Medical Decision Making and Decision Analysis

Chapter 8

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Objectives

- Upon completing this chapter, you will be able to:
  - give the definition and purpose of decision analysis
  - list the steps for performing a decision analysis
  - describe elements of a decision tree's structure
  - draw a decision tree
  - calculate average costs and outcomes from a decision tree

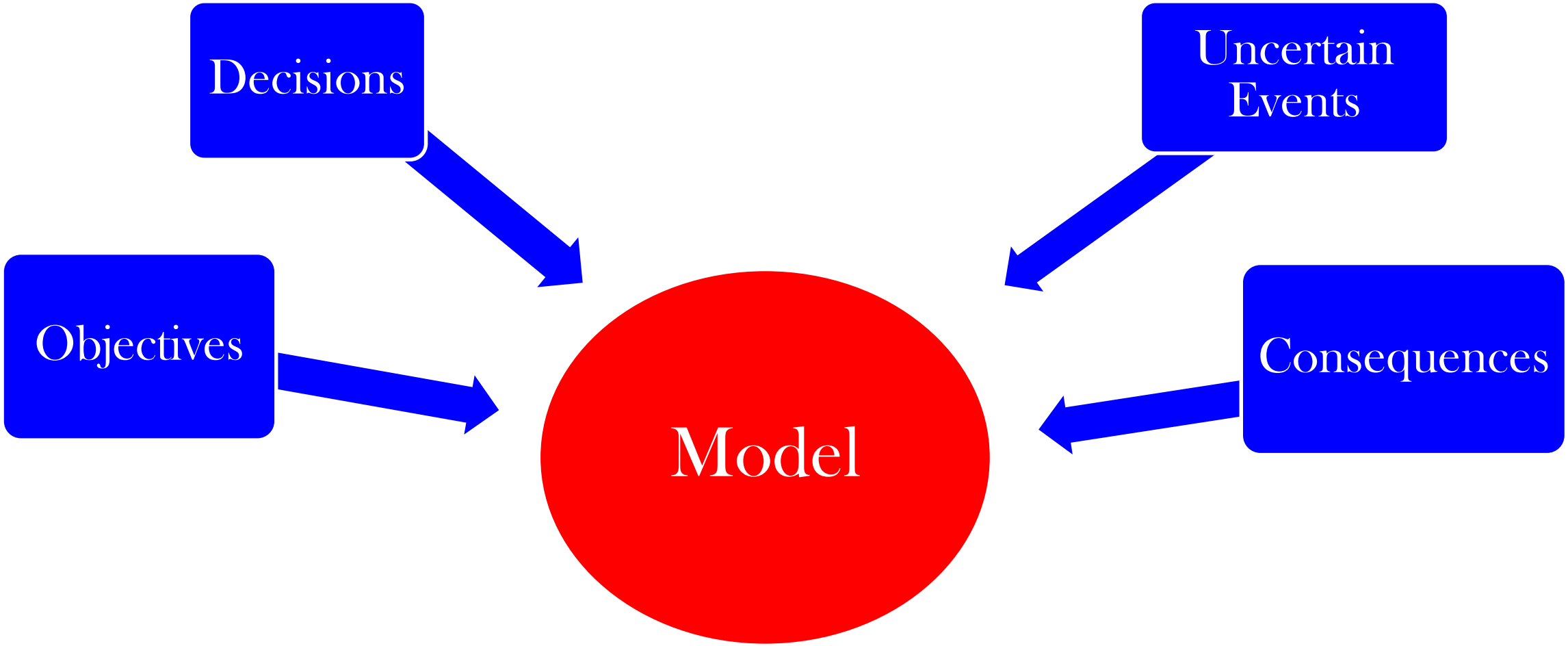
- **Decision analysis** is a quantitative method for evaluating decisions between multiple alternatives in situations of uncertainty

- it is the application of an analytical method for systematically comparing different decision options

- it graphically displays options and facilitates the calculation of values needed to compare these options

- it assists:
  - in selecting the best or most cost-effective alternative when the decision is complex and there is uncertainty about some of the information

Elements of Decision Analysis



Models used for Pharmacoeconomic Evaluation

Model is fundamental analytic tool used in decision analysis to display the temporal and logical sequence of decision problem

- various types of models:
  - decision tree model
  - State transition Markov model
  - Simulation model
  - deterministic (mechanistic) model

The Decision Tree Model

- The tool used in decision analysis is a decision tree
- This simple decision-analysis approach is well-suited for comparisons of t/t alternatives with relatively immediate consequences, i.e, curative t/ts
- However, chronic conditions are difficult to model using simple decision trees for various reasons, including time-dependent clinical outcomes, and thus may require alternate modeling techniques

Steps in Decision Analysis Using Decision Tree Model

1. Framing the problem
2. Structuring the problem
3. Information gathering
4. Analyzing the decision tree
5. Interpret and implement findings

- Example 1: You have been asked to compare a new medication (antibiotic A) with the current standard antibiotic B to add the new antibiotic to a hospital formulary. The data needed for the decision analysis model are presented in the following table. Determine whether to add the new antibiotic A to a hospital formulary using decision tree model.

	Antibiotic A	Antibiotic B
Probability of t/t success	90%	70%
Cost of antibiotic per course of therapy ($)	600	500
Probability of adverse events	15%	20%
Cost of treating adverse events ($)	1,000	800

Step 1: Framing the problem

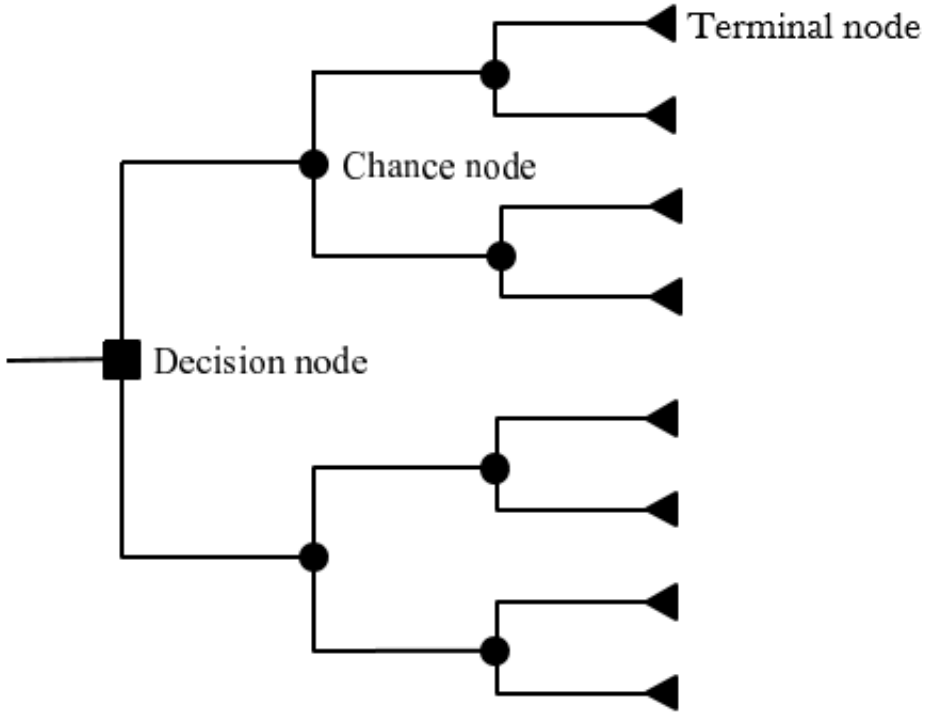
- The specific decision problem to be evaluated should be clearly framed by answering the questions:
  - what is the objective of the analysis?
  - what are the alternatives?

