

## □ 內容介紹：Material, GitHub, NTU Cool

Course Material	Quantity	Location
Handbook (Printed)	1	Distributed in class
Handbook (PDF)	1	GitHub / NTU Cool
Slide Deck	1	GitHub/NTU Cool
Reading	4	GitHub/NTU Cool
Excel Template: Decision Tree	1	GitHub
Excel Template: Markov Model	1	GitHub
TreeAge Template: Decision Tree	1	GitHub
TreeAge Template: Markov Model	1	GitHub
TreeAge Microsimulation Template	1	GitHub
Class Participation Exercises	1	NTU Cool
Homework	1	NTU Cool



Source: 柴語錄 Shiba Says

# □ 內容介紹：Material, GitHub, NTU COOL

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□ 單元一：  
模型結構 Visualization of Decision Tree/ Markov/Microsimulation Modelling

# Decision Analytic Modeling

- Building mathematical relationships to quantify possible outcomes of interest resulting from different alternative options
- Purpose:
  - Integrate evidence on clinical and economic outcomes into a consistent framework to inform decisions about clinical practices and healthcare resource allocations
  - Allow for variability and uncertainty associated with all decisions

# Stages in Developing a Decision Model (1)

## 1. Specifying the decision problem

- Defining population, interventions, comparators and outcomes
- Specifying the perspective (payers, healthcare providers, society)
- Specifying the time span of decision

## 2. Defining the model boundaries (simplification)

- Should we model the effect of certain comorbidities on the outcomes?
- Should we take into account the effect of past events on the outcomes?
- Should we simulate treatment compliance?

# Stages in Developing a Decision Model (2)

## 3. Selecting an appropriate modelling paradigm and developing structure

		Cohort level		Individual level	
		Continuous state	Discrete state	Markovian	Non-Markovian
No interaction among objects	Implicit time	-	<ul style="list-style-type: none"><li>• <b>Decision tree</b></li></ul>	<ul style="list-style-type: none"><li>• <b>Patient-level decision tree</b></li></ul>	
	Explicit time	-	<ul style="list-style-type: none"><li>• <b>Markov model</b></li></ul>	<ul style="list-style-type: none"><li>• <b>Patient-level Markov model</b></li></ul>	<ul style="list-style-type: none"><li>• <b>Discrete time simulation</b></li><li>• <b>Discrete event simulation</b></li></ul>
Interaction among objects	Discrete or continuous time	System dynamics	<ul style="list-style-type: none"><li>• <b>Markov chain model</b></li></ul>	<ul style="list-style-type: none"><li>• <b>Individual event history model</b></li></ul>	<ul style="list-style-type: none"><li>• <b>Discrete event simulation</b></li><li>• <b>Individual-based simulation</b></li></ul>

# Stages in Developing a Decision Model (3)

## 4. Identifying and synthesizing evidence, and analysing data

- Use entirety of existing evidence or representative the entire evidence
- Search electronic databases (e.g. Medline, Embase, Cochrane Library)
- Systematic review and meta-analysis
- In the presence of large data (representative of the target population):
  - Survival analysis or logit models to estimate probabilities
  - Generalized linear models for resource utilization
  - Mixture model for costs and health utility
  - Other regression analysis

# Stages in Developing a Decision Model (4)

## 5. Capturing uncertainty

- Variability
- Parameter uncertainty
- Decision uncertainty
- Heterogeneity

# Two Common Modelling Techniques Used in Health Economic Evaluation

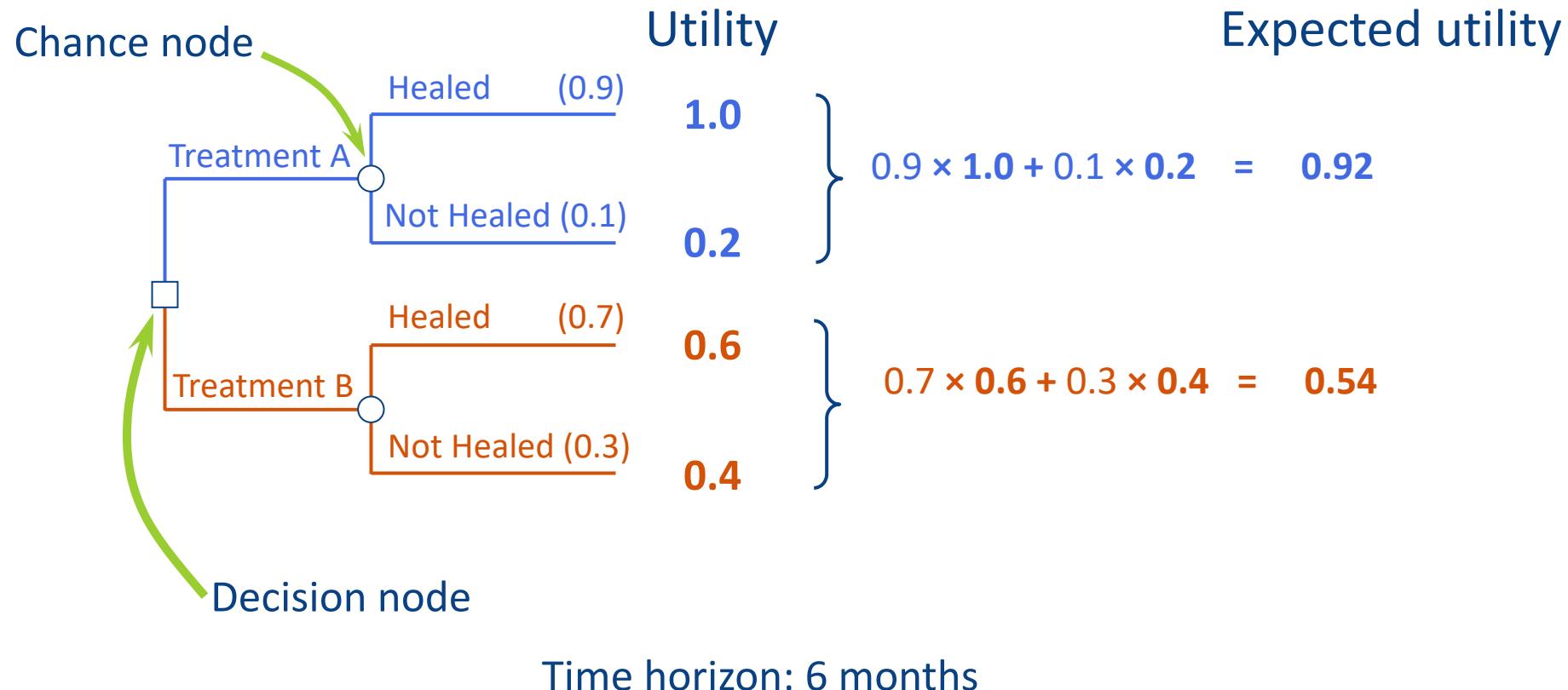
- Decision tree
  - Problem involving chance events that occur over a short time horizon
- Markov modelling
  - Problem involving risk that is on-going over time

## Approach 1- Decision Tree

- A method for estimating the expected payoff of various different options
- Outcomes of a decision are not perfectly known
  - Health of child after mother smoked during pregnancy
- but the probability of each outcome is
  - 80% likely to have a respiratory problem
- Thus decision analysis is a technique for helping decision makers identify the best option

# Key Elements of Decision Analysis

- Probabilities: Likelihood of an event occurring
- Payoffs: Cost and outcomes assigned to each ‘state of the world’
- Expected value: The sum of the probability of each possible outcome multiplied by the outcome value (or payoff).



# Common Steps in Building a Decision Tree

1. Define the problem
2. Structure the tree
3. Estimate the costs and the consequences of each stage in the tree (payoffs)
4. Assign probabilities and folding (rolling) back to calculate expected values
5. Calculate the incremental cost-effectiveness ratio
6. Conduct sensitivity analysis
7. Validate

# Define the Problem

- Some key questions:
  - What are the major issues?
  - What is the perspective?
  - What are the alternatives/options?
  - What is the analytical horizon?
    - Longer term horizons may require other approaches: Markov models, simulations

# Structuring a Decision Tree

- Decision tree built from left to right in a logical sequence
  1. List decision options (Decision nodes)
  2. Identify the sequences of events (pathways) resulting from the decision options (Chance nodes)
  3. Identify terminal events (Terminal nodes)
- Ensure all pathways are mutually exclusive and exhaustive

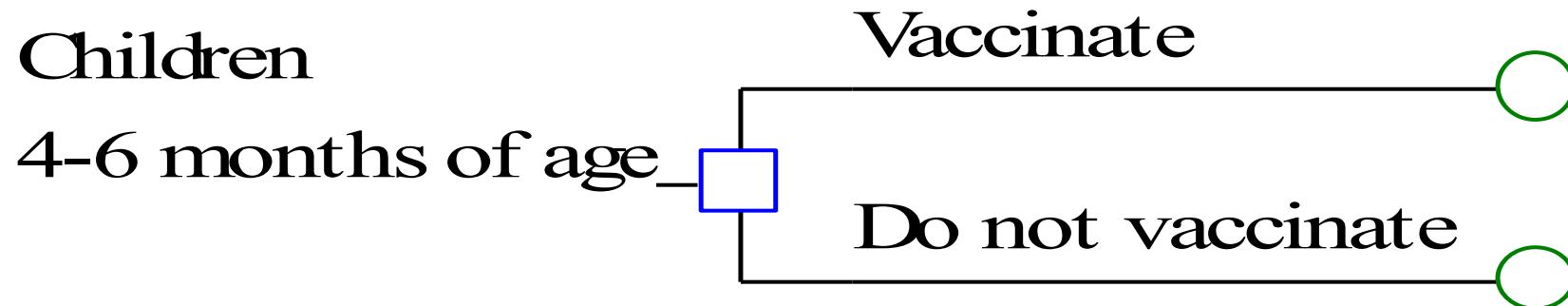
## Case Study of Decision Tree: Communicable Disease

- A communicable disease spreads to Taiwan. There is a risk of mortality from infection with the disease
- Currently no vaccine is available in Taiwan
- A vaccine has been developed, which is effective in reducing risk of infection for the next year
- After that, the disease mutates and the vaccine is no longer effective

# Objective of Case Study

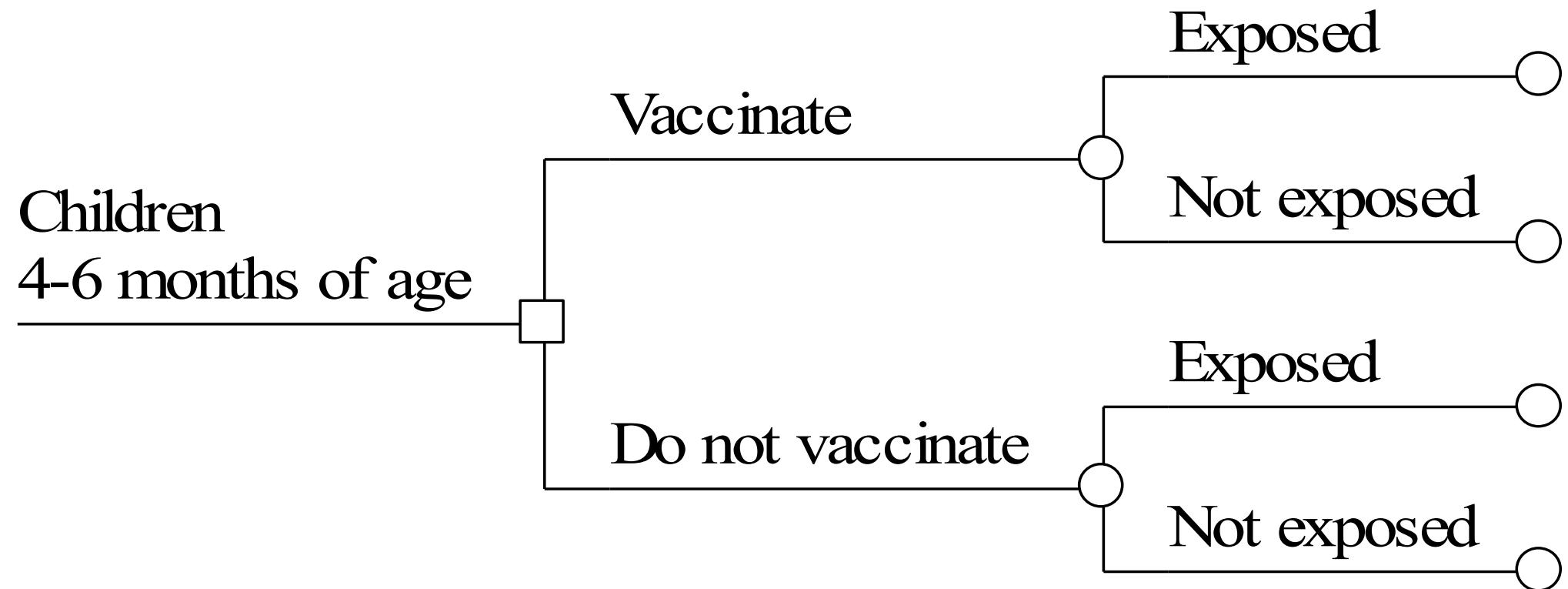
- To estimate the *potential* costs and outcomes associated of the introduction of the vaccine compared to having no vaccine in the Taiwanese setting
- The comparator is *no vaccine*
- The perspective of the analysis is *societal*
- **A short-term (1 year) decision analysis**

# Building the Decision Tree

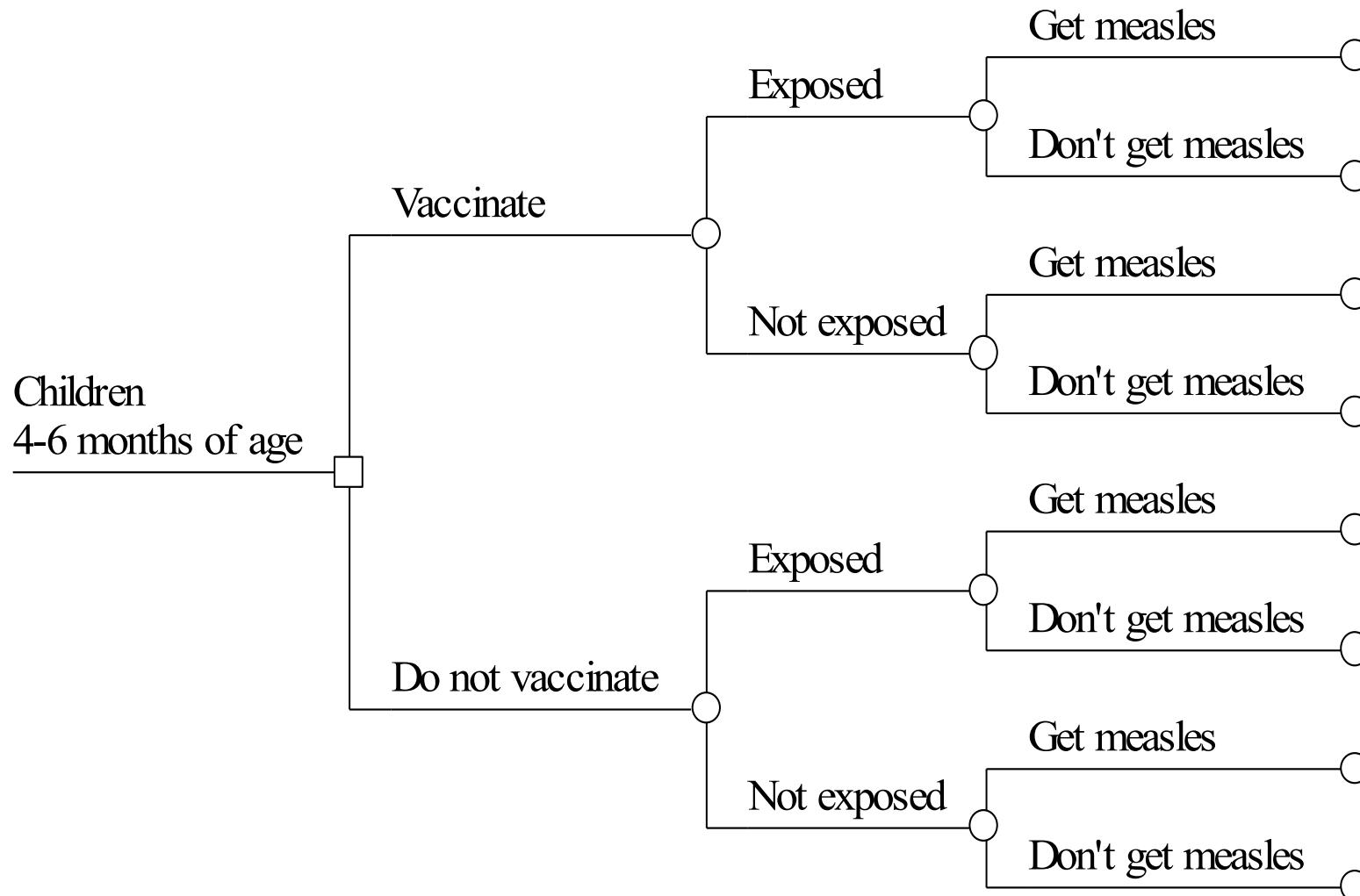


- Root node summarises patient population.
- Decision node drawn as a square (represents alternative actions under control of decision maker).
- The 2 alternatives - vaccinate and do not vaccinate - are represented as branches.

# Building the Decision Tree



# Building the Decision Tree



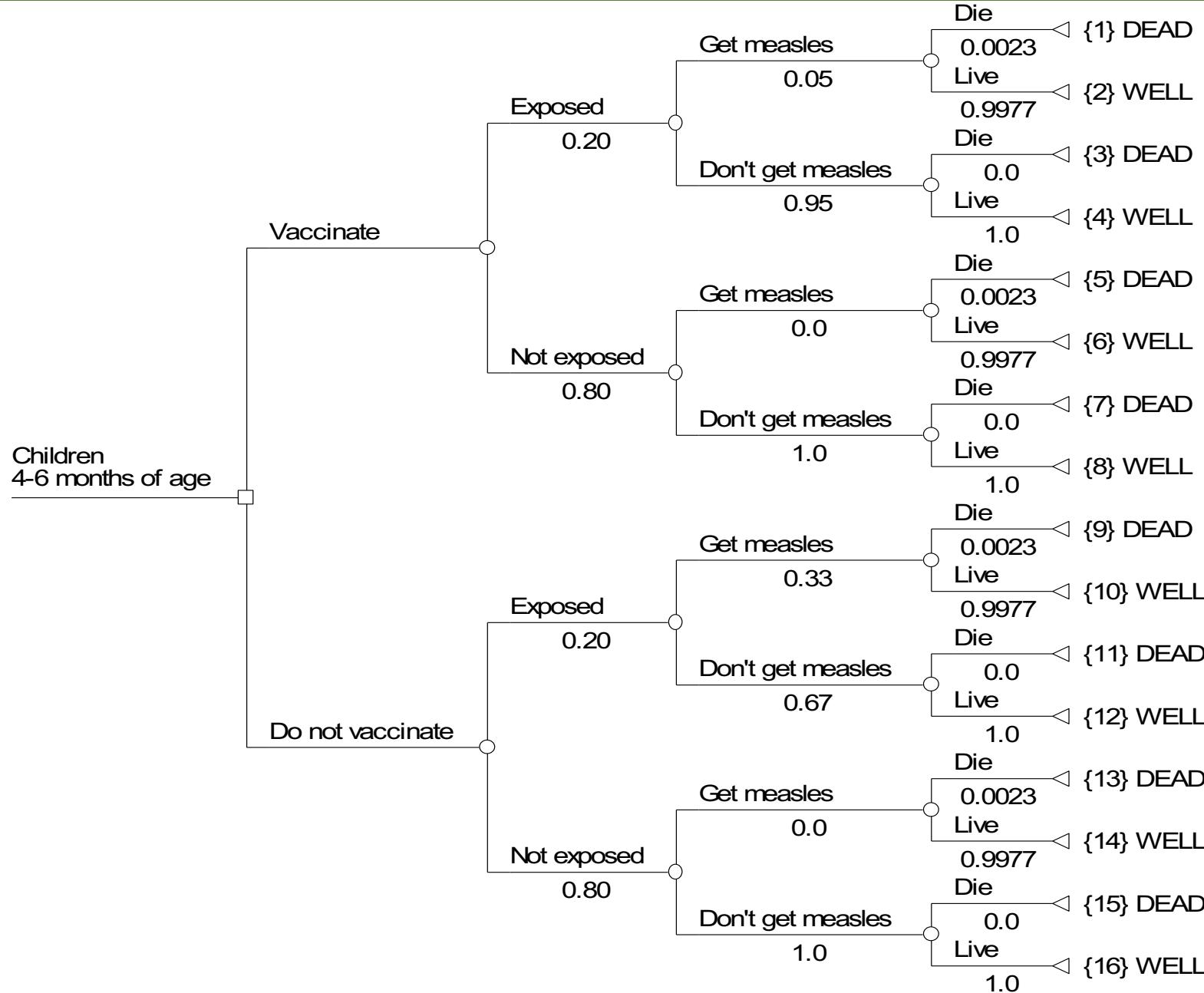
For each branch of exposed/not exposed, chance of getting measles or not is represented by a chance node

# Estimating probabilities

- Gathering information to fill the tree

Event	Probabilities
<b>Vaccinate/do not vaccinate</b>	
Exposed	0.2000
Not exposed	0.8000
<b>Vaccinate</b>	
Exposed	
Get measles	0.0500
Do not get measles	0.0950
Not exposed	
Get measles	0.0000
Do not get measles	1.0000
<b>Do not vaccinate</b>	
Exposed	
Get measles	0.3300
Do not get measles	0.6700
Not exposed	
Get measles	0.0000
Do not get measles	1.0000
<b>Death</b>	
Get measles	
Die	0.0023
Live	0.9977
Do not get measles	
Die	0.0000
Live	1.0000

# Estimating probabilities

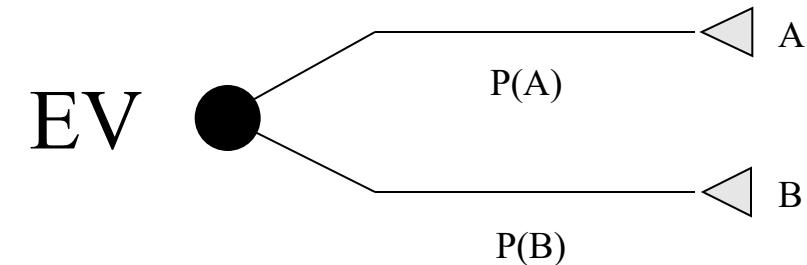


# Rolling Back and Expected Values

- Analysing the decision tree
  - for each pathway, all the probabilities are multiplied together (*rolling back the decision tree*)
  - the products of pathway probabilities and outcomes are summed for each decision option (*weighted average*)
  - the weighted average is the *expected value* of that outcome for the specified decision option

# Rolling Back- Estimating Expected Value

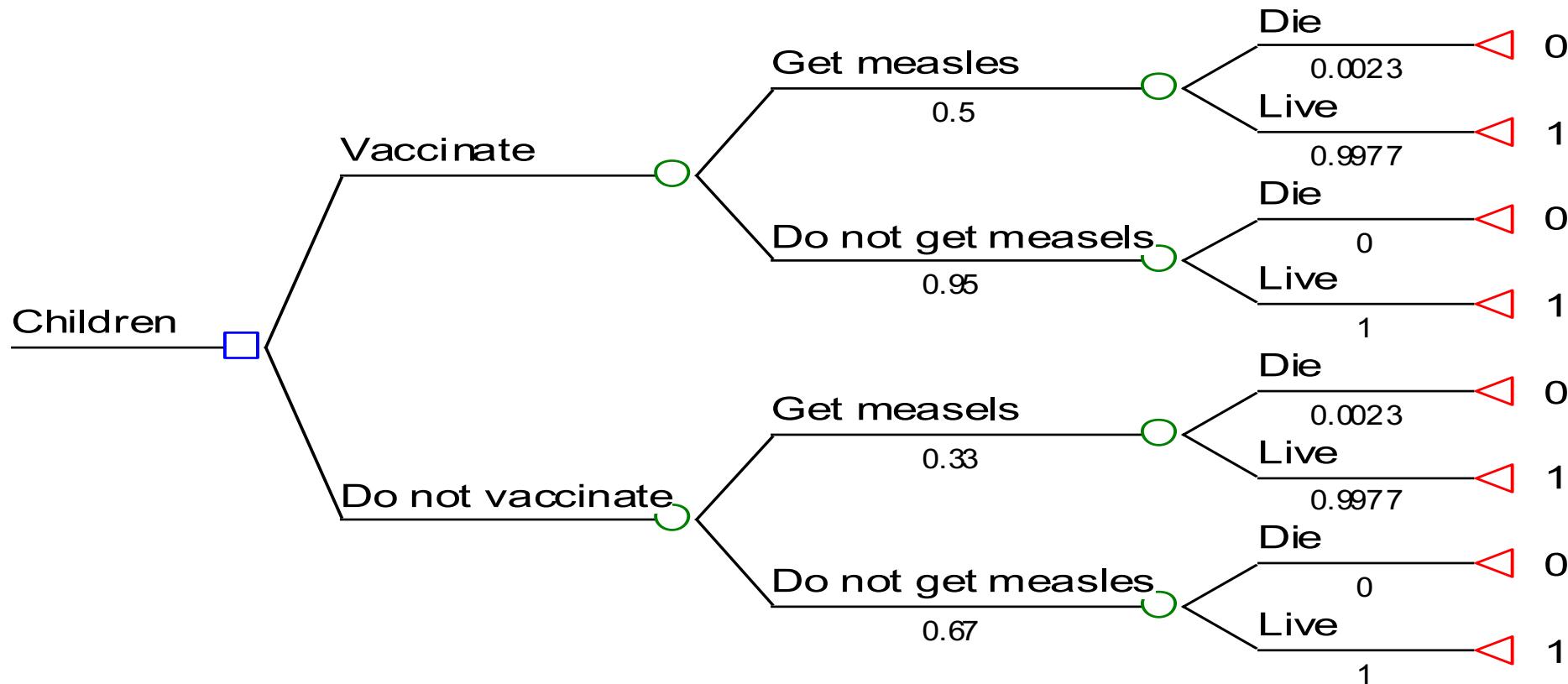
- Calculating the expected value (EV) at a particular chance node:  
multiply along pathways, then sum across pathways



$$EV = P(A) \times A + P(B) \times B$$

# Rolling Back- Estimating Expected Value (Cont'd)

Assume utility of 1 for live and 0 for die

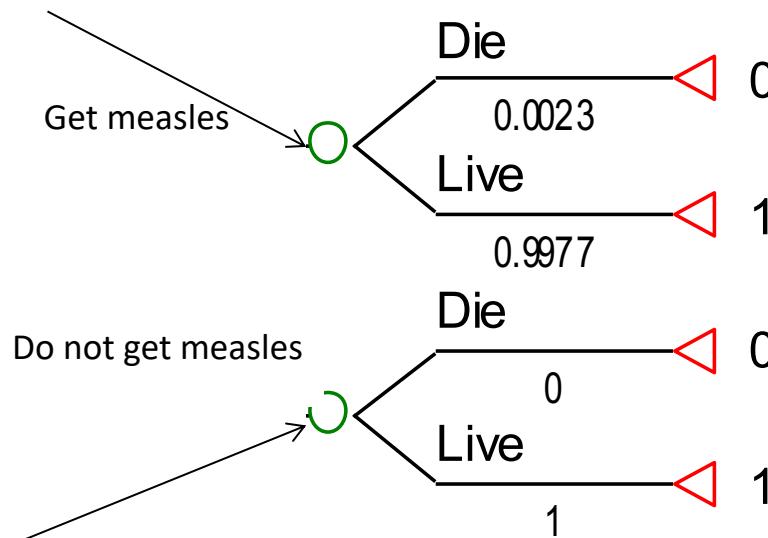


# Rolling Back- Estimating Expected Value (Cont'd)

Assume utility of 1 for live and 0 for die

Expected value measles =

$$(0.0023 \times 0) + (0.9977 \times 1) = 0.9977$$

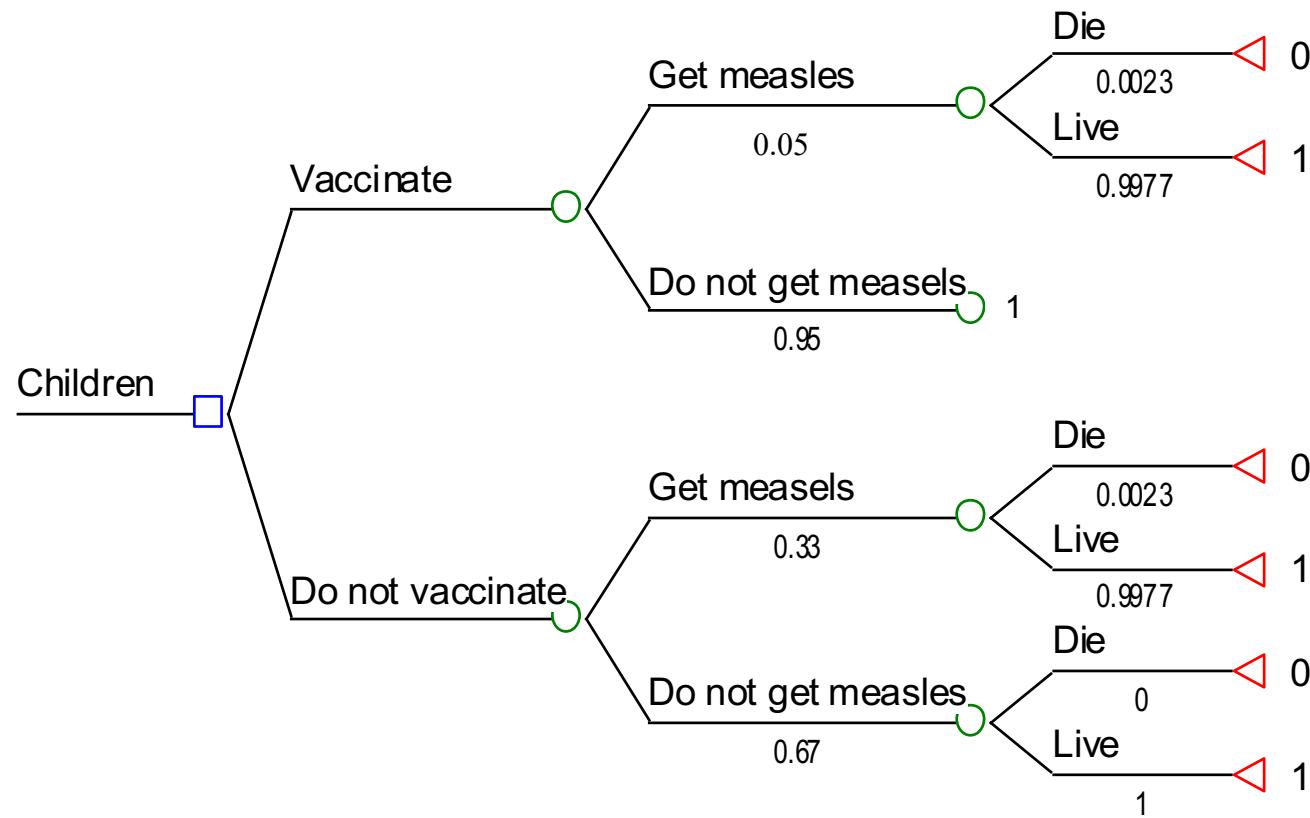


Expected value no measles =

$$(0.0 \times 0) + (1 \times 1) = 1$$

# Rolling Back- Estimating Expected Value (Cont'd)

Assume utility of 1 for live and 0 for die



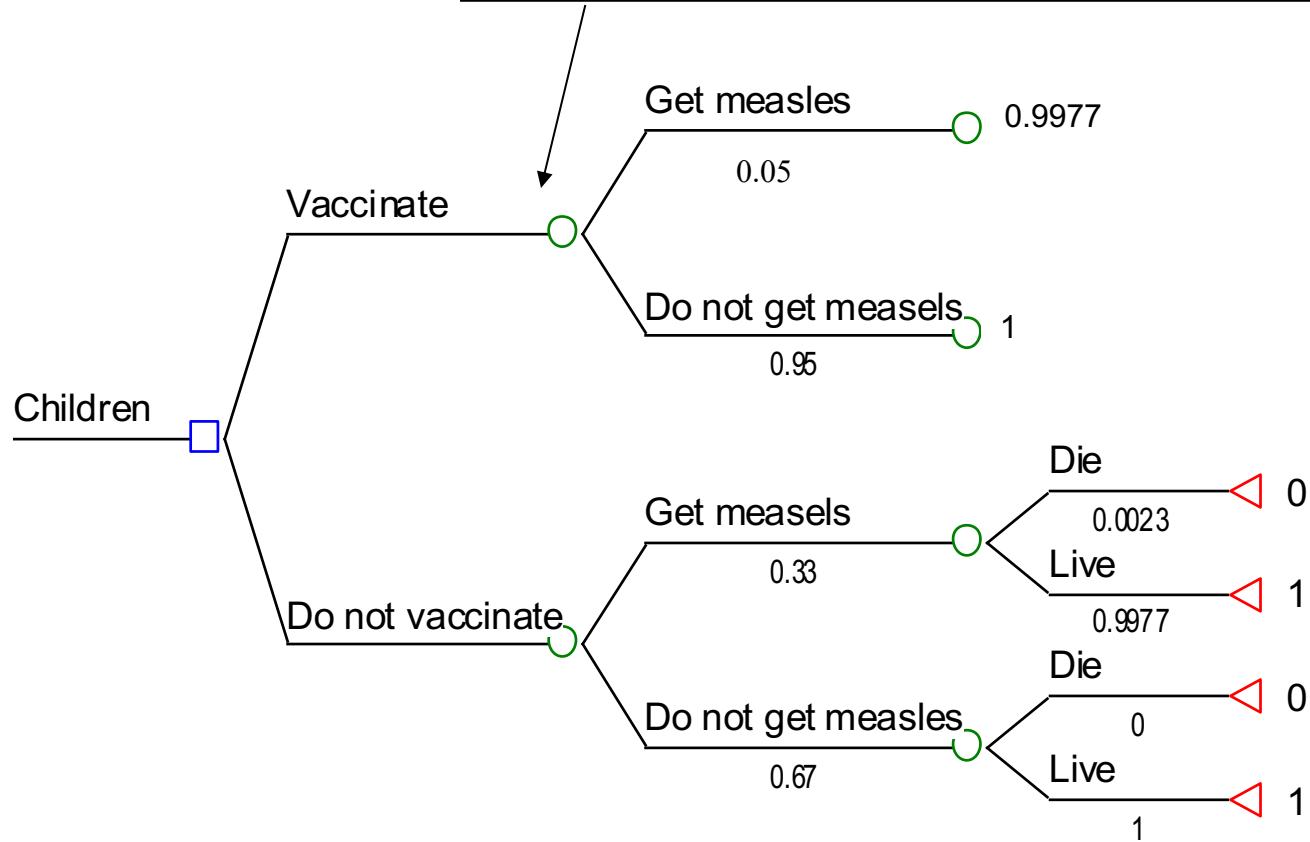
# Rolling Back- Estimating Expected Value (Cont'd)

Assume utility of 1 for live and 0 for die

Expected value at this chance node =

$$(0.05 \times 0.9977) + (0.95 \times 1) = 0.99989$$

The expected value of vaccinating is 0.99989



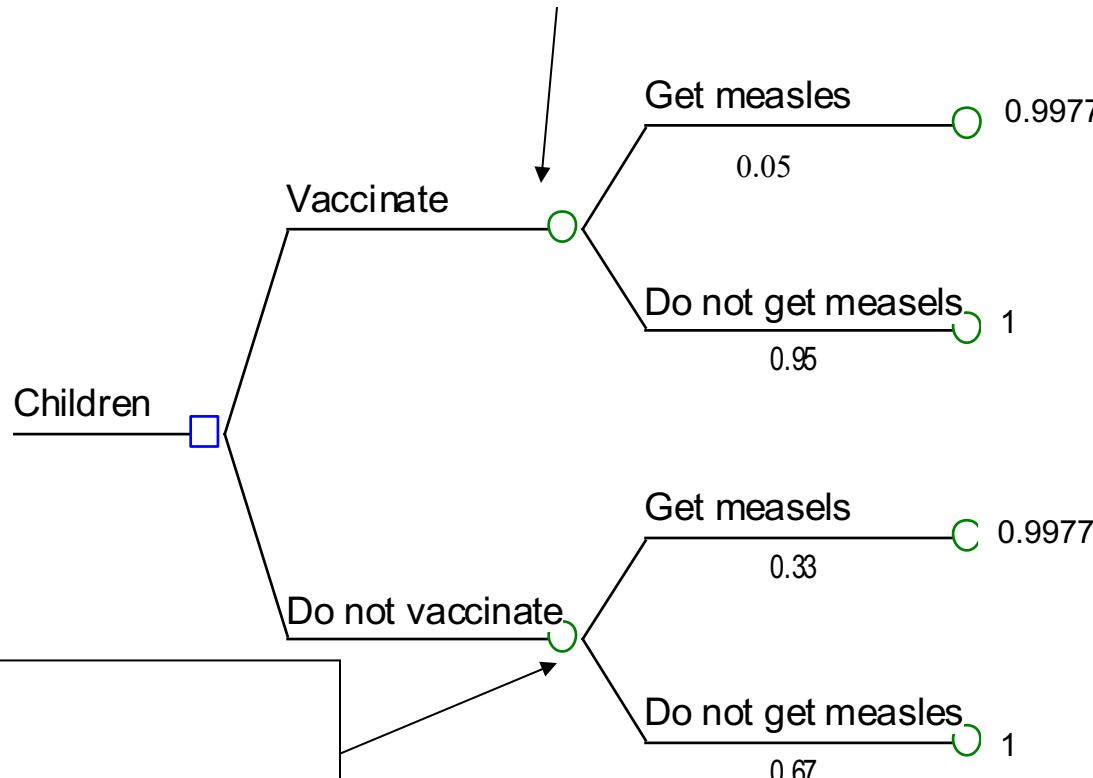
# Rolling Back- Estimating Expected Value (Cont'd)

Assume utility of 1 for live and 0 for die

Expected value at this chance node =

$$(0.05 \times 0.9977) + (0.95 \times 1) = 0.99989$$

The expected value of vaccinating is 0.99989



Expected value at chance node:

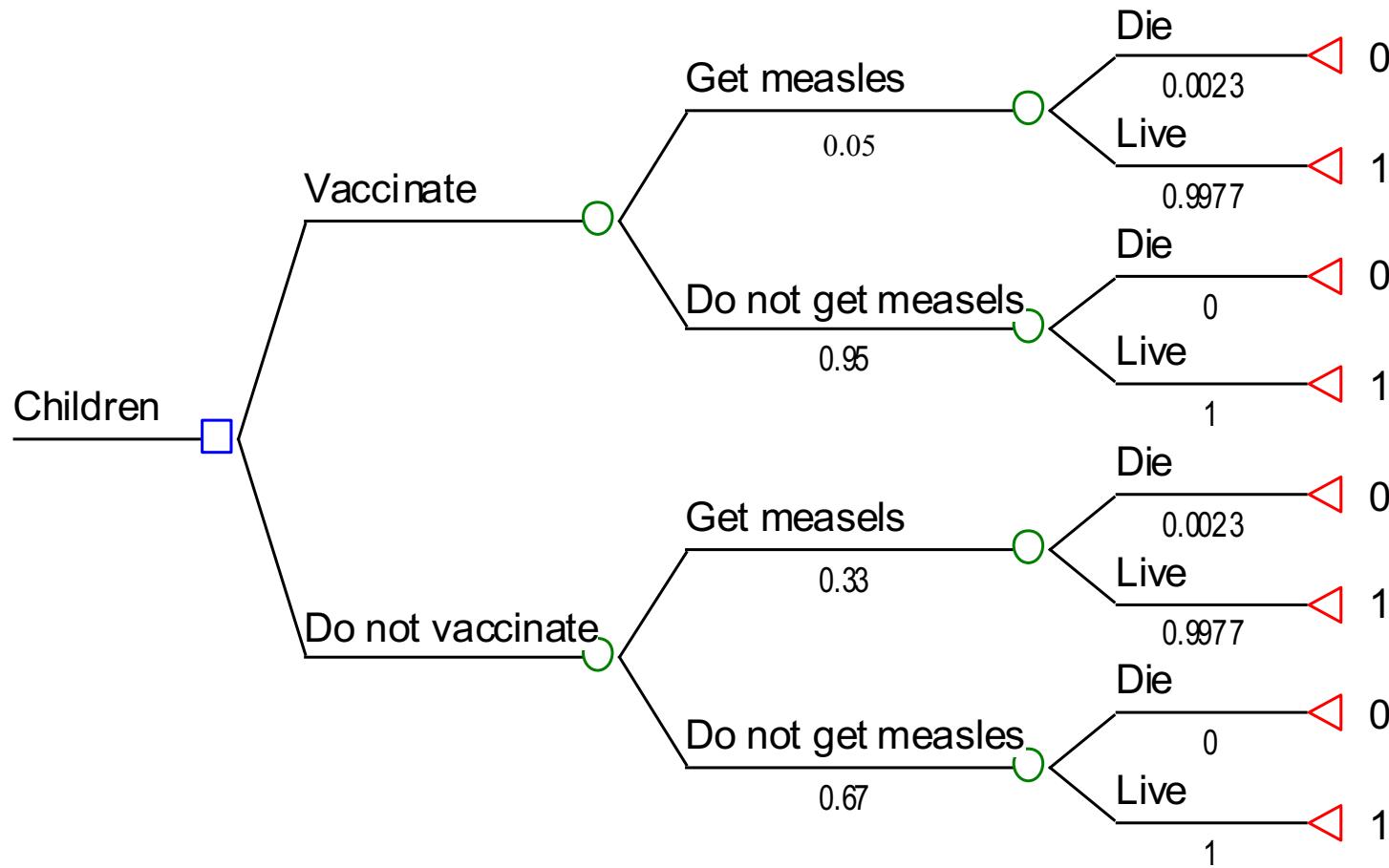
$$(0.33 \times 0.9977) + (0.67 \times 1) = 0.99924$$

The expected value of not vaccinating is 0.99924

# Rolling Back- Estimating Expected Value (Cont'd)

Assume utility of 1 for live and 0 for die

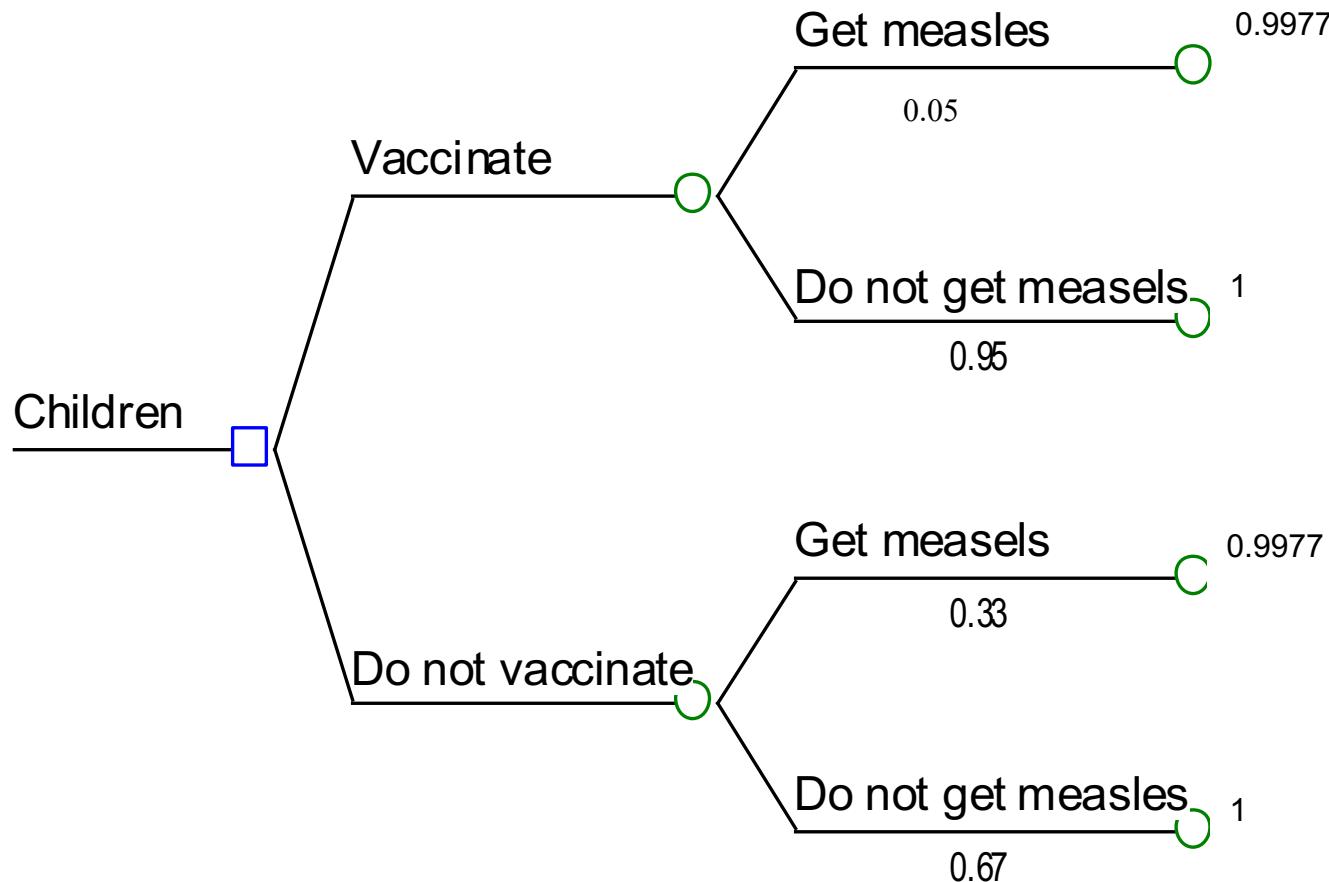
Started with this...



