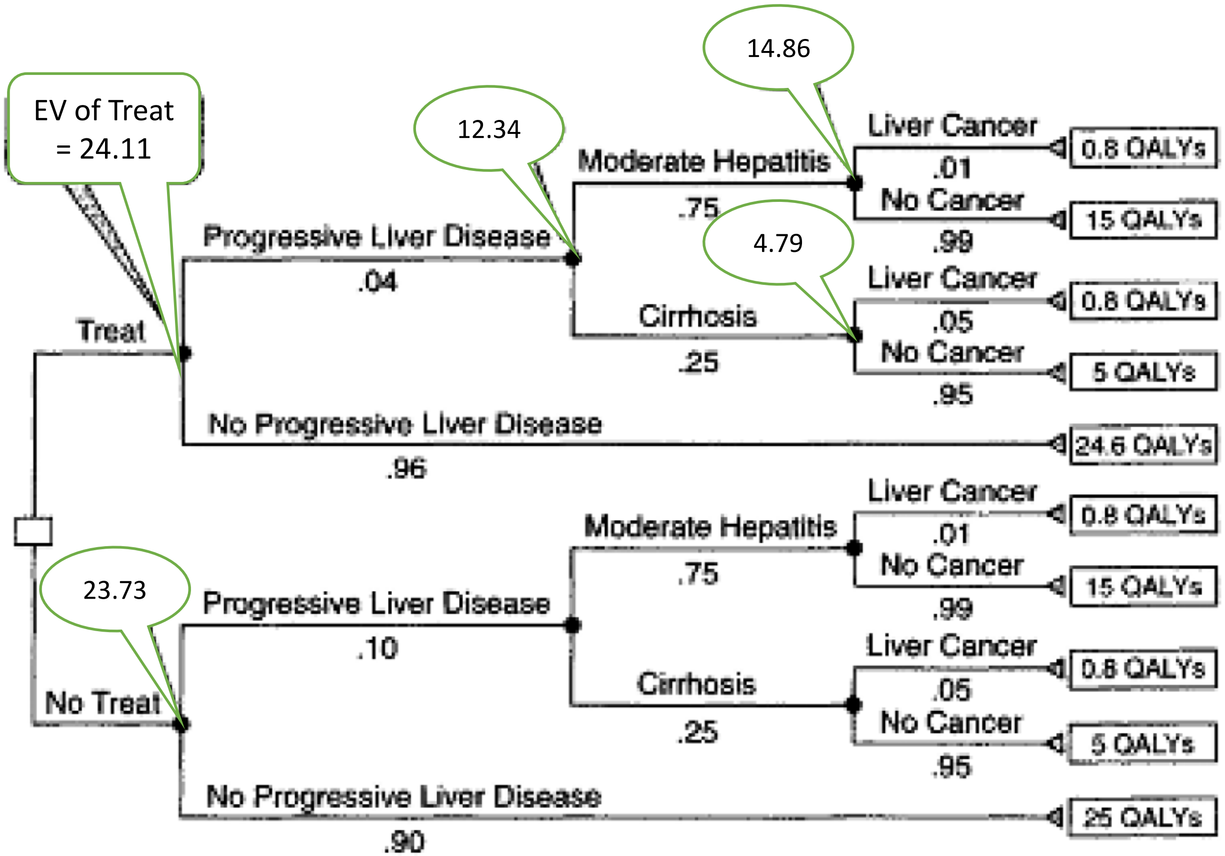


Figure 7.4 Averaging out and folding back to obtain expected values in a decision tree.

Averaging Out and Folding Back - Example

Expected Value of Treat

Step 1 (Branch 3) :

- (0.8*0.01) + (15*0.99) = 0.008 + 14.85 = 14.86 QALYs (At chance node 3)
- (0.8*0.05) + (5.0*0.95) = 0.04 + 4.75 = 4.79 QALYs (At chance node 4)

Step 2 (Branch 2) :

- 14.86*0.75 = 11.145 QALYs
- 4.79*0.25 = 1.1975 QALYs
- At chance node 2 = 12.34 QALYs

Step 3 (Branch 1):

- 12.34*0.04 = 0.4936 QALYs
- 24.6*0.96 = 23.52 QALYs
- At chance node 1 = 24.11 QALYs

Thus the expected value of health outcomes for Treat is 24.11 QALYs

Evaluating Uncertainty

- A critical part of any decision analysis is to evaluate the uncertainty in the model structure, parameter estimates, and assumptions.