Step 2: Structuring the Problem

- Depict the components of the decision problem graphically using decision tree
- A decision tree provides a framework to display graphically different variables, including treatment options, outcomes associated with those treatment options, and probabilities of the outcomes

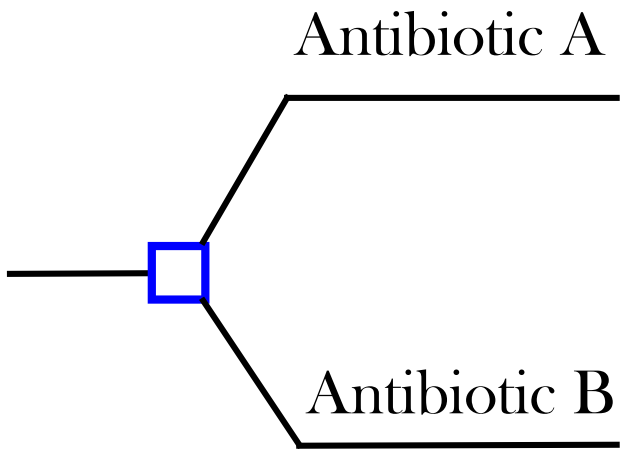
- We can then algebraically reduce all these factors into a single value, allowing for comparison

- Construction of decision tree is guided by a number of conventions:
  - built from left to right
  - consists of:
    - nodes
    - branches



- Nodes
  - are places in the decision tree where different options occur
  - branching becomes possible at this point
- There are three types of nodes:
  - decision node
  - chance
  - terminal node

- **Decision Node**
  - depicted as square □
  - represents alternative actions are under the control of the decision maker
    - therefore, in a decision node, a choice is allowed

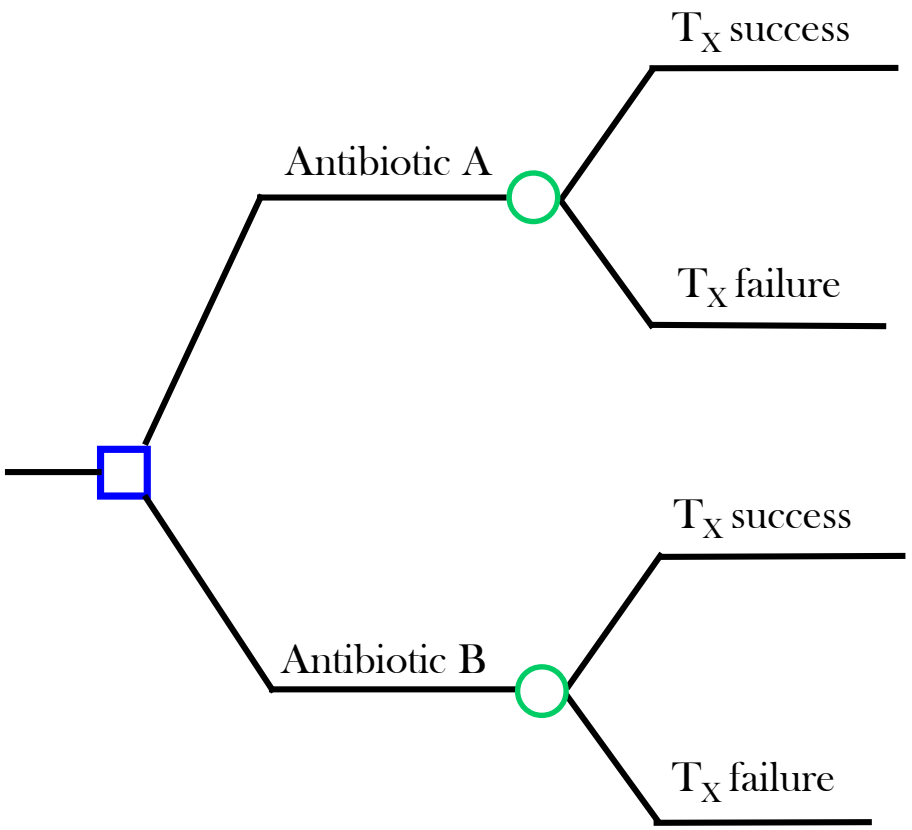


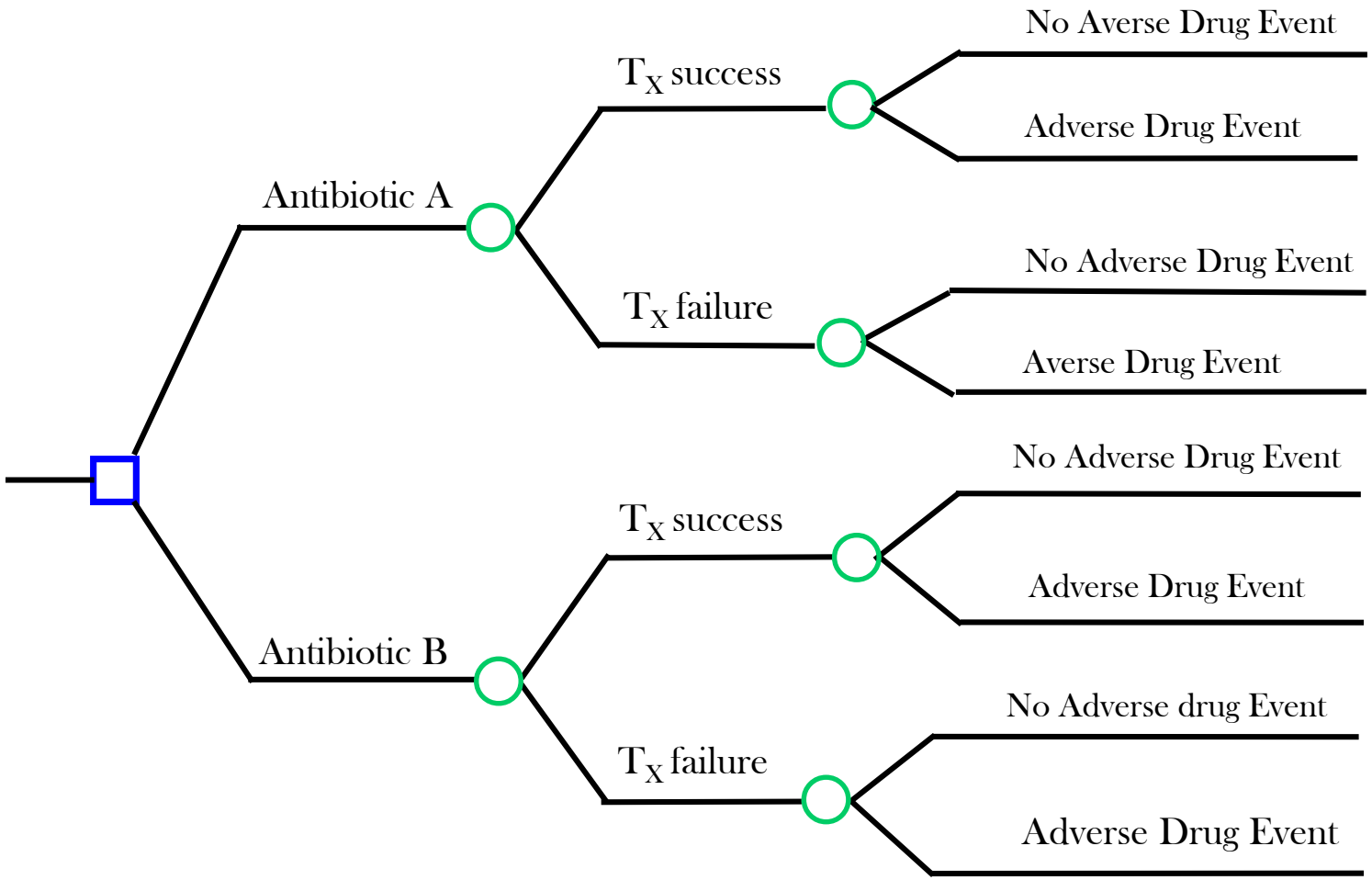
- **Chance Node**
  - depicted as circle 
  - represents events that are beyond the control of the decision maker
  - chances for the same events should line up horizontally
  - defines events that are mutually exclusive and jointly exhaustive
    - E.g. the chance or probability of cure
    - the chance or probability of adverse events
  - at any given chance node the sum of the probabilities of the events must equal 1

What do mutually exclusive and jointly exhaustive mean?