# Rolling Back- Estimating Expected Value (Cont'd)

Assume utility of 1 for live and 0 for die

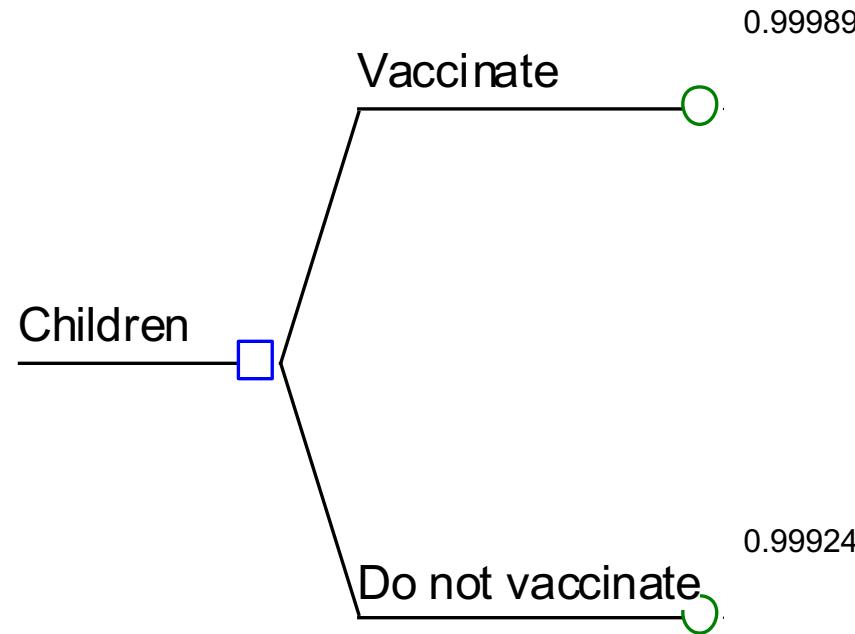
Roll back #1...



# Rolling Back- Estimating Expected Value (Cont'd)

Assume utility of 1 for live and 0 for die

Roll back #2...

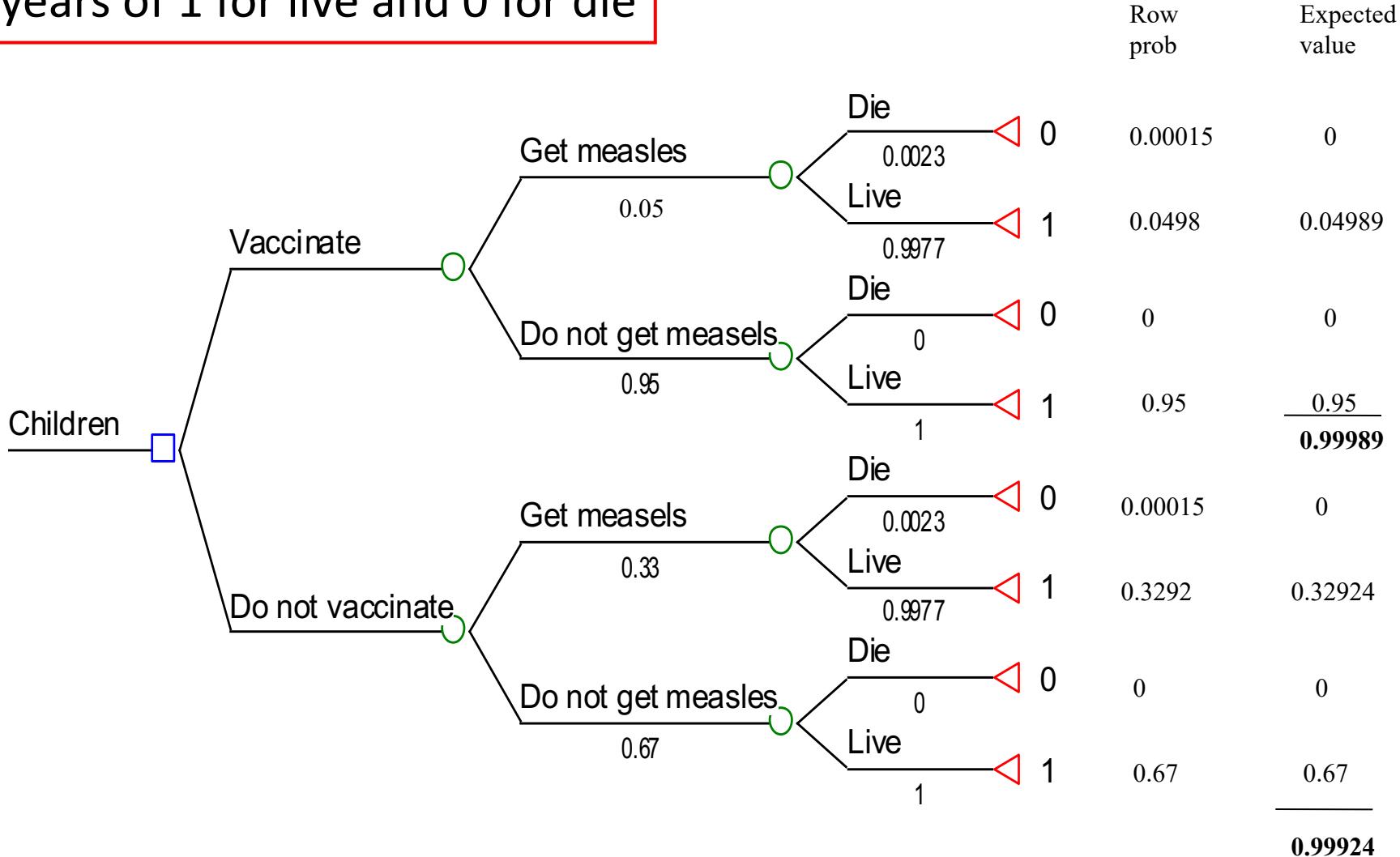


# Incremental Outcomes

- Difference in expected probability of getting measles and dying between a strategy of becoming vaccinated or not being vaccinated
  - Deaths avoided =  $0.9999 - 0.9992 = 0.0007$ 
    - 7 deaths avoided per 10,000 children vaccinated
  - Measles cases prevented =  $0.33 - 0.05 = 0.27$ 
    - 27 cases prevented per 100 children vaccinated

# Other Method of Estimating Payoffs

Assume life years of 1 for live and 0 for die



## Approach 2- Markov Model

A decision-analytic technique that involves a **Markov process**, a ***modelling*** technique derived from matrix algebra, which describes the ***transitions*** a cohort of patients make among a number of ***health states*** during a series of short intervals or ***cycles***.

# Key Elements of Markov Models

- Conventional tree describes the ways in which a patient (or cohort) in one health state might end up in other health states over a fixed time period
- Markov model is concerned with health state transitions over time
  - Repeats a series of short intervals or cycles

# Key Elements of Markov Models

- **Health states**

- The health state defines how a patient is counted for a given cycle.
- Health states have to be mutually exclusive and exhaustive
- This status determines their costs, their risks and any other benefits/ payoffs.

- **Transition probabilities**

- These are the probabilities that a patient will move from one health state to another in a given cycle.

- **State rewards (no longer called payoffs)**

- Accumulated for each cycle that a patient resides in a health state
- Payoffs can also be assigned to specific events in the model (as opposed to just time spent in the health state)

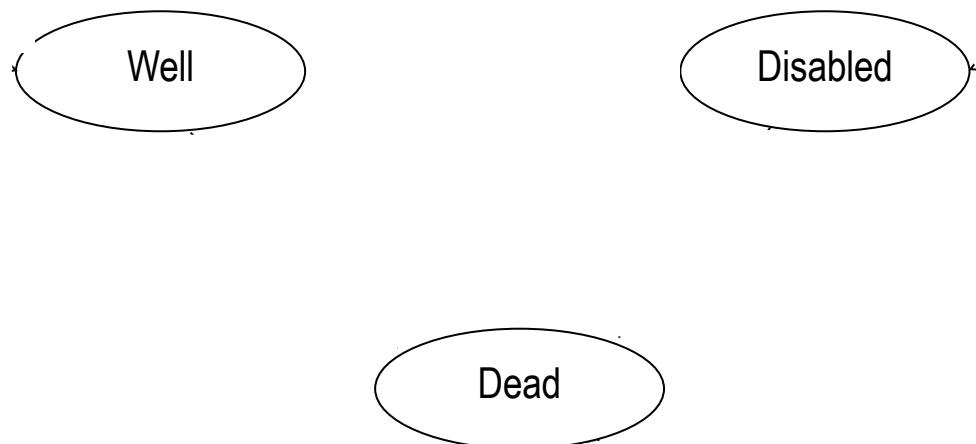
- **Termination condition**

- The number of Markov cycles that the patient cohort is followed for

# Key Elements of Markov Models

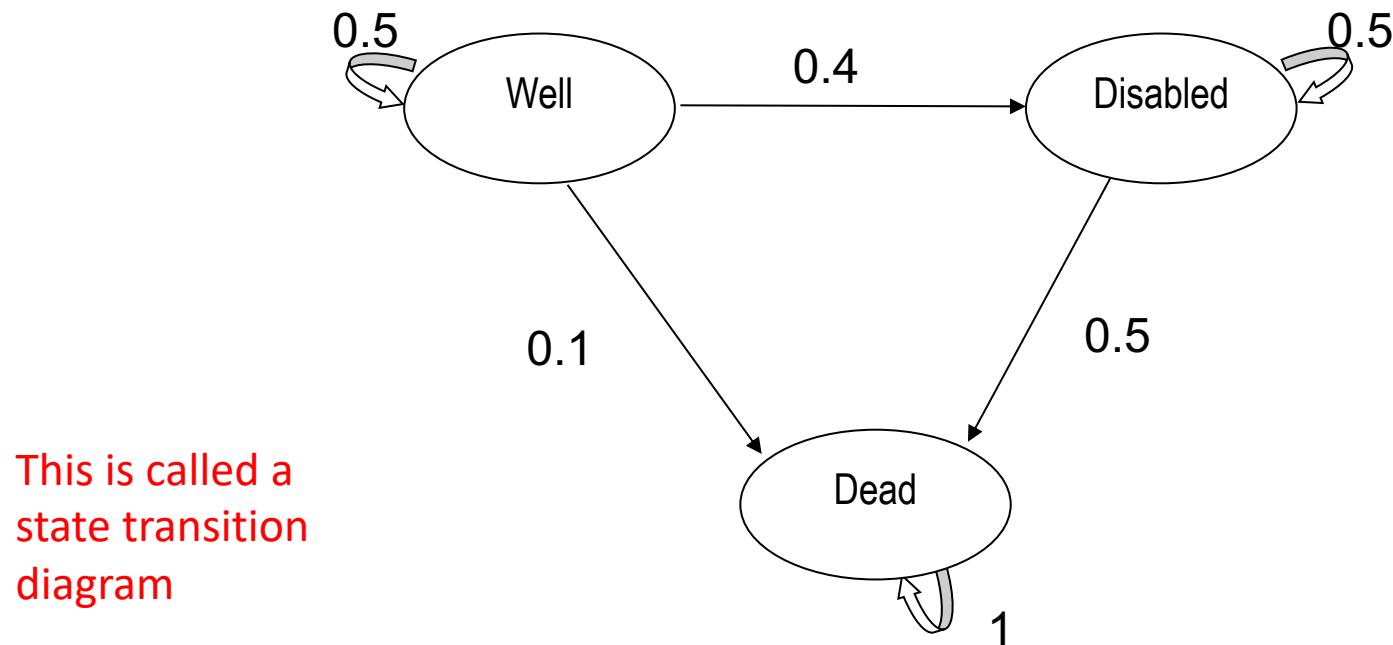
- Health states

- The health state defines how a patient is counted for a given cycle.
- Health states have to be **mutually exclusive** and **exhaustive**
- Determines their costs, their risks and any other benefits/ payoffs.

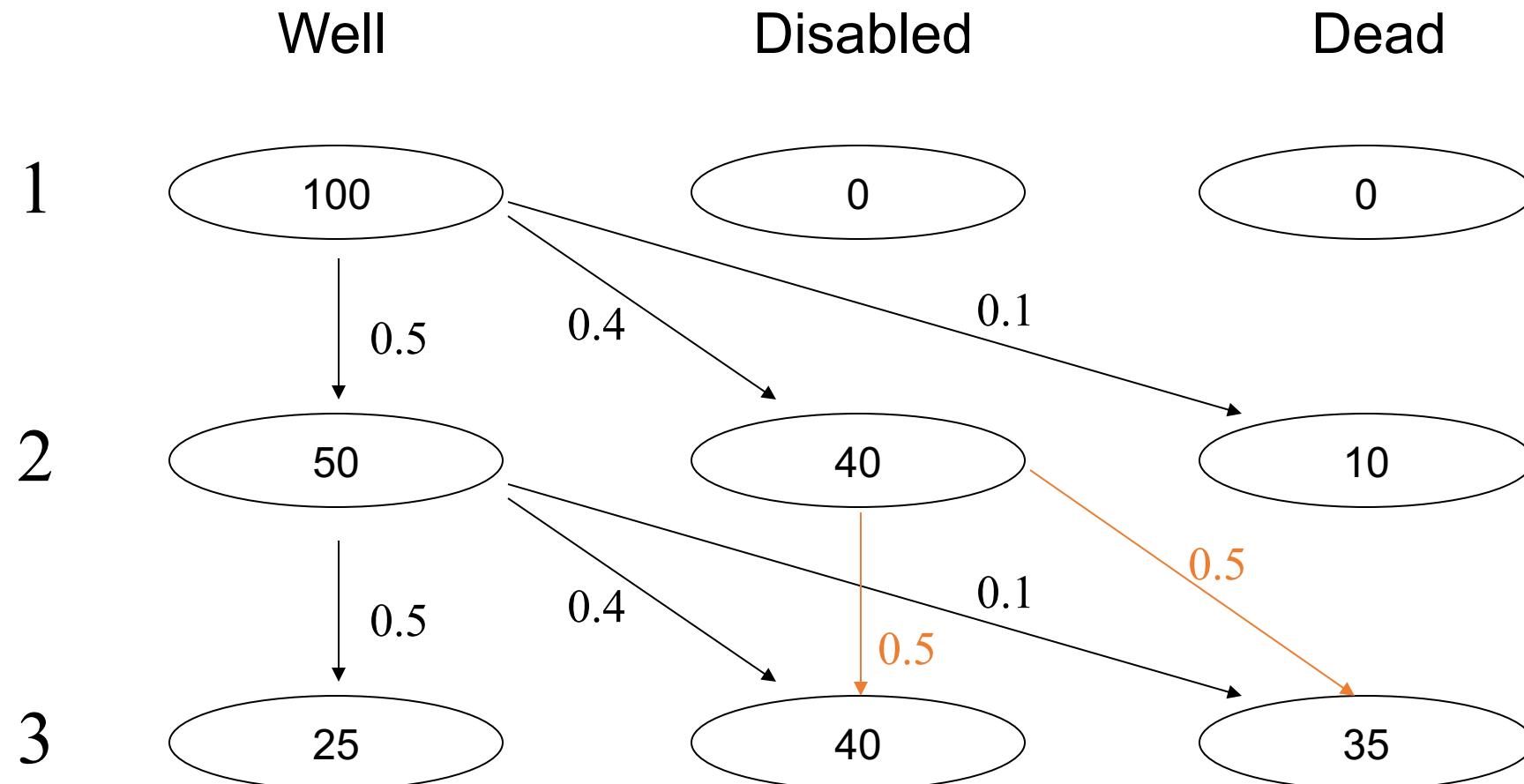


# Key Elements of Markov Models

- Transition probabilities
  - These are the probabilities that a patient will move from one health state to another in a given cycle.



# Health State Transitions



# Key Elements of Markov Models

- Termination condition
  - The number of Markov cycles that the patient cohort is followed for

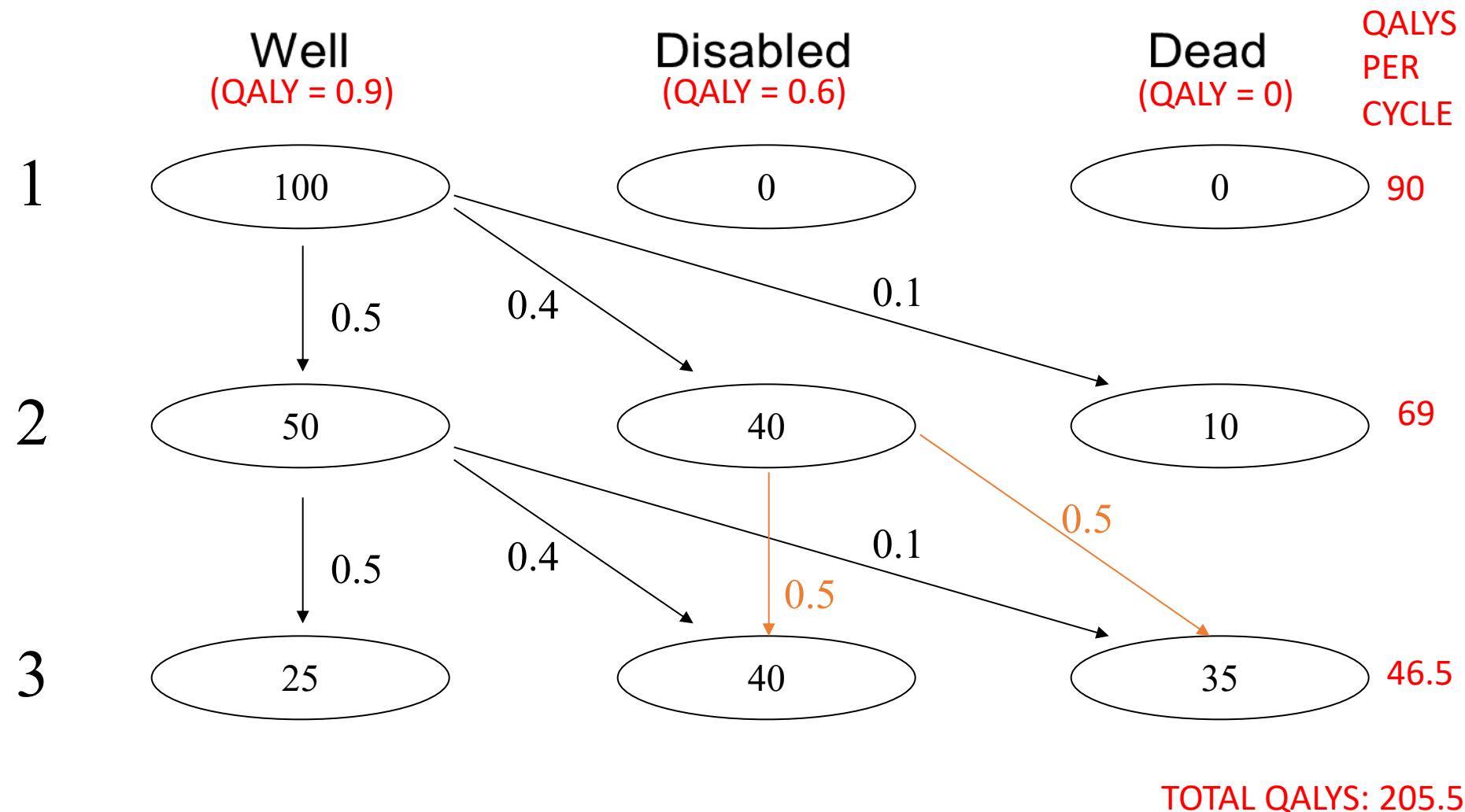
Cycle	State A	State B	State C	State D	Total
0	1000	0	0	0	1000
	$1000 \times 0.721$	$1000 \times 0.202$	$1000 \times 0.067$	$1000 \times 0.01$	
1	721	202	67	10	1000
2	520	263	181	36	1000
3	375	258	277	90	1000
4	270	226	338	166	1000
5	195	186	363	256	1000
6	140	147	361	351	1000
7	101	114	340	445	1000
8	73	87	308	532	1000
9	53	65	271	611	1000
10	38	48	234	680	1000
11	27	36	197	739	1000
12	20	26	164	789	1000
13	14	19	135	831	1000
14	10	14	110	865	1000
15	7	10	89	893	1000
16	5	7	72	916	1000
17	4	5	57	934	1000
18	3	4	45	948	1000
19	2	3	36	959	1000
20	1	2	28	968	1000

**Fig. 9.6** The results of the Markov trace for the monotherapy group in the HIV example. The trace assumes a starting cohort of 1000 beginning in State A.

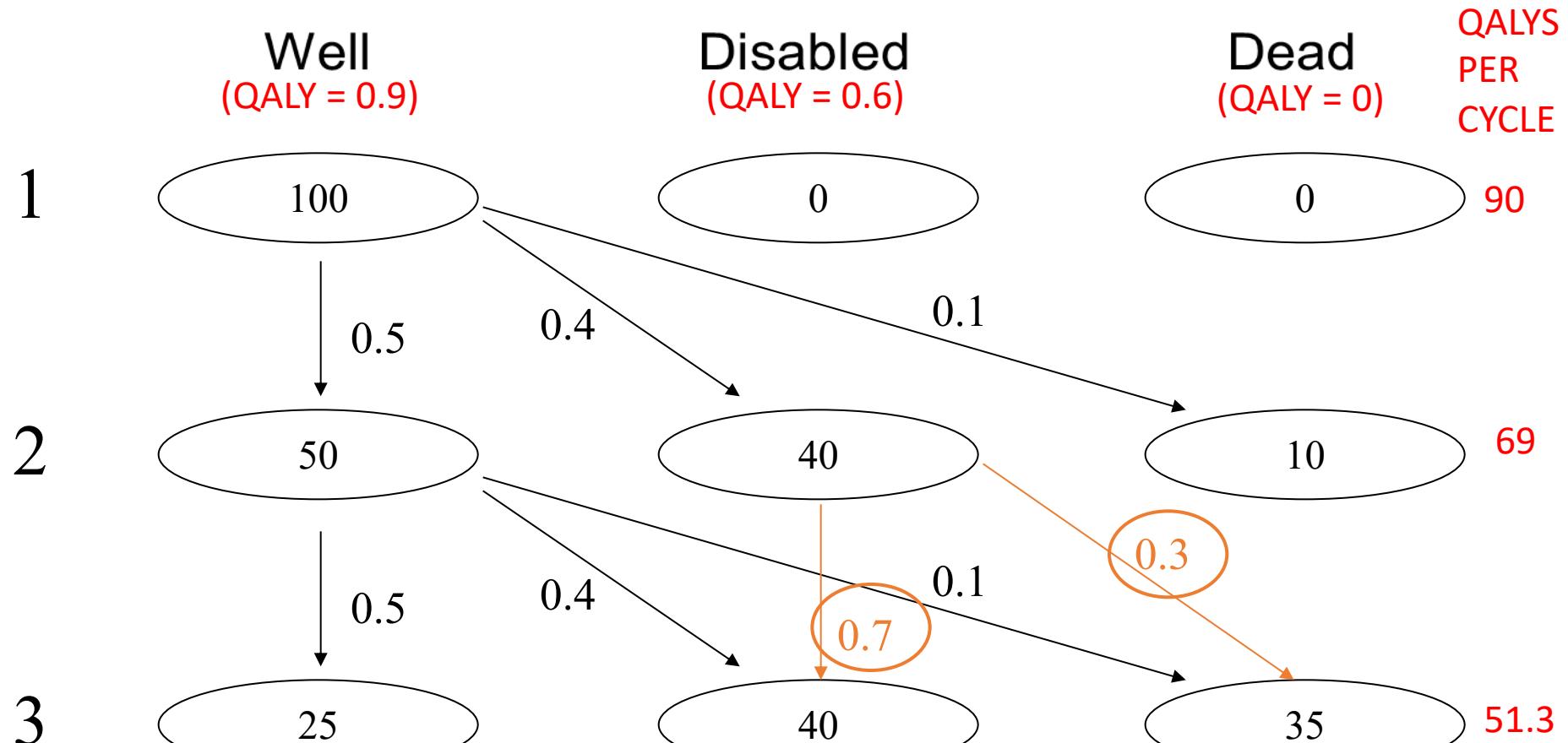
# Analysing a Markov Model

- The Markov trace tells us the proportion of patients in each health state at each time point
- From there, the expected costs and benefits accruing in each cycle can be calculated
- Summing all the costs and benefits across the cycles will provide the total expected cost/benefits
- Compare Markov outcomes for treatment versus control to estimate ICER

# Health State Transitions: Control



# Health State Transition: Treatment



Treatment reduces mortality for disabled

# Key Practical Modeling Message

- **Keep model as simple as possible**
  - What question are you answering?
- **Use a multi-disciplinary team to build model**
  - Can't simplify if don't know your issue
- **Good modelling takes time and resources**
  - Iterative – normally don't get it right first time
- **Don't overlook your data**
  - Garbage in – garbage out
- **Presentation of results of model as transparent as possible**
  - Back of the Envelope!
- **Use sensitivity analysis to check robustness of results**
- **Validation a process rather than a 'tick the box'**

# Key Elements of Markov Models

- The “Markov property”

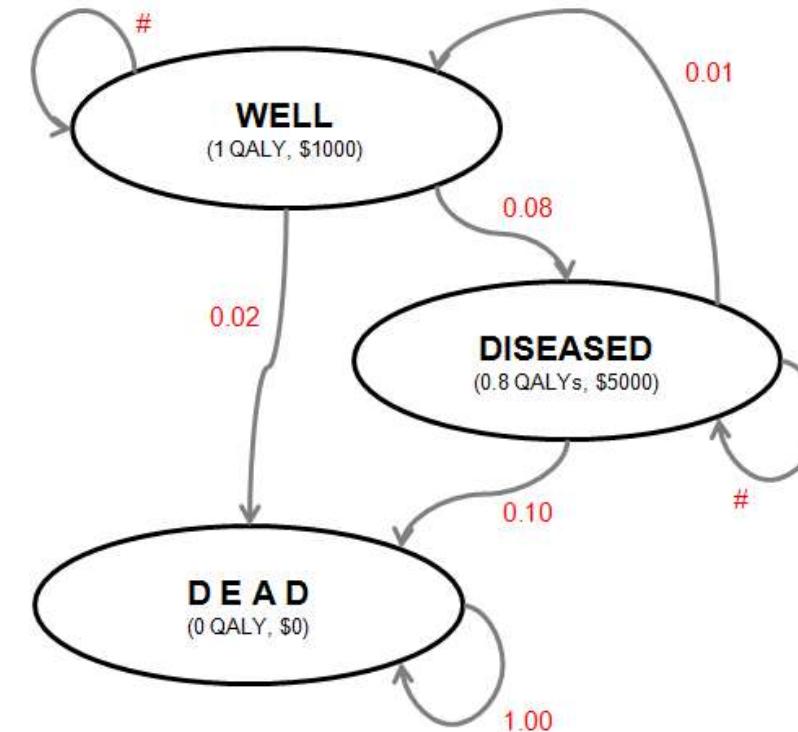
- Memoryless

The model does not take into account of all previous health states, just the one immediately before.

- *“The behaviour of the process subsequent to any cycle depends only on its description in that cycle”*

(Sonnenberg and Beck, 1993)

- Not necessarily ideal in all health applications



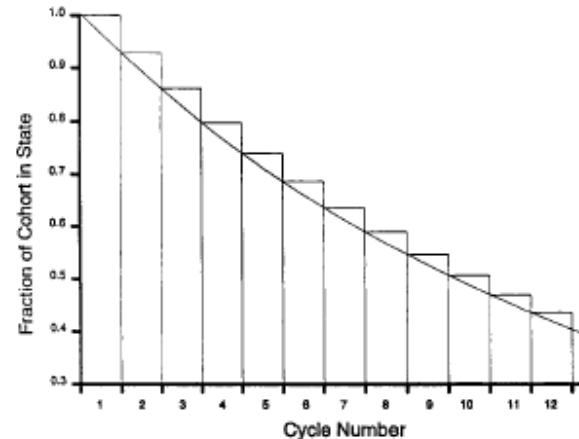
## Determine Transition Probabilities

- Most available information about transitions between health states expressed as a *rate* and *not a probability*
  - A rate is a number of events per unit time (e.g. infection attack rate per 100 person years)
  - A probability is a quantity that is unitless (time is built into it)
  - A rate  $r$  can be used to estimate a transition probability  $p$  of an event occurring over a time interval  $t$  based on the following formula:

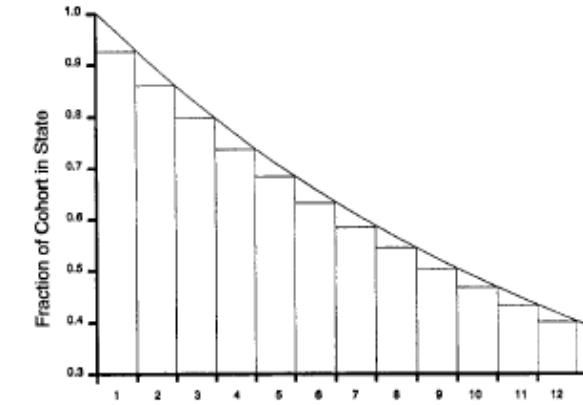
$$p = 1 - e^{-rt}$$
$$r = -\ln(1-p)/t$$

# Half-Cycle Correction

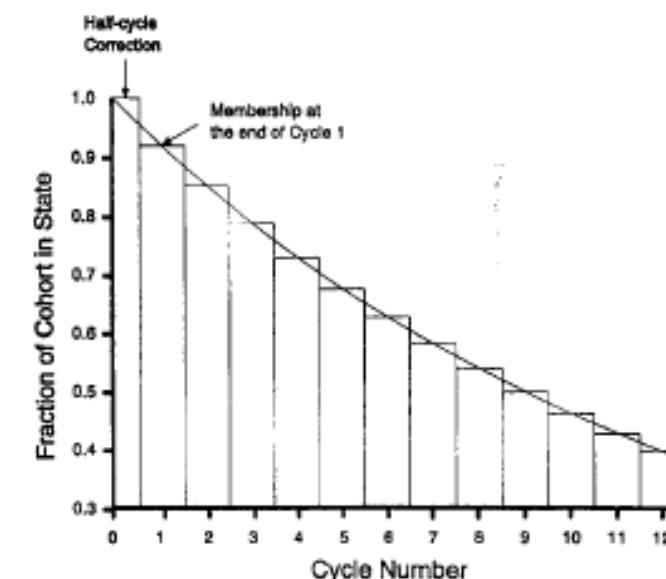
Payoffs attributed to the population in the health state at beginning of the cycle  
→ Markov model overestimates true effect



Payoffs at end of the cycle → Markov model underestimates true effect



**Half-cycle correction:** Only half the payoff is accumulated in the very first cycle of the model, and in the very last cycle of the model. The implicit over and underestimates of the discrete cycle cancel each other out (approximately).



# COHORT VERSUS MICROSIMULATIONS (1)

- **Cohort simulation**

Model a group of hypothetical patients at the same time

Time horizon is fixed

Computationally less intensive

- **Individual or microsimulations (Monte Carlo)**

Individuals are modeled through the Markov models one at a time

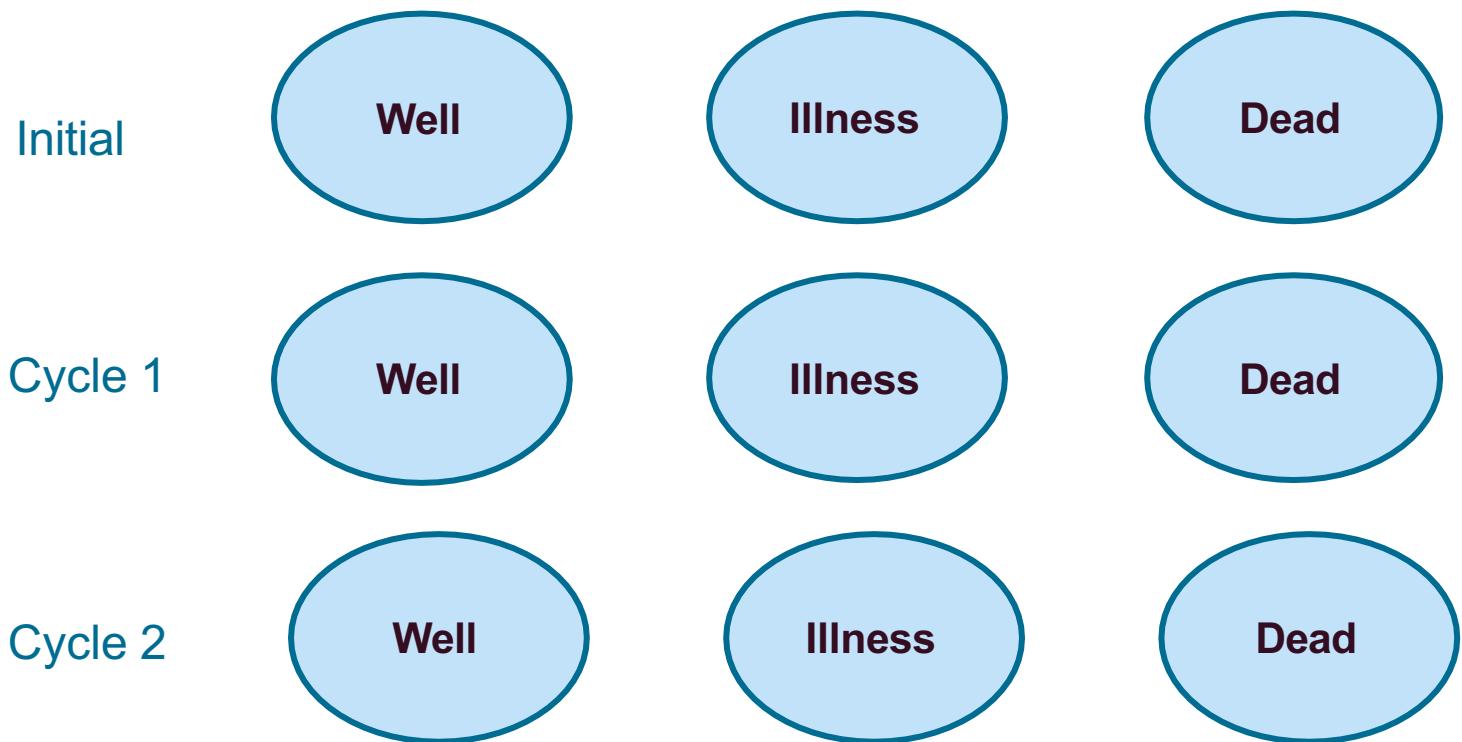
Time for each patient can be short or long