- It involves varying one or many key model parameter values to evaluate their impact on the model outcomes.

- We can use the results to answer the following questions:
    - If the probability or the value of an outcome is changed, how does the expected value change?
    - Does the conclusion change when the above estimates are changed within a reasonable range?
    - How much would an estimate have to change to produce a different result?
    - At what value would a variable need to change for the two strategies to be of equal value? (*threshold analysis*)
    - What happens to the results of the model if the estimates for the best-case/worst-case scenarios are used?

Scenario

- The population of Country X now has access to the COVID-19 vaccine, which can prevent infection and the associated outcomes caused by the coronavirus. The associated outcomes can be in the following sequence: (1) with COVID-19 or no illness; followed by (2) Hospitalization or No utilization.

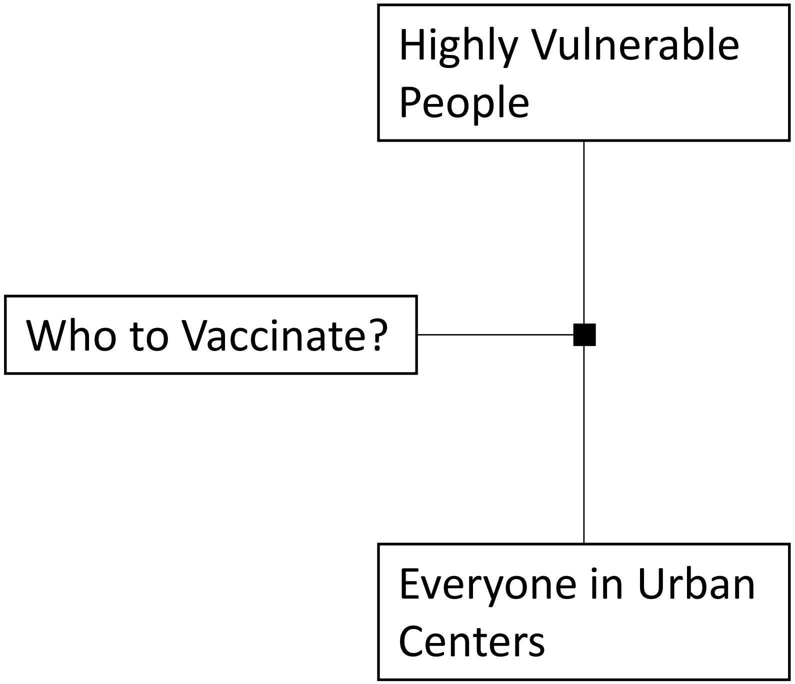
- However, given the initial start-up costs and resources required, there are two particular strategies on who to vaccinate first, that were put forward for evaluation:
  1. Vaccinate everyone in highly populated urban centers
  2. Vaccinate the highly vulnerable population in the entire city. This includes those that are elderly, immuno-compromised, and healthcare workers

- You are asked to develop a cost-effectiveness analysis to provide evidence and direction in implementing the best strategy. The immunization program and vaccine costs will be covered by the government. You will be developing a simple decision tree model where patients are followed for 1-year or until hospitalization.

Questions: Scope of the Study

- What is the study question?
- What are the comparators?
- Who is the target audience?
- Who is the target population?
- Which perspective?
- What is the time horizon?

Build the Decision Tree Model



Take a few minutes to complete the case-study by yourself before proceeding to the solutions

Scope of the Study

- What is the study question?
  - Evaluate which of the two provided strategies is the most cost-effective
- What are the comparators?
  - Vaccinating only the highly vulnerable population in the country
  - Vaccinating everyone in highly populated urban centers

- Who is the target audience?
  - Government and public health policymakers
- Who is the target population?
  - The population of Country X

- Which perspective?
  - Government and social perspectives
- What is the time horizon?
  - 1 year

Build the Decision Tree Model