- **Mutually exclusive**
  - only one alternative can be chosen
  - only one event can occur

- **Jointly exhaustive**
  - at least one event must occur
  - one of the possibilities must happen
  - taken together, the possibilities make up the entire range of outcomes

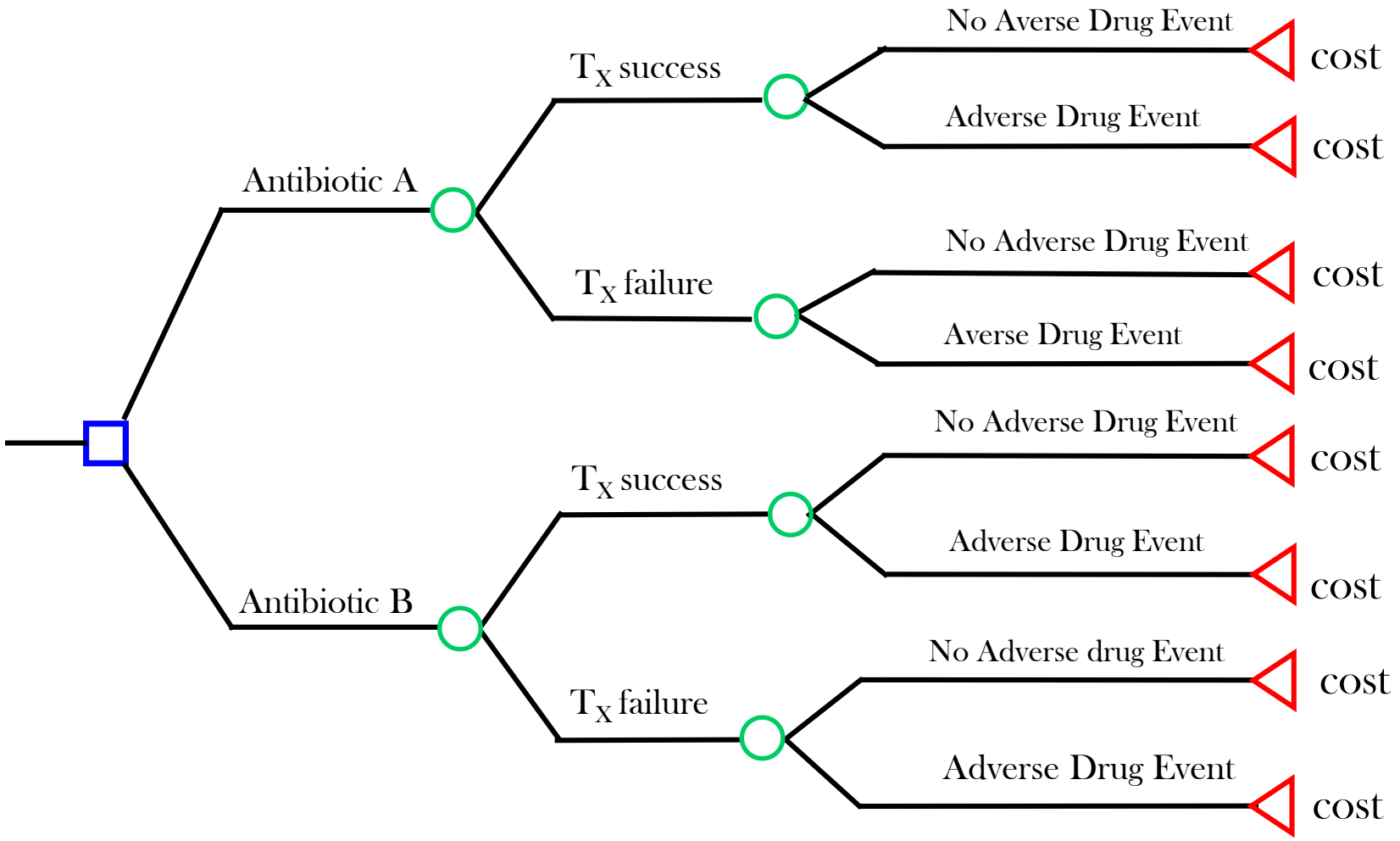

T_X success
Antibiotic A
T_X failure
T_X success
Antibiotic B
T_X failure


Antibiotic A
Antibiotic B
T_X success
T_X failure
T_X success
T_X failure
No Averse Drug Event
Adverse Drug Event
No Adverse Drug Event
Averse Drug Event
No Adverse Drug Event
Adverse Drug Event
No Adverse drug Event
Adverse Drug Event

- **Terminal node**
  - depicted as triangle ◁
  - represents the final outcome of interest for each option
    - E.g. life or death, disability or health, positive or negative, QALYs, costs, …

- **Branches**
  - lines used to connect nodes with the nodes

The complete decision tree for the antibiotic example problem

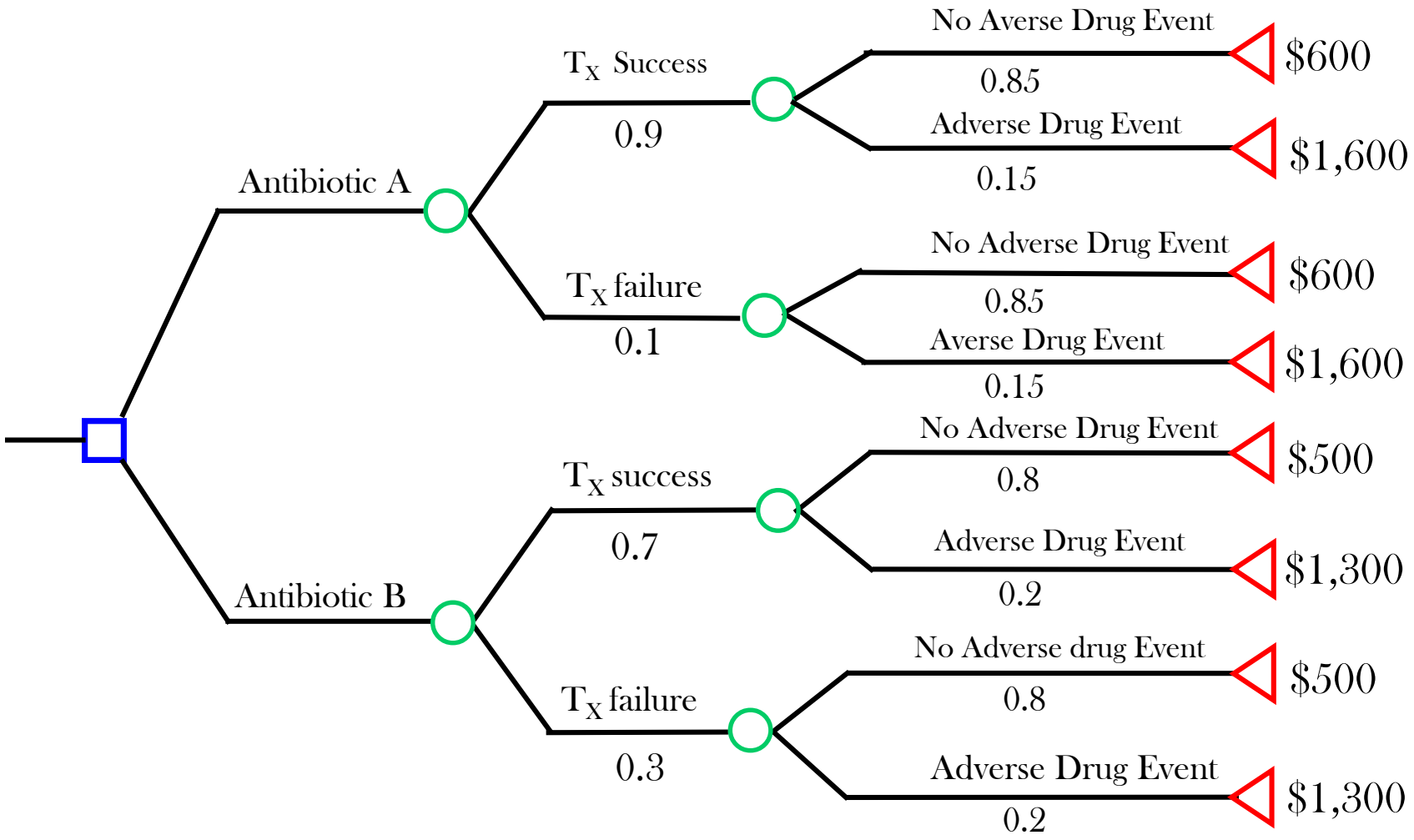


Step 3: Gathering Information

- the probabilities of outcomes can be manifested as efficacy rates and incidence of ADRs
- information on the probabilities of outcomes can be obtained from:
  - literature review, including meta analysis
  - primary data collection
  - consultation with experts
- then the information will be recorded on a decision tree
- information on the probabilities and outcomes/costs for the antibiotic example problem is presented in the next slide