Computationally intensive

# COHORT VERSUS MICROSIMULATIONS (1)

Cohort simulation

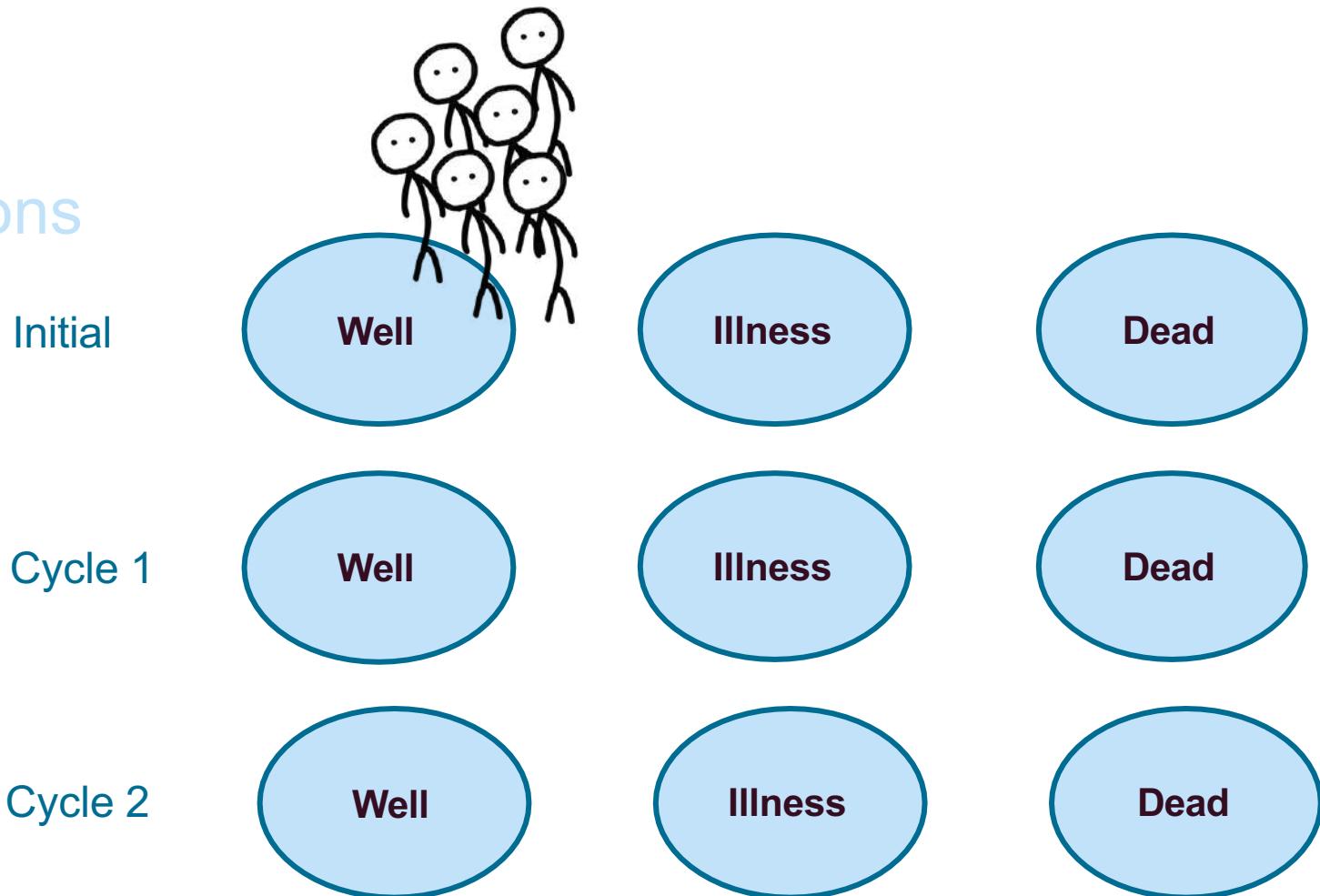
Individual or microsimulations



# COHORT VERSUS MICROSIMULATIONS (2)

Cohort simulation

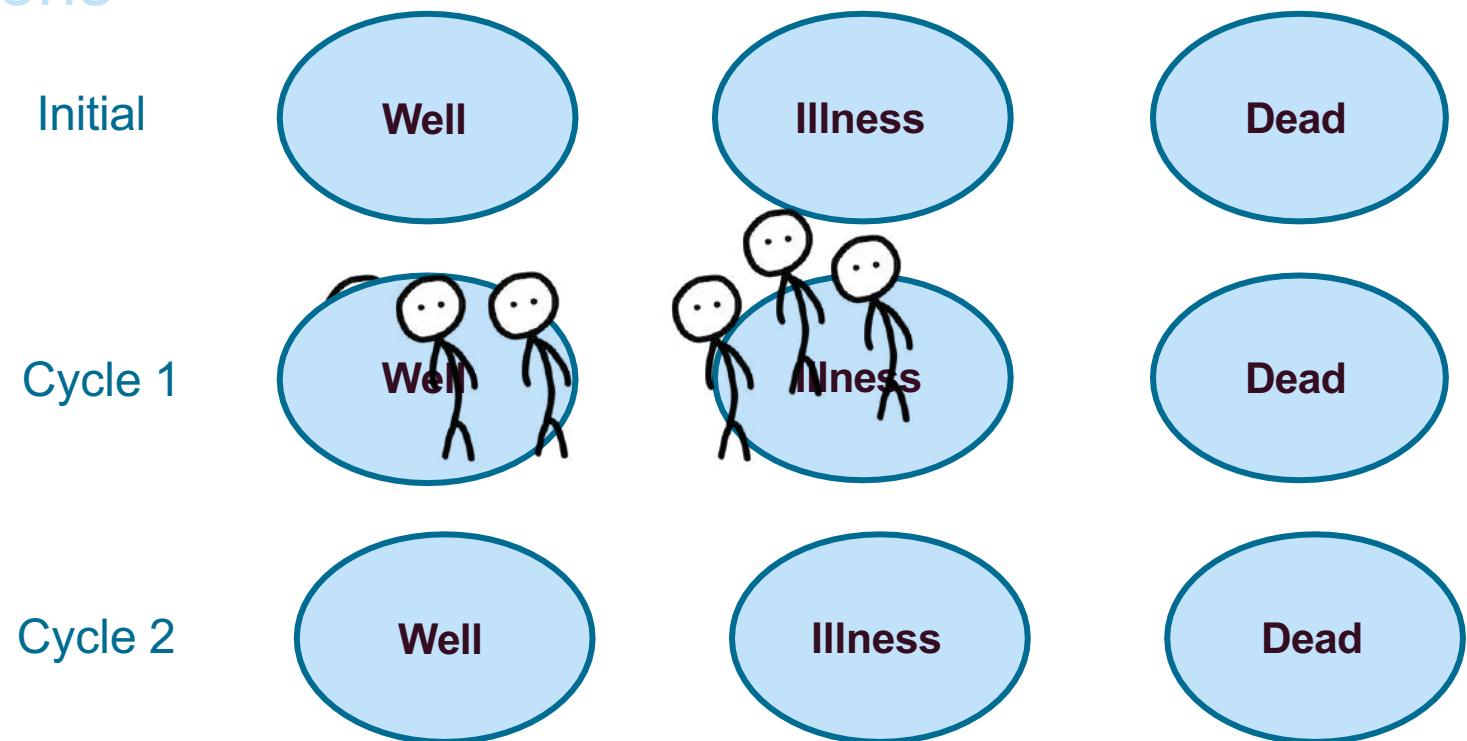
Individual or microsimulations



# COHORT VERSUS MICROSIMULATIONS (3)

## Cohort simulation

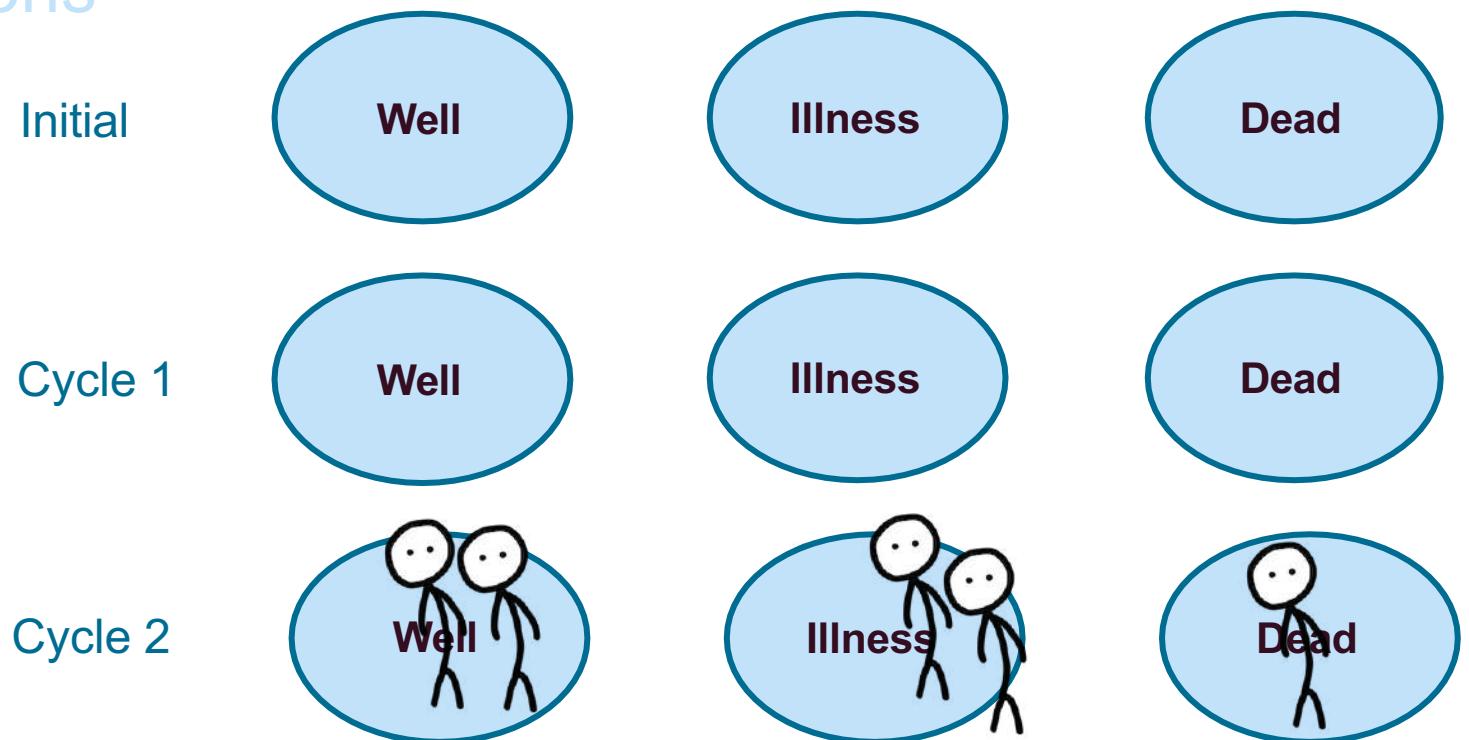
### Individual or microsimulations



# COHORT VERSUS MICROSIMULATIONS (4)

## Cohort simulation

Individual or microsimulations

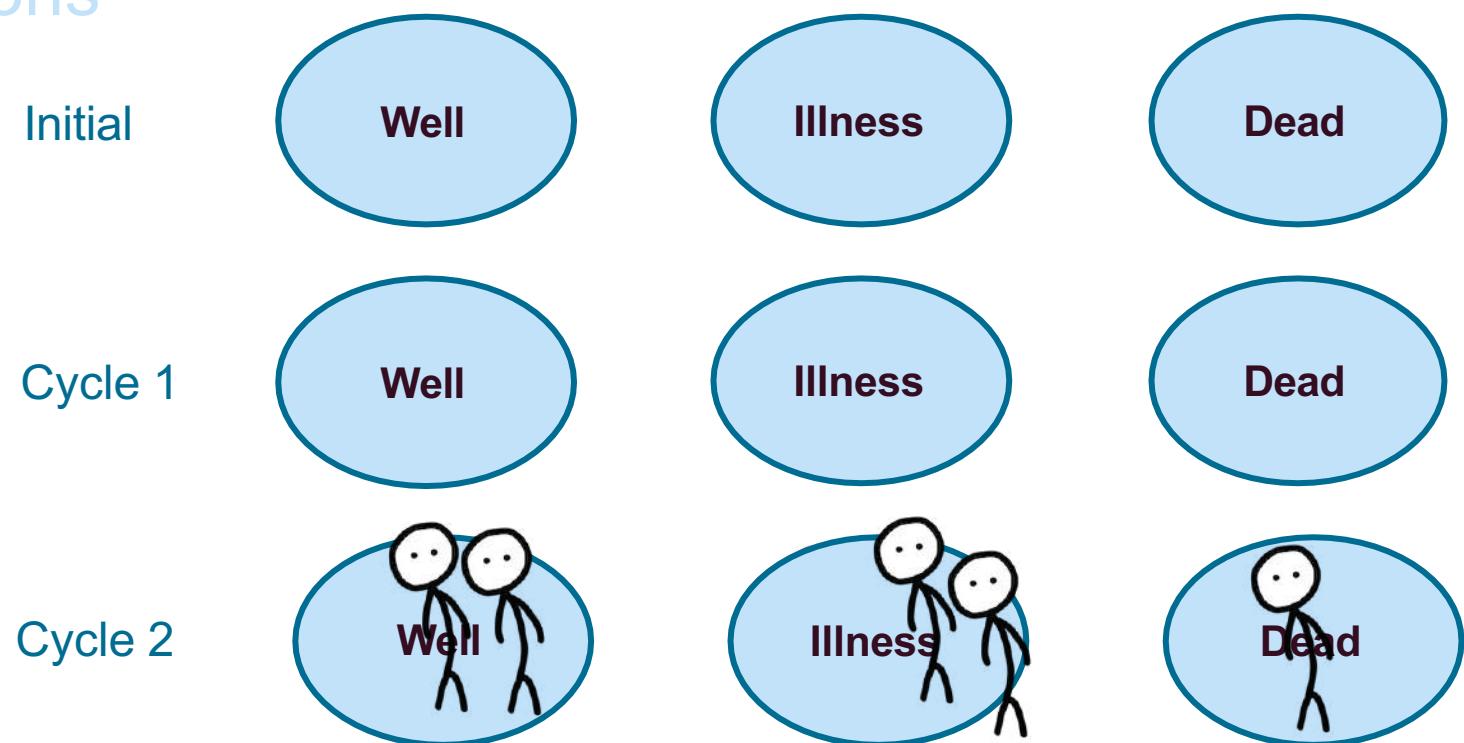


# COHORT VERSUS MICROSIMULATIONS (5)

## Cohort simulation

### Individual or microsimulations

“Memoryless”  
(Markovian Assumption)



# COHORT VERSUS MICROSIMULATIONS (6)

Cohort simulation

Individual or microsimulations

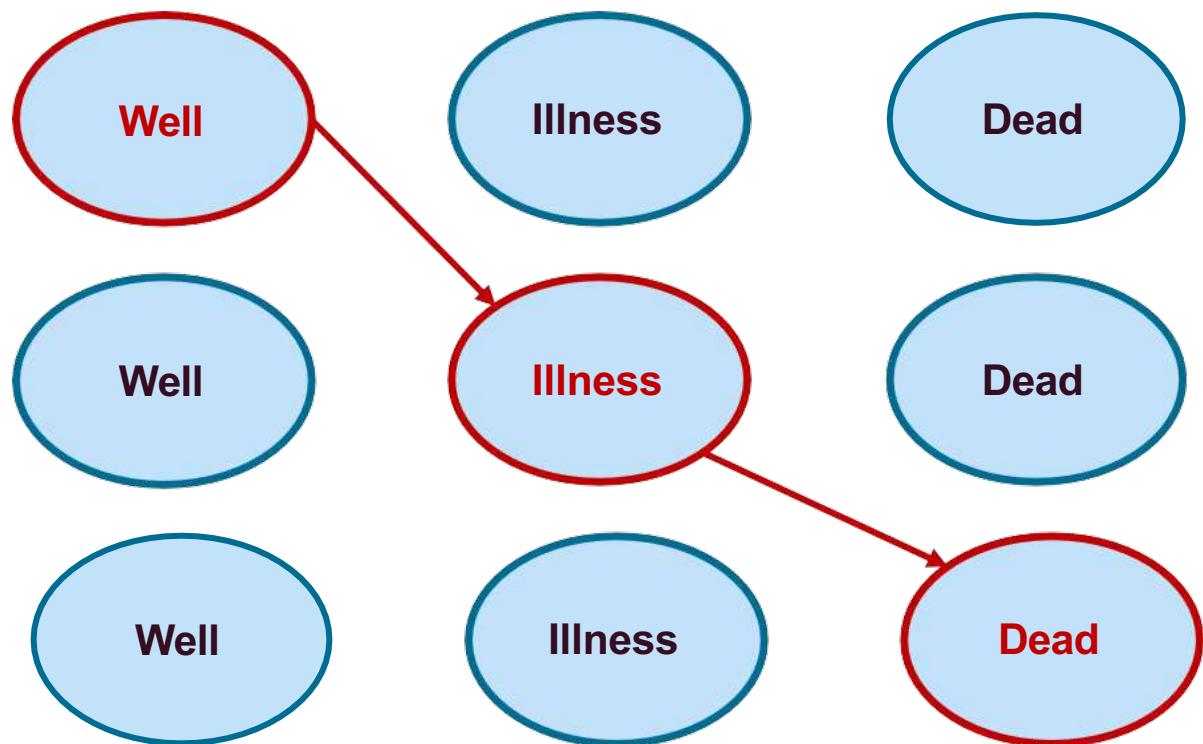
“Memoryless”  
(Markovian Assumption)

Initial

Cycle 1

Cycle 2

Tunnel states are used to force  
the model to consider the  
previous state



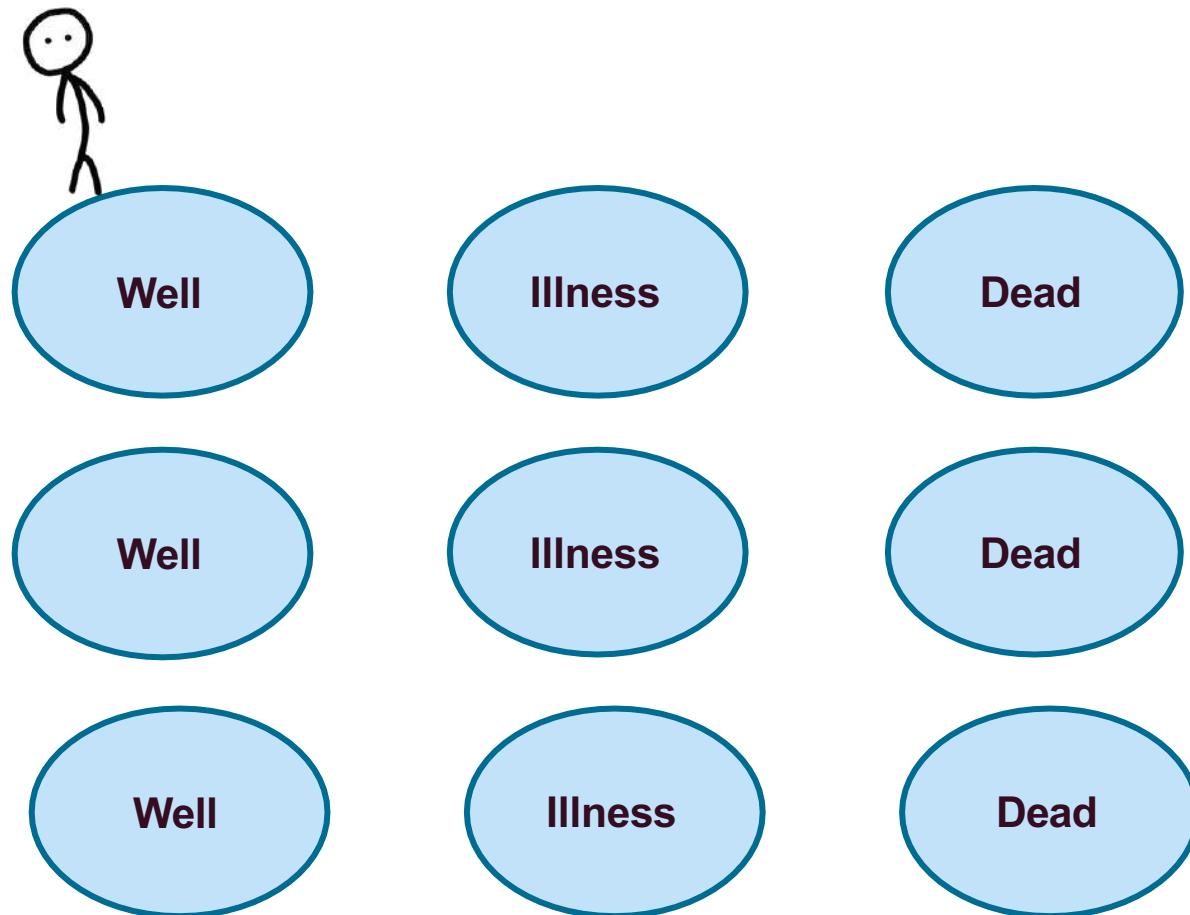
# COHORT VERSUS MICROSIMULATIONS (7)

## Cohort simulation

### Individual or microsimulations

- “First order” Monte Carlo
- Generate variance around the cost and benefits

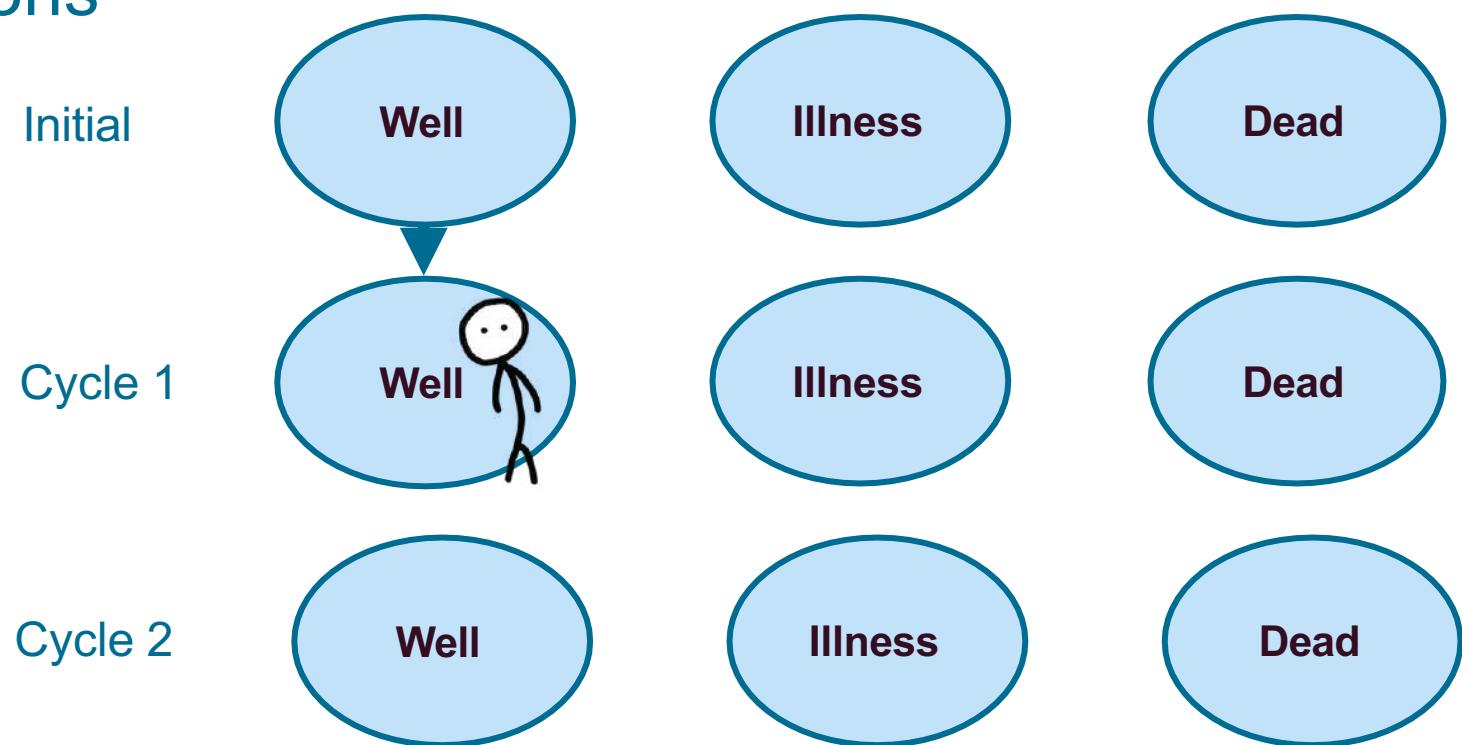
Initial



# COHORT VERSUS MICROSIMULATIONS (8)

Cohort simulation

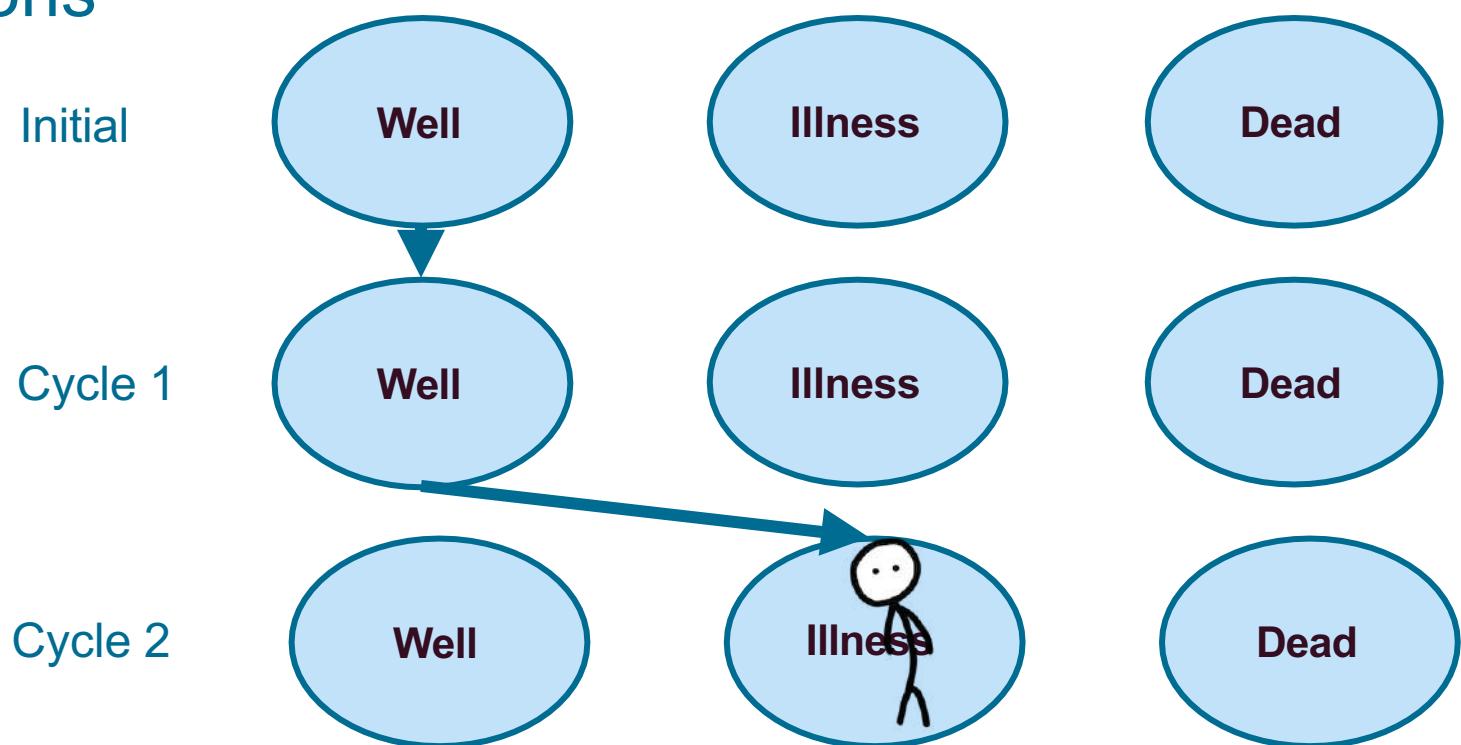
Individual or microsimulations



# COHORT VERSUS MICROSIMULATIONS (9)

Cohort simulation

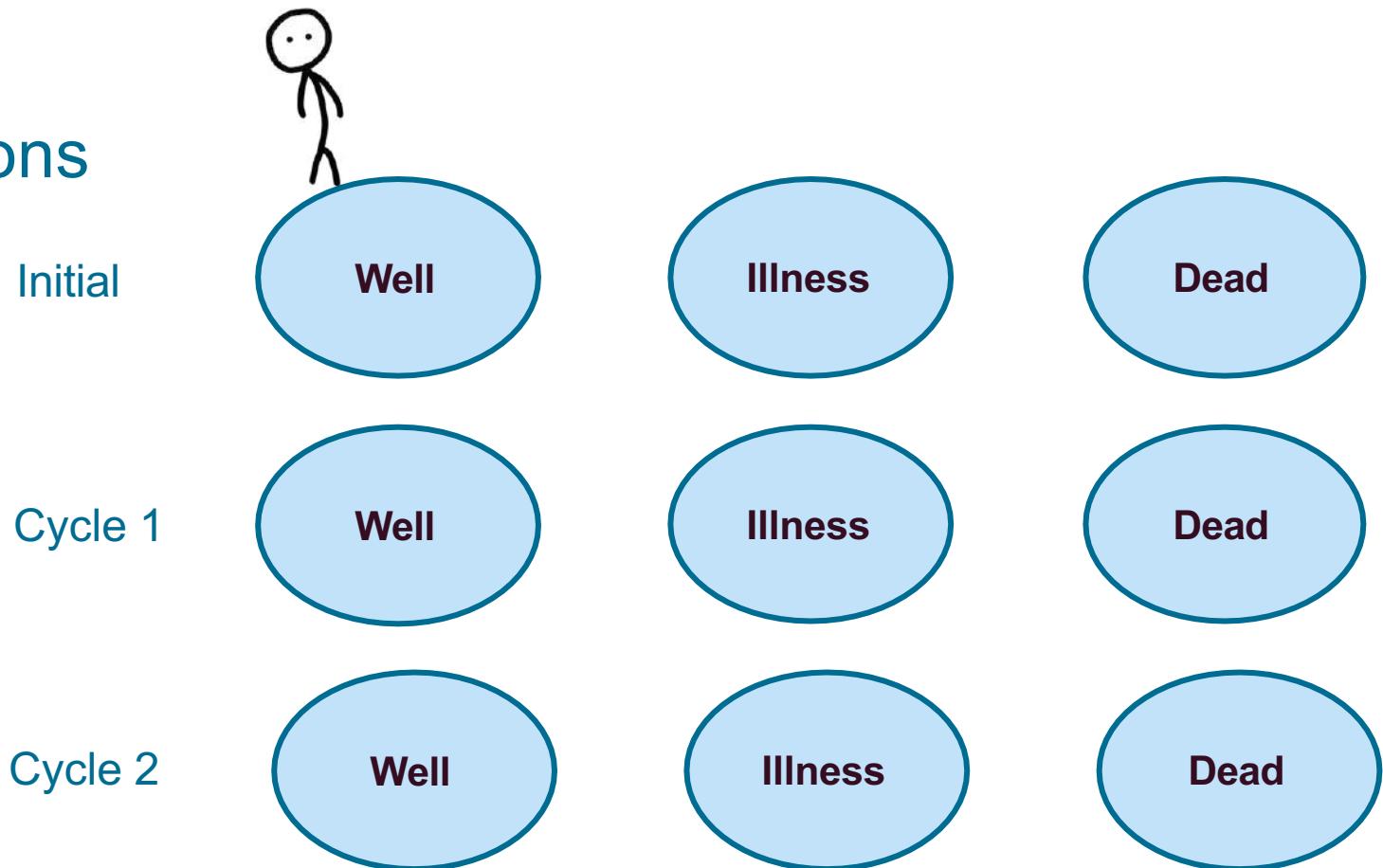
Individual or microsimulations



# COHORT VERSUS MICROSIMULATIONS (10)

Cohort simulation

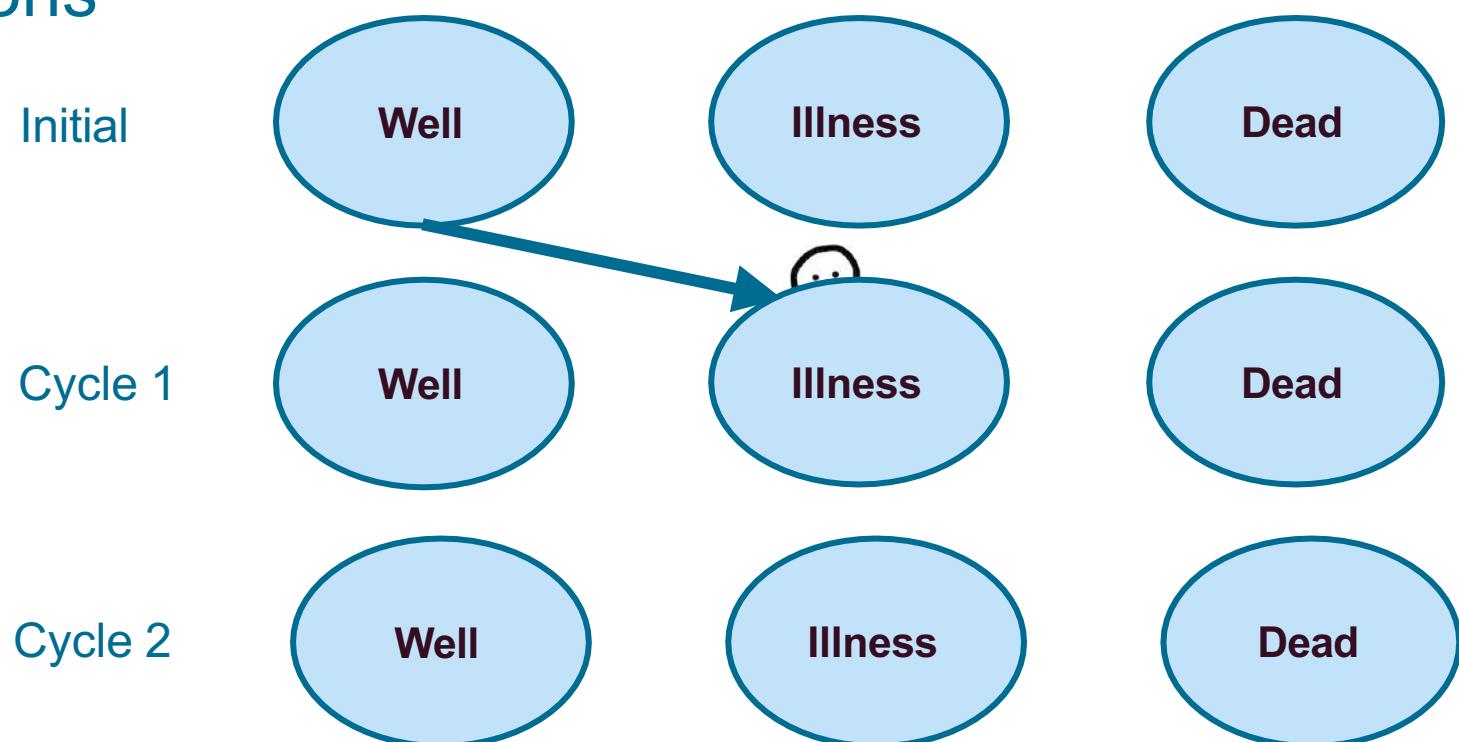
Individual or microsimulations



# COHORT VERSUS MICROSIMULATIONS (11)

Cohort simulation

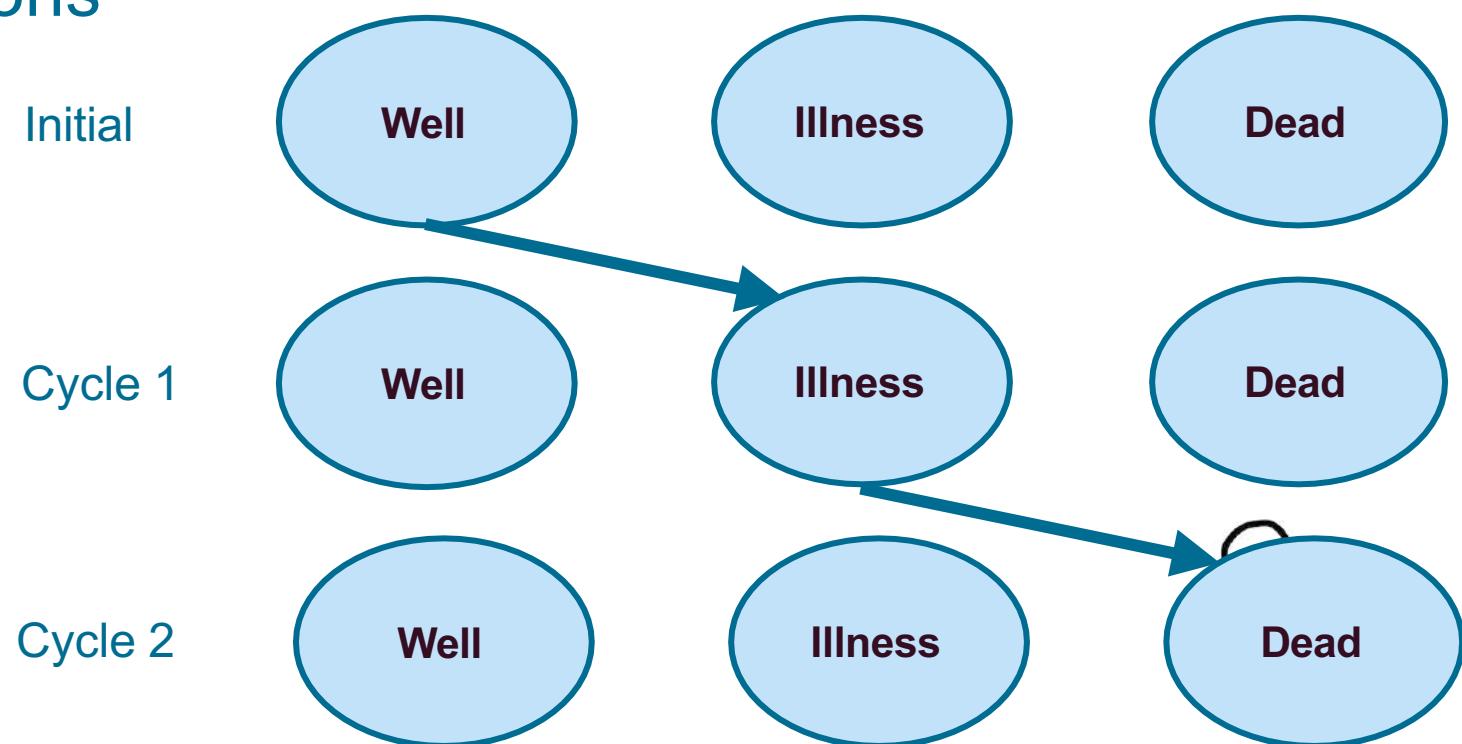
Individual or microsimulations



# COHORT VERSUS MICROSIMULATIONS (12)

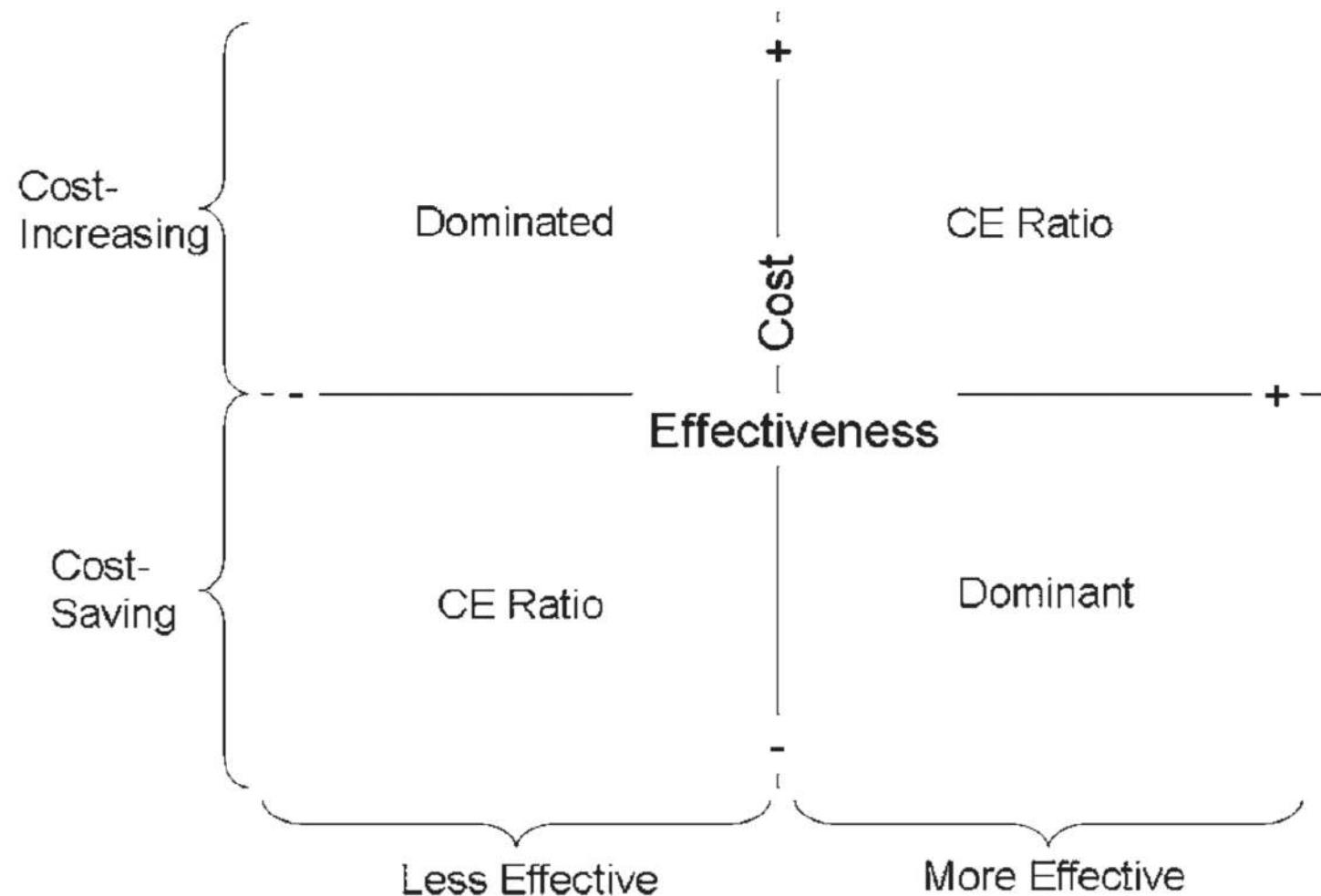
Cohort simulation

Individual or microsimulations

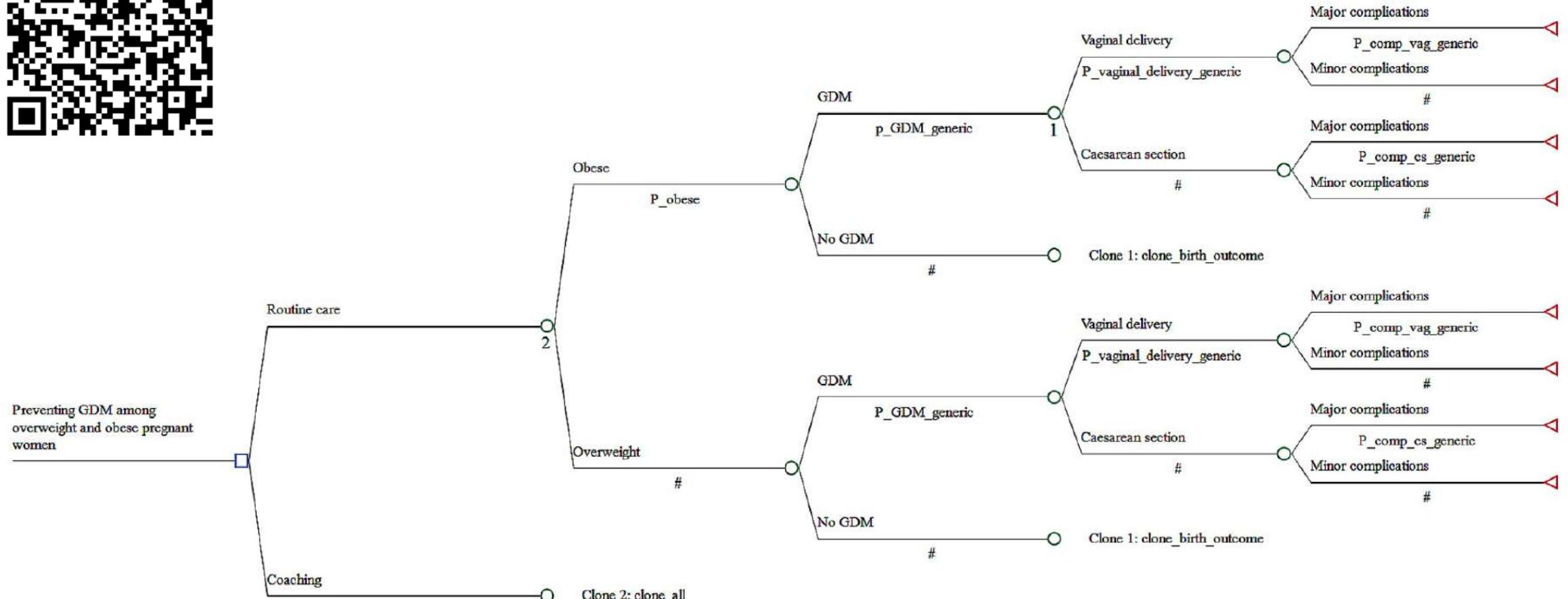


□ 單元二：  
Presentation of Results

# 實例 1- Decision Tree Diagram/ Schematic

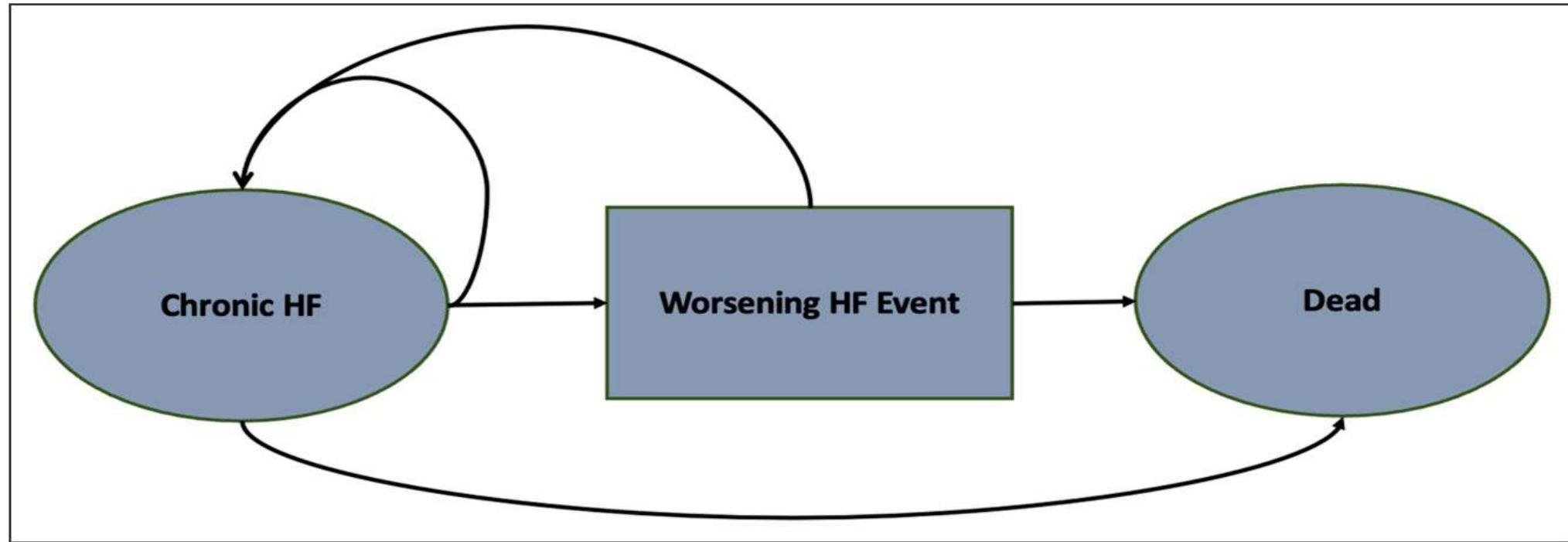


# 實例 1- Decision Tree Diagram/ Schematic



**Fig. 1** Simplified diagram of the decision tree model used to analyze the cost-effectiveness of coaching to prevent GDM

## 實例 2- Markov Model Diagram/ Schematic

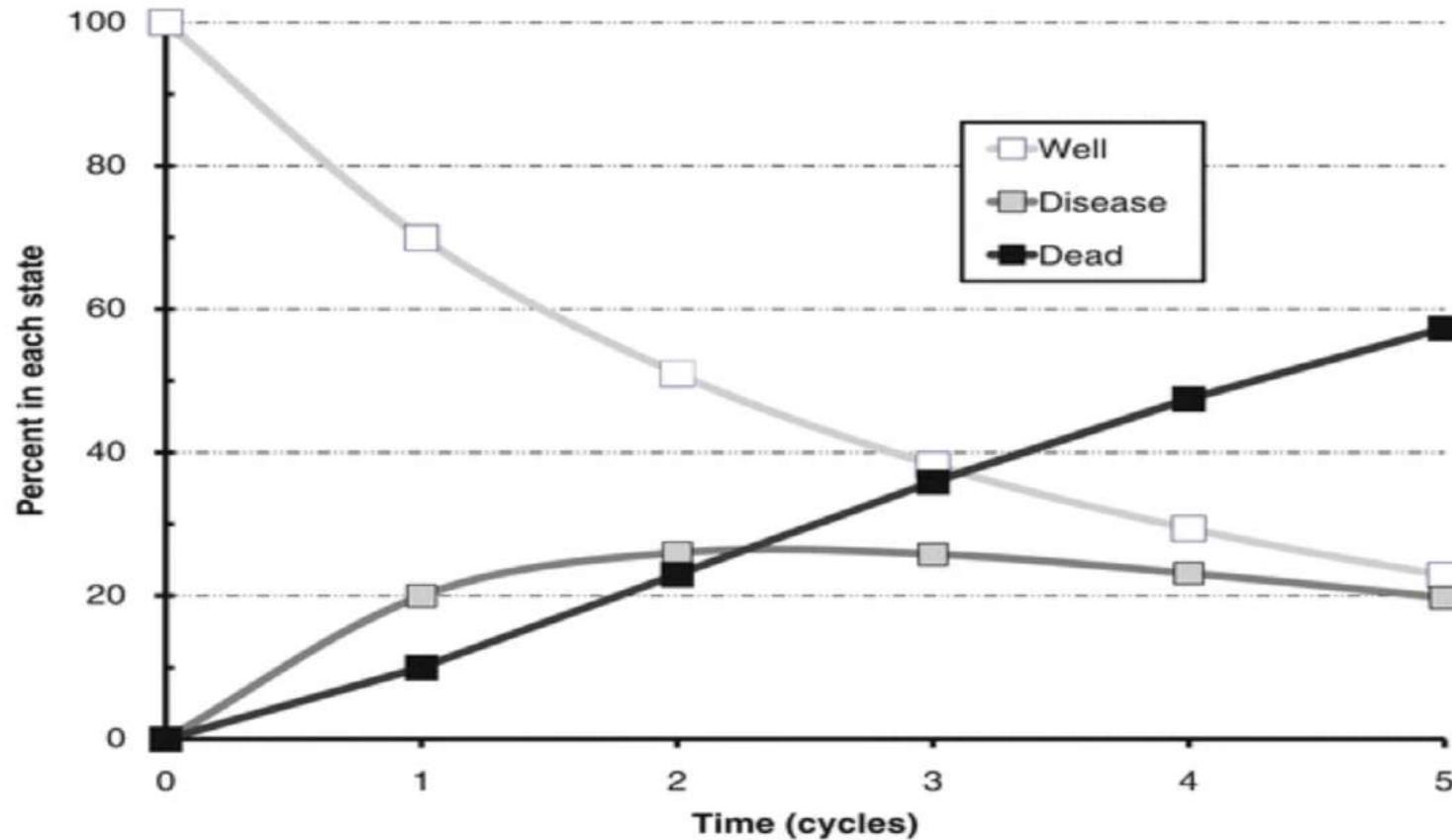


**Figure 1.** Diagram of the Markov model.

Patients occupy health states, shown in the ovals and boxes. Patients transition from different health states represented as arrows based on transition probabilities derived from participant-level data from DAPA-HF and DELIVER. Worsening HF events include hospitalization for HF and urgent HF visits. DAPA-HF indicates Dapagliflozin and Prevention of Adverse Outcomes in Heart Failure; DELIVER, Dapagliflozin Evaluation to Improve the Lives of Patients With Preserved Ejection Fraction Heart Failure; and HF, heart failure.

# 實例 3- Markov Trace

**Fig. 5.3**



Graphical depiction of the Markov trace for a simple Markov model

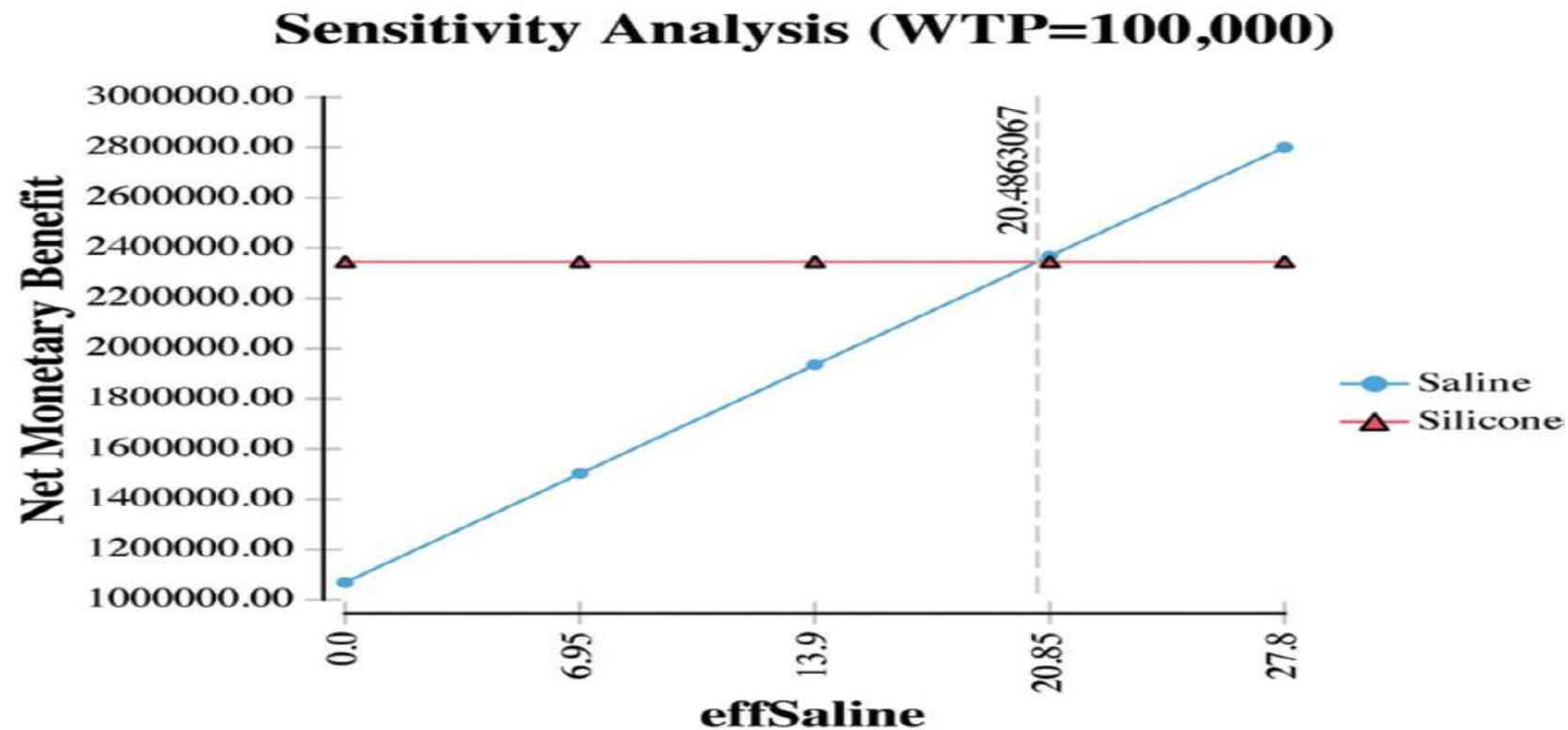
# 實例 4- ICER

**Table 3** Within-trial cost-effectiveness analysis

Cost-effectiveness	Costs (95% CI)	QALYs (95% CI)	Inc Costs (95% CI)	Inc QALY (95% CI)	ICER
	[P(most costly)]	[P(most effective)]			
<b>Dyad</b>					
Services as usual	£1,988.61 (146.79, 2615.43) [0.037]	2.58680 (2.54927, 2.62129) [0.06]			
E-SEE Steps	£2,609.46 (2312.07, 2951.04) [0.963]	2.61775 (2.60252, 2.6342) [0.94]	£620.85 (-103.32, 1288.70)	0.03095 (-0.00830, 0.07094)	£20,061.02
<b>Primary carer</b>					
Services as usual	£942.44 (604.51, 1461.11) [0.052]	1.31392 (1.27465, 1.35166) [0.044]			
E-SEE Steps	£1,388.26 (1142.31, 1639.19) [0.948]	1.34818 (1.33322, 1.36373) [0.956]	£445.82 (-136.90, 890.20)	0.03427 (-0.00643, 0.07679)	£13,010.68
<b>Child</b>					
Services as usual	£1,000.28 (746.07, 1322.25) [0.143]	1.27420 (1.26722, 1.28191) [0.868]			
E-SEE Steps	£1,177.33 (1034.65, 1340.39) [0.856]	1.26957 (1.26629, 1.27261) [0.132]	£177.05 (-175.88 484.85)	-0.00463 (-0.01333, 0.00331)	Dominated



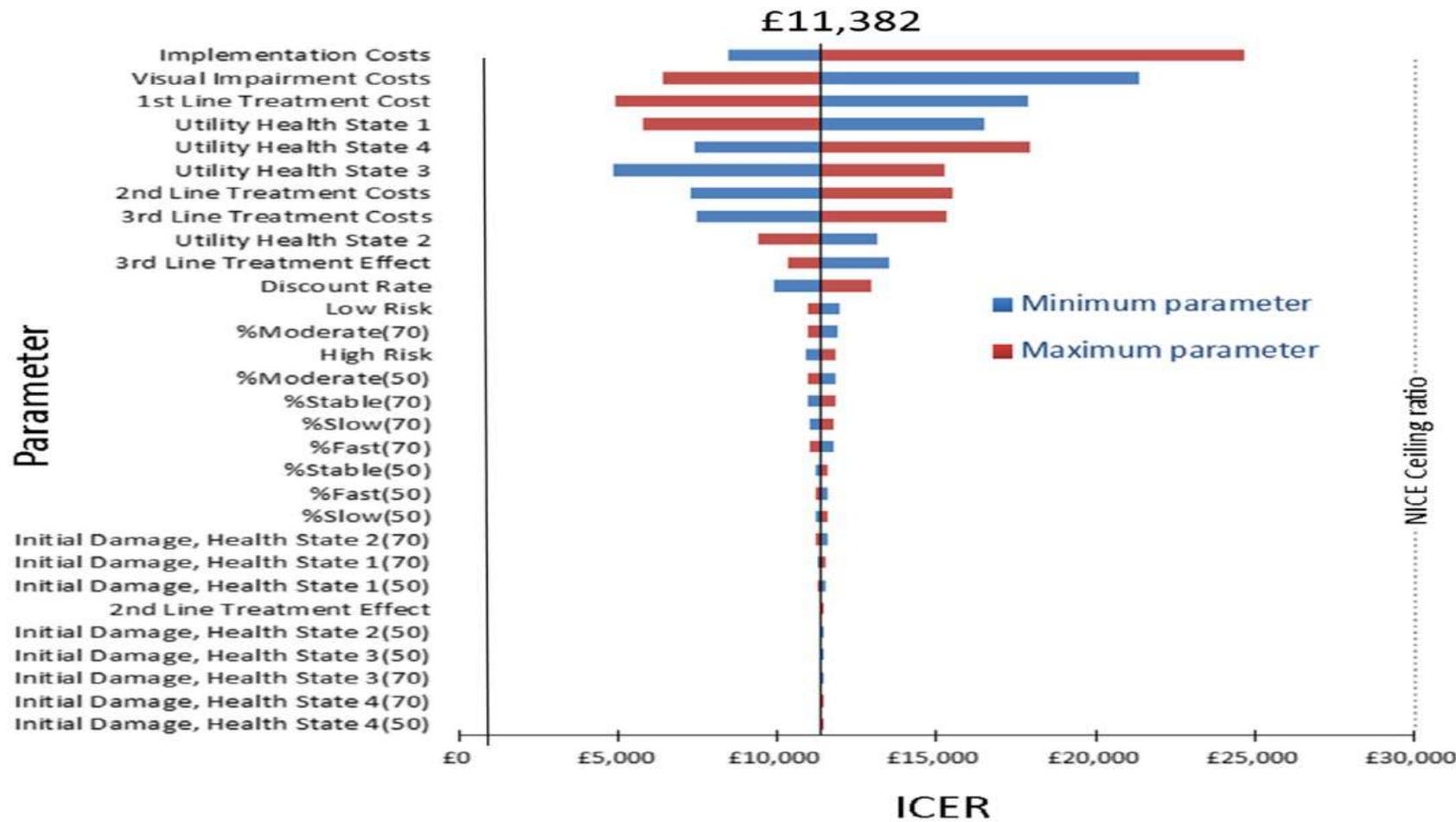
# 實例 5- Net Monetary Benefit



**Fig. 2.** Sensitivity analysis by differential effectiveness showing the BREAST-Q-adjusted life-year threshold (20.5) at which saline yields a greater net monetary benefit. The net monetary benefit calculation combines cost, effectiveness (*eff*), and willingness-to-pay (*WTP*) (set at \$100,000) into a single measurement (created using TreeAge Pro 2017).



# 實例 6- Tornado Diagram

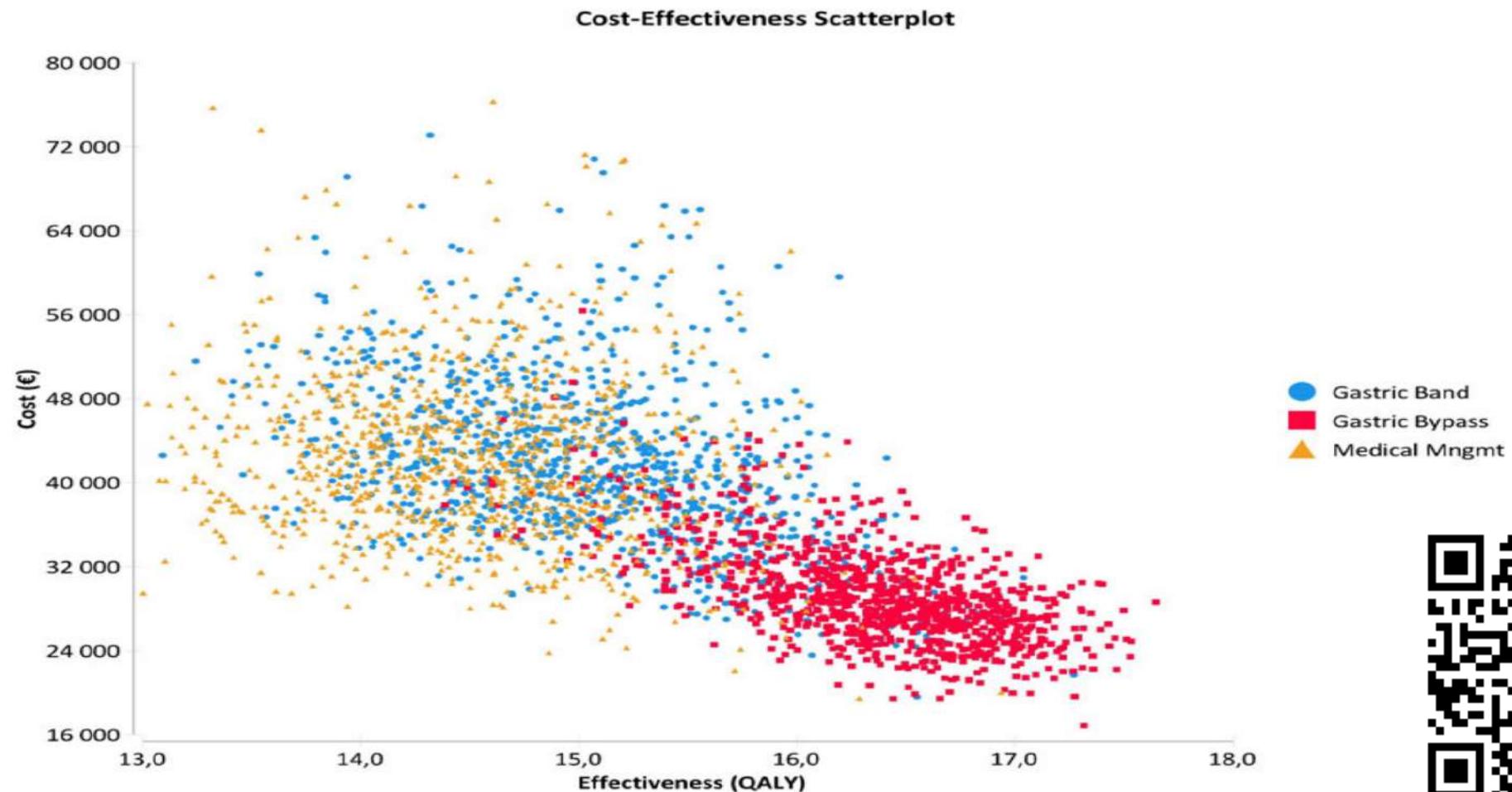


**Fig. 4** Tornado Diagram measuring the impact in variation in parameters for the health economic model with included visual impairment costs (ICER = £11,382). Maximum and minimum limits for parameters were identified. ICERs were derived and ordered in terms of impact (greatest to lowest ICER variation)

Source: Boodhna et al (2016) BMC Health Service Research



# 實例 7- Cost-Effectiveness Scatterplot



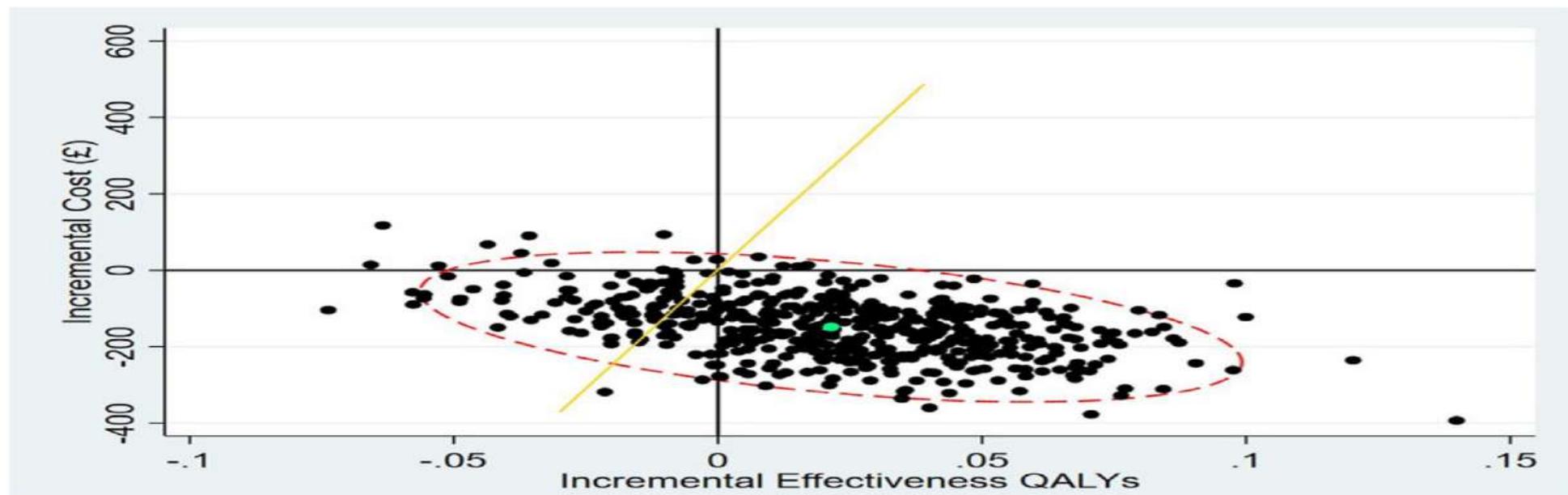
**Fig. 2** Cost-effectiveness scatter plot

Source: Faria et al (2013) Obesity Surgery

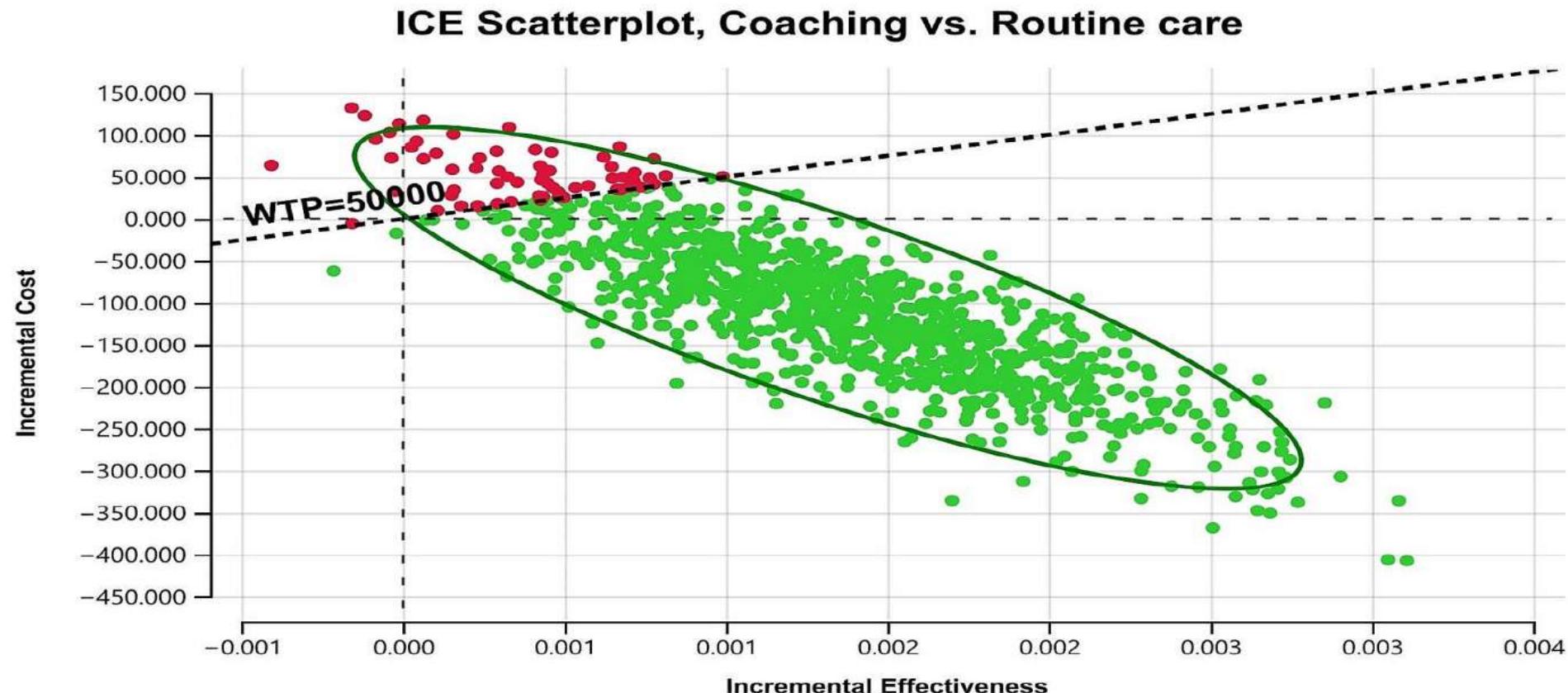


# 實例 8- Cost-Effectiveness Scatterplot

**Figure 1.** Incremental cost-effectiveness scatterplot of self-management compared with clinic-based care for 10 000 sampled individuals (5% of values shown). The dotted red line denotes the 95% confidence interval, the green coloured dot denotes the mean and the yellow line denotes the willingness to pay threshold.



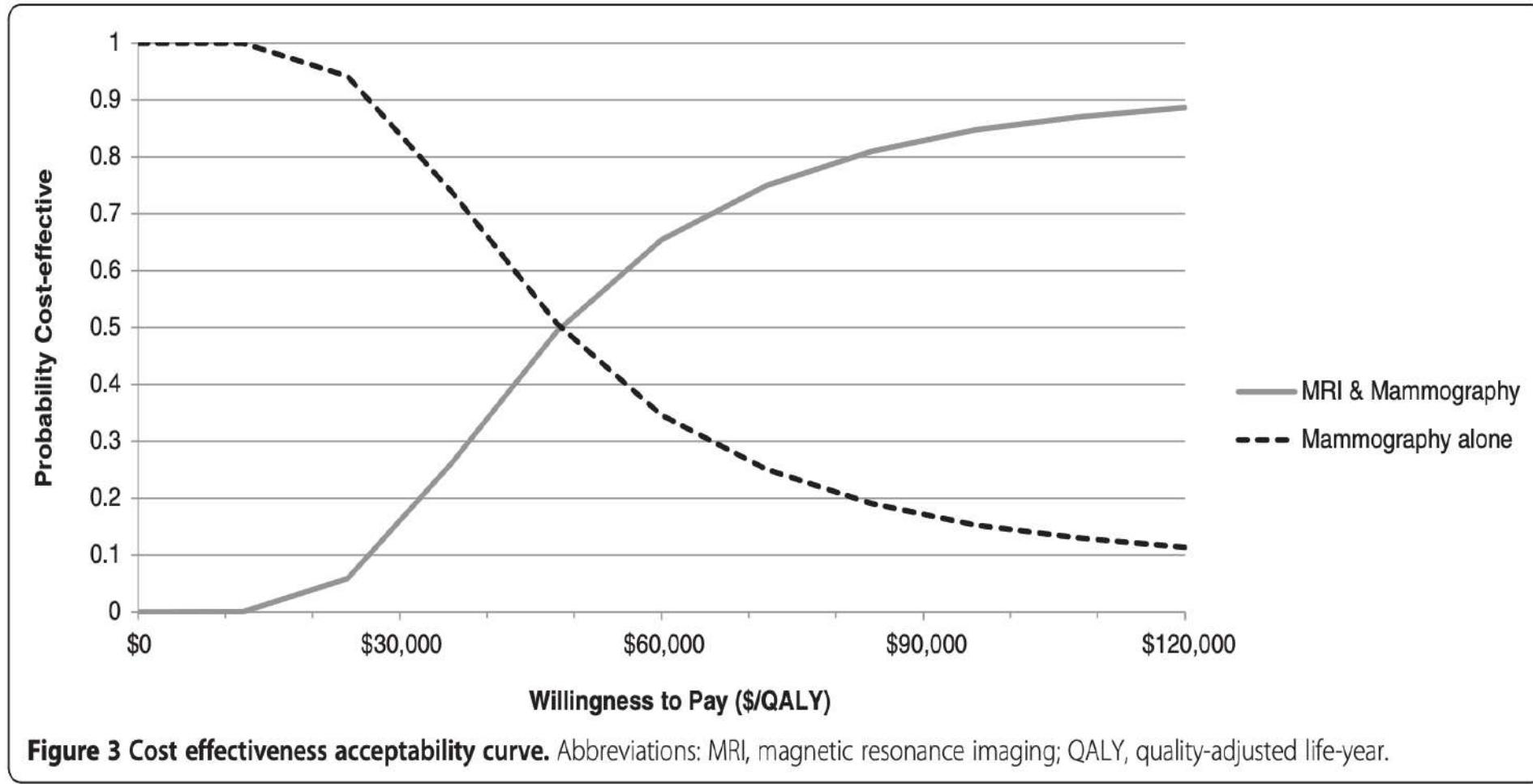
# 實例 9- Monte Carlo Simulation of Incremental Cost-Effectiveness



**Fig. 4** Monte Carlo simulations scatter plot of incremental cost-effectiveness of coaching compared with routine care with a willingness to pay (WTP) of AUD50,000



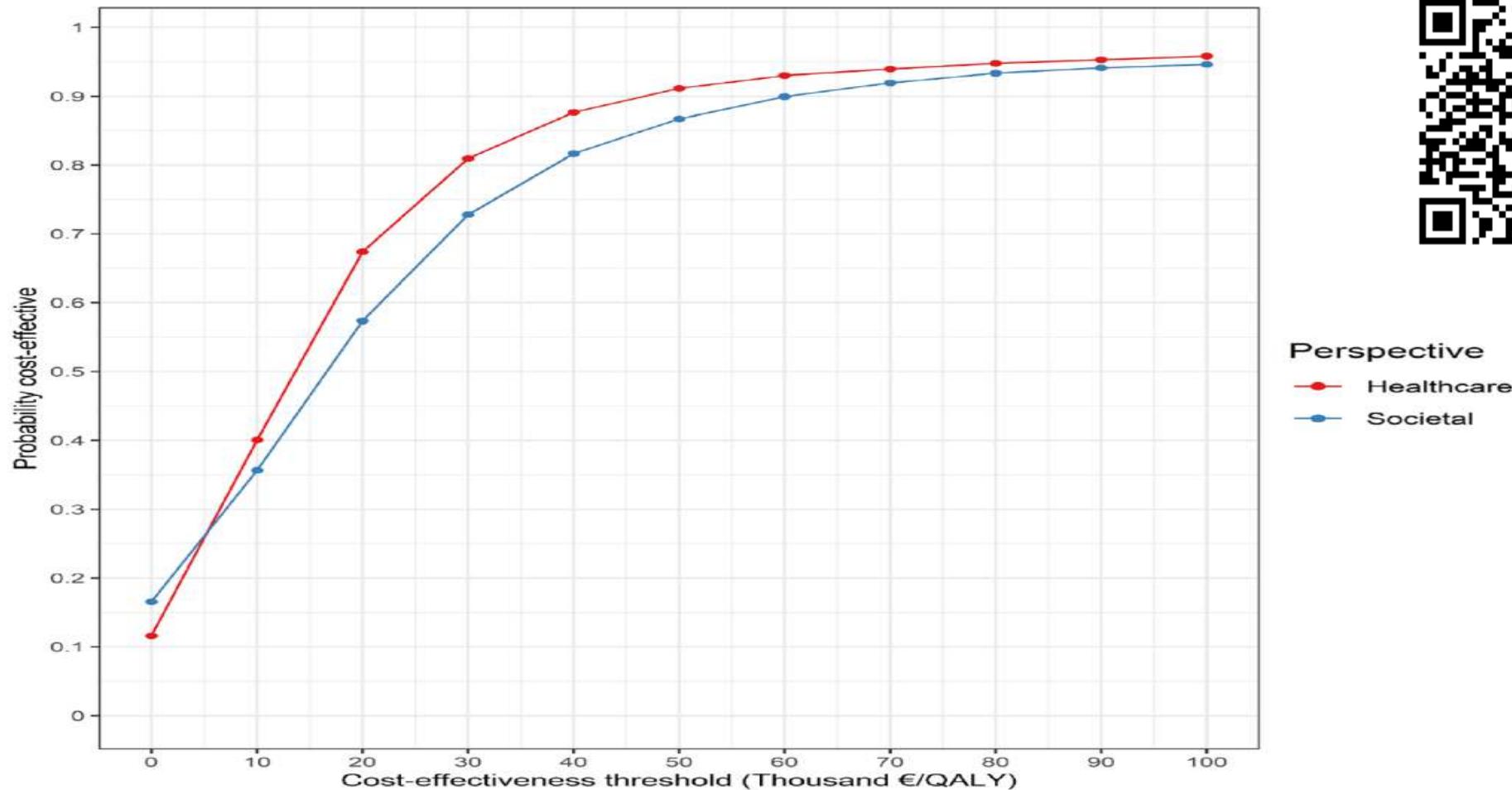
# 實例 10- Cost-Effectiveness Acceptance Curve(s)



Source: Pataky et al (2013) BMC Cancer



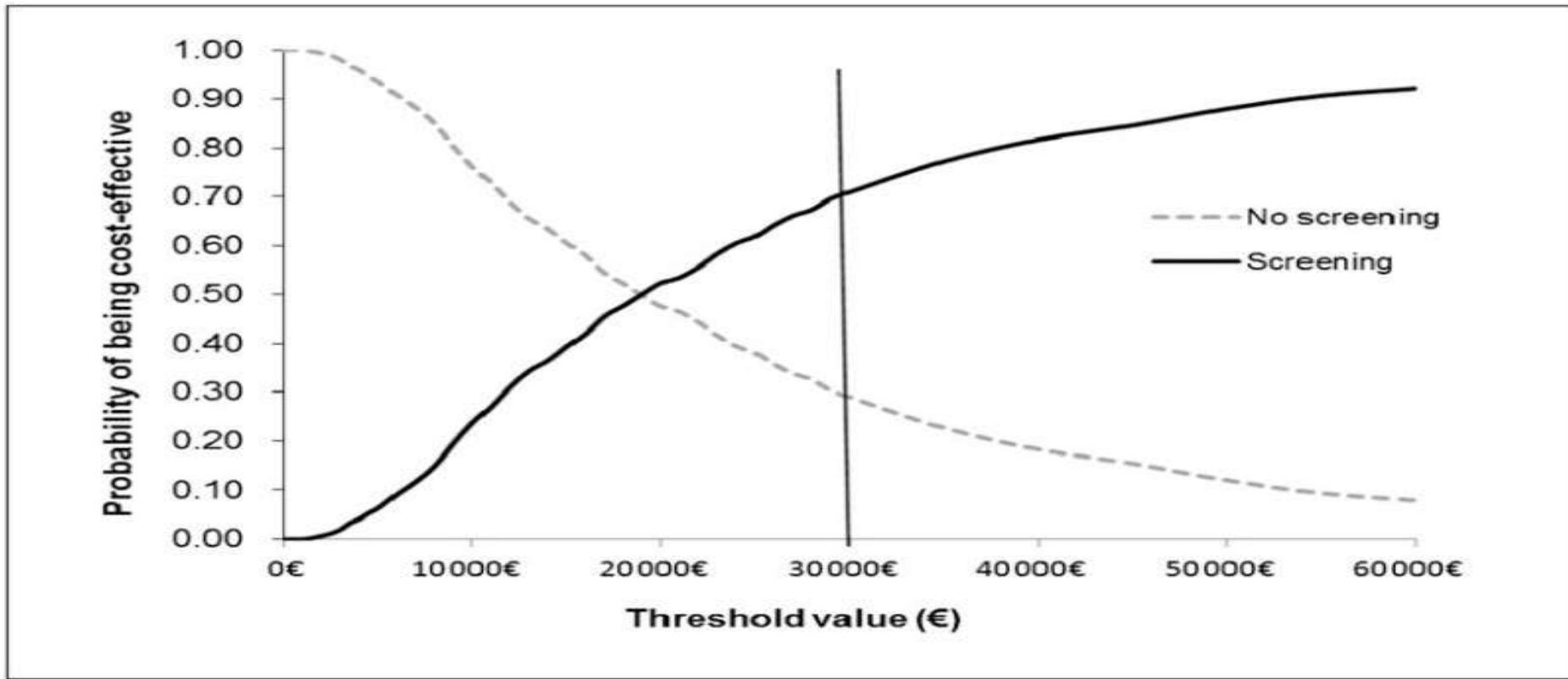
# 實例 11- Cost-Effectiveness Acceptance Curve(s)



Perspective  
— Healthcare  
— Societal

**Figure 3.** Cost-effectiveness acceptability curve. At a cost-effectiveness threshold of €50,000/QALY, EVT was cost-effective in 87% of replications from a societal perspective, and in 91% of replications from a healthcare perspective.

## 實例 12- Cost-Effectiveness Acceptance Curve(s)



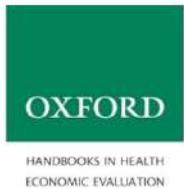
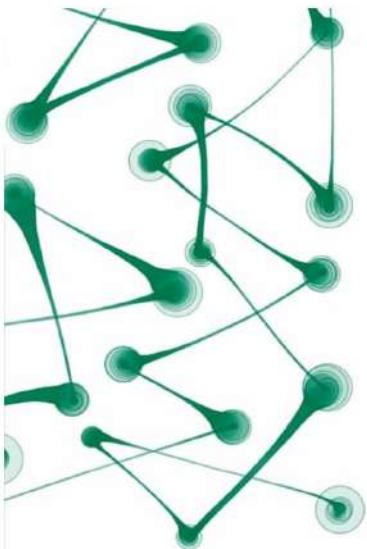
**FIGURE 2**

Cost-effectiveness acceptability curves. Note: Threshold value of €30 000 = US\$40 000.



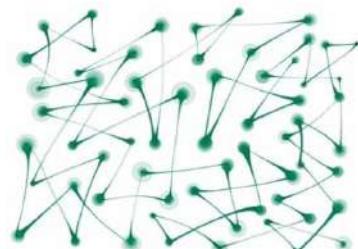
□ 單元三：  
Decision Tree Modelling in Excel

# Decision Tree Modelling in Excel (1)



**Decision Modelling for  
Health Economic Evaluation**

ANDREW BRIGGS  
MARK SCULPHER  
KARL CLAXTON



**Cost-Effectiveness  
Analysis in  
Health**

THIRD EDITION

**A Practical Approach**

**JOSSEY-BASS™**  
A Wiley Brand

# Decision Tree Modelling in Excel (2)

ORIGINAL RESEARCH ARTICLE

Pharmacoconomics 1997 Nov; 12 (5): 565-577  
1170-7690/97/0011-0565/\$06.50/0

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## Economic Evaluation of Oral Sumatriptan Compared with Oral Caffeine/Ergotamine for Migraine

Kenneth W. Evans,<sup>1</sup> John A. Boan,<sup>2</sup> John L. Evans<sup>3</sup> and Ashfaq Shuaib<sup>4</sup>

<sup>1</sup> Saskatchewan Health, Regina, Saskatchewan, Canada

<sup>2</sup> Department of Economics, University of Regina, Regina, Saskatchewan, Canada

<sup>3</sup> Department of Health, Government of Canada, Vancouver, British Columbia, Canada

<sup>4</sup> Department of Neurology, University of Saskatchewan, Saskatoon, Saskatchewan, Canada

### Summary

We conducted an economic comparison of oral sumatriptan with oral caffeine/ergotamine in the treatment of patients with migraine. Cost-effectiveness, cost-utility and cost-benefit analyses were conducted from societal and health-departmental perspectives. A decision tree was used. Utilities were assigned to health states using the Quality of Well-Being Scale. Simple and probabilistic sensitivity analyses were also carried out.

From a societal perspective, using sumatriptan instead of caffeine/ergotamine resulted in an incremental cost-effectiveness ratio of -25 Canadian dollars (\$Can) per attack aborted, an incremental cost-utility ratio of -\$Can7507 per quality-adjusted life-year (QALY), and a net economic benefit of \$Can42 per patient per year (1995 values). From the perspective of the health department, the incremental cost-effectiveness ratio was \$Can98 per attack aborted, the incremental cost-utility ratio was \$Can29 366 per QALY; the grade of recommendation based on past decisions regarding health technology for adoption into health insurance plans was 'moderate'. Sensitivity analysis showed that the results were robust to relatively large changes in the input variables.

The incremental health benefits obtained from using oral sumatriptan rather than oral caffeine/ergotamine were achieved at moderately acceptable incremental costs, if past decisions on the adoption of other health technologies are used as a guide.

Source: Evans et al (1997) Pharmacoconomics

# Decision Tree Modelling in Excel (3)

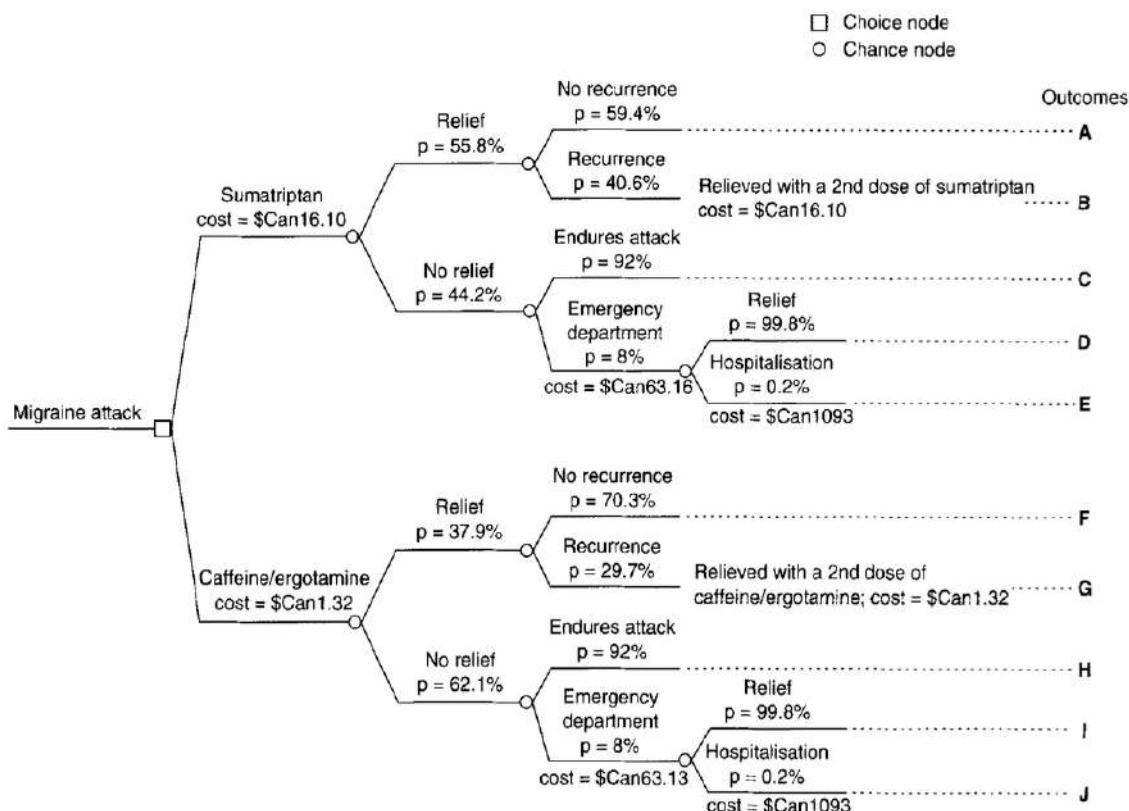


Fig. 1. Decision tree used in the model.

Table VI. Outcome values of the decision tree (outcomes are shown in figure 1) [all costs are expressed in 1995 Canadian dollars (\$Can)]

Outcome	Probability (%)	Cost (\$Can)	Expected cost (\$Can)	Utility	Expected utility
<b>Sumatriptan</b>					
A	33.1	16.10	5.34	1.00	0.33
B	22.7	32.20	7.29	0.90	0.20
C	40.7	16.10	6.55	-0.30	-0.12
D	3.5	79.26	2.80	0.10	0.0035
E	0.007	1172	0.08	-0.30	-0.000021
<b>Total</b>	<b>100</b>		<b>22.06</b>		<b>0.42</b>
<b>Caffeine/ergotamine</b>					
F	26.6	1.32	0.35	1.00	0.27
G	11.3	2.64	0.30	0.90	0.10
H	57.1	1.32	0.75	-0.30	-0.17
I	5.0	64.45	3.20	0.10	0.0050
J	0.010	1157	0.11	-0.30	-0.000030
<b>Total</b>	<b>100</b>		<b>4.71</b>		<b>0.20</b>

## Results

### Base-Case Evaluation

The outcome values of the decision tree are shown in table VI. Assuming an incremental effect with the use of sumatriptan of  $(55.8 - 37.9\%) = 17.9\%$ , the incremental cost was \$Can17.34, and the incremental utility was 0.22.