	Antibiotic A	Antibiotic B
Probability of t/t success	90%	70%
Cost of antibiotic per course of therapy ($)	600	500
Probability of adverse events	15%	20%
Cost of treating adverse events ($)	1,000	800

Record the information on a decision tree



- For patients taking antibiotic A, the costs can range from $600 (for medication and no adverse events) to $1,600 (for medication and treatment of adverse events)
  - Total cost when there is no adverse event = $600
  - Total cost when there is adverse event = $600 + $1,000 = $1,600

- For patients taking antibiotic B, the costs can range from $500 (for medication and no adverse events) to $1,300 (for medication and treatment of adverse events)
  - Total cost when there is no adverse event = $500
  - Total cost when there is adverse event = $500 + $800 = $1,300

Step 4: Analyzing the decision tree

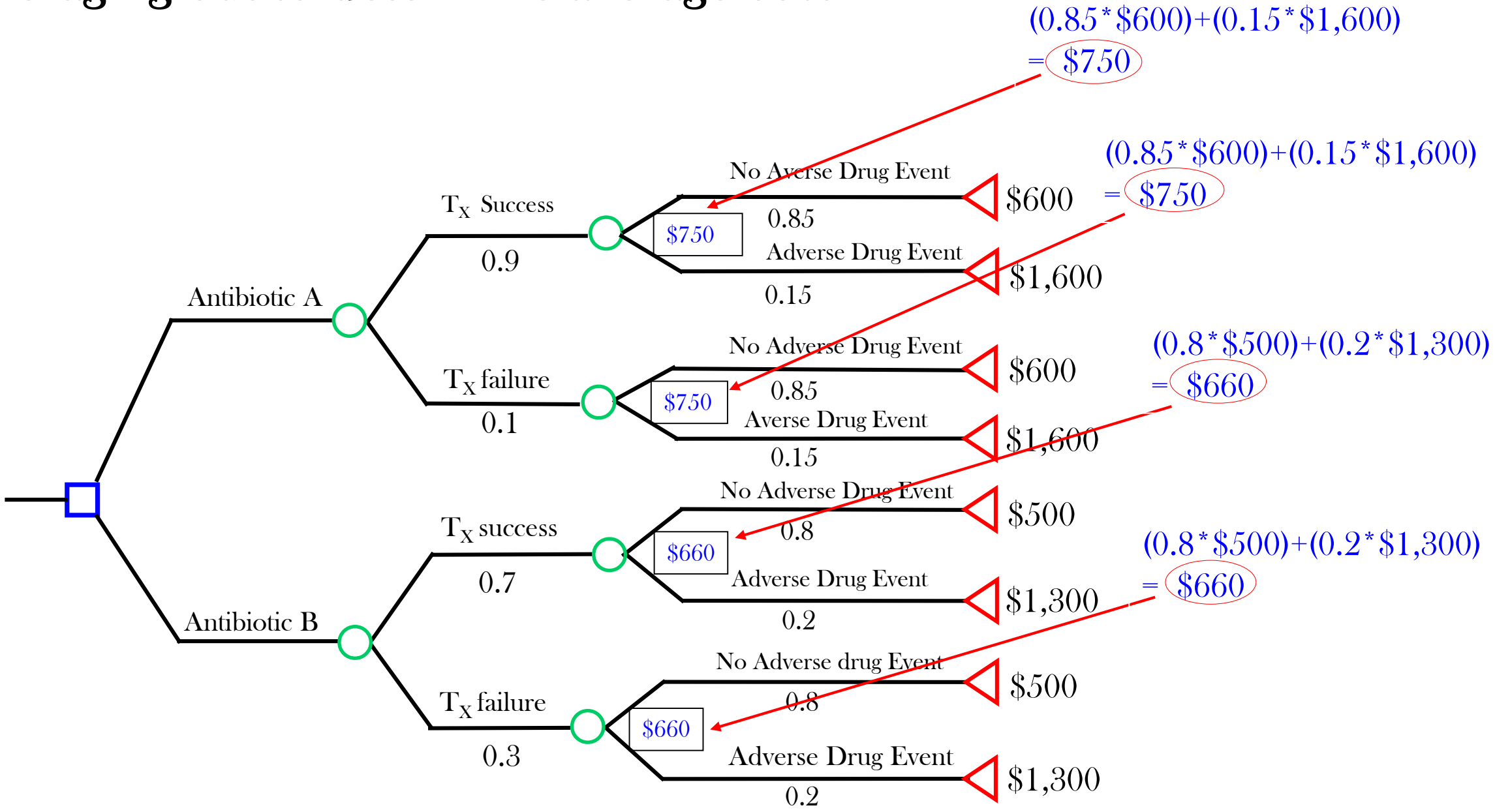
- the analysis is done by a process called averaging out and folding back to determine average outcome value

- the product of the probability of the event multiplied by the total outcome values (*p* of the event * outcome value of the event) is calculated for each node and then summed for each option

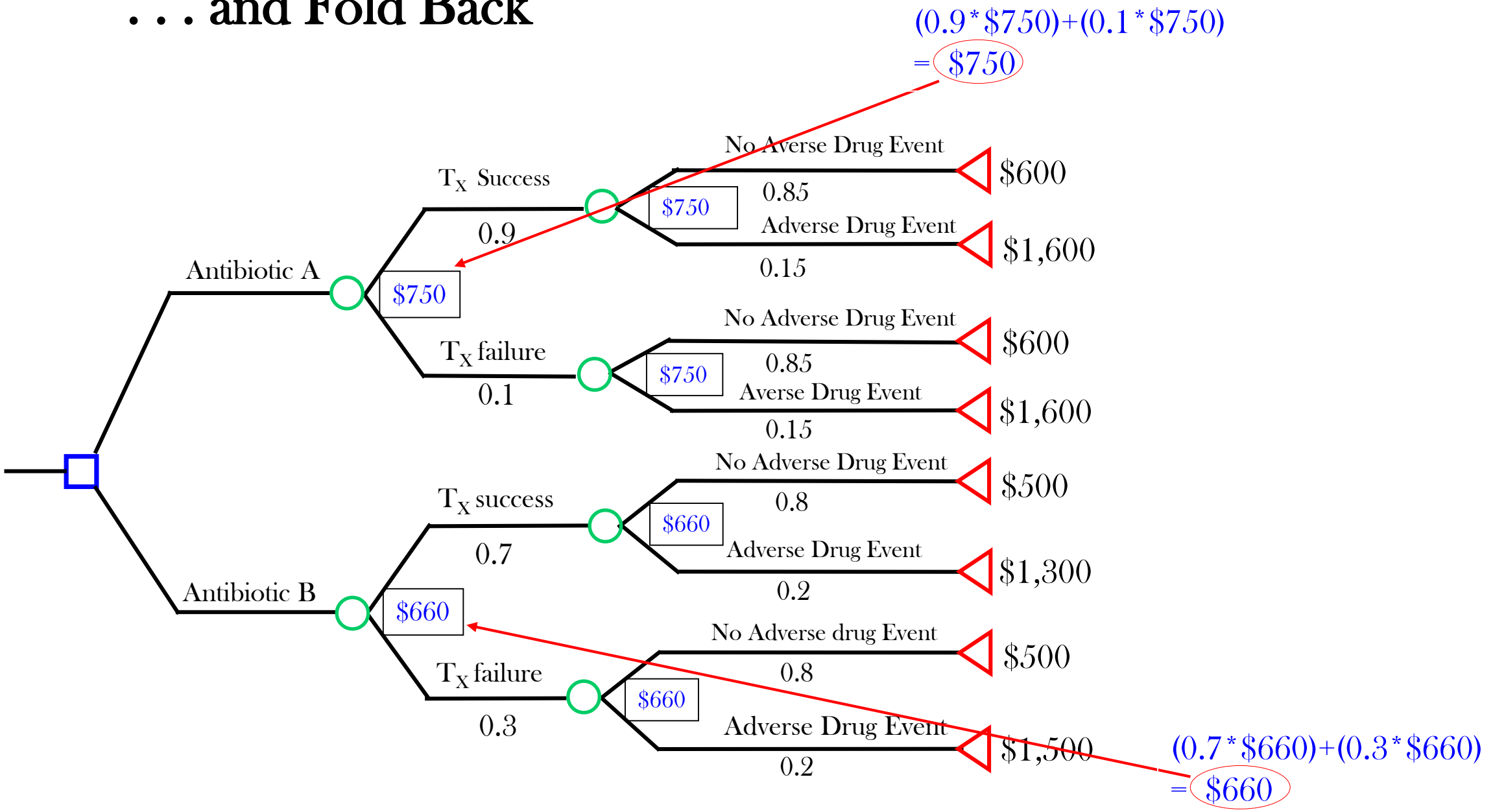
WA = [(*p* of event A) * (outcome value A)]+[(*p* of event B) * (outcome value B)]

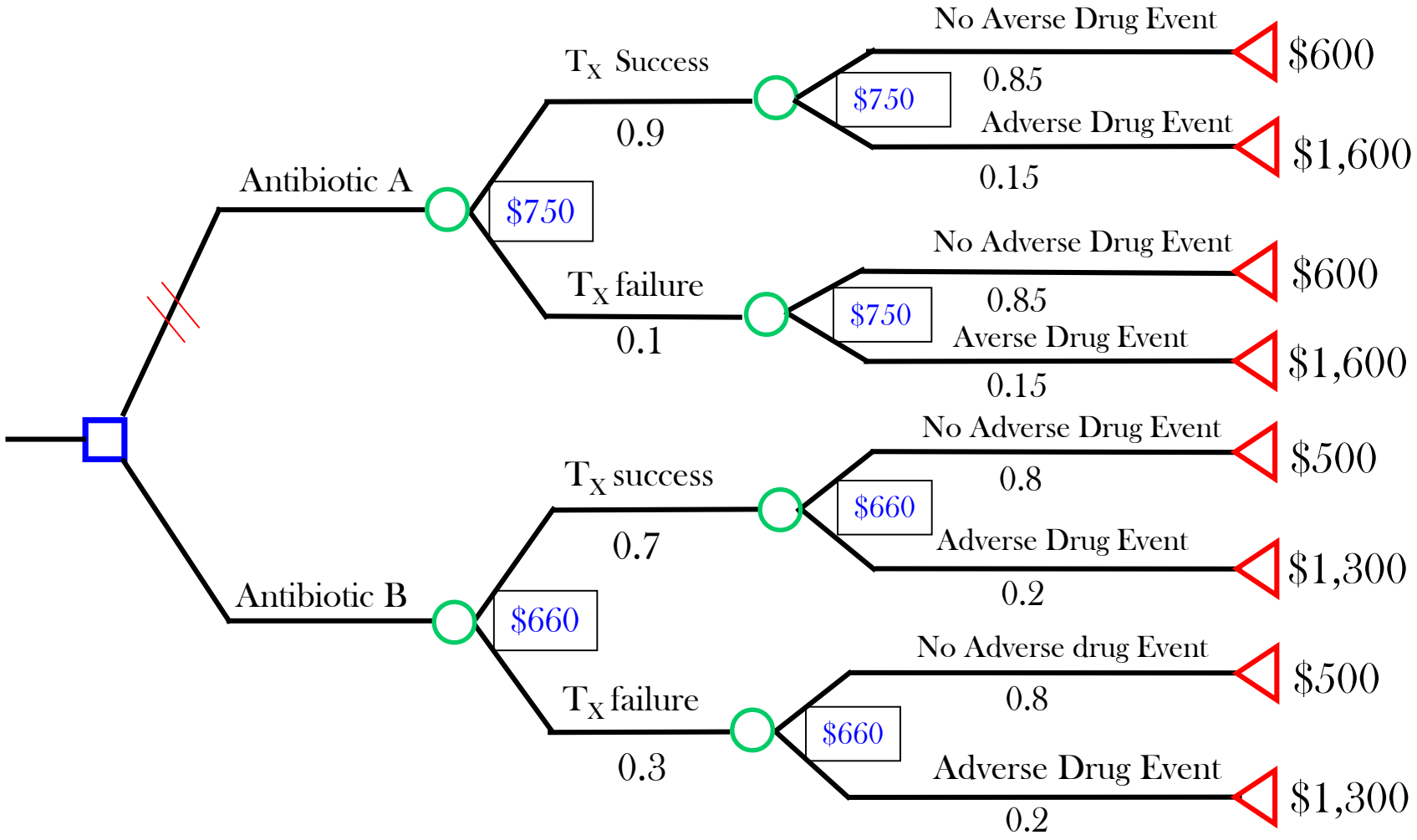
Where, WA = weighted average and *P* = probability

Averaging out to determine average cost



. . . and Fold Back




Antibiotic A
Antibiotic B
T_X Success
0.9
T_X failure
0.1
T_X success
0.7
T_X failure
0.3
$750
$750
$660
$660
No Averse Drug Event
0.85
Adverse Drug Event
0.15
No Adverse Drug Event
0.85
Averse Drug Event
0.15
No Adverse Drug Event
0.8
Adverse Drug Event
0.2
No Adverse drug Event
0.8
Adverse Drug Event
0.2
$600
$1,600
$600
$1,600
$500
$1,300
$500
$1,300

Step 5: Interpret and Implement Findings

- For antibiotic A, the average cost is $750 per patient
- For antibiotic B, the average cost is $660 per patient

- Antibiotic B is less expensive even when including the costs of treating adverse events ($660 Vs $750)

- Since antibiotic A is a better clinical option (higher probability of success and lower probability of adverse events), We have to determine ICER for decision making

$$ICER = \frac{\Delta \text{Cost}}{\Delta \text{Effectiveness}} = \frac{\$750 - \$660}{0.9 - 0.7}$$

$$= \underline{\$450 \text{ per additional t/t success}}$$

- If We choose antibiotic A, each extra successful outcome costs $450. This is lower than costs of treatment failure with antibiotic B which range from $500 to $1,300
- For extra successful outcome We achieve with an expense of $450, there will be faster patient discharged from the hospital, We can avoid second round treatment costs with another antibiotic, and so on…

 Antibiotic A is more cost effective

- therefore, antibiotic A will be added to the formulary and antibiotic B will be deleted from the formulary

- Example 2: You have been asked to compare two long acting insulin alternatives (NPH insulin Vs Glargine insulin) for the mgmt of DM
- NPH insulin
  - the cheapest, available in Pre-filled devices
  - greater frequency of nocturnal hypoglycemia, more weight gain, lower glycemic control

- Glargine insulin
  - has a 24 hours duration of action, once daily dosing, reduced frequency of nocturnal hypoglycemia
  - most expensive

- Data estimates needed for model for both drugs are presented in the next slide. Employ decision analysis techniques to decide the more cost effective intervention

Data Estimates for Model

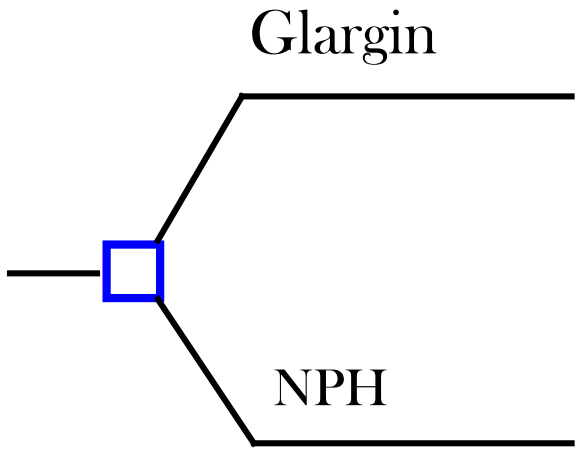
Variable	Data Estimates	
	NPH	Glargine
Probability of attaining A_1C goal*	0.439	0.579
Probability of hypoglycemia*	0.382	0.165
Probability hypoglycemia managed by patient†	0.95	0.95
Cost of 3 years insulin t/t	$162	$564
Cost of complications if A_1C goal not attained §	$1565	$1565
Cost of medical intervention if hypoglycemic requiring t/t †	$125	$125

*Fritsche, et al 2003 *Ann Int Med 138(12):952-9; †Expert opinion; §Gilmer, et al. 1997
*Diabetes Care 20(12):1847-53