Table VII shows the incremental cost-effectiveness and cost-utility ratios, and the net economic benefit, associated with using sumatriptan in place of caffeine/ergotamine.

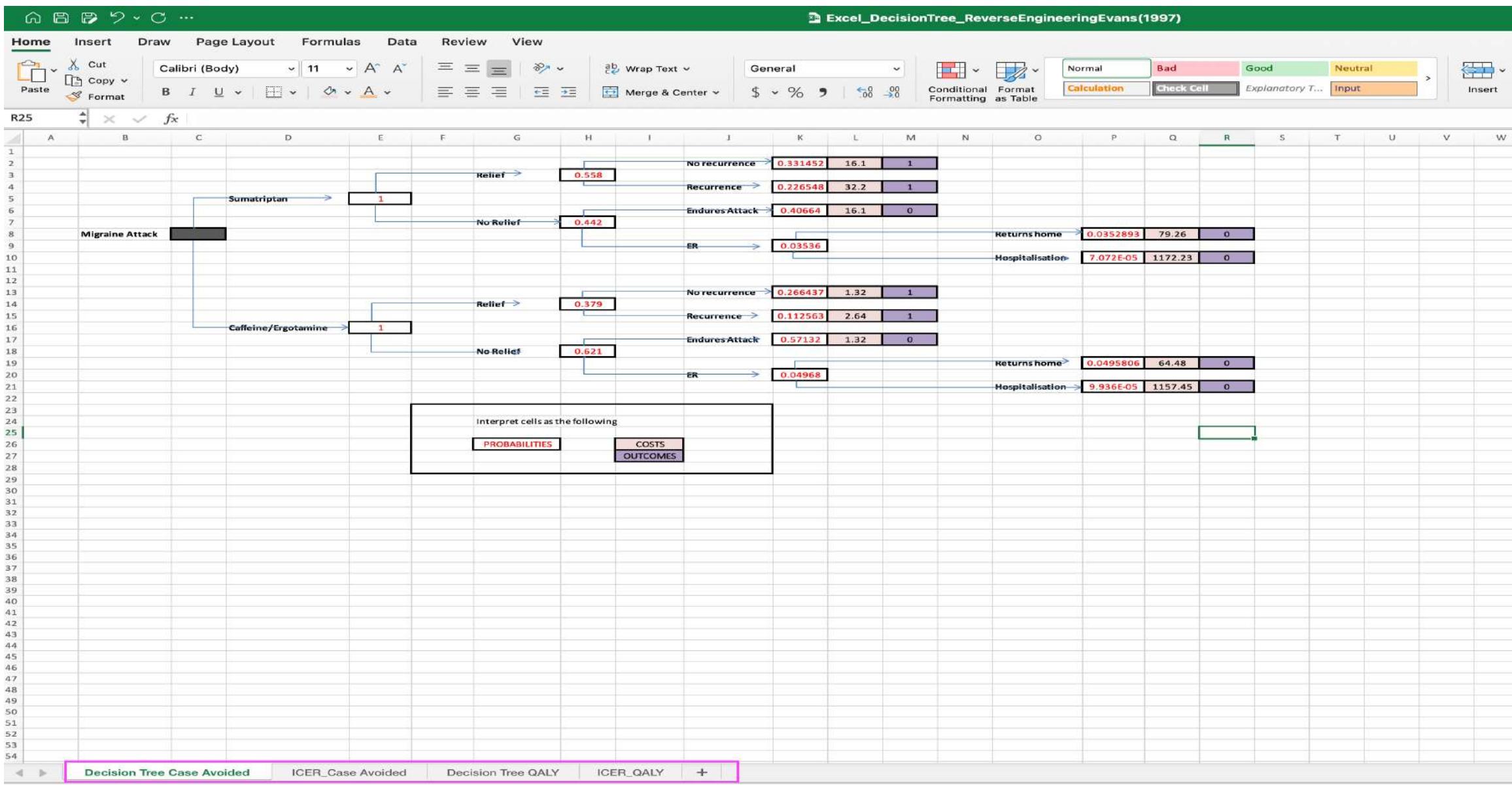
From the societal perspective, the use of oral sumatriptan resulted in net savings as well as improved health outcomes, as evidenced by the negative cost-effectiveness and cost-utility ratios and the positive net economic benefit.

From the health-departmental perspective, the use of oral sumatriptan resulted in net costs for improved health outcomes. The cost-effectiveness ratio was \$Can98 per attack aborted, and the cost-utility ratio was \$Can29 366 per QALY. This cost-utility ratio translates into a 'moderate' recommendation for adoption according to Laupacis et al.<sup>[34]</sup> (table IV).

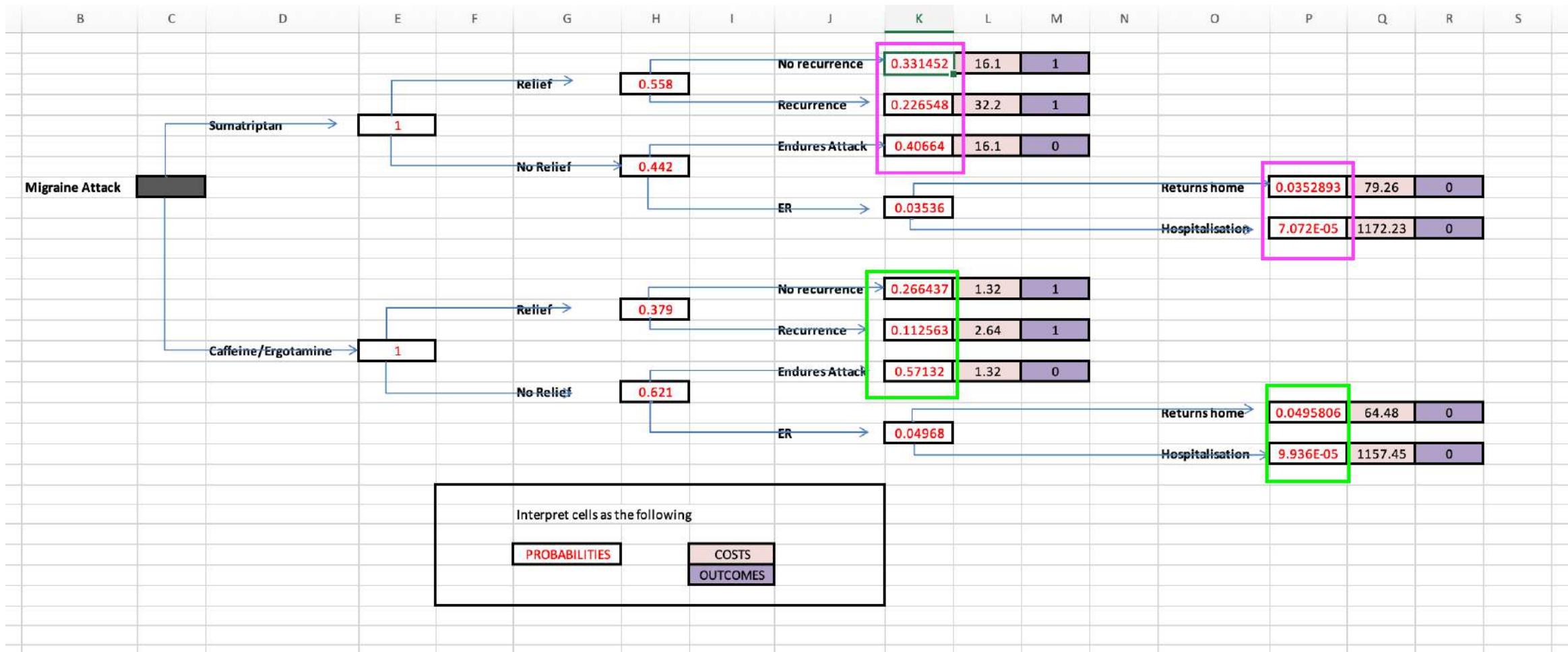
### Sensitivity Analyses

The simple sensitivity analysis (table VIII) showed that from the health-departmental perspective, the results are not sensitive to changes in the various input variables. However, from the societal perspective, the results were sensitive to large changes in relative effectiveness. A threshold analysis indicated that the net economic benefit

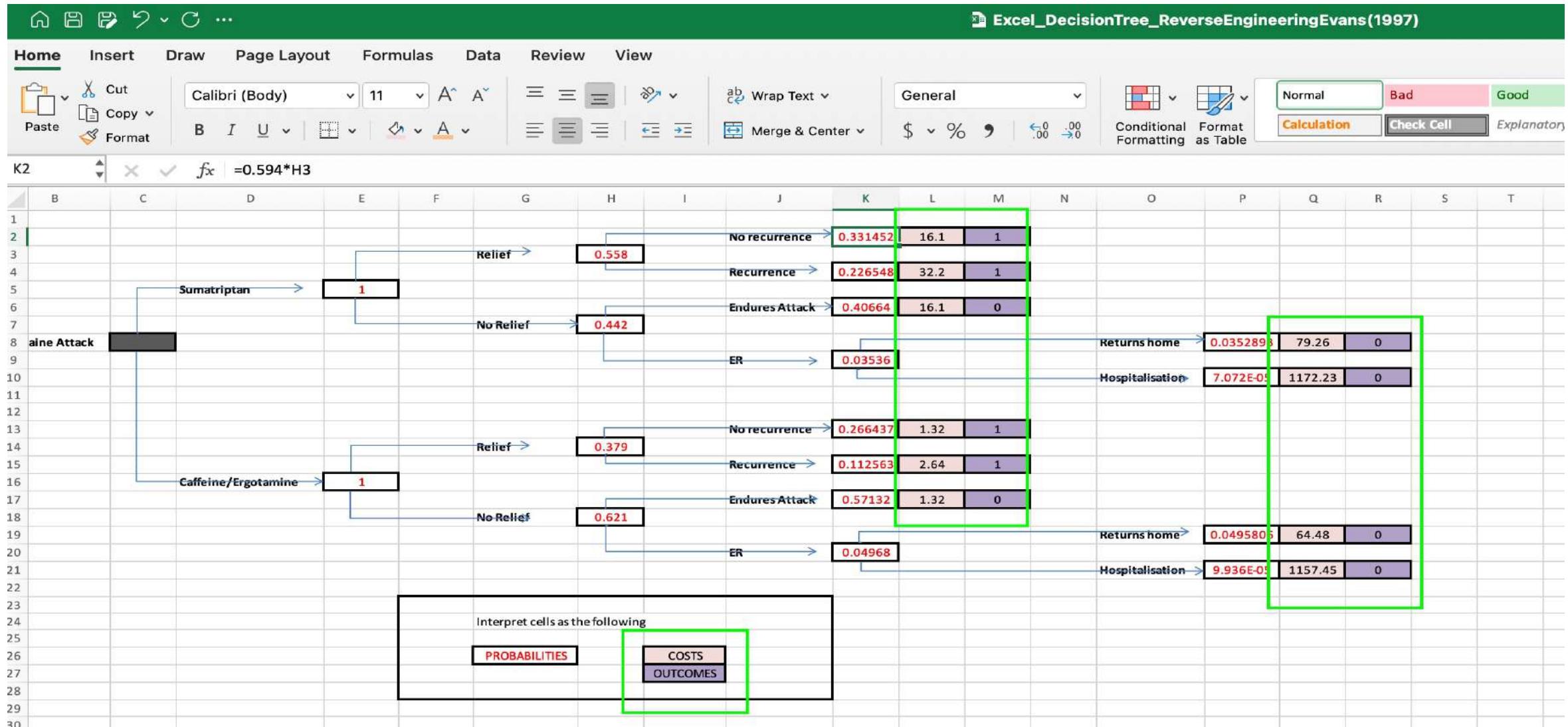
# Decision Tree Modelling in Excel (4)



# Decision Tree Modelling in Excel (5)



# Decision Tree Modelling in Excel (6)



# Decision Tree Modelling in Excel (7)

Excel\_DecisionTree\_ReverseEngineeringEvans(1997)

**Sumatriptan**

	Sumatriptan			Caffeine/Ergotamine		
	Prob	Cost	Outcomes	Prob	Cost	Outcomes
All cases	1.000			1.000		
Initial Relief	0.558			0.379		
No Recurrence	0.331452	\$ 16.10	1.00	0.266437	\$ 1.32	1.00
Recurrence	0.226548	\$ 32.20	1.00	0.112563	\$ 2.64	1.00
No Relief	0.442			0.621		
Endures Attack	0.40664	\$ 16.10	-	0.57132	\$ 1.32	-
ER	0.035			0.050		
Relief	0.035289	\$ 79.26	-	0.0495806	\$ 64.48	-
Hospitalisation	7.07E-05	\$ 1,172.23	-	9.936E-05	\$ 1,157.45	-

**Sumatriptan**

	Prob	Cost	Outcomes
No Recurrence	0.331452	\$ 16.10	1.00
Recurrence	0.226548	\$ 32.20	1.00
Endures Attack	0.40664	\$ 16.10	-
Relief	0.035289	\$ 79.26	-
Hospitalisation	7.07E-05	\$ 1,172.23	-

**EXPECTED VALUES**

	\$ 22.06	0.56
Caffeine/Ergotamine	\$ 4.71	0.38

ICER\_Case\_Avoided: 96.88875

Decision Tree Case Avoided    ICER\_Case\_Avoided    Decision Tree QALY    ICER\_QALY

# Decision Tree Modelling in Excel (8)

Excel\_DecimalTree\_ReverseEngineeringEvans(1997)

Home Insert Draw Page Layout Formulas Data Review View

Cut Copy Format Paste

Calibri (Body) 11 A A Wrap Text General \$ % , .00 .00 Conditional Formatting Format as Table Normal Bad Good Neutral Calculation Check Cell Explanatory T... Input

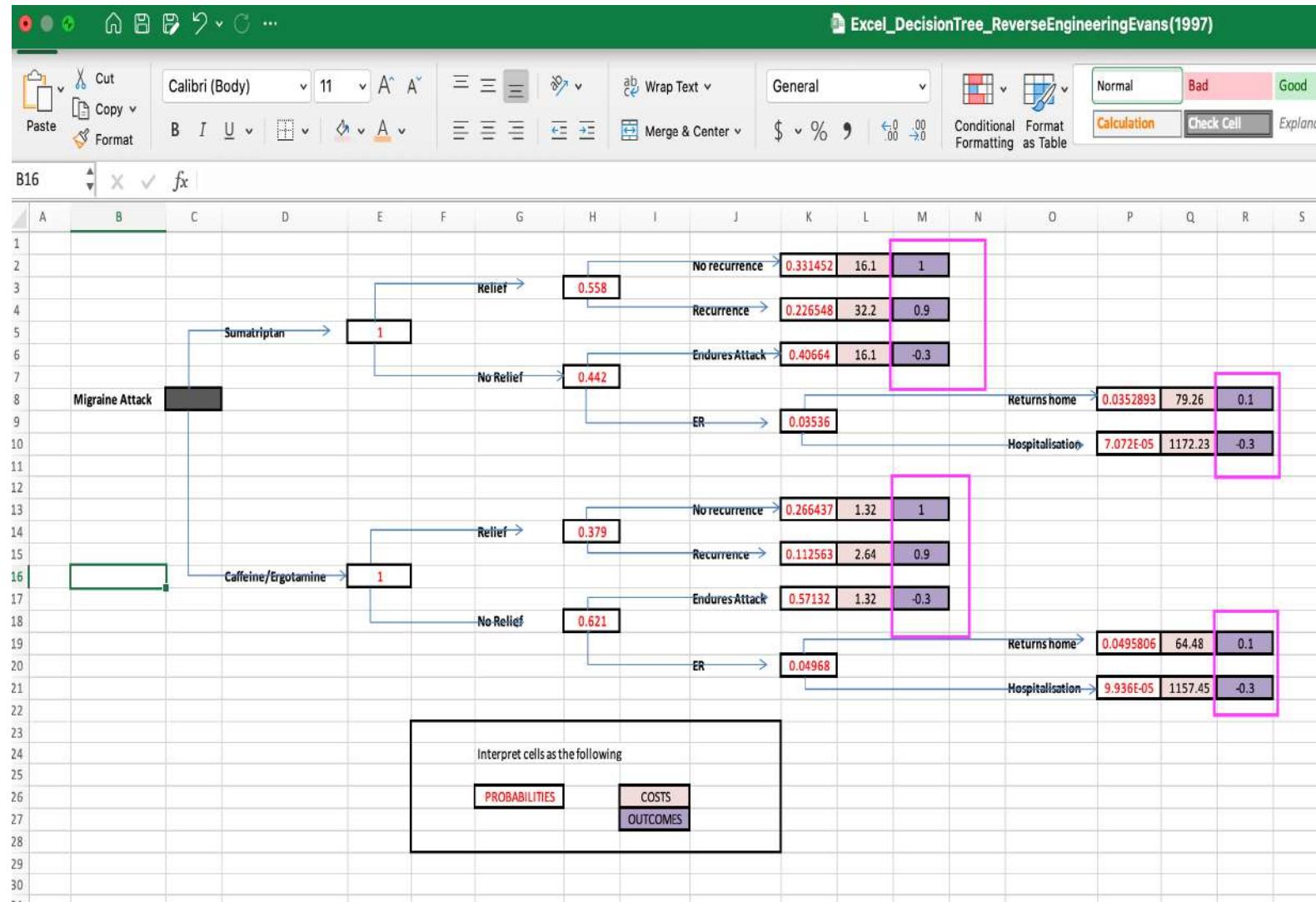
M18 fx = (N13-R13)/(O13-S13)

Sumatriptan			Caffeine/Ergotamine			
	Prob	Cost	Outcomes	Prob	Cost	Outcomes
All cases	1.000			1.000		
Initial Relief	0.558			0.379		
No Recurrence	0.331452	\$ 16.10	1.00	0.266437	\$ 1.32	1.00
Recurrence	0.226548	\$ 32.20	1.00	0.112563	\$ 2.64	1.00
No Relief	0.442			0.621		
Endures Attack	0.40664	\$ 16.10	-	0.57132	\$ 1.32	-
ER	0.035			0.050		
Relief	0.035289	\$ 79.26	-	0.0495806	\$ 64.48	-
Hospitalisation	7.07E-05	\$ 1,172.23	-	9.936E-05	\$ 1,157.45	-

Sumatriptan			Caffeine/Ergotamine			
	Prob	Cost	Outcomes	Prob	Cost	Outcomes
No Recurrence	0.331452	\$ 16.10	1.00	0.266437	\$ 1.32	1.00
Recurrence	0.226548	\$ 32.20	1.00	0.112563	\$ 2.64	1.00
Endures Attack	0.40664	\$ 16.10	-	0.57132	\$ 1.32	-
Relief	0.035289	\$ 79.26	-	0.049581	\$ 64.48	-
Hospitalisation	7.07E-05	\$ 1,172.23	-	9.94E-05	\$ 1,157.45	-
EXPECTED VALUES	\$ 22.06	0.56		\$ 4.71	0.38	

ICER\_Case\_Avoided 96.88875

# Decision Tree Modelling in Excel (9)



**Table II.** Table of utilities (outcomes are shown in figure 1)

Outcome	Mean utility	Standard deviation
A	1.0	0.00
B	0.9	0.01
C	-0.3	0.10
D	0.1	0.10
E	-0.3	0.10
F	1.0	0.00
G	0.9	0.01
H	-0.3	0.10
I	0.1	0.10
J	-0.3	0.10

# Decision Tree Modelling in Excel (10)

Excel\_DecisionTree\_ReverseEngineeringEvans(1997)

M18 
$$fx = (N13-R13)*365/(O13-S13)$$

Sumatriptan			Caffeine/Ergotamine			
Prob	Cost	Outcomes	Prob	Cost	Outcomes	
All cases	1.000		1.000			
Initial Relief	0.558		0.379			
No Recurrence	0.331452	\$ 16.10	1.00	0.266437	\$ 1.32	1.00
Recurrence	0.226548	\$ 32.20	0.90	0.112563	\$ 2.64	0.90
No Relief	0.442		0.621			
Endures Attack	0.40664	\$ 16.10	- 0.30	0.57132	\$ 1.32	- 0.30
ER	0.035		0.050			
Relief	0.035289	\$ 79.26	0.10	0.049581	\$ 64.48	0.10
Hospitalisation	7.07E-05	\$ 1,172.23	- 0.30	9.94E-05	\$ 1,157.45	- 0.30

Sumatriptan			Caffeine/Ergotamine			
Prob	Cost	Outcomes	Prob	Cost	Outcomes	
No Recurrence	0.331452	\$ 16.10	1.00	0.266437	\$ 1.32	1.00
Recurrence	0.226548	\$ 32.20	0.90	0.112563	\$ 2.64	0.90
Endures Attack	0.40664	\$ 16.10	- 0.30	0.57132	\$ 1.32	- 0.30
Relief	0.035289	\$ 79.26	0.10	0.049581	\$ 64.48	0.10
Hospitalisation	7.07E-05	\$ 1,172.23	- 0.30	9.94E-05	\$ 1,157.45	- 0.30

EXPECTED VALUES			
\$ 22.06	0.42	\$ 4.71	0.20

ICER\_QALY 29363.02

incremental cost-utility ratio = incremental cost  
× attack frequency/incremental QALYs  
= incremental cost × 365/incremental utility (Eq. 4)

□ 單元四：  
Building Markov Model in Excel

## □ 單元四： Markov Model in Excel

情境：

小李想用Markov Model 了解2007年~2015年  
iPhone、Samsung或他牌，各個品牌市佔率的變化。

請開啟一個空白的Excel檔案，並輸入以下的值建立表格：

	A	B	C	D	E
1		To			
2		Iphone	Samsung	Others	
3	From	Iphone	90%	10%	0%
4		Samsung	60%	20%	20%
5		Others	40%	10%	50%

轉移機率 ( Transition Probability ) 總和應為1

→ 品牌忠誠度

# Markov Model in Excel (2)

## 【概念說明】

建立另一個表格 (I~L) , 如右圖  
假設第一年有1000人使用Samsung ,  
且設定一個Cycle是一年 , 一直到2015年  
針對不同品牌將數量乘以轉移機率。

	A	B	C	D	E
1			To		
2			Iphone	Samsung	Others
3	From	Iphone	90%	10%	0%
4	Samsung	60%	20%	20%	
5	Others	40%	10%	50%	

以2008年iPhone為例：

$$0*90\% + 1000*60\% + 0*40\% = \underline{\underline{600}}$$

( 1000人中有600人拿iPhone )

	I	J	K	L
1	Cycle	Iphone	Samsung	Others
2	2007	0.0	1000.0	0.0
3	2008	600.0	200.0	200.0
4	2009	740.0	120.0	140.0
5	2010	794.0	112.0	94.0
6	2011	819.4	111.2	69.4
7	2012	831.9	111.1	56.9
8	2013	838.2	111.1	50.7
9	2014	841.3	111.1	47.6
10	2015	842.9	111.1	46.0

# Markov Model in Excel (3)

【概念說明】

接下來看看2009年要怎麼算？

	A	B	C	D	E
1			To		
2			Iphone	Samsung	Others
3	From	Iphone	90%	10%	0%
4	Samsung	60%	20%	20%	
5	Others	40%	10%	50%	

以2009年iPhone為例：

$$600 * 90\% + 200 * 60\% + 200 * 40\% = \underline{\text{740}}$$

(1000人中有740人拿iPhone)

	I	J	K	L
1	Cycle	Iphone	Samsung	Others
2	2007	0.0	1000.0	0.0
3	2008	600.0	200.0	200.0
4	2009	740.0	120.0	140.0
5	2010	794.0	112.0	94.0
6	2011	819.4	111.2	69.4
7	2012	831.9	111.1	56.9
8	2013	838.2	111.1	50.7
9	2014	841.3	111.1	47.6
10	2015	842.9	111.1	46.0

# Markov Model in Excel (4)

不過一個一個算太複雜了！

可以使用Excel內建的Function，  
公式長這樣：

=MMULT(J2:L2,\$C\$3:\$E\$5)

↑  
加入金錢符號鎖定欄位

	A	B	C	D	E
1			To		
2			Iphone	Samsung	Others
3	From	Iphone	90%	10%	0%
4		Samsung	60%	20%	20%
5		Others	40%	10%	50%

	I	J	K	L
1	Cycle	Iphone	Samsung	Others
2	2007	0.0	1000.0	0.0
3	2008			
4	2009			
5	2010			
6	2011			
7	2012			
8	2013			
9	2014			
10	2015			

在J3年這格輸入  
=MMULT(J2:L2,\$C\$3:\$E\$5)  
按enter

鎖定欄位快捷鍵：Mac 是Fn+F4 / Windows是 F4

# Markov Model in Excel (5)

不過一個一個算太複雜了！

可以使用Excel內建的Function，

公式長這樣：

=MMULT(J2:L2,\$C\$3:\$E\$5)

↑  
加入金錢符號鎖定欄位

	A	B	C	D	E
1		To			
2		Iphone	Samsung	Others	
3	From	Iphone	90%	10%	0%
4		Samsung	60%	20%	20%
5		Others	40%	10%	50%

	I	J	K	L
1	Cycle	Iphone	Samsung	Others
2	2007	0.0	1000.0	0.0
3	2008	600.0	200.0	200.0
4	2009			
5	2010			
6	2011			
7	2012			
8	2013			
9	2014			
10	2015			

輸入好公式之後  
並框下J3~L3，  
游標移到右下角出現 +  
長按複製下拉到2015年

鎖定欄位快捷鍵：Mac 是Fn+F4 / Windows是 F4

# Markov Model in Excel (6)

不過一個一個算太複雜了！

可以使用Excel內建的Function，

公式長這樣：

=MMULT(J2:L2,\$C\$3:\$E\$5)

↑  
加入金錢符號鎖定欄位

	A	B	C	D	E
1			To		
2			Iphone	Samsung	Others
3	From	Iphone	90%	10%	0%
4		Samsung	60%	20%	20%
5		Others	40%	10%	50%

結果就出來拉！

	I	J	K	L
1	Cycle	Iphone	Samsung	Others
2	2007	0.0	1000.0	0.0
3	2008	600.0	200.0	200.0
4	2009	740.0	120.0	140.0
5	2010	794.0	112.0	94.0
6	2011	819.4	111.2	69.4
7	2012	831.9	111.1	56.9
8	2013	838.2	111.1	50.7
9	2014	841.3	111.1	47.6
10	2015	842.9	111.1	46.0

鎖定欄位快捷鍵：Mac 是Fn+F4 / Windows是 F4

# Markov Model in Excel (7) – 生(老)病死

情境：

最近國健署想要降低台灣人的肥胖率，以避免心血管疾病發生，因此投入每個人500元的成本去健身房運動，看看未來50年的狀況，透過Markov Model來進行成本效益分析：

- Population: 1000位健康的人
- Intervention : 上健身房
- Comparator : usual care

STEP1：先替Usual Care組建立兩張表格，計算每個cycle在不同的健康狀態裡分別有多少人。

	A	B	C	D	E	F	G	H	I
1	Transition matrix					Cycle			
2		Healthy	Sick	Dead			Healthy	Sick	Dead
3	Healthy		0.91	0.07	0.02		1	1000	0
4	Sick		0	0.95	0.05			=MMULT(G2:I2,\$B\$3:\$D\$5)	
5	Dead		0	0	1				
6									
7									
8									
9									

1. 建立每個不同健康狀態的轉移機率的列聯表

1	Healthy	Sick	Dead
2	1000	0	0
3	=MMULT(G2:I2,\$B\$3:\$D\$5)		
4	2. 初始值是1000位健康的人，		
5	3. 接著在G2這格輸入上列公式		
6	=MMULT(G2:I2,\$B\$3:\$D\$5)		
7	4. 按enter，複製往下拉到Cycle		
8	第50年		

# Markov Model in Excel (8) – 生(老)病死

情境：

最近國健署想要降低台灣人的肥胖率，以避免心血管疾病發生，因此投入每個人500元的成本去健身房運動，看看未來50年的狀況，透過Markov Model來進行成本效益分析：

- Population: 1000位健康的人
- Intervention : 上健身房
- Comparator : usual care

STEP1：先替Usual Care組建立兩張表格，計算每個cycle在不同的健康狀態裡分別有多少人。

數值結果如下，供參照

	A	B	C	D	E	F	G	H	I
1	Transition matrix					Cycle	Healthy	Sick	Dead
2		Healthy	Sick	Dead		1	1000	0	0
3	Healthy		0.91	0.07	0.02	2	910	70	20
4	Sick		0	0.95	0.05	3	828.1	130.2	41.7
5	Dead		0	0	1	4	753.571	181.657	64.772
6						5	685.74961	225.32412	88.92627
7						6	624.032145	262.060387	113.907468
8						7	567.869252	292.639618	139.49113
9						8	516.761019	317.758484	165.480496

# Markov Model in Excel (9) – 生(老)病死

STEP 2：另外要計算COSTs和QALY，在同張表單裡面建立下列表格1、2，

表格1

	A	B	C
10		Costs	QALY
11	Healthy	50	0.9
12	Sick	1000	0.6
13		1. 建立表格1	
14			
15	Discount Rate		3%

Cost這樣算

參照上一張表格Cycle 2的人數：

- Healthy =  $910 \times 50 = 45,500$
- Sick =  $70 \times 1000 = 70,000$
- Total Cost =  $115,500$

F	G	H
Cycle	Healthy	Sick
1	1000	0
2	910	70
3	828.1	130.2
4	753.571	181.657
5	685.74961	225.32412
6	624.032145	262.060387
7	567.869252	292.639618
8	516.761019	317.758484

表格2

M2	L	M	N	O
1	Costs	Healthy	Sick	Total
2		50000	0	50000
3				
4				
5				
6				
7				
8				
9				
10				

2. 建立表格2  
 3. 在M2輸入公式  
 $=G2*\$B\$11$   
 4. 在N2輸入公式  
 $=H2*\$B\$12$   
 5. 在O2輸入公式  
 $=M2+N2$   
 6. 複製往下拉到cycle 50



# Markov Model in Excel (10) – 生(老)病死

STEP 2：另外要計算COSTs和QALY，在同張表單裡面建立下列表格1、2，

表格1

	A	B	C
10		Costs	QALY
11	Healthy	50	0.9
12	Sick	1000	0.6
13			
14			
15	Discount Rate	3%	

Cost這樣算

參照上一張表格Cycle 2的人數：

- Healthy =  $910 \times 50 = 45,500$
- Sick =  $70 \times 1000 = 70,000$
- Total Cost =  $115,500$

F	G	H
Cycle	Healthy	Sick
1	1000	0
2	910	70
3	828.1	130.2
4	753.571	181.657
5	685.74961	225.32412
6	624.032145	262.060387
7	567.869252	292.639618
8	516.761019	317.758484

表格2 結果如下，數字供參照

L	M	N	O
1 Costs	Healthy	Sick	Total
2	50000	0	50000
3	45500	70000	115500
4	41405	130200	171605
5	37678.55	181657	219335.55
6	34287.4805	225324.12	259611.601
7	31201.6073	262060.387	293261.994
8	28393.4626	292639.618	321033.08
9	25838.051	317758.484	343596.535
10	23512.6264	338043.831	361556.458
11	21396.49	354059.317	375455.807
12	19470.8059	366311.437	385782.243
13	17718.4334	375254.993	392973.427
14	16123.7744	381298.05	397421.825
15	14672.6347	384806.432	399479.067
16	13352.0976	386107.799	399459.897
17	12150.4088	385495.346	397645.754
18	11056.872	383231.151	394288.023
19	10061.7535	379549.214	389610.967
20	9156.19569	374658.208	383814.404

# Markov Model in Excel (11) – 生(老)病死

STEP 2 : 算完COST，  
另外要算QALY，方法一樣。

	A	B	C
10		Costs	
11	Healthy	50	0.9
12	Sick	1000	0.6
13			
14			
15	Discount Rate		3%

1.保留表格1

QALY這樣算

例：參照Cycle 2的人數

- Healthy =  $910 \times 0.9 = 819$
- Sick =  $70 \times 0.6 = 42$
- Total QALY = 861

F	G	H
Cycle	Healthy	Sick
1	1000	0
2	910	70
3	828.1	130.2
4	753.571	181.657
5	685.74961	225.32412
6	624.032145	262.060387
7	567.869252	292.639618
8	516.761019	317.758484

R2       $=G2*\$C\$11$

	Q	R	S	T
1	QALY	Healthy	Sick	Total
2		900	0	900
3		819	42	861
4				
5				
6				
7				
8				
9				
10				

2.建立表格3  
 3.在R2輸入公式  
 $=G2*\$C\$11$   
 4.在S2輸入公式  
 $=H2*\$C\$12$   
 5.在T2輸入公式  
 $=R2+S2$   
 6.複製往下拉到cycle 50



# Markov Model in Excel (12) – 生(老)病死

STEP 2 : 算完COST，  
另外要算QALY，方法一樣。

	A	B	C
10		Costs	
11	Healthy	50	0.9
12	Sick	1000	0.6
13			
14			1.保留表格1
15	Discount Rate		3%

QALY這樣算

例：參照Cycle 2的人數

- Healthy =  $910 \times 0.9 = 819$
- Sick =  $70 \times 0.6 = 42$
- Total QALY = 861

F	G	H
Cycle	Healthy	Sick
1	1000	0
2	910	70
3	828.1	130.2
4	753.571	181.657
5	685.74961	225.32412
6	624.032145	262.060387
7	567.869252	292.639618
8	516.761019	317.758484

結果如下，數字供參照

R2	Q	R	S	T
1	QALY	Healthy	Sick	Total
2		900	0	900
3		819	42	861
4		745.29	78.12	823.41
5		678.2139	108.9942	787.2081
6		617.174649	135.194472	752.369121
7		561.628931	157.236232	718.865163
8		511.082327	175.583771	686.666097
9		465.084917	190.655091	655.740008
10		423.227275	202.826299	626.053574

# Markov Model in Excel (13) – 生(老)病死

## STEP 3 : 計算成本和QALY折現

	A	B	C
10	Costs	QALY	
11	Healthy	50	0.9
12	Sick	1000	0.6
13			
14			
15	Discount Rate	3%	

Discount factor 這樣算  
Excel的Function:

=POWER(1/(1+\$B\$15),\$F2-1)

	F	G	H	I
1	Cycle	Healthy	Sick	Dead
2	1	1000	0	0
3	2	910	70	20
4	3	828.1	130.2	41.7
5	4	753.571	181.657	64.772
6	5	685.74961	225.32412	88.92627
7	6	624.032145	262.060387	113.907468
8	7	567.869252	292.639618	139.49113
9	8	516.761019	317.758484	165.480496
10	9	470.252528	338.043831	191.703641

	V	W	X	Y	Z
1	Discount factor		Discounted Costs		Discounted QALY
2		1	50000		900
3					835.9223301
4					776.1428975
5					720.4069269
6					668.4702193
7					620.0994041
8					
9					
10					

1. 在V2輸入  
=POWER(1/(1+\$B\$15),\$F2-1)

2. 在X2輸入  
Cycle 1的Total cost \* V2  
( =O2\*V2 )

3. 在Z2輸入  
=Cycle 1 的Total QALY \* V2  
(=T2\*V2)

4. V2:Z2框起來往下複製拉到cycle 第50年

# Markov Model in Excel (14) – 生(老)病死

## STEP 3 : 計算成本和QALY折現

	A	B	C
10		Costs	QALY
11	Healthy	50	0.9
12	Sick	1000	0.6
13			
14			
15	Discount Rate	3%	

Discount factor 這樣算  
Excel的Function:

=POWER(1/(1+\$B\$15),\$F2-1)

	F	G	H	I
1	Cycle	Healthy	Sick	Dead
2	1	1000	0	0
3	2	910	70	20
4	3	828.1	130.2	41.7
5	4	753.571	181.657	64.772
6	5	685.74961	225.32412	88.92627
7	6	624.032145	262.060387	113.907468
8	7	567.869252	292.639618	139.49113
9	8	516.761019	317.758484	165.480496
10	9	470.252528	338.043831	191.703641

結果如下請參考

	V	W	X	Y	Z
1	Discount factor		Discounted Costs		Discounted QALY
2		1	50000		900
3		0.970873786	112135.9223		835.9223301
4		0.942595909	161754.171		776.1428975
5		0.915141659	200723.0992		720.4069269
6		0.888487048	230661.5445		668.4702193
7		0.862608784	252970.3721		620.0994041
8		0.837484257	268860.1505		575.0720461
9		0.813091511	279375.4261		533.1766341
10		0.789409234	285416.0065		494.2124723

# Markov Model in Excel (15) – 生(老)病死

STEP 4 : 計算Usual Care的Total、平均 COST、QALY

	V	W	X	Y	Z
1	Discount factor		Discounted Costs		Discounted QALY
2		1	50000		900
3	0.970873786		112135.9223		835.9223301
4	0.942595909		161754.171		776.1428975
5	0.915141659		200723.0992		720.4069269
6	0.888487048		230661.5445		668.4702193
7	0.862608784		252970.3721		620.0994041
8	0.837484257		268860.1505		575.0720461
9	0.813091511		279375.4261		533.1766341
10	0.789409234		285416.0065		494.2124723

Total Discounted	=SUM(X2:X51)	=SUM(Z2:Z51)
Average Discounted	=X52/G2	=Z52/G2

結果如右

Total Discounted	7573928.394	11996.60304
Average Discounted	7573.928394	11.99660304

# Markov Model in Excel (16) – 生(老)病死

試試看用同樣的方法，接著計算Intervention組，Costs變成多了500元。

Transition matrix (Intervention)		Healthy	Sick	Dead
Healthy	0.95	0.03	0.02	
Sick	0	0.95	0.05	
Dead	0	0	1	
Costs		QALY		
Healthy	550	0.9		
Sick	1000	0.6		
Discount Rate		3%		

# Markov Model in Excel (17) – 生(老)病死

情境：

最近國健署想要降低台灣人的肥胖率，以避免心血管疾病發生，因此投入每個人500元的成本去健身房運動，看看未來50年的狀況，透過Markov Model來進行成本效益分析：

- Population: 1000位健康的人
- Intervention : 上健身房
- Comparator : usual care

STEP1：先替Intervention組建立兩張表格，計算每個cycle在不同的健康狀態裡分別有多少人。

	AE	AF	AG	AH	AI	AJ			
1	Transition matrix								
2	Healthy	Sick		Dead					
3	Healthy	0.95	0.03	0.02					
4	Sick	0	0.95	0.05					
5	Dead	0	0	1					

1. 建立每個不同健康狀態的轉移機率的列聯表

Cycle	Healthy	Sick	Dead
1	1000	0	0
2	=MMULT(AK2:AM2,\$AF\$3:\$AH\$5)		
3	2. 初始值是1000位健康的人，		
4	AK2:AM2分別輸入1000,0,0		
5	3. 接著在AK3這格輸入上列公式		
6	=MMULT(AK2:AM2,\$AF\$3:\$AH\$5)		
7	4. 按enter，複製往下拉到Cycle第50年		

# Markov Model in Excel (18) – 生(老)病死

情境：

最近國健署想要降低台灣人的肥胖率，以避免心血管疾病發生，因此投入每個人500元的成本去健身房運動，看看未來50年的狀況，透過Markov Model來進行成本效益分析：

- Population: 1000位健康的人
- Intervention : 上健身房
- Comparator : usual care

STEP1：先替Intervention組建立兩張表格，計算每個cycle在不同的健康狀態裡分別有多少人。

數值結果如下，供參照

	AE	AF	AG	AH	AI	AJ	AK	AL	AM
1	Transition matrix					Cycle	Healthy	Sick	Dead
2		Healthy	Sick	Dead		1	1000	0	0
3	Healthy	0.95	0.03	0.02		2	950	30	20
4	Sick	0	0.95	0.05		3	902.5	57	40.5
5	Dead	0	0	1		4	857.375	81.225	61.4
6						5	814.50625	102.885	82.60875
7						6	773.780938	122.175938	104.043125
8						7	735.091891	139.280569	125.627541
9						8	698.337296	154.369297	147.293407

# Markov Model in Excel (19) – 生(老)病死

STEP 2：另外要計算COSTs和QALY，在同張表單裡面建立下列表格1、2

表格1

	AE	AF	AG
10		Costs	QALY
11	Healthy	550	0.9
12	Sick	1000	0.6
13			
14			
15	Discount Rate	3%	
16			

1. 建立表格1

Cost這樣算

參照上一張表格Cycle 2的人數：

- Healthy =  $950 * 550 = 522,500$
- Sick =  $30 * 1000 = 30,000$
- Total Cost =  $552,500$

表格2

	AP	AQ	AR	AS
1	Costs	Healthy	Sick	Total
2		550000	0	550000
3				
4				
5				
6				
7				
8				
9				
10				

2. 建立表格2

3. 在AQ2輸入公式

=AK2\*\$AF\$11

4. 在AR2輸入公式

=AL2\*\$AF\$12

5. 在AS2輸入公式

=AQ2+AR2

6. 複製往下拉到cycle 50

	AJ	AK	AL
Cycle	Healthy	Sick	
1	1000	0	
2	950	30	
3	902.5	57	
4	857.375	81.225	
5	814.50625	102.885	
6	773.780938	122.175938	
7	735.091891	139.280569	
8	698.337296	154.369297	

# Markov Model in Excel (20) – 生(老)病死

STEP 2：另外要計算COSTs和QALY，在同張表單裡面建立下列表格1、2

表格1

	AE	AF	AG
10		Costs	QALY
11	Healthy	550	0.9
12	Sick	1000	0.6
13			
14			
15	Discount Rate	3%	
16			

Cost這樣算

參照上一張表格Cycle 2的人數：

- Healthy =  $950 * 550 = 522,500$
- Sick =  $30 * 1000 = 30,000$
- Total Cost =  $552,500$

AJ	AK	AL
Cycle	Healthy	Sick
1	1000	0
2	950	30
3	902.5	57
4	857.375	81.225
5	814.50625	102.885
6	773.780938	122.175938
7	735.091891	139.280569
8	698.337296	154.369297

表格2 結果如下，數字供參照

AP	AQ		AR	AS
1	Costs	Healthy	Sick	Total
2		550000	0	550000
3		522500	30000	552500
4		496375	57000	553375
5		471556.25	81225	552781.25
6		447978.438	102885	550863.438
7		425579.516	122175.938	547755.453
8		404300.54	139280.569	543581.109
9		384085.513	154369.297	538454.81
10		364881.237	167600.951	532482.188

# Markov Model in Excel (21) – 生(老)病死

STEP 3 : 算完COST  
另外要算QALY · 方法一樣

	AE	AF	AG
10		Costs	QALY
11	Healthy	550	0.9
12	Sick	1000	0.6
13			1.保留表格1
14			
15	Discount Rate	3%	
16			

QALY這樣算

例：參照Cycle 2的人數

- Healthy =  $950 \times 0.9 = 855$
- Sick =  $30 \times 0.6 = 18$
- Total QALY = 873

AJ	AK	AL
Cycle	Healthy	Sick
1	1000	0
2	950	30
3	902.5	57
4	857.375	81.225
5	814.50625	102.885
6	773.780938	122.175938
7	735.091891	139.280569
8	698.337296	154.369297

	AU	AV	AW	AX
1	QALY	Healthy	Sick	Total
2		900	0	900
3		855	18	873
4				
5				
6				
7				
8				
9				
10				

- 2.建立表格3  
 3.在AV2輸入公式  
 $=AK2*$C$11$   
 4.在AW2輸入公式  
 $=AL2*$C$12$   
 5.在O2輸入公式  
 $=AV2+AW2$   
 6.複製往下拉到cycle 50
- 