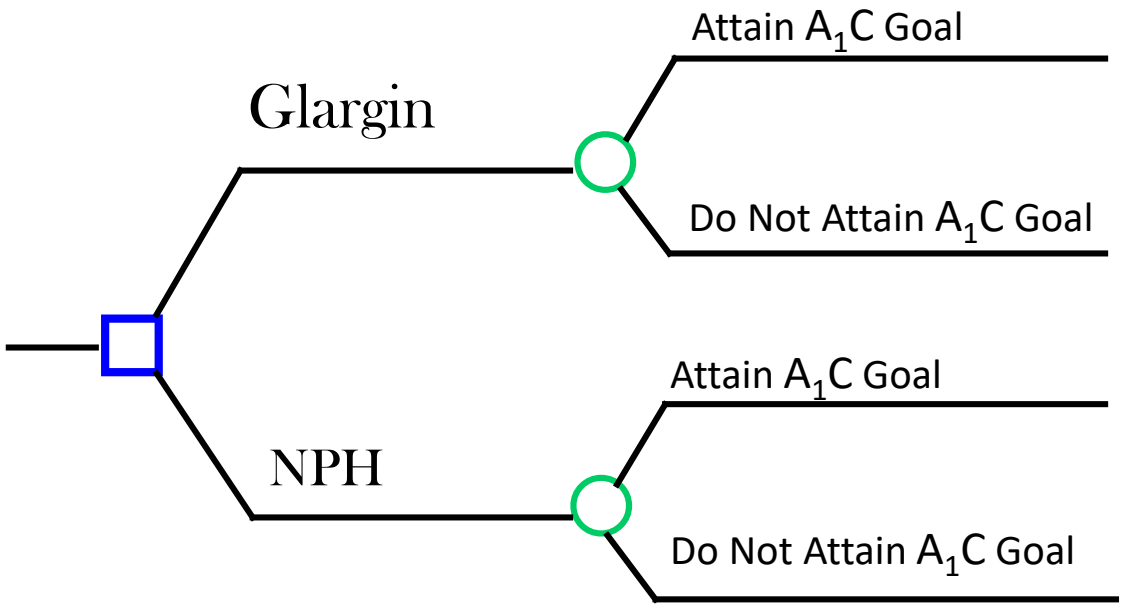
Frame the Problem

- NPH insulin Vs glargine insulin
- Choosing the more cost effective option

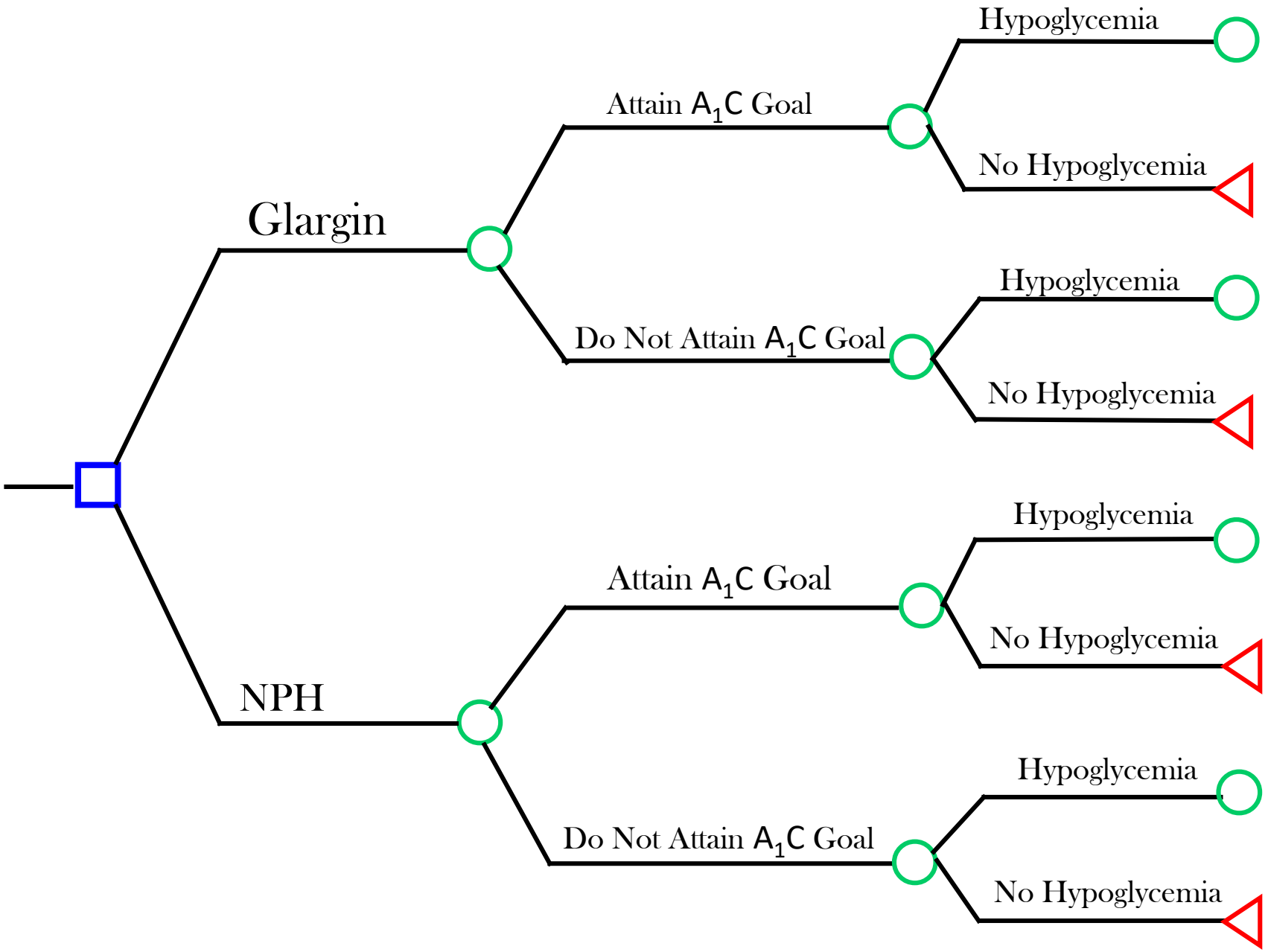
Structure the problem



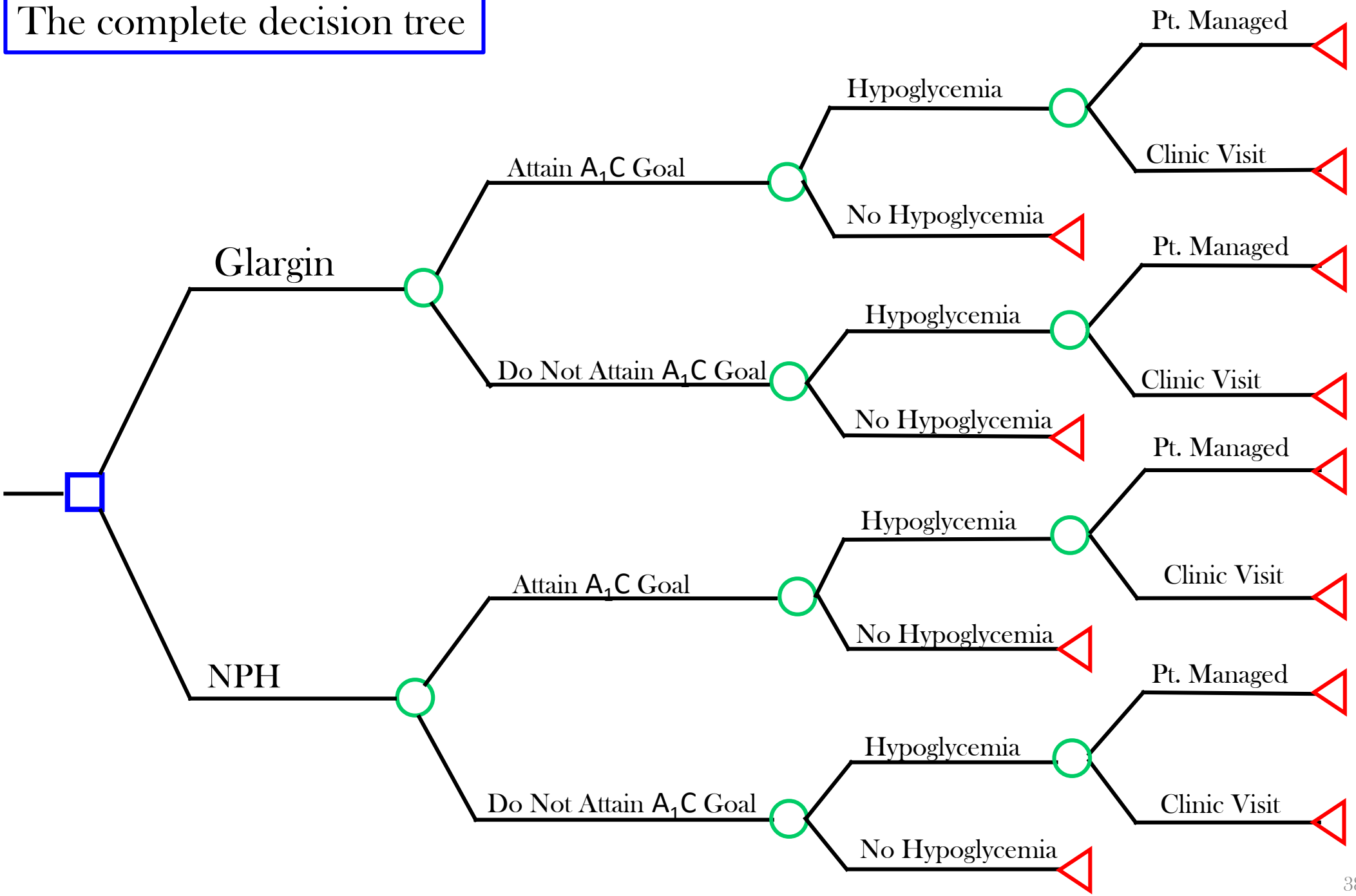
Structure ...cont'd



Structure ...cont'd



The complete decision tree



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Gather information

- Literature review
  - estimates from clinical trials (e.g. efficacy, adverse events)
- Primary data collection
- Expert opinion
  - good where no clinical trial data exists

Data needed for this model

Probabilities

- Probability of attaining A_1C target
  - Probability of having hypoglycemic event
  - Probability that patient manages hypoglycemia
  - Probability that hypoglycemia requires medical intervention

Consequences (Costs)

- Cost of t/t with NPH
- Cost of t/t with glargine
- Cost of complications if A_1C goal not attained
- Cost of medical intervention if hypoglycemia is severe

Data Estimates for Model

Variable	Data Estimates	
	NPH	Glargine
Probability of attaining A_1C goal*	0.439	0.579
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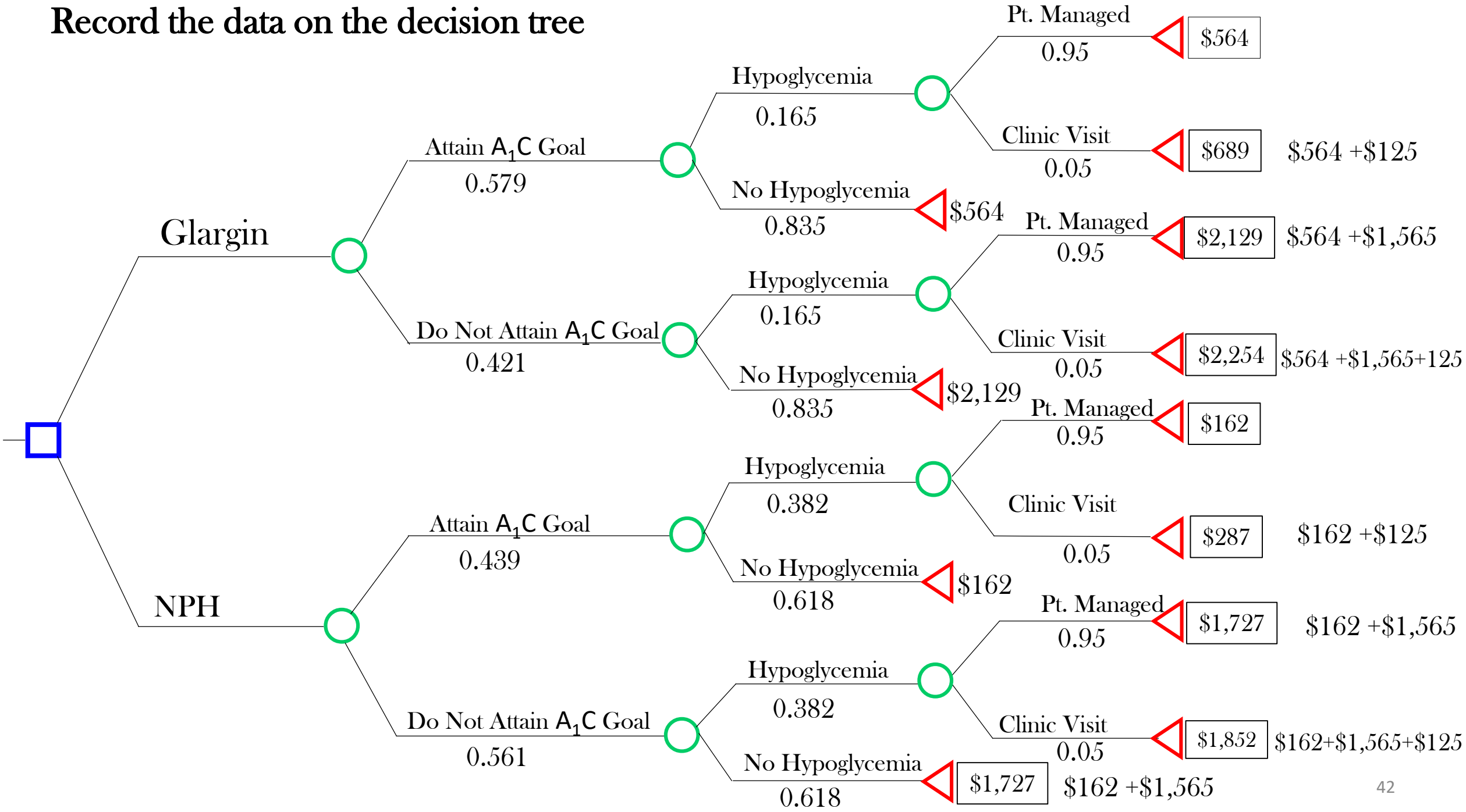
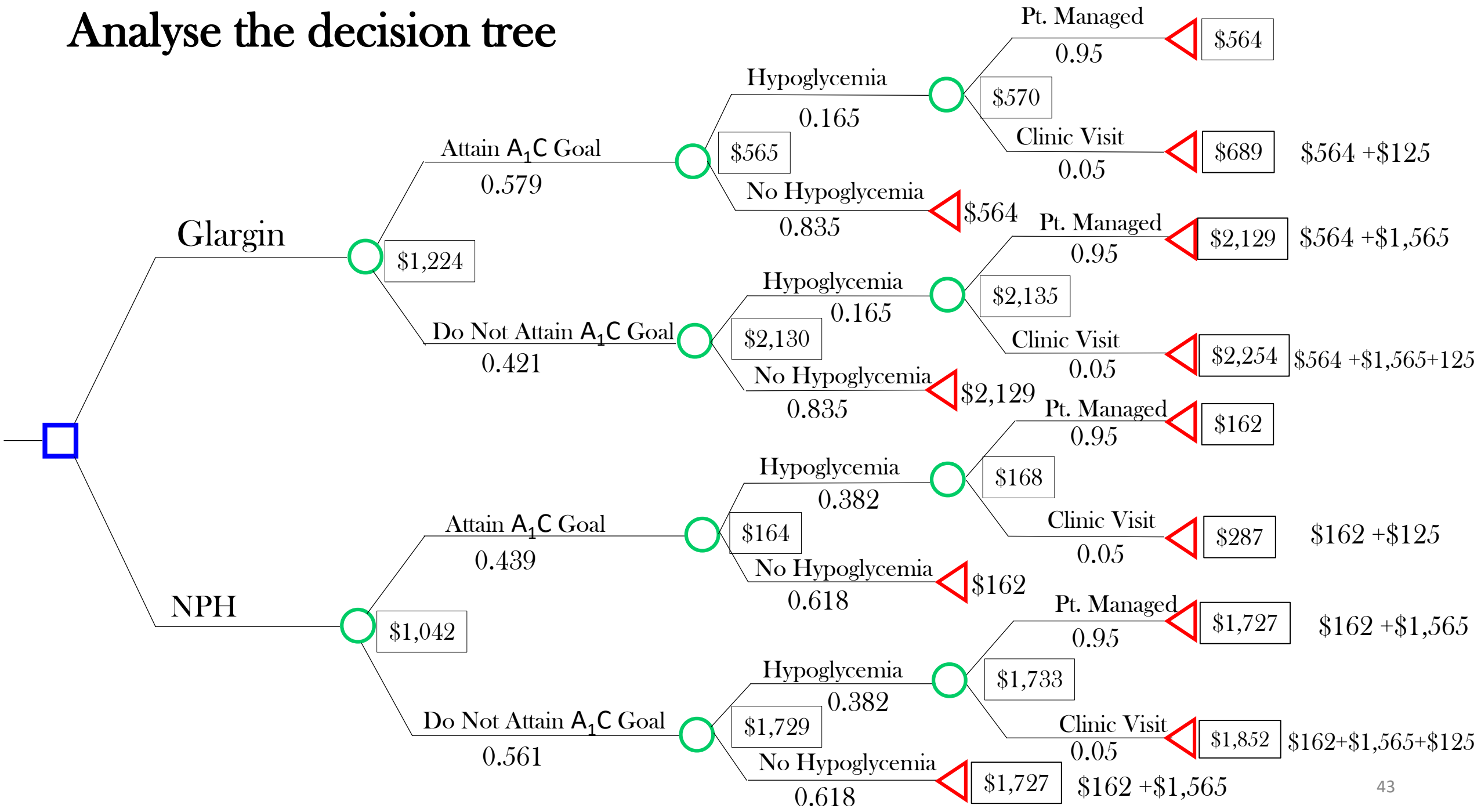
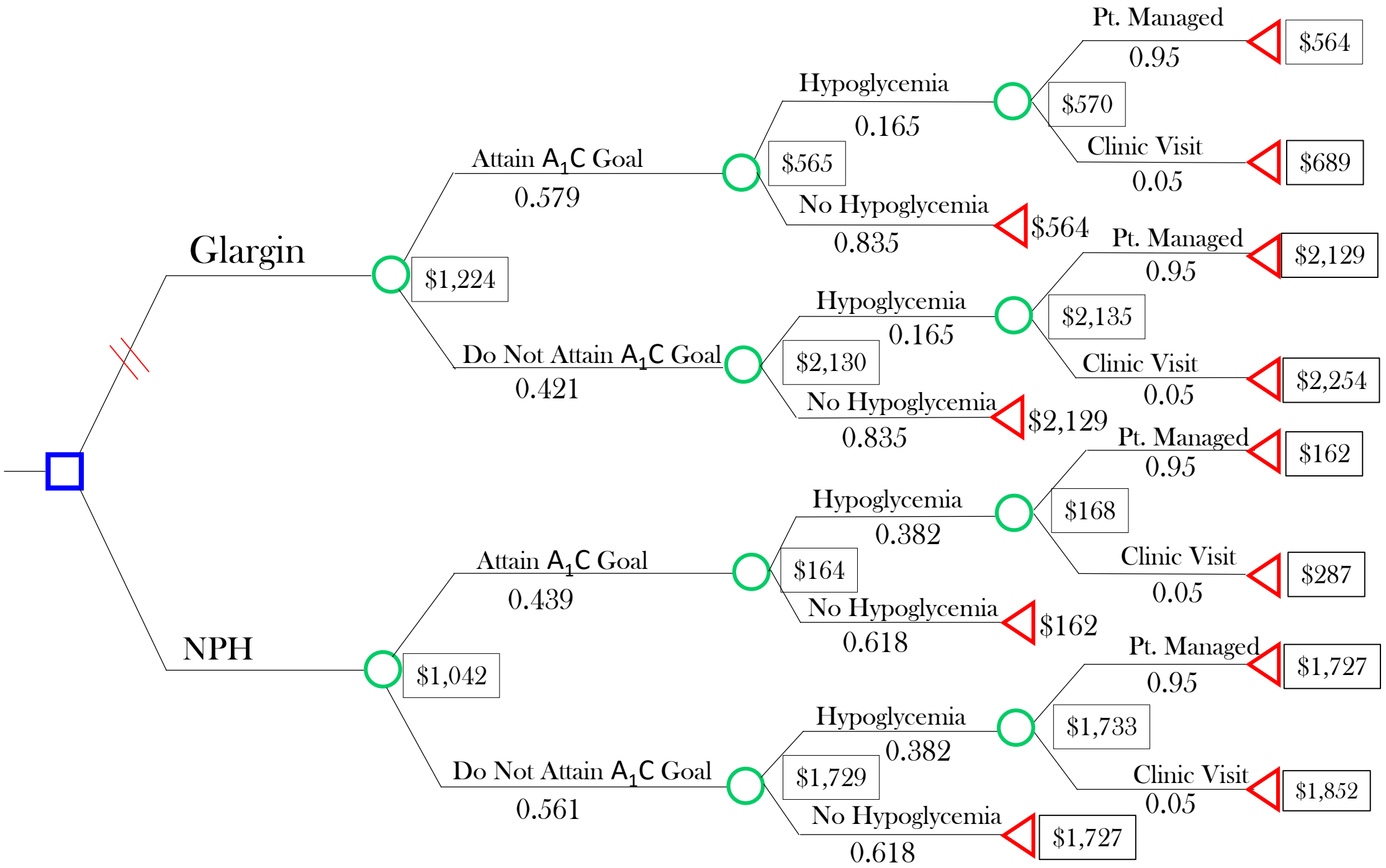
Record the data on the decision tree