# Markov Model in Excel (22) – 生(老)病死

STEP 3 : 算完COST，  
另外要算QALY，方法一樣

	AE	AF	AG
10		Costs	QALY
11	Healthy	550	0.9
12	Sick	1000	0.6
13			
14			
15	Discount Rate	3%	
16			

QALY這樣算

- 例：參照Cycle 2的人數
- Healthy =  $910 \times 0.9 = 819$
- Sick =  $70 \times 0.6 = 42$
- Total QALY = 861

結果如下，數字供參照

	AU	AV	AW	AX
1	QALY	Healthy	Sick	Total
2		900	0	900
3		855	18	873
4		812.25	34.2	846.45
5		771.6375	48.735	820.3725
6		733.055625	61.731	794.786625
7		696.402844	73.3055625	769.708406
8		661.582702	83.5683413	745.151043
9		628.503566	92.6215782	721.125145
10		597.078388	100.560571	697.638959

AJ	AK	AL
Cycle	Healthy	Sick
1	1000	0
2	950	30
3	902.5	57
4	857.375	81.225
5	814.50625	102.885
6	773.780938	122.175938
7	735.091891	139.280569
8	698.337296	154.369297

# Markov Model in Excel (23) – 生(老)病死

## STEP 4 : 計算成本和QALY折現

	AE	AF	AG
10		Costs	QALY
11	Healthy	550	0.9
12	Sick	1000	0.6
13			
14			
15	Discount Rate	3%	
16			

Discount factor 這樣算  
Excel的Function:

=POWER(1/(1+\$AF\$15),\$AJ2-1)

	AJ	AK	AL	AM
1	Cycle	Healthy	Sick	Dead
2	1	1000	0	0
3	2	950	30	20
4	3	902.5	57	40.5
5	4	857.375	81.225	61.4
6	5	814.50625	102.885	82.60875
7	6	773.780938	122.175938	104.043125
8	7	735.091891	139.280569	125.627541
9	8	698.337296	154.369297	147.293407
10	9	663.420431	167.600951	168.978618

	AZ	BA	BB	BC	BD
1	Discount factor		Discounted Costs		Discounted QALY
2		1	550000		900
3	0.970873786		536407.767		847.5728155
4	0.942595909		521609.0112		797.8603073
5	0.915141659		505873.1504		750.7570509
6	0.888487048		490145.0001		706.1576222
7	0.862608784		474416.0000		663.9572326
8	1.在AZ2輸入 =POWER(1/(1+\$AF\$15),\$AJ2-1)		458687.0000		624.0522672
9			443040.0000		586.3407338
10			427340.0000		550.7226363

2. 在BB2輸入  
Cycle 1的Total cost\*V2  
( =AS2\*AZ2 )

3. 在BD2輸入  
=Cycle 1 的Total QALY\*V2  
( =AX2\*AZ2 )

4. AZ2:BD2框起來往下複製拉到cycle 第50年

# Markov Model in Excel (24) – 生(老)病死

## STEP 4 : 計算成本和QALY折現

	AE	AF	AG
10		Costs	QALY
11	Healthy	550	0.9
12	Sick	1000	0.6
13			
14			
15	Discount Rate	3%	
16			

Discount factor 這樣算

Excel的Function:

=POWER(1/(1+\$AF\$15),\$AJ2-1)

	AJ	AK	AL	AM
1	Cycle	Healthy	Sick	Dead
2	1	1000	0	0
3	2	950	30	20
4	3	902.5	57	40.5
5	4	857.375	81.225	61.4
6	5	814.50625	102.885	82.60875
7	6	773.780938	122.175938	104.043125
8	7	735.091891	139.280569	125.627541
9	8	698.337296	154.369297	147.293407
10	9	663.420431	167.600951	168.978618

結果如下請參考

	AZ	BA	BB	BC	BD
1	Discount factor		Discounted Costs		Discounted QALY
2		1		550000	900
3	0.970873786			536407.767	847.5728155
4	0.942595909			521609.0112	797.8603073
5	0.915141659			505873.1504	750.7570509
6	0.888487048			489435.0294	706.1576222
7	0.862608784			472498.6656	663.9572326
8	0.837484257			455240.6207	624.0522672
9	0.813091511			437813.0352	586.3407338
10	0.789409234			420346.3565	550.7226363

# Markov Model in Excel (25) – 生(老)病死

STEP 5 : 計算Intervention的Total、平均 COST、QALY

	AZ	BA	BB	BC	BD
1	Discount factor		Discounted Costs		Discounted QALY
2		1		550000	900
3		0.970873786		536407.767	847.5728155
4		0.942595909		521609.0112	797.8603073
5		0.915141659		505873.1504	750.7570509
6		0.888487048		489435.0294	706.1576222
7		0.862608784		472498.6656	663.9572326
8		0.837484257		455240.6207	624.0522672
9		0.813091511		437813.0352	586.3407338
10		0.789409234		420346.3565	550.7226363

Total Discounted	=SUM(BB2:BB51)	=SUM(BD2:BD51)
Average Discounted	=BB52/AK2	=BD52/AK2

結果如右

Total Discounted	11343537.84	14016.06521
Average Discounted	11343.53784	14.01606521

# Markov Model in Excel (26) – 生(老)病死

## STEP 6 : 計算Usual Care和 Intervention的ICER

	A	B	C	D	E
57	Strategy	Average Discounted Cost	Average Discounted QALY	Incremental Cost	Incremental QALY
58	A (Usual Care)	7573.928394	11.99660304	3769.609449	2.019462173
59	B (Intervention)	11343.53784	14.01606521		
60					
61	ICER	1866.640286			

ICER：  
Incremental成本 /  
Incremental QALY  
 $=(D58/E58)$

把剛才分別計算出  
Intervention和Usual care的  
Average Discounted Cost和  
Average Discounted QALY  
帶入(輸入=所在的儲存格位置)

Incremental  
成本：  
新方案-舊方案  
 $=(B59-B58)$

Incremental  
QALY：  
新方案-舊方案  
 $=(C59-C58)$

# Markov Model in Excel (27) – 生(老)病死

STEP 7 : 用Excel 畫出Markov trace圖

1. 用滑鼠點選長拉，把整個表格框起來

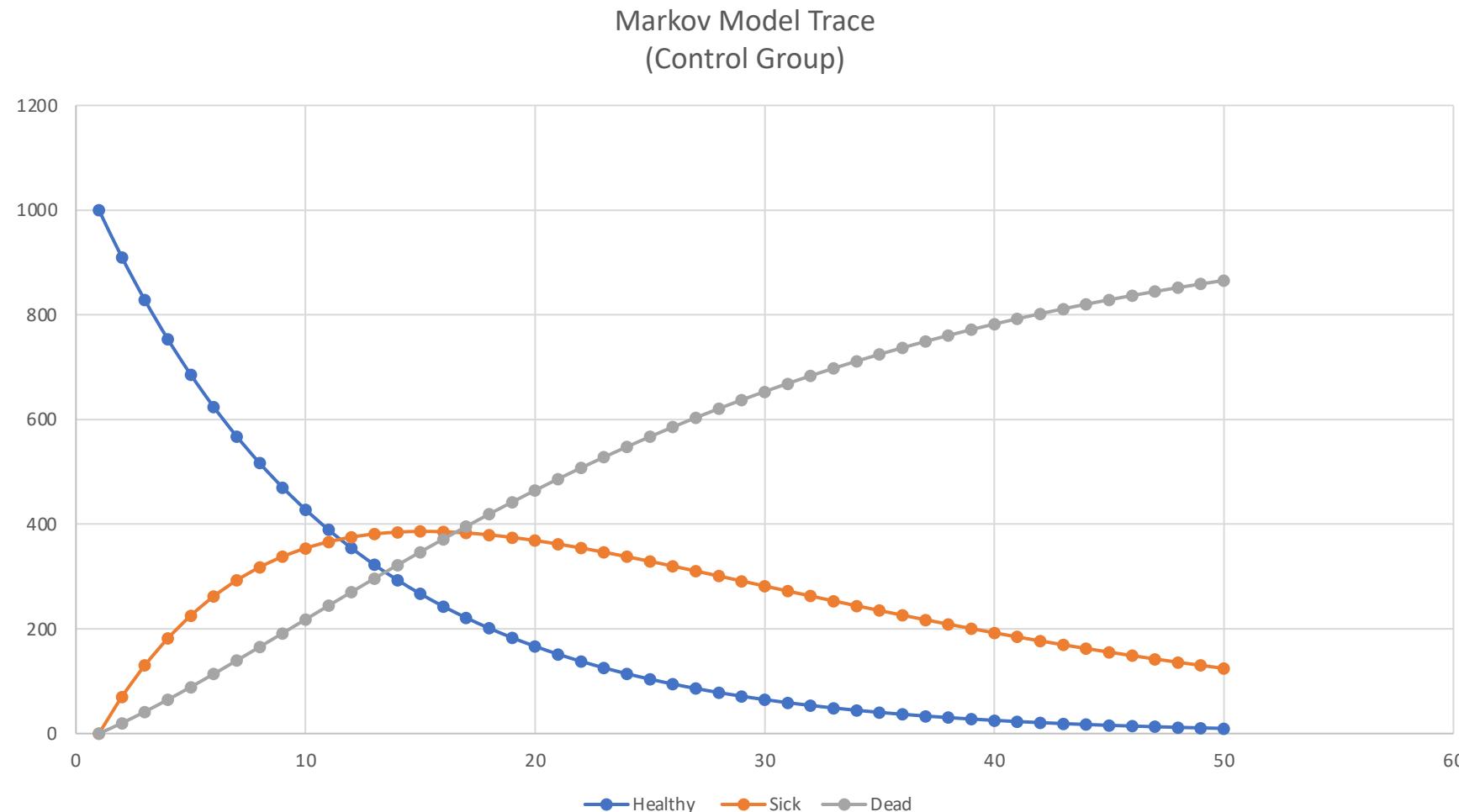
2. 點選上排的插入，再點選紅色框框的按鈕

3. 點選第二張散佈圖，完成！

The screenshot shows the Microsoft Excel ribbon at the top. The '常用' (Home) tab is selected, indicated by a red box. Below the ribbon, there is a large data table titled 'Cycle' with columns for Cycle, Healthy, Sick, Dead, Costs, and Total. The '插入' (Insert) tab is highlighted with a red box. On the right side, the 'Chart' ribbon is open, showing various chart types like bar, line, and pie charts. A specific scatter plot icon is highlighted with a red box. The status bar at the bottom shows '平均值: 256.375 項目個數: 204 加總: 51276'.

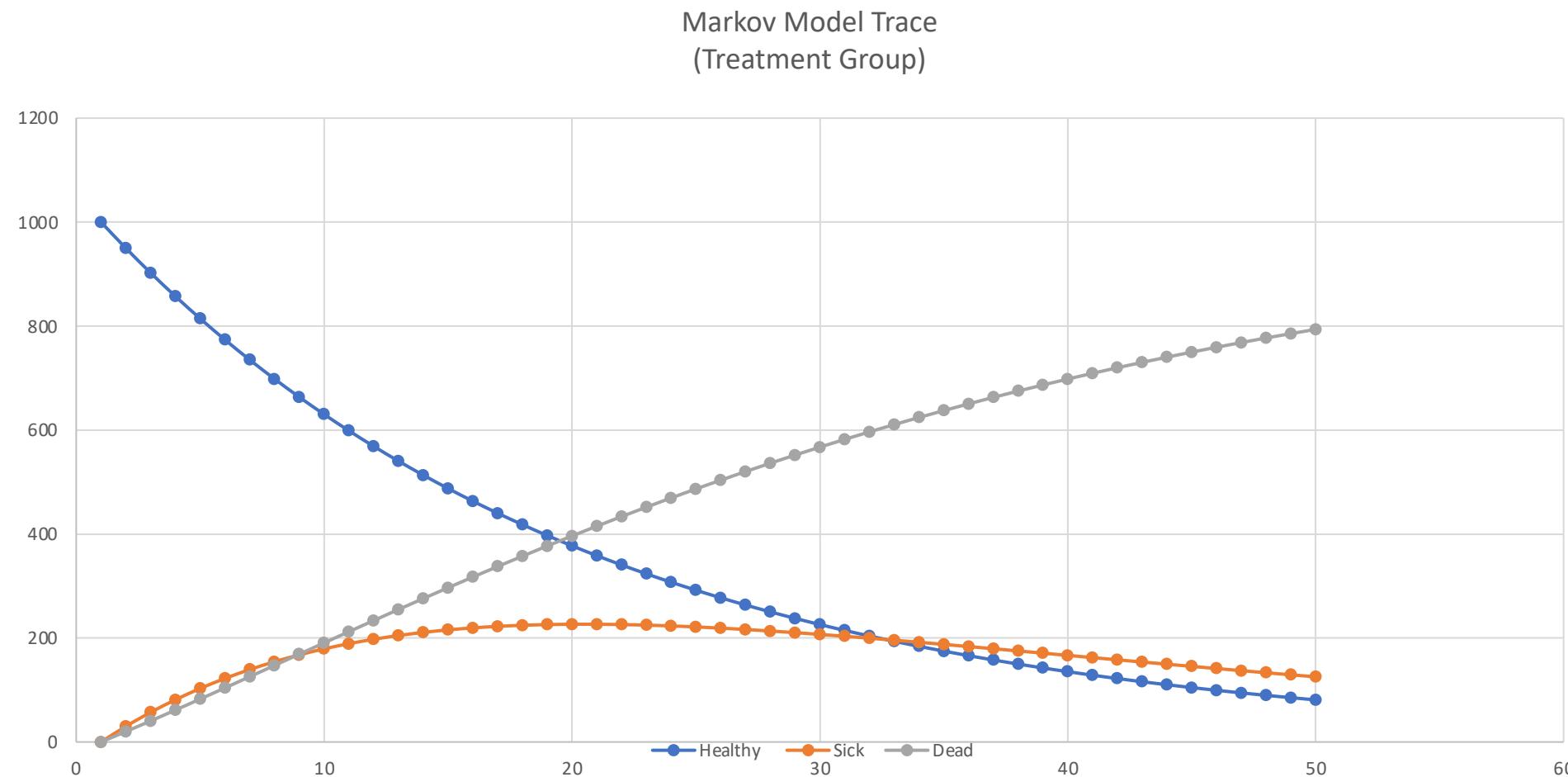
# Markov Model in Excel (28) – 生(老)病死

可以分別做出Comparator跟Intervention的Markov Trace圖：



# Markov Model in Excel (29) – 生(老)病死

可以分別做出Comparator跟Intervention的Markov Trace圖：



□ 單元五：  
TreeAge Workbench

# TreeAge 下載

## 1. 至TreeAge(以下網址)填寫資料申請試用版

<https://www.treeage.com/trial-download/>

Features Products Learn More Support Resources Training Free Trial Buy Now 

## Free Trial

Try TreeAge Pro today to see how it can help with your most complex decisions.



**Choose Your Trial Type**

- Evaluation Healthcare
  - Evaluate Healthcare model building and analyses
- Evaluation Legal/Business
  - Evaluate Legal/Business model building and analyses
- Viewer Healthcare
  - Open and view TreeAge Pro Healthcare models
- Viewer Legal/Business
  - Open and view TreeAge Pro Business models

**Get Started with Free Training**

- [Healthcare Training](#)
- [Legal Training](#)

**Evaluation Terms & Limitations**

### Trial Request Form

Your evaluation license will be sent to the email address provided below.

**Trial License Type \***

- Evaluation Healthcare
- Evaluation Legal/Business
- Viewer Healthcare
- Viewer Legal/Business

Last Name \*

Search...

Features Products Learn More Support Resources Training **Free Trial** Buy Now 

## Free Trial

Try TreeAge Pro today to see how it can help with your most complex decisions.



**Choose Your Trial Type**

- Evaluation Healthcare
  - Evaluate Healthcare model building and analyses
- Evaluation Legal/Business
  - Evaluate Legal/Business model building and analyses
- Viewer Healthcare
  - Open and view TreeAge Pro Healthcare models
- Viewer Legal/Business
  - Open and view TreeAge Pro Business models

**Get Started with Free Training**

- [Healthcare Training](#)
- [Legal Training](#)

**Evaluation Terms & Limitations**

- Build and analyze models with up to 25 nodes.
- Models cannot be saved or printed.
- The 14 day trial period begins today.
- Use for evaluation purposes only.
- You grant TreeAge Software permission to contact you about our new releases, products, features, and training.

**Viewer**

- Allows you to open and examine models.
- Does not expire.

**Trial Request Form**

Your evaluation license will be sent to the email address provided below.

**Trial License Type \***

Choose Trial Type

- Evaluation Healthcare
- Evaluation Legal/Business
- Viewer Healthcare
- Viewer Legal/Business

First Name \*

Last Name \*

Email (valid email required) \*

Phone \*

Organization Type \*

Commercial

Company/Organization \*

Country \*

Interests \*

- Healthcare
- Legal/Business

Evaluation License Terms \*

- I agree to the terms for evaluation/licensor license usage.

CAPTCHA

I'm not a robot 

**Submit**

# TreeAge 下載

## 2. 至信箱收信,依指示下載軟體安裝, 點Click Here

TreeAge Pro Evaluation Software Download 收件匣 ×

 TreeAge Software, Inc. <website@treeage.com> 10月15日 週二 下午10:47 ☆ ☺ ← :

寄給我 ▾

翻譯成中文 (繁體) ×

Thank you for your interest in the [evaluation version](#) of TreeAge Pro.

**IMPORTANT:** You must fully complete steps 1-6 below to be able to build and analyze models.

**Installation/Authorization Instructions**

1. Your evaluation or viewer serial number is [REDACTED]
2. Download the latest version of TreeAge Pro via [Click Here](#).
3. Once installed and launched the TreeAge License Manager will open automatically.
4. Click **Internet Authorization** within the License Manager and enter the serial number provided above. Use Manual Authorization if Internet Authorization fails.
5. Register the evaluation license.
6. When authorization is complete, TreeAge Pro will restart in a licensed state with model building and analysis functions enabled.

If you have any trouble installing or authorizing TreeAge Pro, please contact us at [support@treeage.com](mailto:support@treeage.com).

**Helpful tips:**

- [Online Tutorials](#): View a series of videos to help you get started with TreeAge Pro.
- [Capabilities PDF](#): Click for a summary of TreeAge Pro's capabilities. Compare with alternatives and review with management.
- [Free Intro Training](#): Attend a 1-hour live session to see the broad range of modeling functions within TreeAge Pro.
- [Free Intro Materials](#): Use our introductory healthcare materials that cover fundamental topics related to health economics and decision-making.

[Click here](#) to contact Sales or call +1-413-241-3224 with any questions about sales and license options.

Best,

# TreeAge 下載

## 3. Download 符合您電腦的版本

### TreeAge Pro 2024, R2 Healthcare

TreeAge Pro Healthcare 2024, Release 2.1. [Click here](#) for feature details.

Requires license or maintenance to be active through July 1, 2024.

*Note that this page provides installers for TreeAge Pro Healthcare, intended for Healthcare Modelers and not for Business Analysts or Attorneys.*

#### TreeAge Pro Healthcare - Windows

You can install directly over older versions of TreeAge Pro.

[Download](#)

*If you install TreeAge Pro to an existing folder, that folder and its contents will be deleted.*

*We recommend you use the default installation path.*

If clicking on the download link does not work, please right click on link and open in a new tab or browser.

#### TreeAge Pro Healthcare - Mac (Intel Chip)

**This installer is for Macs using Intel chips.**

[Download](#)

You can install directly over older versions of TreeAge Pro.

*Mac OS Catalina, Mojave, High Sierra, Sierra and Maverick are no longer supported.*

If clicking on the download link does not work, please right click on link and open in a new tab or browser.

#### TreeAge Pro Healthcare - Mac (Apple Silicon Chip)

**This installer is for Macs using Apple Silicon (M1/M2) chips.**

[Download](#)

You can install directly over older versions of TreeAge Pro.

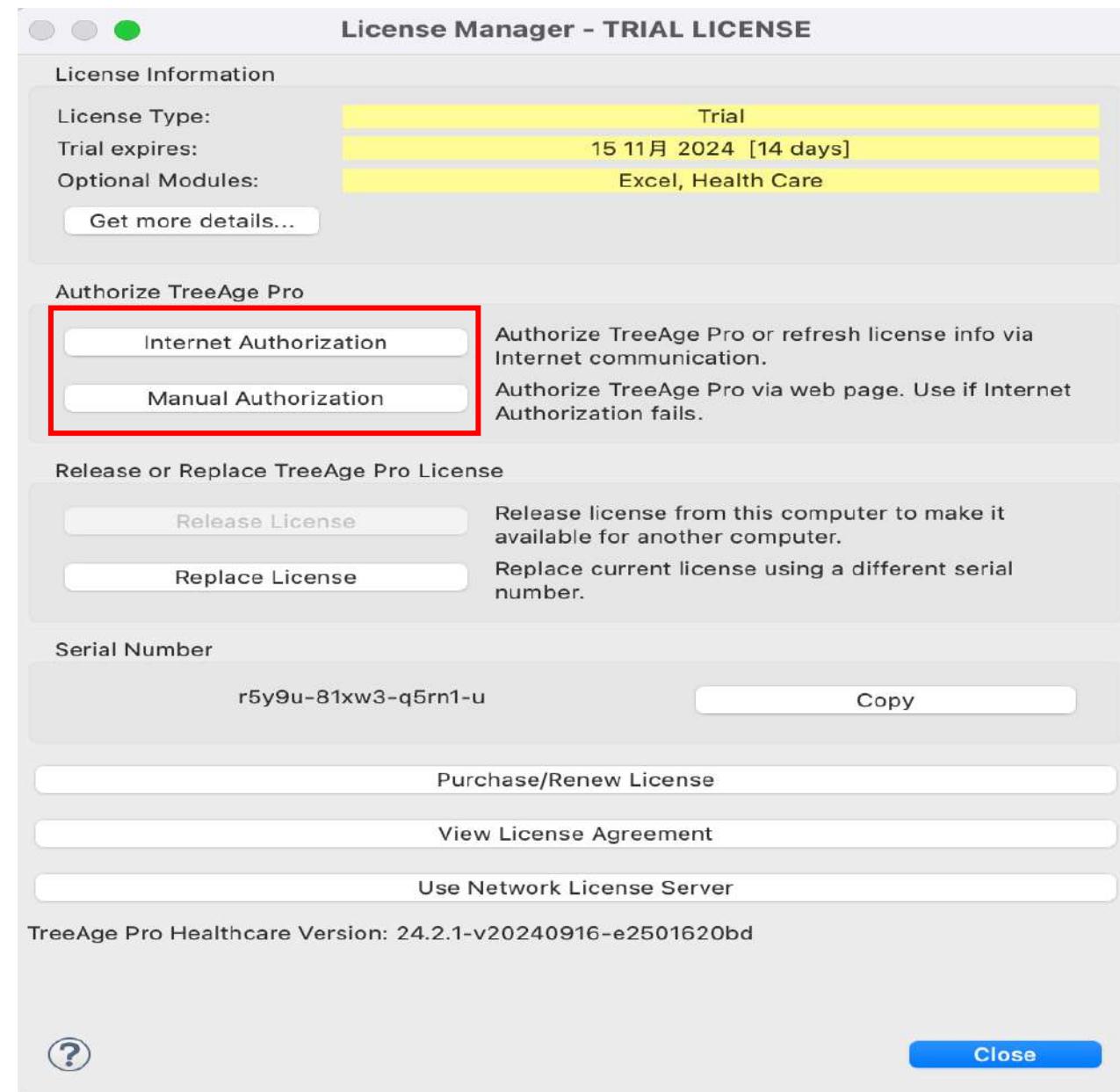
*Mac OS Catalina, Mojave, High Sierra, Sierra and Maverick are no longer supported.*

If clicking on the download link does not work, please right click on link and open in a new tab or browser.

# TreeAge 下載

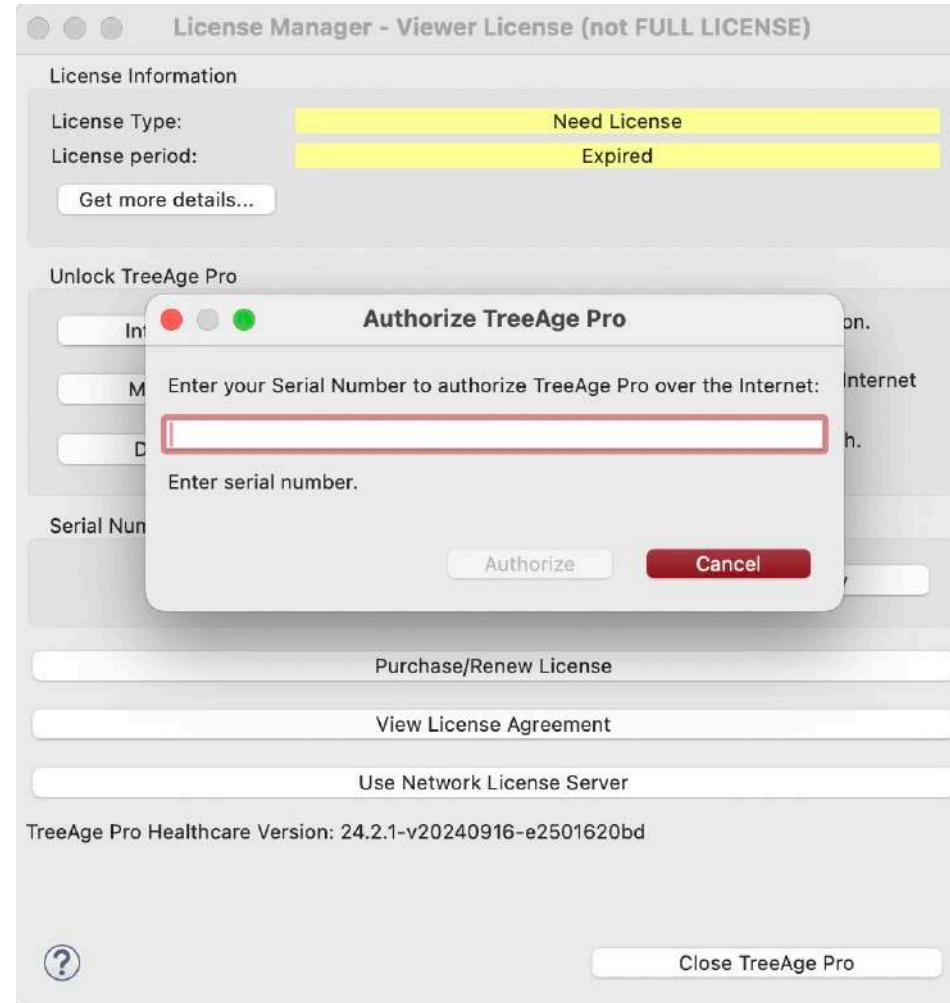
## 4.手動授權

Internet Authorization或  
Manual Authorization都可以，  
但Internet容易遭防火牆擋下，  
建議點選Manual Authorization



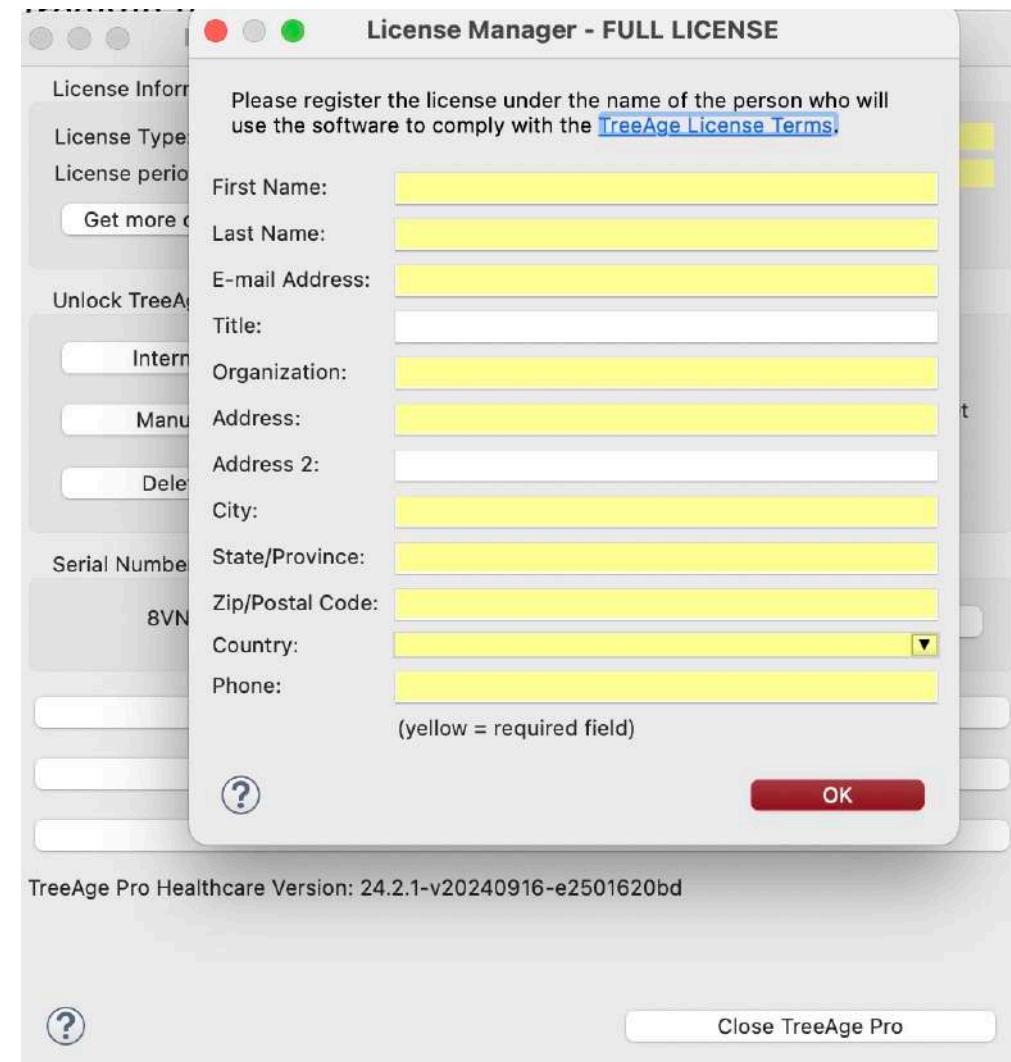
# TreeAge 下載

## 5. 複製Serial Number並貼上

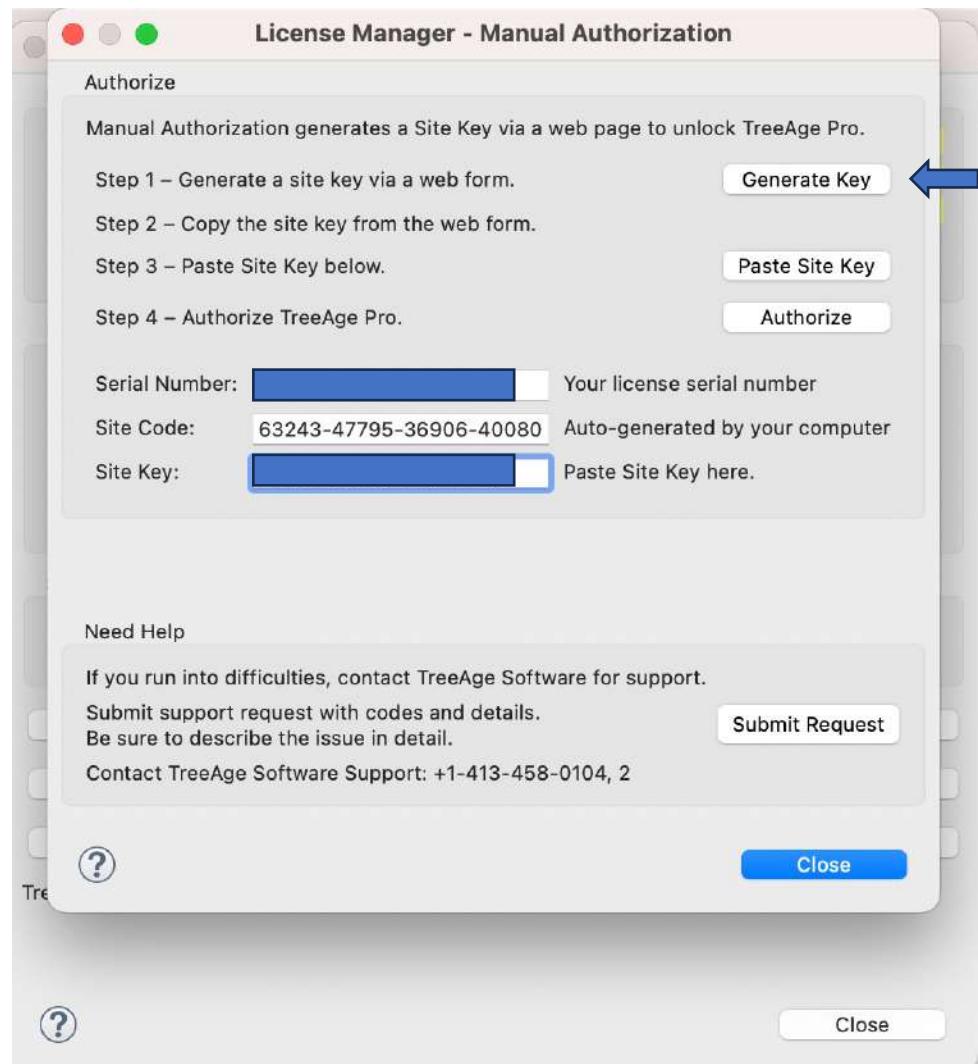


# TreeAge 下載

6. 填寫黃色網底必填欄位之資料後  
按OK(Save)



# TreeAge 下載



7. Generate Key ,跳到下面網站把資料填完

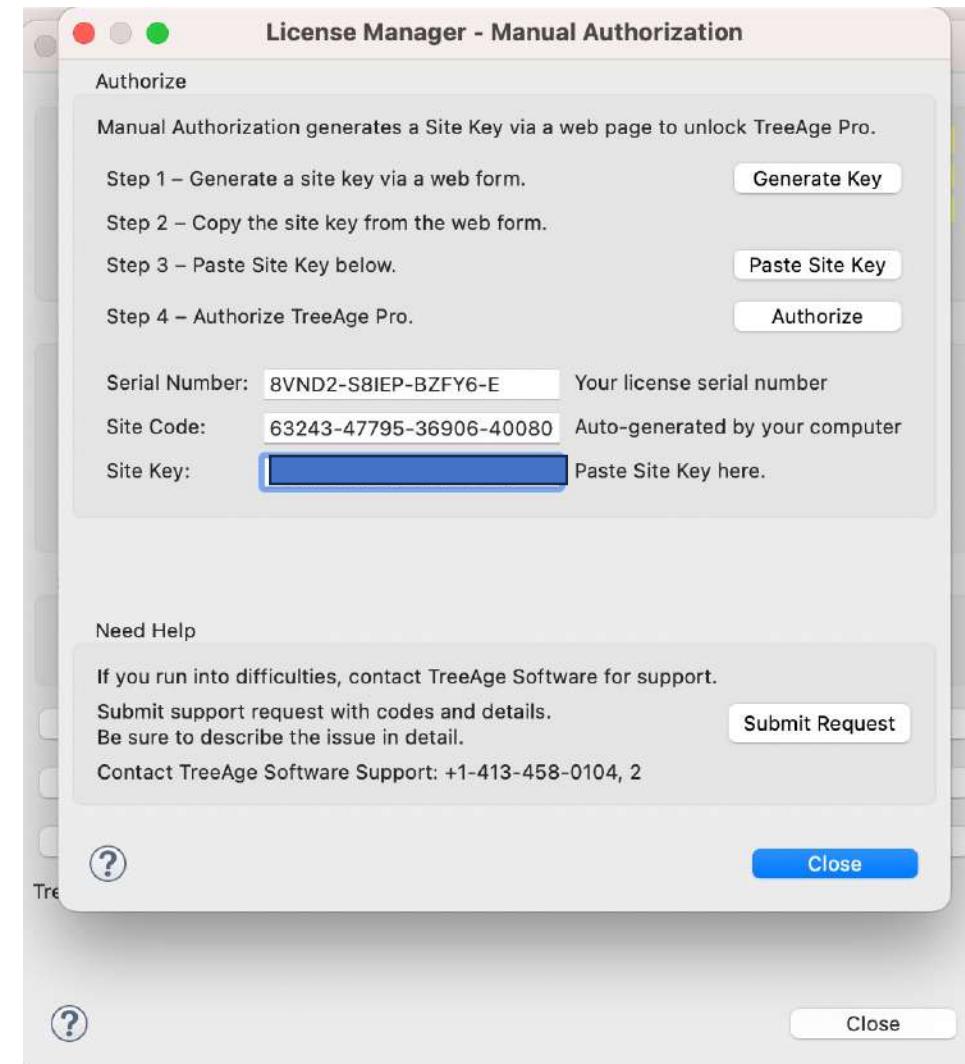
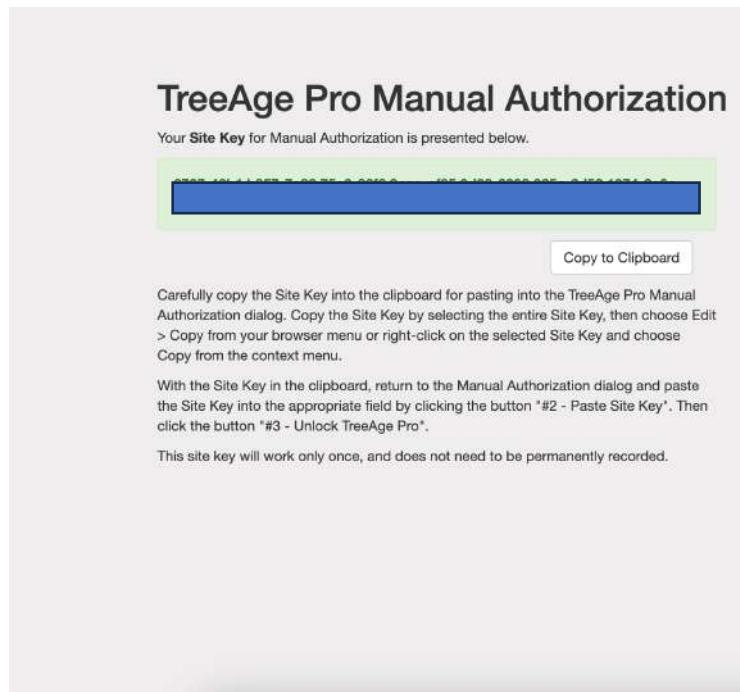
The screenshot shows the 'Enter User Details' form. It includes the following fields:

- First Name: [redacted]
- Last Name: [redacted] (highlighted in red with an error message: "Last Name" is not allowed to be empty)
- Title: [redacted]
- Organization: [redacted]
- Phone: [redacted]
- Email: [redacted]

Small text at the top right: BuildDate: 2014-09-07T17:13:16Z | BuildNumber: 917 | Revision: 92540 | CommitHash: 4a7fca0e00

# TreeAge 下載

8.複製綠色底的全部號碼，  
回到TreeAge,貼上到Site Key  
按Authorize



# TreeAge 下載



# Workbench

TreeAge Pro 2024 File Edit Node Subtree Tree Values Analysis Window Help 10月27日 週日 上午 3:05

Tree editor

Select a optimal treatment

```
cMedicine_annual = dis_cMedicin_annual  
cSurgery = dis_cSurgery  
leF = 8  
leS = 12  
pS_Medicine = dis_pS_medicine  
pS_Surgery = dis_pS_surgery  
uF = 0.70  
uS = 0.85
```

Tree Nodes

- Chance
- Terminal
- Decision
- Logic
- Markov
- Label
- Summation
- DES
- Time
- Entry
- Stop
- PartSA

Notes and Arrows

Value (at: Select a optimal treatment)

Add to Expression:

Group: Recent expressions Element: cMedicine\_annual  
Variables cSurgery  
Distributions leF  
Functions leS  
Operators pS\_Medicine  
Keywords pS\_Surgery

Calculated value (at Select a optimal treatment):

View

Project View , Model Validation And Model Overview

Name	Root Definition	Description	Calculated Value	Show In	Edit on Web	Category
cMedicine_annual	dis_cMedicin_annual	Cost of Medicine per year	7,000	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
cSurgery	dis_cSurgery	Cost of Surgery	50,000	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
leF	8	Life Expectancy Post Treatment ...	8	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
leS	12	Life Expectancy Post Treatment ...	12	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
pS_Medicine	dis_pS_medicine	Probability of success with Medi...	0.8	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
pS_Surgery	dis_pS_surgery	Probability of success with Surg...	0.75	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
uF	0.70	Utility Failure Post Treatment	0.7	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
uS	0.85	Utility Success Post Treatment	0.85	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

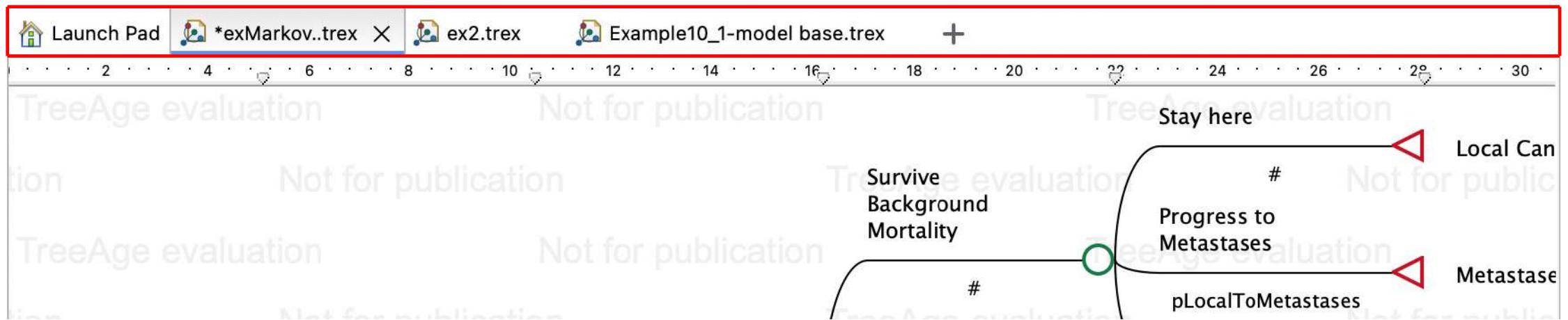
Files Tree Explorer Model Overview

Example Models

- Business
- Discrete Event Simulation
- Get Started
- Healthcare
- Healthcare Training Examples
- Legal
- Oil
- Other