Analyse the decision tree




Glargin
NPH
$1,224
$1,042
Attain A1C Goal
0.579
Do Not Attain A1C Goal
0.421
Attain A1C Goal
0.439
Do Not Attain A1C Goal
0.561
$565
$2,130
$164
$1,729
Hypoglycemia
0.165
No Hypoglycemia
0.835
Hypoglycemia
0.165
No Hypoglycemia
0.835
Hypoglycemia
0.382
No Hypoglycemia
0.618
Hypoglycemia
0.382
No Hypoglycemia
0.618
$570
$2,135
$168
$1,733
Pt. Managed
0.95
Clinic Visit
0.05
Pt. Managed
0.95
Clinic Visit
0.05
Pt. Managed
0.95
Clinic Visit
0.05
Pt. Managed
0.95
Clinic Visit
0.05
$564
$689
$564
$2,129
$2,254
$2,129
$162
$287
$162
$1,727
$1,852
$1,727

Step 5: Interpret and Implement Findings

- the average cost of treatment for glargin insulin is $1,224 per patient and that of NPH insulin is $1,042 per patient

- Since antibiotic glargin insulin is a better clinical option (higher probability of success and lower probability of hypoglycemic side effect), We have to determine ICER for decision making

$$\text{ICER} = \frac{\Delta \text{ Cost}}{\Delta \text{ Effectiveness}}$$

$$= \frac{\$1{,}224 - \$1{,}042}{0.579 - 0.439}$$

= $480 per additional t/t success or additional glycemic control

- For patients using NPH insulin, the costs of not attaining A_1C goal can range from $1,727 *(cost of t/t +cost of complications) to $1,852 (cost of t/t + cost of complications+ Cost of medical intervention if hypoglycemia require t/t)*, and the average cost is $1,042 per patient

- If We choose glargin insulin, each extra successful outcome has an additional cost of $480
  - this is lower than cost of t/t failure with NPH insulin which ranges from $1,727 to $1,852
- For each extra successful outcome We achieve with an additional expense of $480, We can avoid cost of complications if A_1C goal is not attained, second round treatment costs with another antidiabetic agent, and so on…

  Glargin insulin is more cost effective

Example 3: You have been asked to compare two t/t options, Drug A and Drug B. Drug A has been on the market for over 5 years and drug B is a new product recently approved for prescribing. Using the data available in the next slide employ decision analysis techniques to compare the cost effectiveness of the two t/ts.

Parameter	Drug A	Drug B
Cure rate	70%	90%
Significant adverse event rate	20%	10%
Cost per course of t/t	$100	$150
Cost per adverse event	$25	$25
Cost of t/t failure	$200	$200


Thank You