198M of 390M

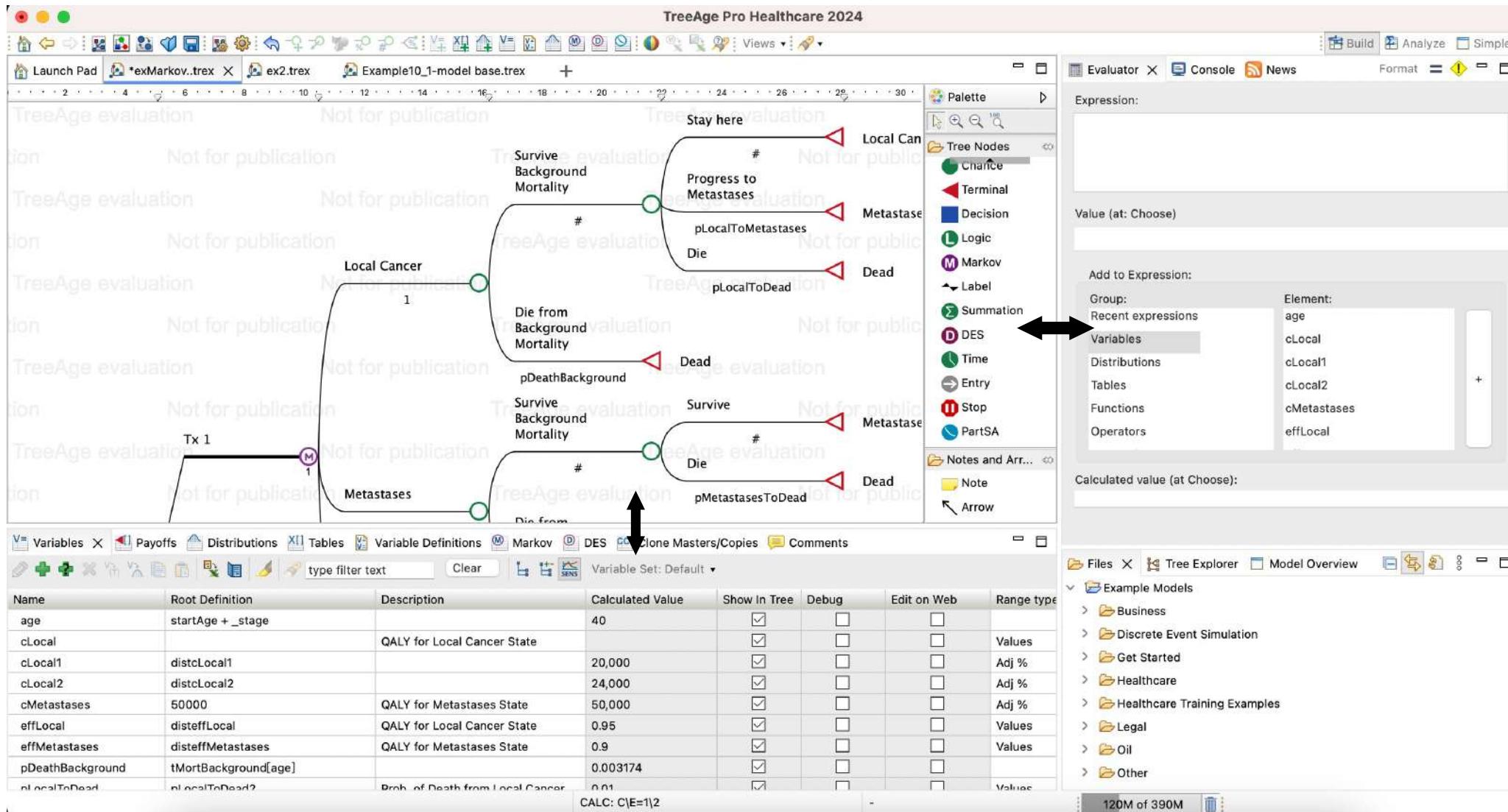
# Workbench-Tree Diagram Editor



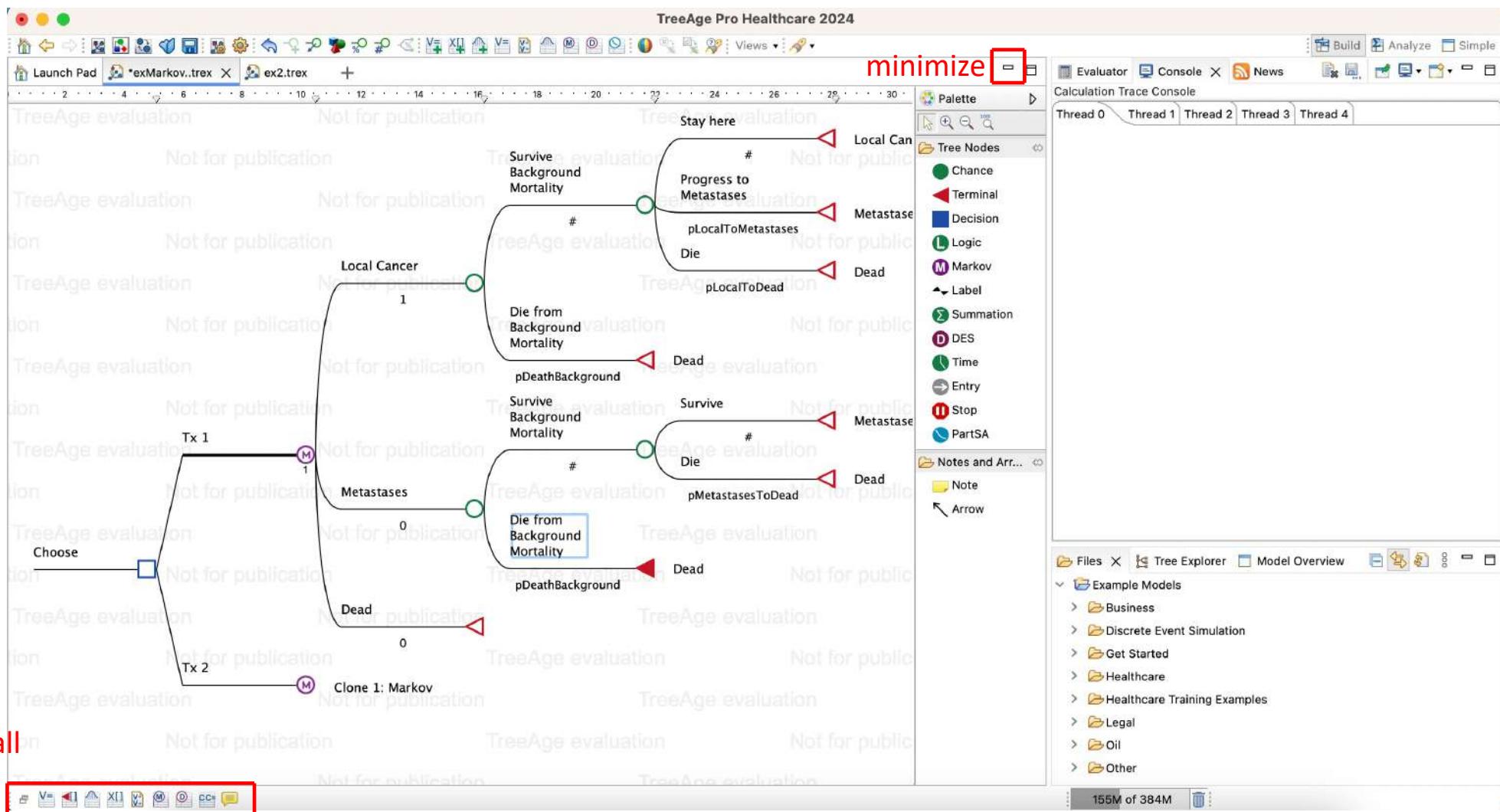
You can open multiple Tree Diagram Editors to edit multiple models. You can also open multiple synchronized editors for the same model. When multiple editor windows are open, the inactive windows will appear as tabs at the top of the active window.

# Workbench

Use the arrows between panes to re-size editors and views.



# Workbench



# Workbench

**TreeAge Pro Healthcare 2024**

The screenshot displays the TreeAge Pro Healthcare 2024 software interface. The main window shows two decision trees:

- Decision Tree 1 (Left):** A tree starting with a "Choose" node. It branches into "Tx 1" (probability 1) and "Metastases" (probability 0). "Tx 1" leads to "Local Cancer" (probability 1) and "Metastases" (probability 0). "Local Cancer" leads to "Die from Background Mortality" (probability  $pDeathBackground$ ) and "Survive Background Mortality" (probability  $1 - pDeathBackground$ ). "Metastases" leads to "Die from Background Mortality" (probability  $pDeathBackground$ ) and "Survive Background Mortality" (probability  $1 - pDeathBackground$ ).
- Decision Tree 2 (Right):** A tree starting with a "Select an optimal treatment" node. It branches into "Medicine" and "Surgery". "Medicine" leads to "Success" (probability  $pS_Medicine$ ) and "Failure" (probability  $1 - pS_Medicine$ ). "Surgery" leads to "Success" (probability  $pS_Surgery$ ) and "Failure" (probability  $1 - pS_Surgery$ ). Both "Success" branches lead to "Enter label" and "Enter prob" nodes.

**Palette:**

- Tree Nodes: Chance, Terminal, Decision, Logic, Markov, Label, Summation, DES, Time, Entry, Stop, PartSA.
- Notes and Arrows: Note, Arrow.

**Variables:**

Name	Root Definition	Description	Calculated Value	Show In Tree
cMedicine_annual	dis_cMedicin_annual	Cost of Medicine per year	7,000	<input checked="" type="checkbox"/>
cSurgery	dis_cSurgery	Cost of Surgery	50,000	<input checked="" type="checkbox"/>
leF	8	Life Expectancy Post Treatment ...	8	<input checked="" type="checkbox"/>
leS	12	Life Expectancy Post Treatment ...	12	<input checked="" type="checkbox"/>
pS_Medicine	dis_pS_medicine	Probability of success with Medi...	0.8	<input checked="" type="checkbox"/>

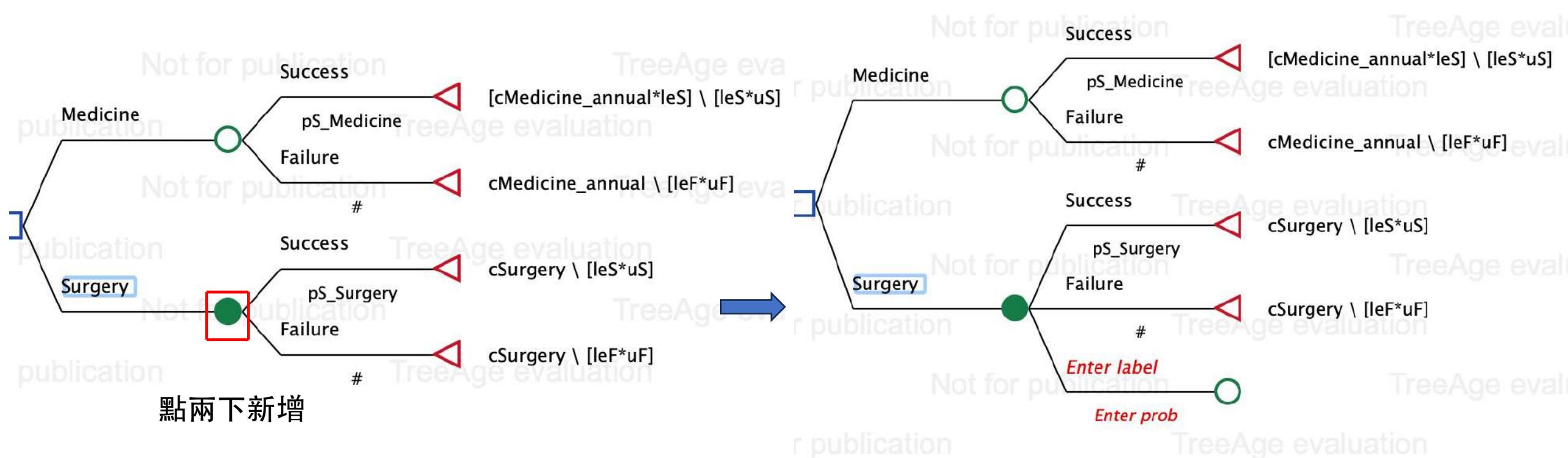
**File Explorer:**

- Example Models: Business, Discrete Event Simulation, Get Started, Healthcare, Healthcare Training Examples.

**Model Overview:**

- Nodes: 4/8
- Memory Usage: 226M of 724M

# Workbench



# Node Types



Decision

- Point where a choice must be made from the options available



Chance

- Point where there are two or more possible event outcomes



Terminal

- non-Markov: End point for a scenario within the model

- Markov: End point for a cycle



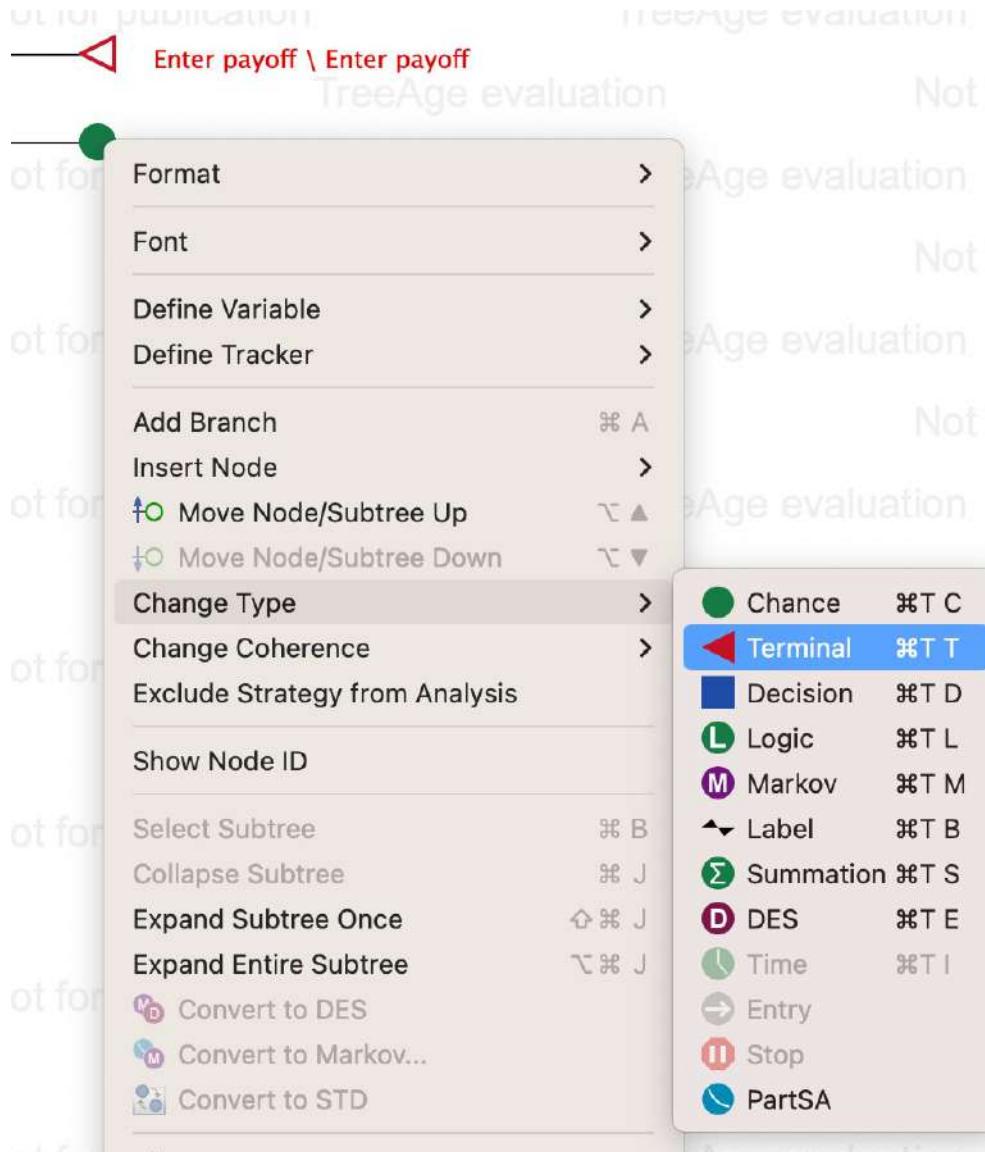
Markov

- Indicates the start of Markov model



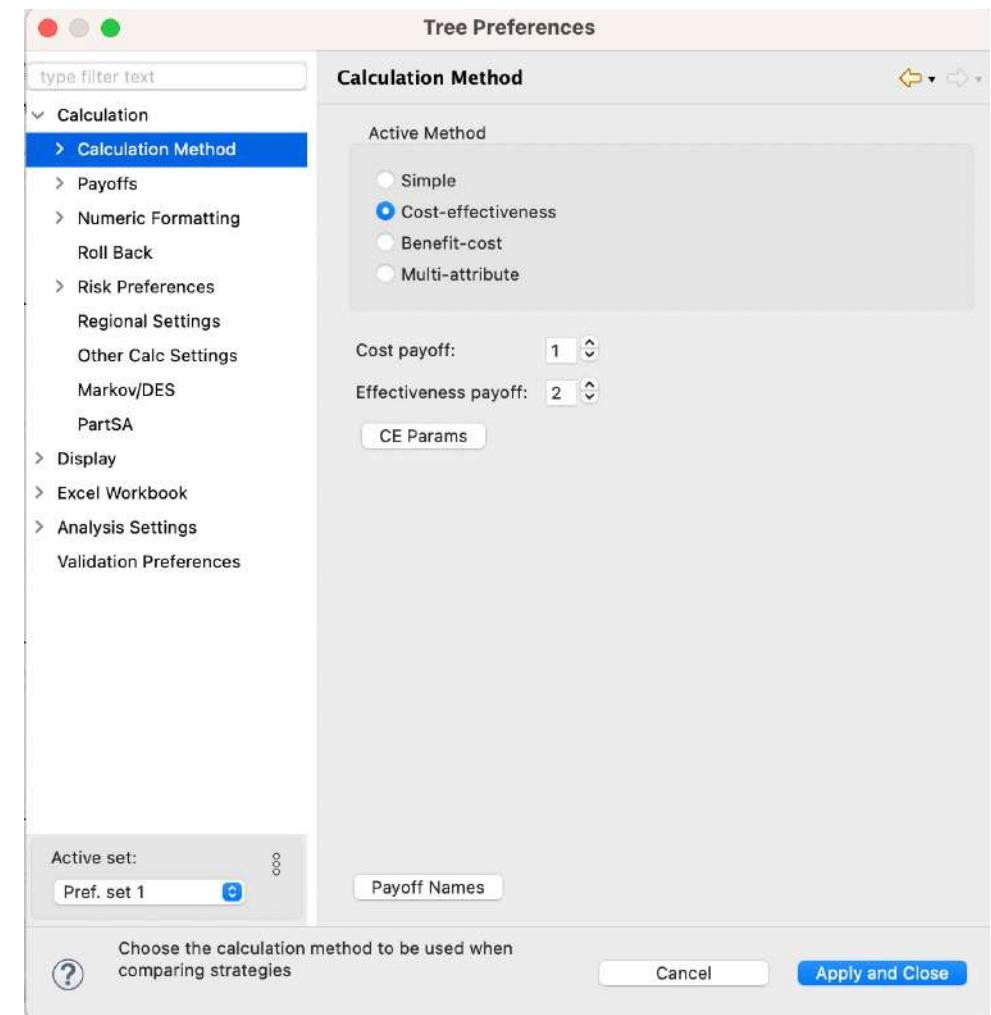
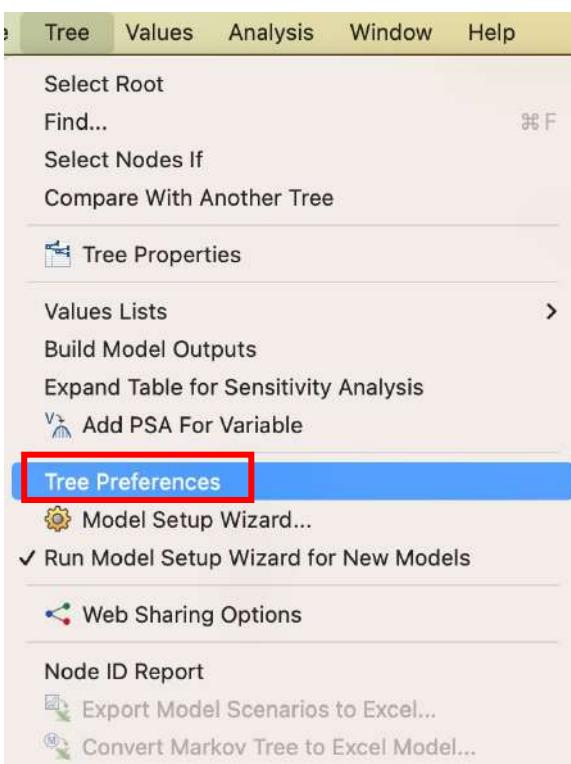
# Change Node Types

按住Node/右鍵/Change Type

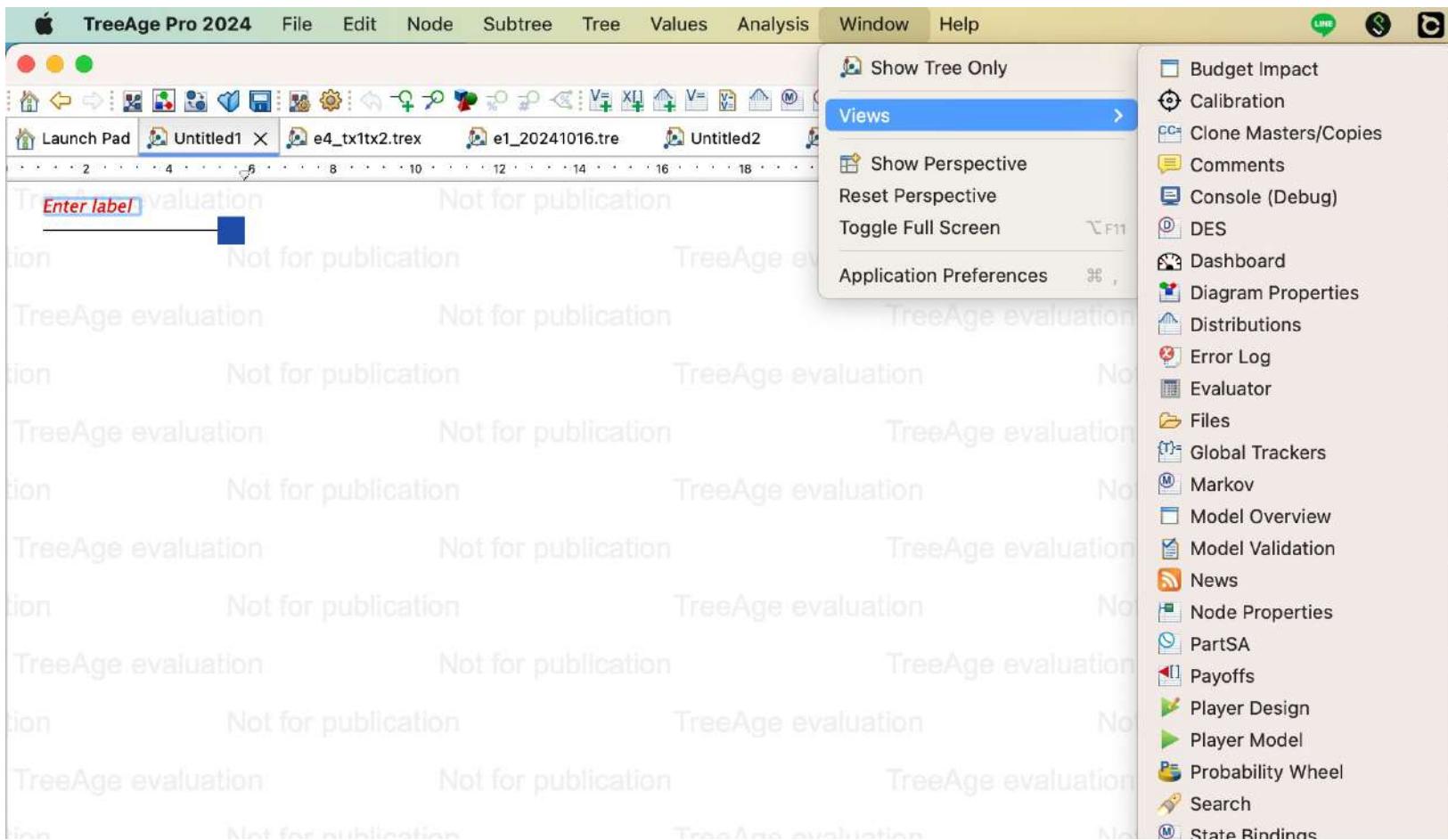


# Tree Preferences

- To compare strategies on the basis of cost-effectiveness
- Calculation Method: Cost-effectiveness
- Two active payoffs (cost and effectiveness)
- Willingness-to-Pay (WTP)



# Views



# Variable Properties View

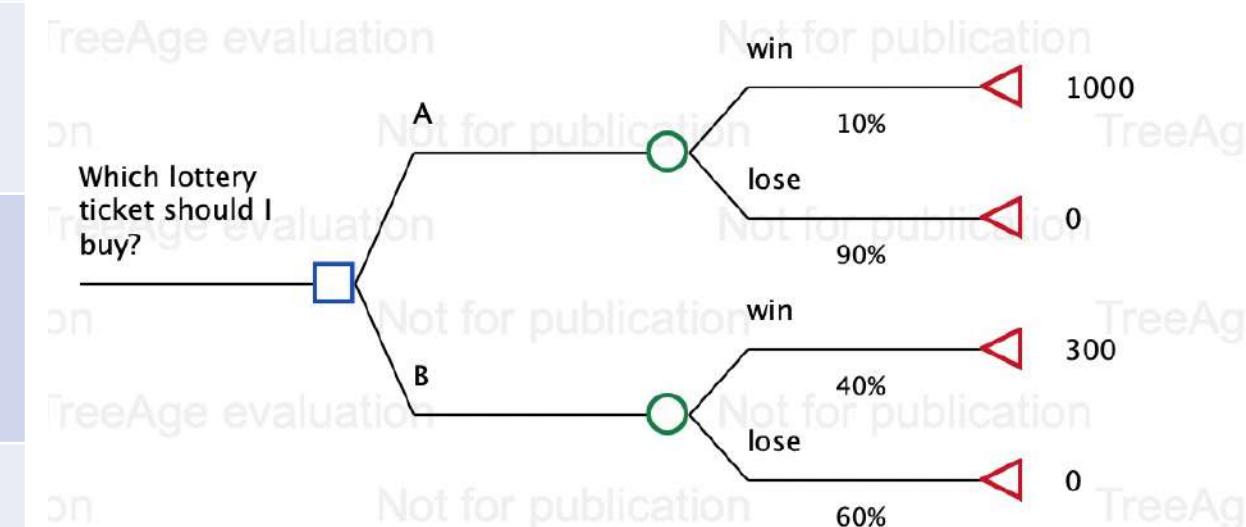
- most numeric values should be entered as variables
- variables assign a name to a numeric value (parameter) or a formula within the model variables
- variables can then be referenced throughout the model to return the appropriate value

Name	Root Definition	Description	Calculated Value	Show In Tree
age	startAge + _stage		17.5	<input checked="" type="checkbox"/>
cLocal	cLocal2	QALY for Local Cancer State	24,333.33333333333	<input checked="" type="checkbox"/>
cLocal1	distcLocal1		20,000	<input checked="" type="checkbox"/>
cLocal2	distcLocal2		24,333.33333333333	<input checked="" type="checkbox"/>
cMetastases	50000	QALY for Metastases State	50,000	<input checked="" type="checkbox"/>
effLocal	disteffLocal	QALY for Local Cancer State	0.96	<input checked="" type="checkbox"/>
effMetastases	disteffMetastases	QALY for Metastases State	0.88	<input checked="" type="checkbox"/>

□ 單元六：  
Decision Tree in TreeAge

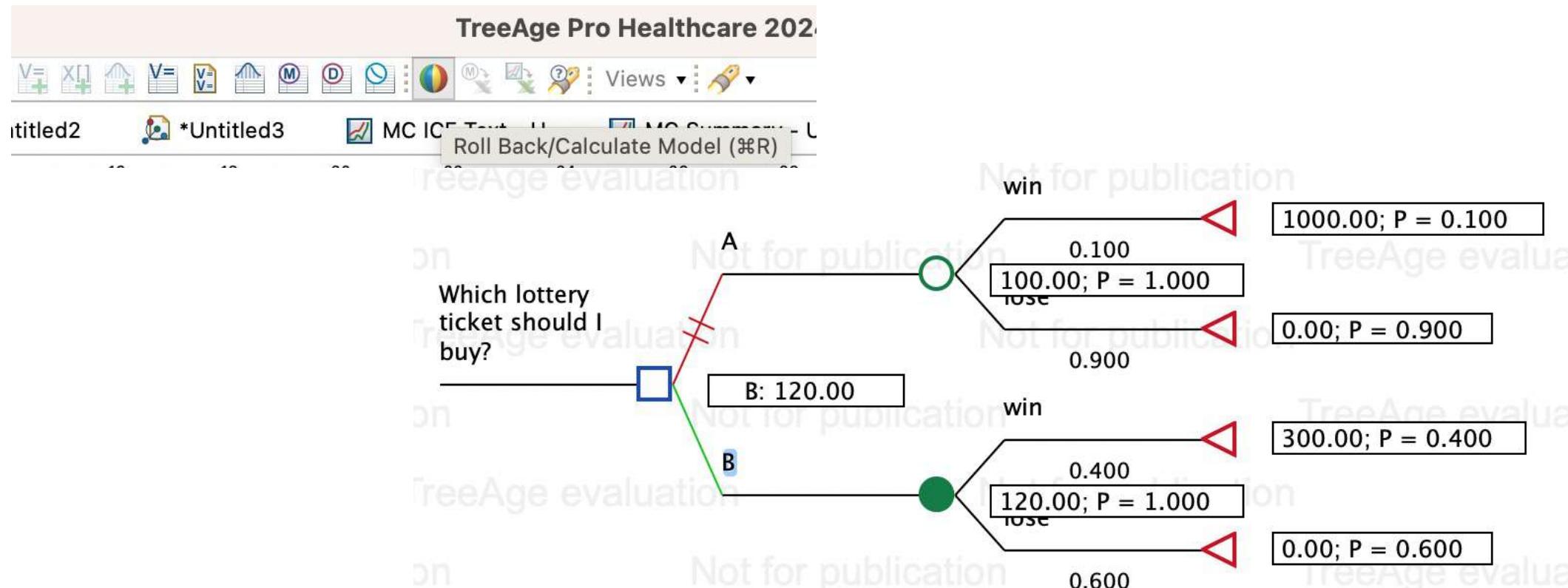
# Example 1: A decision about playing a lottery

STEP		EX1
Decision Problem		Which lottery ticket should I buy?
Structure the tree	Decision alternatives	Lottery A Lottery B
	Outcomes of each Alternatives	Lottery A Win/Lose Lottery B Win/Lose
Estimate probabilities for each outcome		Lottery A Win(10%)/Lose(90%) Lottery B Win(40%)/Lose(60%)
Assign a value to each outcome		Lottery A Win(\$1000)/Lose(\$0) Lottery B Win(\$300) /Lose(\$0)



# Example 1: A decision about playing a lottery

- Analyze the tree to get the **expected value** for each strategy and to choose the optimal strategy.



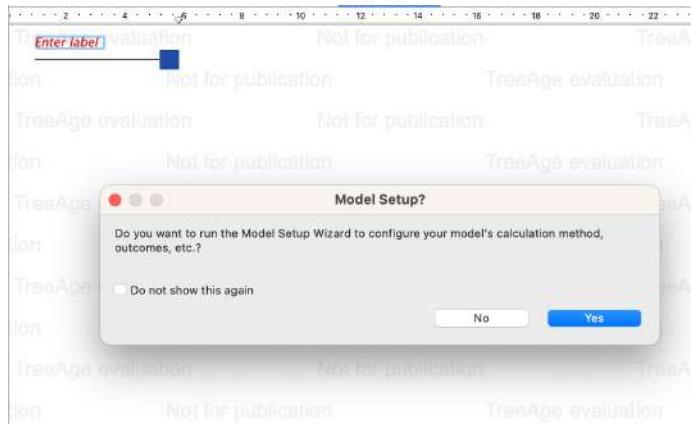
## Example 2:Select a optimal treatment

- Before you build any model, you need to have a firm understanding of the **goals** and **measurable outcomes** within the model.
- To establish this understanding, answer the following 3 questions

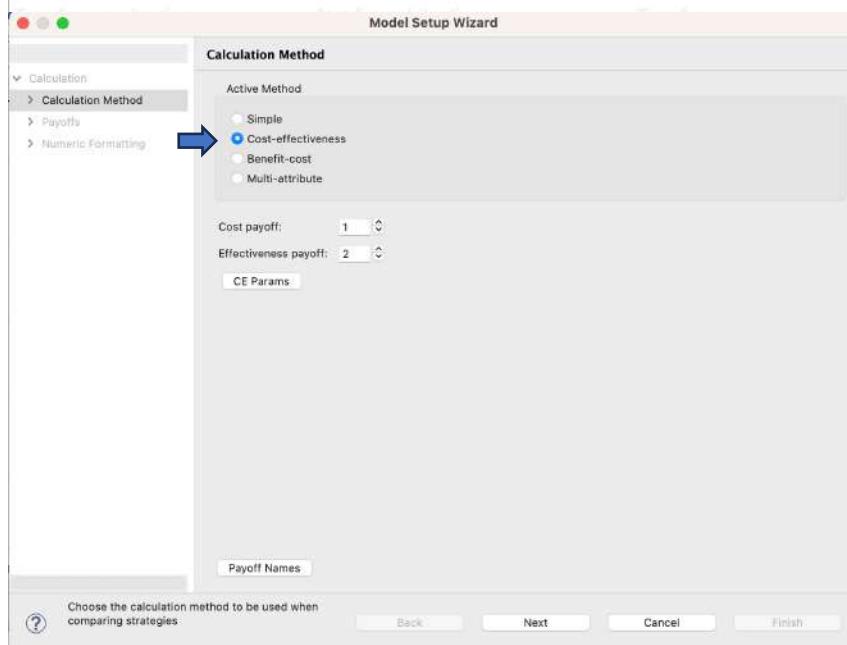
Question	Answer for this example
What is the underlying problem?	<p>Patients with disease X have historically only had one treatment option.</p> <p>A new treatment has become available.</p> <p>We want to identify the most cost-effective treatment for patients with disease X.</p>
What are our strategies/options?	<ol style="list-style-type: none"><li>1. Medicine (new treatment)</li><li>2. Surgery (standard of care)</li></ol>
How do we measure the outcomes associated with these strategies?	<p>Cost is measured in NT\$</p> <p>Effectiveness is measured in QALYs</p>

# Example 2-Model Setup

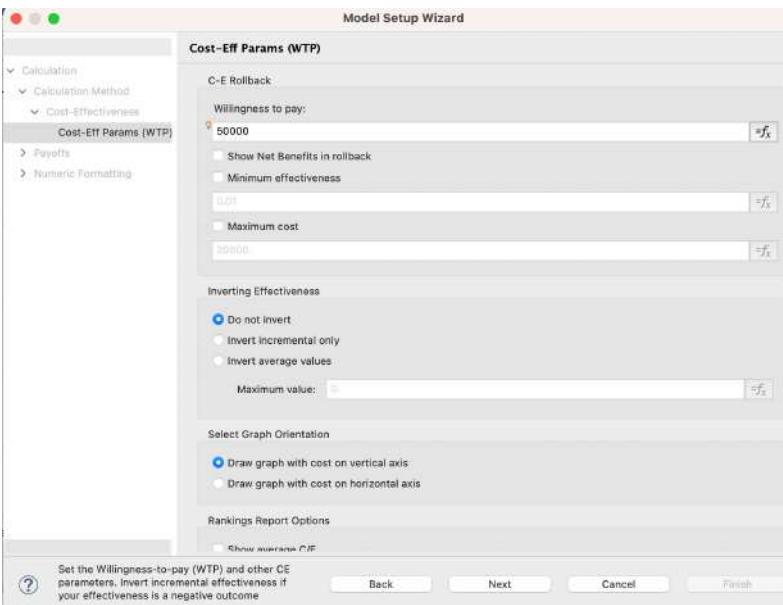
1.



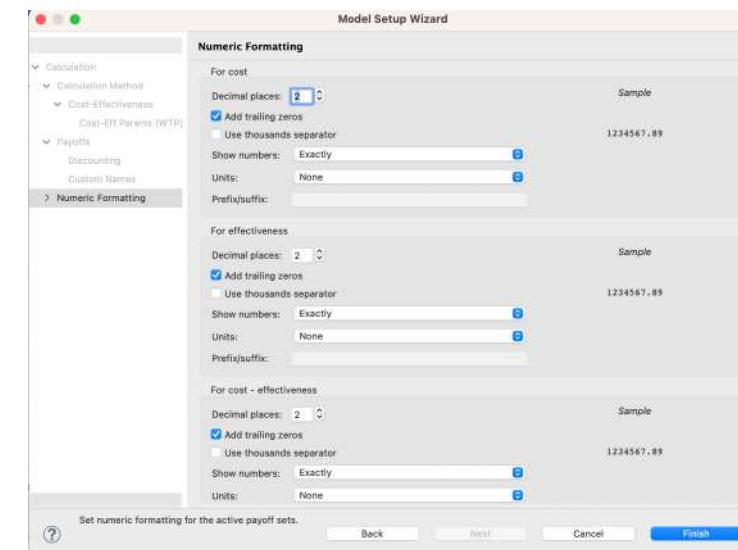
2.



3.



4.



# Example 2-Model Setup

- Set Calculation Method as "Cost-effectiveness"
- Set the Willingness to pay

The screenshot shows two overlapping dialog boxes from the Treehouse software interface:

**Left Dialog: Tree Preferences - Calculation Method**

- Active Method:** Cost-effectiveness (selected)
- Cost payoff:** 1
- Effectiveness payoff:** 2
- CE Params:** (button)

**Right Dialog: Tree Preferences - Cost-Eff Params (WTP)**

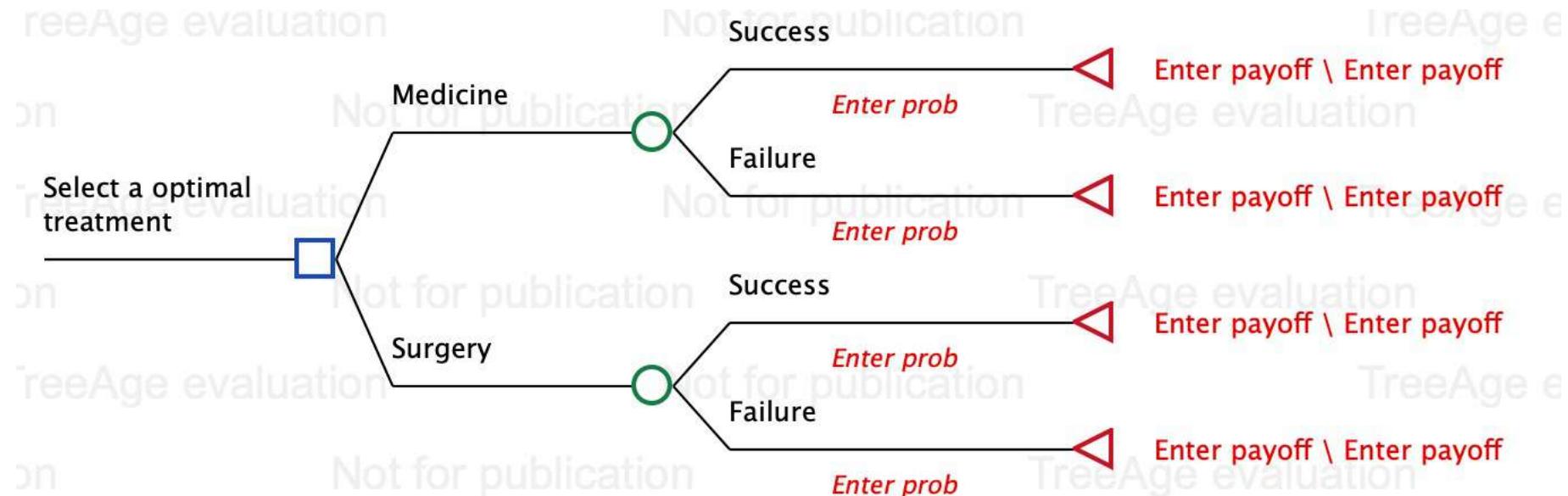
- Cost-Eff Params (WTP):** Willingness to pay: 5000
- Inverting Effectiveness:** Do not invert (selected)
- Rankings Report Options:** Show average C/E, Show common baseline, Show increasing effectiveness

**Bottom Status Bar:**

- Active set: Pref. set 1
- Payoff Names
- Choose the calculation method to be used when comparing strategies
- Cancel
- Apply and Close

## Example 2-Model Setup

- Develop the model
  - define patient pathways for each strategy



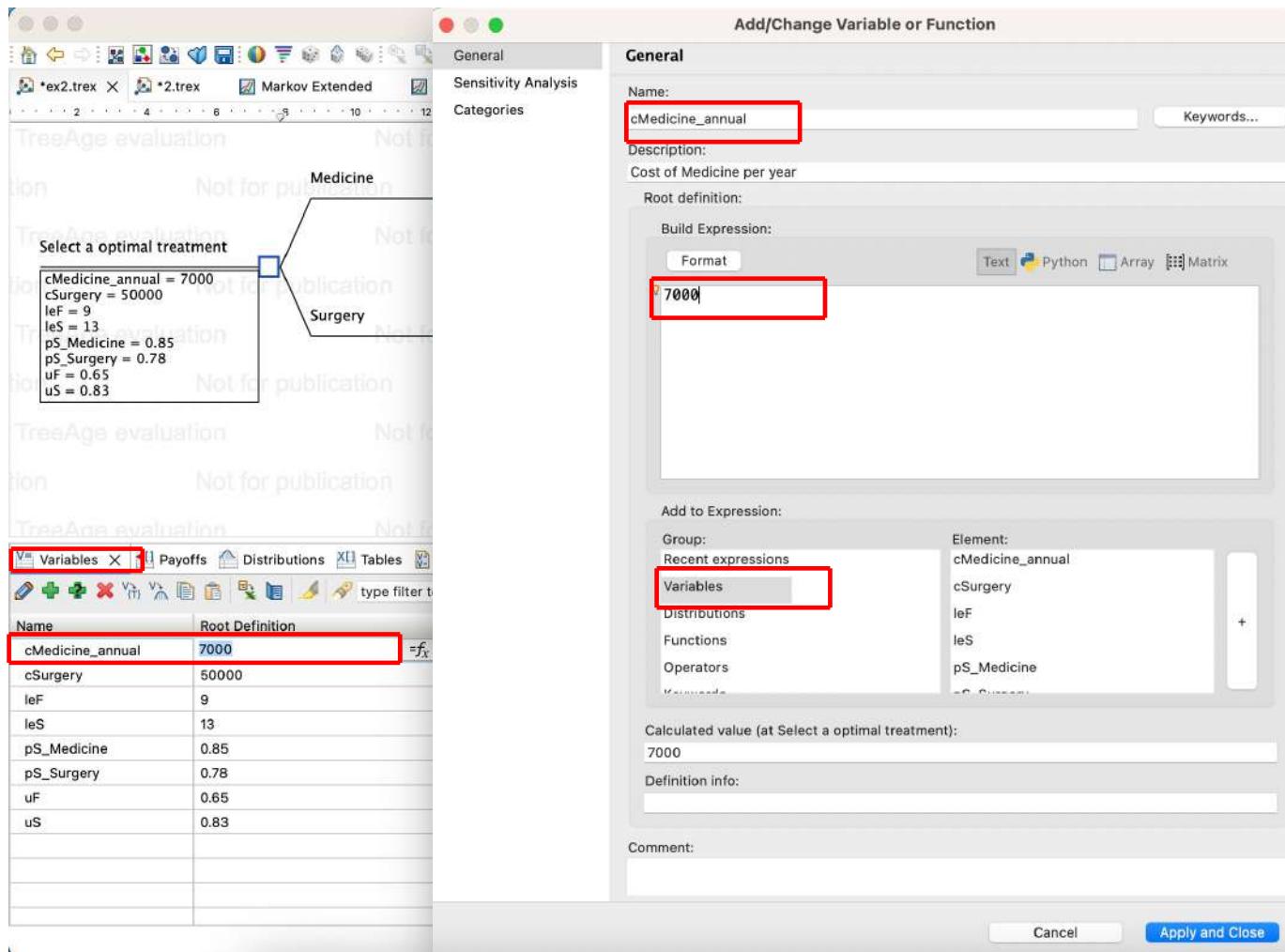
## Example 2-Parameter definition and estimation

Parameter	Variable Name	
Probability of success with Surgery	pS_Surgery	0.78
Probability of success with Medicine	pS_Medicine	0.85
Cost of Surgery	cSurgery	50,000
Cost of Medicine per year*	cMedicine_annual	7,000
Life Expectancy Post Treatment Success	leS	13
Life Expectancy Post Treatment Failure	leF	9
Utility Success Post Treatment	uS	0.83
Utility Failure Post Treatment	uF	0.65

\* Medicine costs 7,000 per year for the treatment over the course of a patient's lifetime. But if a patient fails on Medicine, treatment is stopped after Year 1.

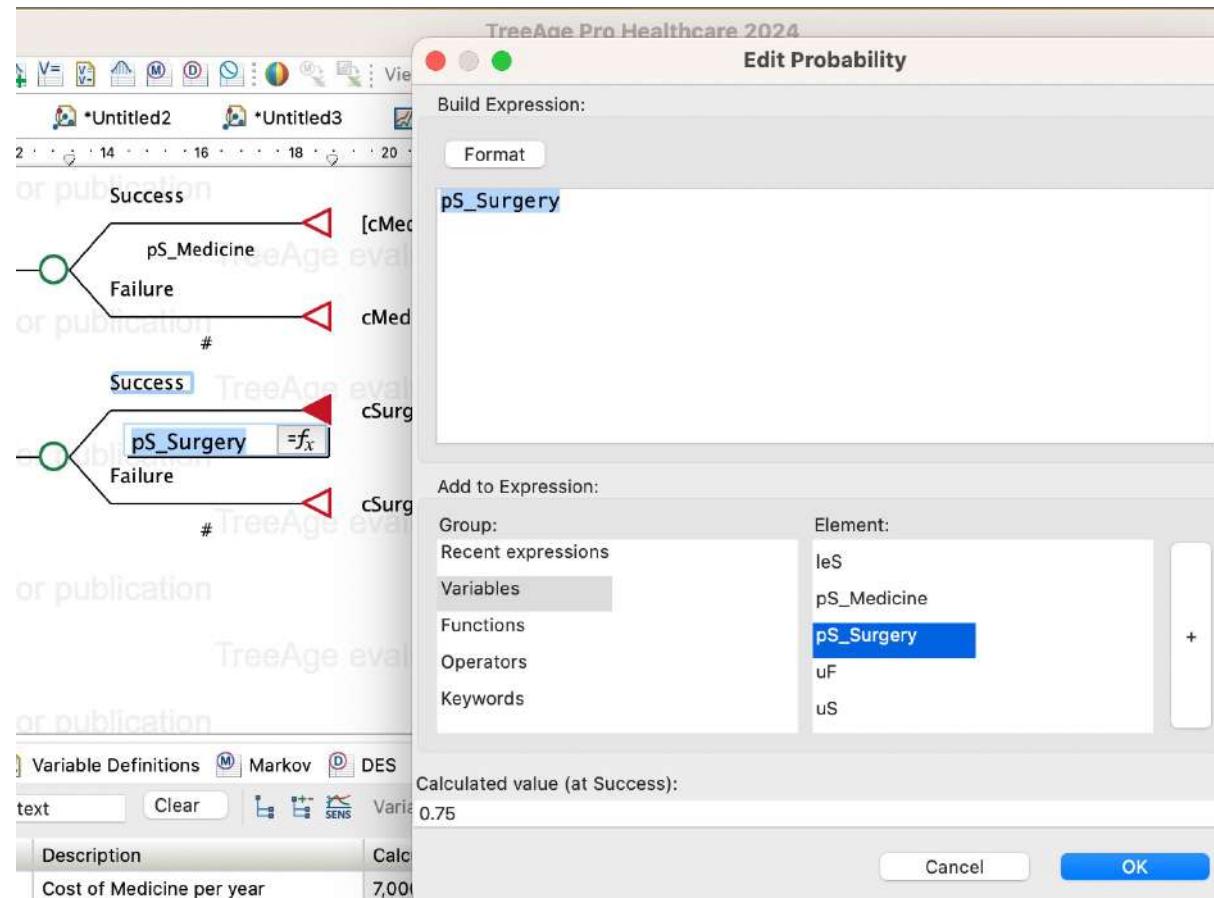
## Example 2-Add variables at the root node

- these variable definitions will be used throughout the model



## Example 2-Add probabilities at each chance node branch

For each chance node, probabilities must sum to 1. In TreeAge, the complement to each known is represented by a "#"

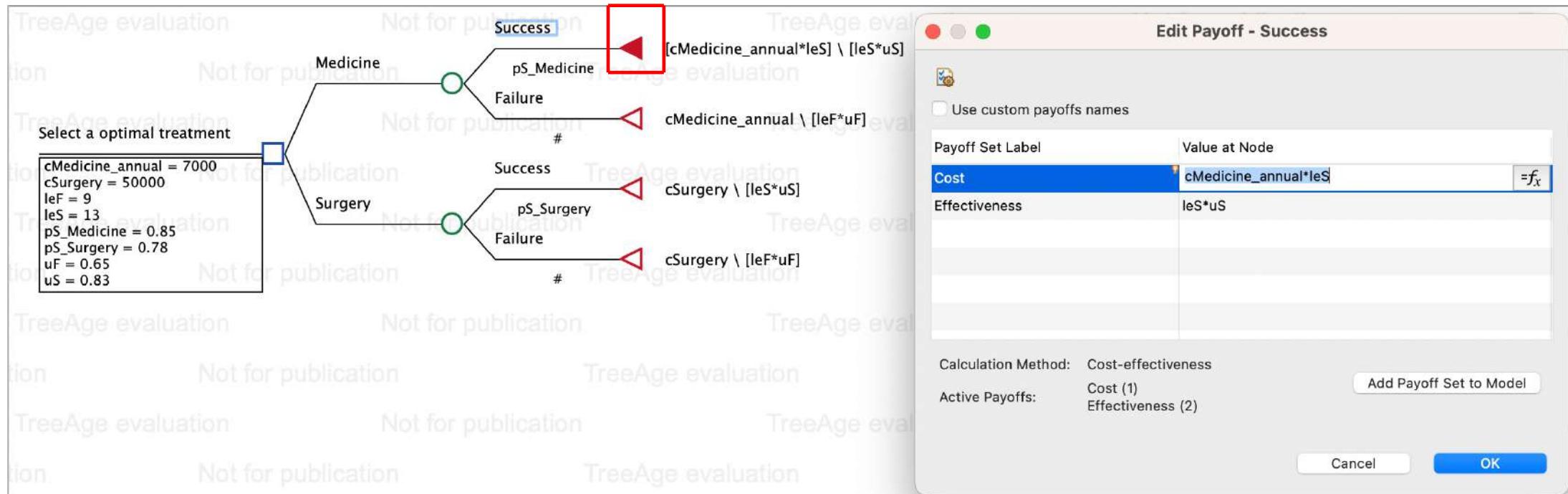


## Example 2- Define outcome measures

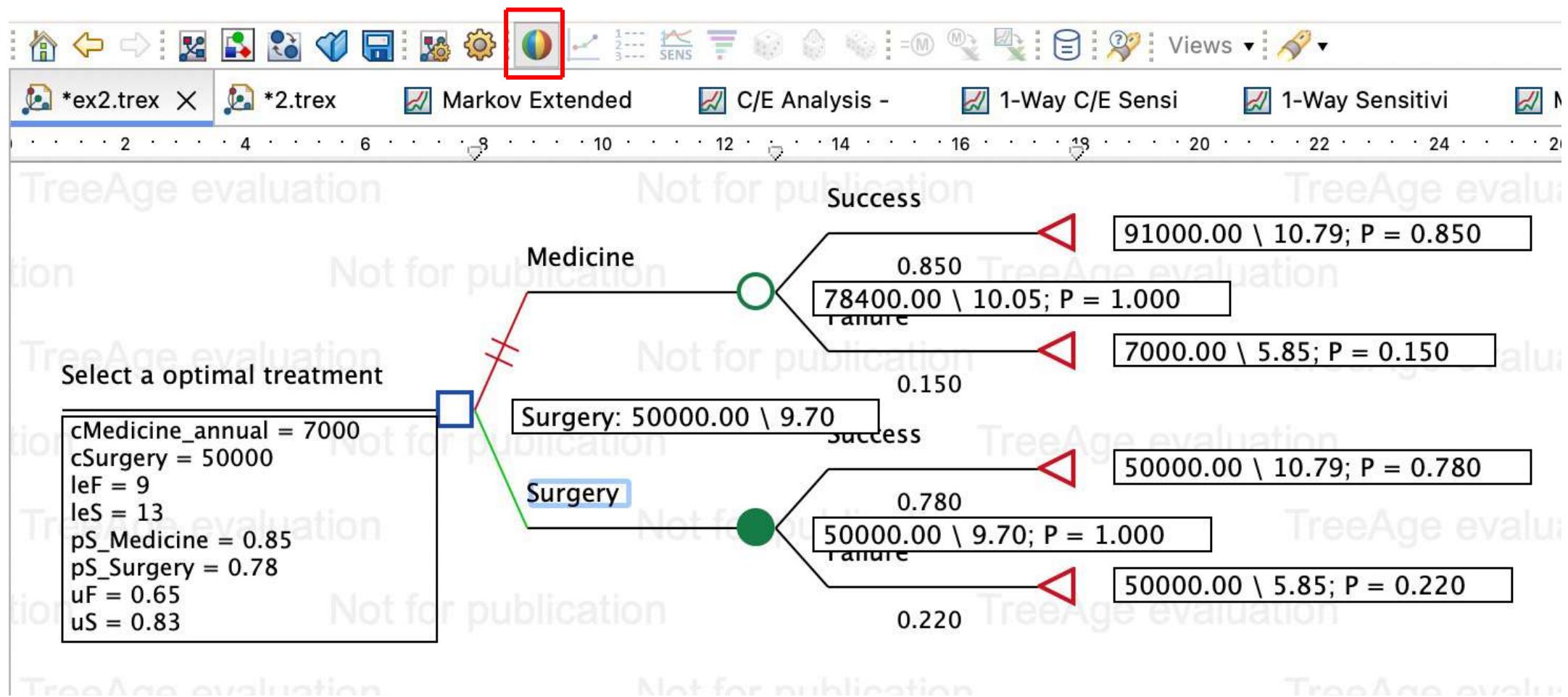
Treatment	Consequence	Costs*	Effectiveness (QALYs)
Medicine	success	cMedicine_annual*leS =7,000*13	leS*uS =13*0.83
	failure	cMedicine_annual =7,000	leF*uF =9*0.65
Surgery	success	cSurgery=50,000	leS*uS =13*0.83
	failure	cSurgery=50,000	leF*uF =9*0.65

\* Medicine costs 7,000 per year for the treatment over the course of a patient's lifetime. But if a patient fails on Medicine, treatment is stopped after Year 1.

# Example 2- Add outcome measures



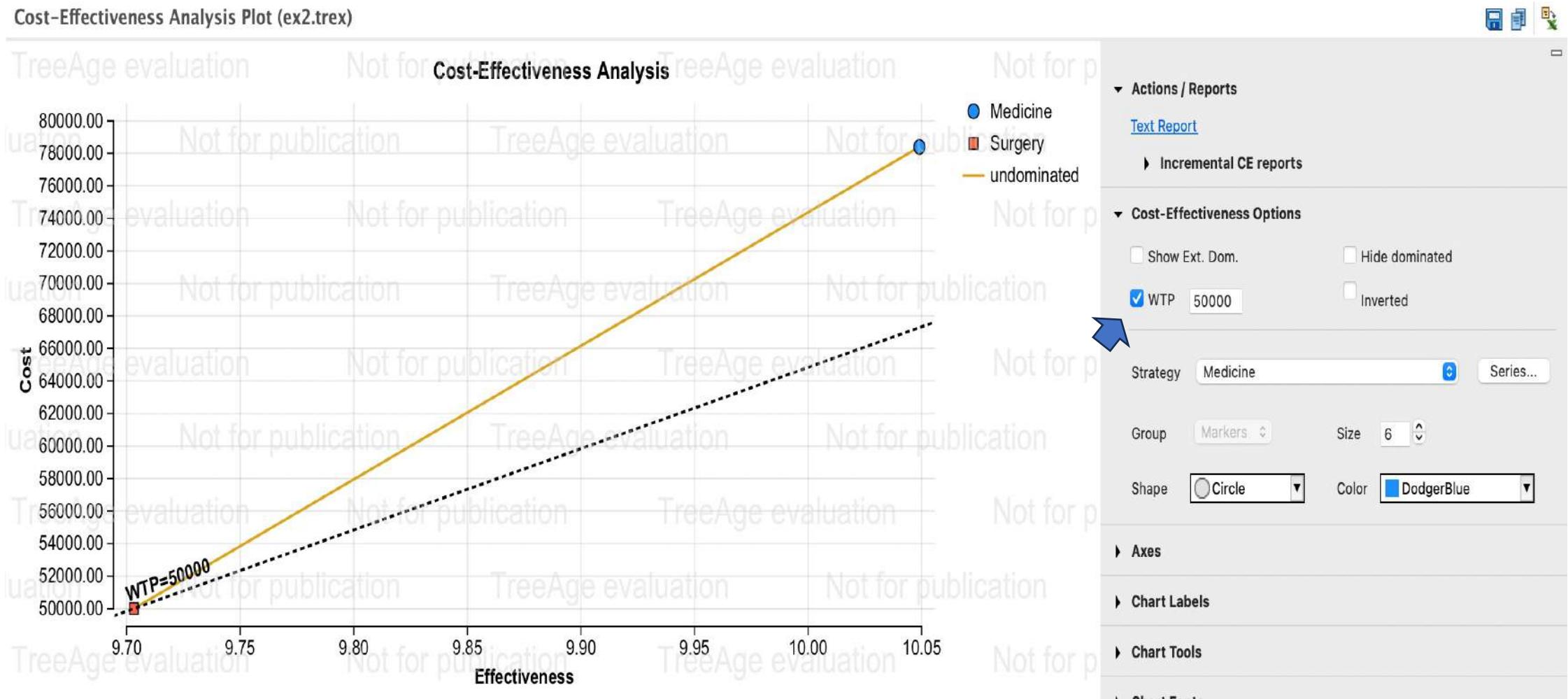
## Example 2- Analyze the tree (run Roll Back)



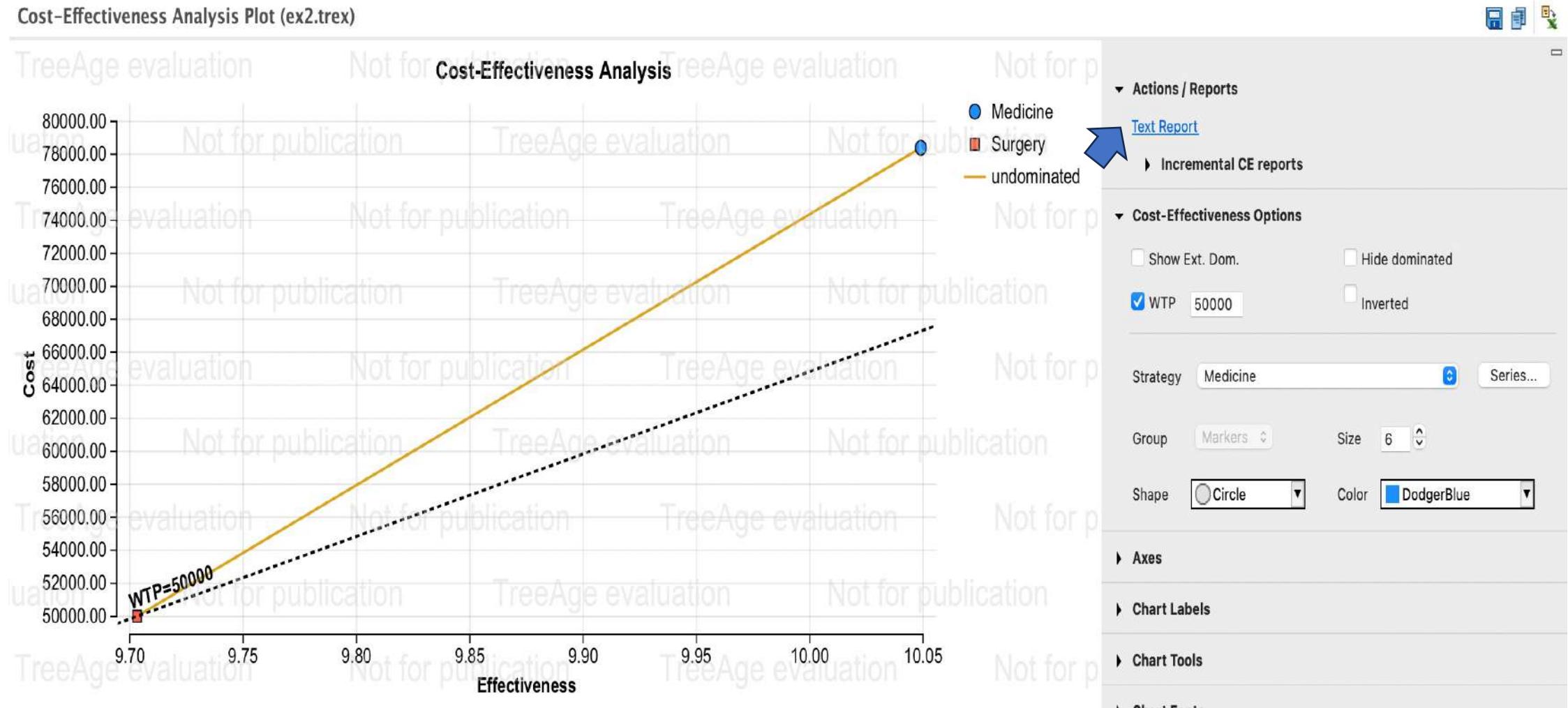
Example 2- Analyze the tree (run Cost-Effectiveness)

The screenshot shows the TreeAge Pro 2024 interface. The menu bar includes File, Edit, Node, Subtree, Tree, Values, Analysis, Window, and Help. The toolbar contains various icons for file operations and analysis types. The main workspace displays a decision tree with two main branches: "Medicine" and "Surgery". Each branch leads to a chance node representing "Success" or "Failure". A box on the left lists parameters: cMedicine\_annual = 7000, cSurgery = 50000, leF = 9, leS = 13, pS\_Medicine = 0.85, pS\_Surgery = 0.78, uF = 0.65, and uS = 0.83. The "Analysis" menu is open, showing options like Roll Back, Rankings, Cost-Effectiveness (selected), Sensitivity Analysis, Monte Carlo Simulation, Markov Cohort, Partitioned Survival Analysis, Decision Tree Pathway Report, NMB vs. WTP..., Price Threshold..., Comparative Distributions, Stored Analyses, Expected Value, Expected Value of Perfect Information, Standard Deviation, Path Probability, Payoff Range, and Over/Under Probabilities. Shortcuts for many of these analyses are listed on the right.

## Example 2- Analyze the tree (run Cost-Effectiveness and add WTP)



## Example 2- Analyze the tree (run Rankings)



## Example 2- Analyze the tree (run Rankings)

Cost-Effectiveness Rankings Report (ex2.trex)							
Category	Strategy	Cost	Incr. Cost	Effectiveness	Incr. Effectiveness	ICER (IC/IE)	NMB
All (no dominance)							
undominated	Surgery	50000.00		9.70			435160.00
undominated	Medicine	78400.00	28400.00	10.05	0.35	82128.40	424050.00

The optimal strategy will have the highest Net Benefit value

- Net Monetary Benefits (NMB) = Effectiveness \* WTP - Cost
- Net Health Benefits (NHB) = Effectiveness - Cost / WTP

What if the willingness to pay threshold is 100,000/QALY?

## □ 單元七： Sensitivity Analysis

# Example 2-One-way Sensitive Analysis

Variable	Value(range)
pS_surgery	0.78 (0.72-0.82)
pS_medicine	0.85 (0.84-0.93)
cSurgery	5,0000 (45,000-55,000)
cMedicine_annual	7,000 (6,650-7,350)

Variables X Payoffs Distributions Variable Def

Name Root Definition

cMedicine_annual	7000	$=f_x$
cSurgery	50000	

type filter te

Add/Change Variable or Function

Sensitivity Analysis

General Sensitivity Analysis Categories

Low value: 6650  
High value: 7350  
Range type: Values  
Adj %  
Adj #

Deterministic correlated variables

Available variables: pS\_Surgery, pS\_Medicine, cSurgery, leS, leF, uF, uS

Variable Type

Cancel Apply and Close

# Example 2-One-way Sensitive Analysis

Analysis   Window   Help

Roll Back    R

Rankings    K

Cost-Effectiveness    F6

Sensitivity Analysis   >  F6

Monte Carlo Simulation   >  F6

Markov Cohort    F6

Partitioned Survival Analysis   >  F7

Decision Tree Pathway Report

NMB vs. WTP...    F6

Price Threshold...    F6

Comparative Distributions    F6

Stored Analyses    A

Expected Value    E

Expected Value of Perfect Information

Standard Deviation

Path Probability

 1 Way...   F5

 2 Way...   F5

3 Way...   F5

Threshold Analysis...   F7

 Tornado Diagram...   F5

# Example 2-One-way Sensitive Analysis

One-Way Sensitivity Analysis Setup

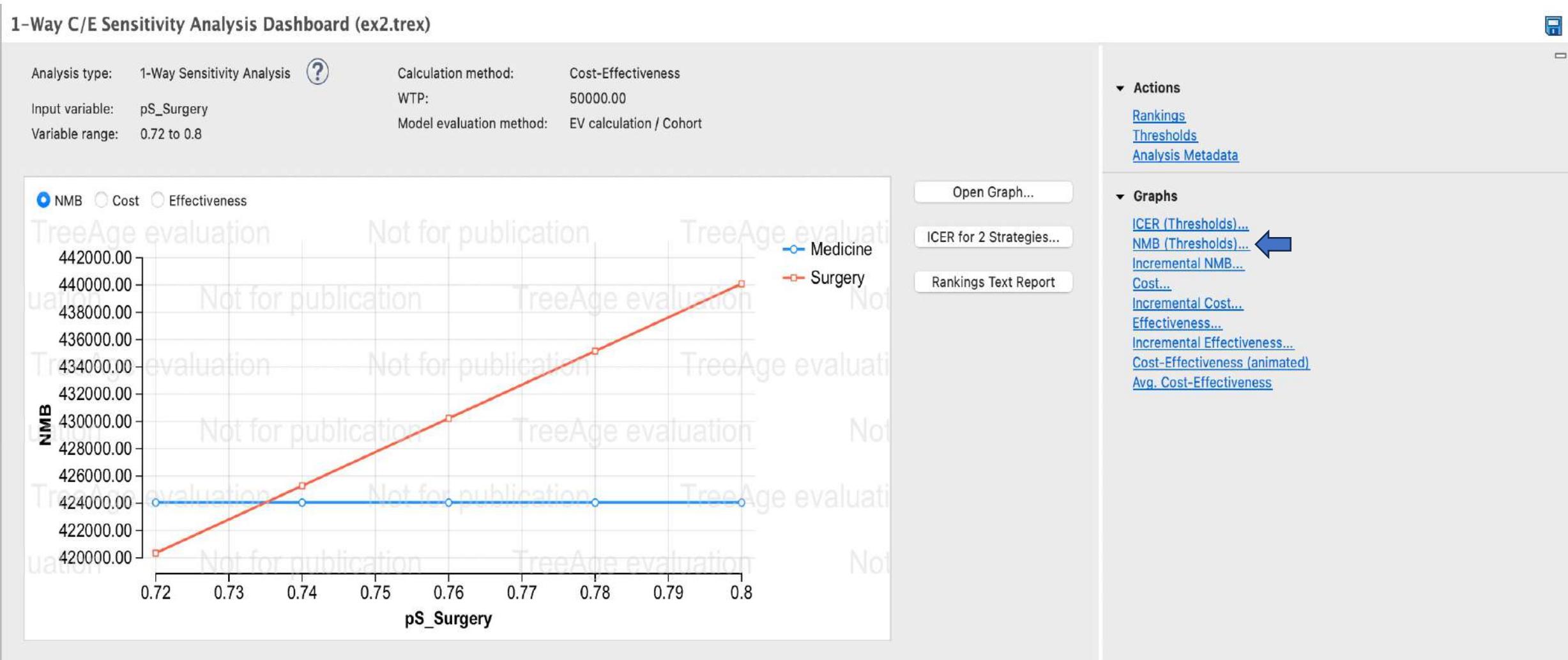
Variable	Type	Low entry	High entry	Intervals	Low value	High value	Definitions	Correlations
pS_Surgery	Values	0.72	0.8	4	0.72	0.8	[Select a optimal treatn	
cMedicine_annual								
cSurgery								
leF								
leS								
pS_Medicine								
<b>pS_Surgery</b>								
uF								
uS								

One-Way Sensitivity Analysis Setup

Variable	Type	Low entry	High entry	Intervals	Low value	High value	Definitions	Correlations
pS_Surgery	Values	0.72	0.82	4	0.72	0.82	[Select a optimal treatn	

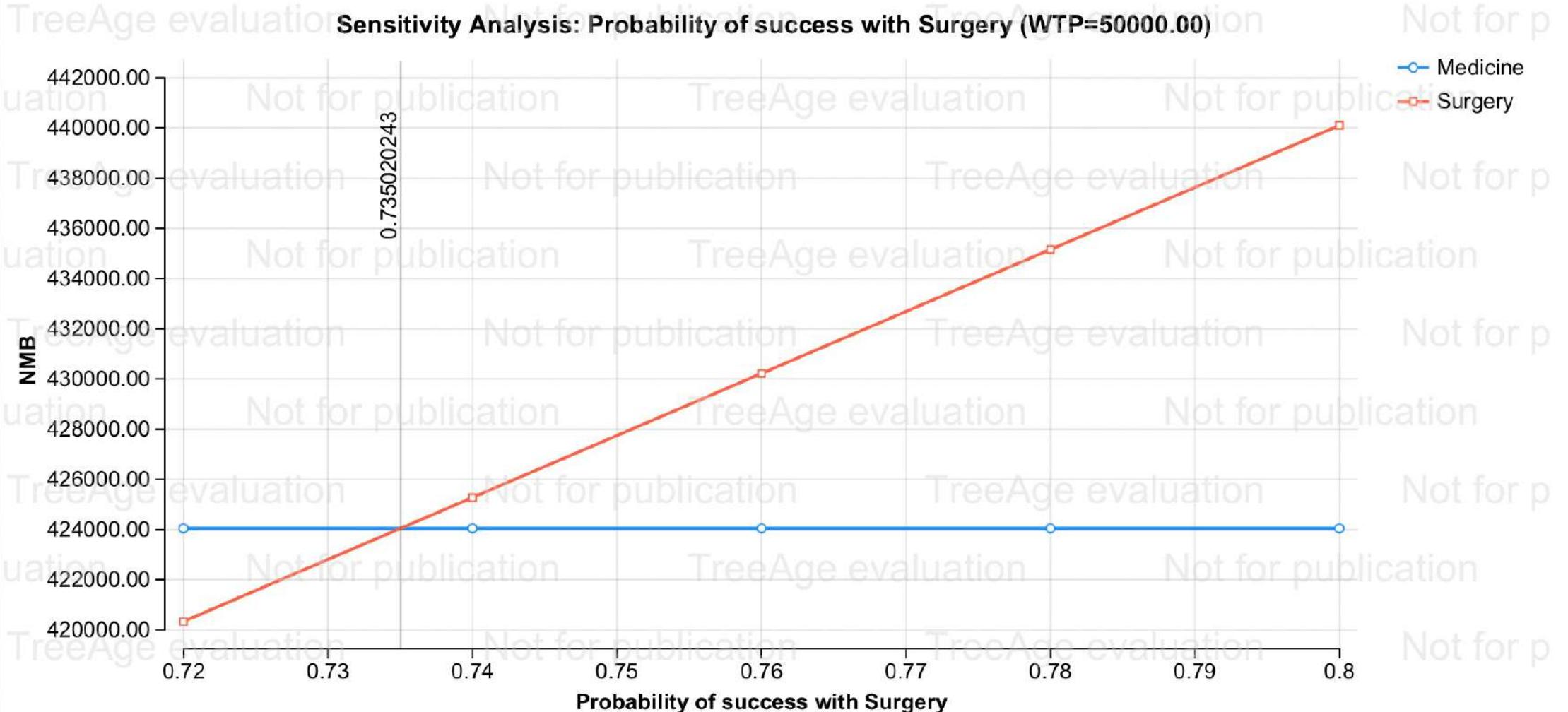
Run microsimulation rather than EV

## Example 2-Net Monetary Benefits Chart

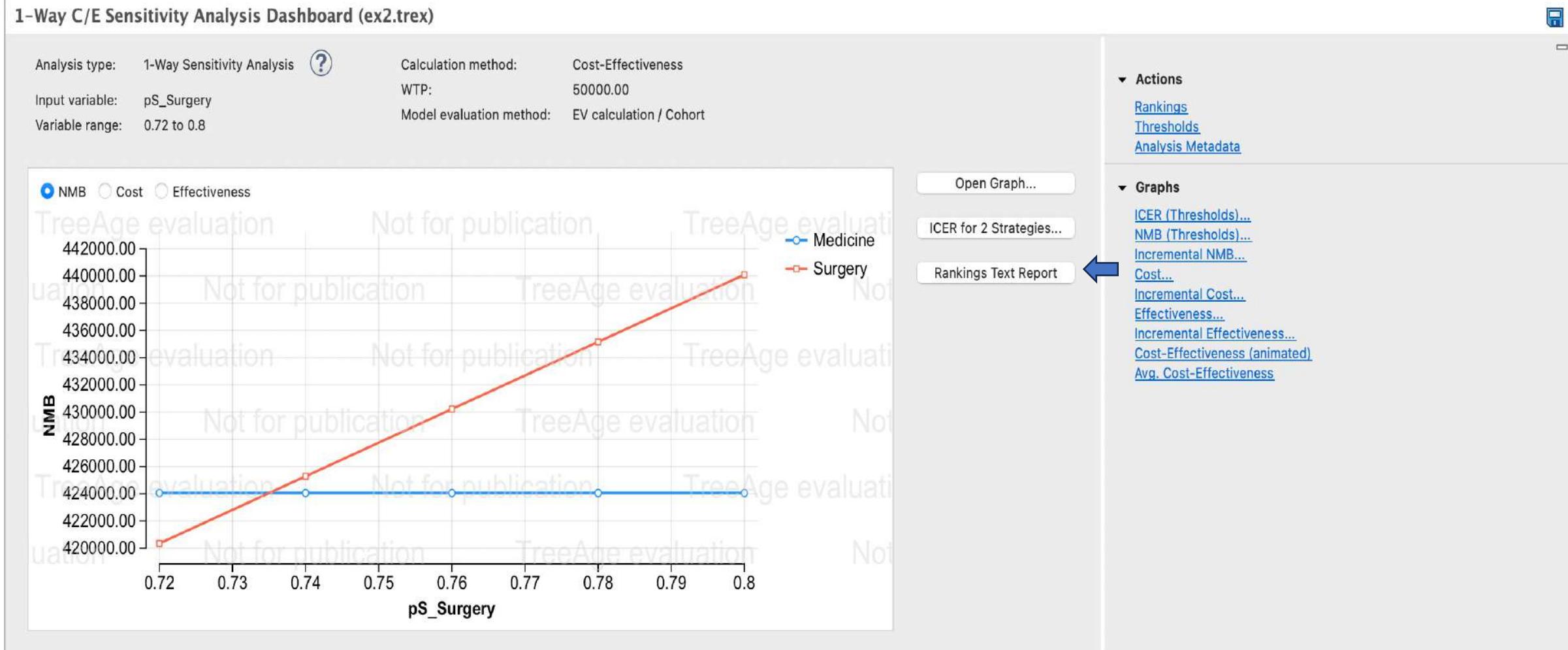


# Example 2-One-way Sensitive Analysis-Net Monetary Benefits Chart

1-Way Sensitivity Analysis – Net Monetary Benefit Chart (ex2.trex)



# Example 2-Net Monetary Benefits Chart



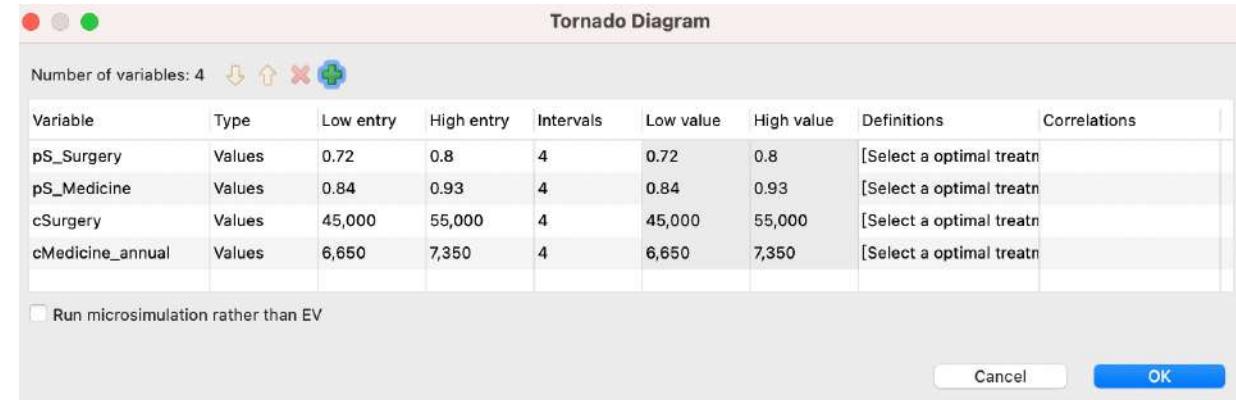
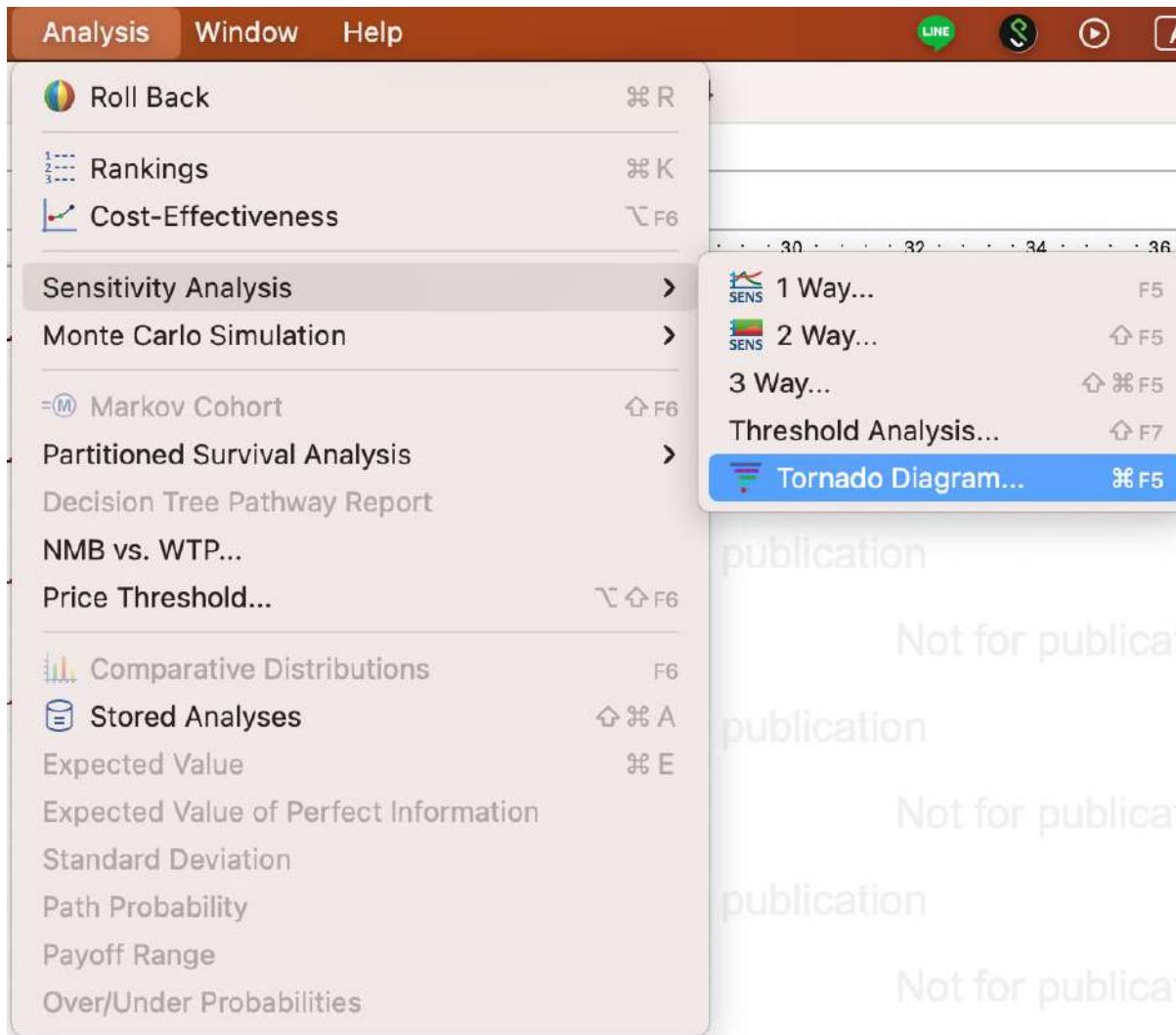
# Example 2-One-way Sensitive Analysis

Medicine is the optimal strategy

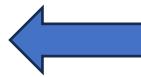
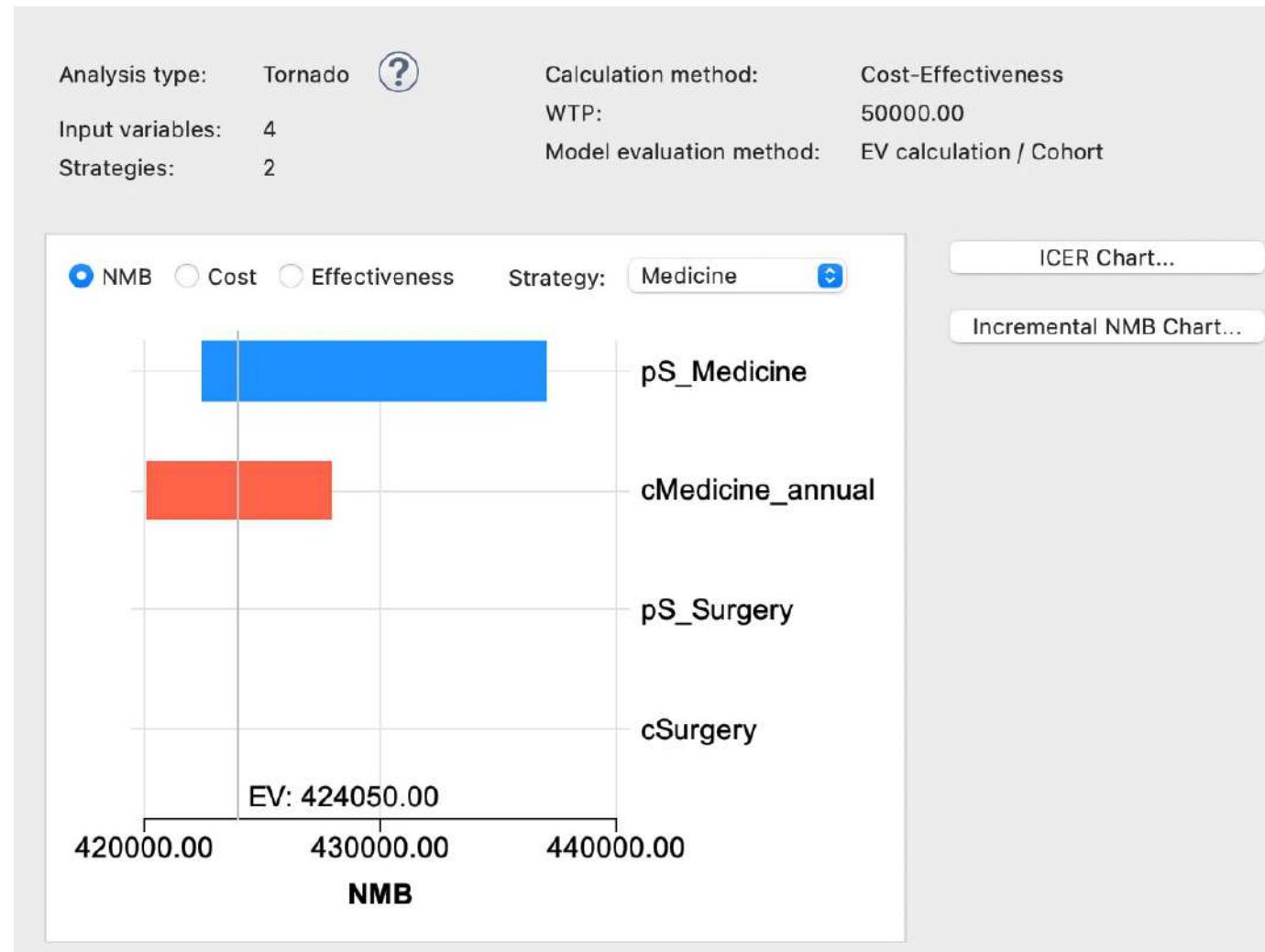
Surgery is the optimal strategy

1-Way Sensitivity Analysis - C/E Text Report (ex2.trex)										
pS_Surgery	Strategy	Cost	Incr. Cost	Effectiveness	Incr. Effectiveness	ICER	NMB	C/E	Dominance	
0.72										
0.72	Surgery	50000.00	0.00	9.41	0.00	0.00	420340.00	5315.30		
0.72	Medicine	78400.00	28400.00	10.05	0.64	44222.98	424050.00	7801.77		
0.74										
0.74	Surgery	50000.00	0.00	9.51	0.00	0.00	425280.00	5260.06		
0.74	Medicine	78400.00	28400.00	10.05	0.54	52263.53	424050.00	7801.77		
0.76										
0.76	Surgery	50000.00	0.00	9.60	0.00	0.00	430220.00	5205.95		
0.76	Medicine	78400.00	28400.00	10.05	0.44	63877.64	424050.00	7801.77		
0.78										
0.78	Surgery	50000.00	0.00	9.70	0.00	0.00	435160.00	5152.94		
0.78	Medicine	78400.00	28400.00	10.05	0.35	82128.40	424050.00	7801.77		
0.8										
0.8	Surgery	50000.00	0.00	9.80	0.00	0.00	440100.00	5101.00		
0.8	Medicine	78400.00	28400.00	10.05	0.25	114979.76	424050.00	7801.77		

# Example 2-Tornado Diagrams

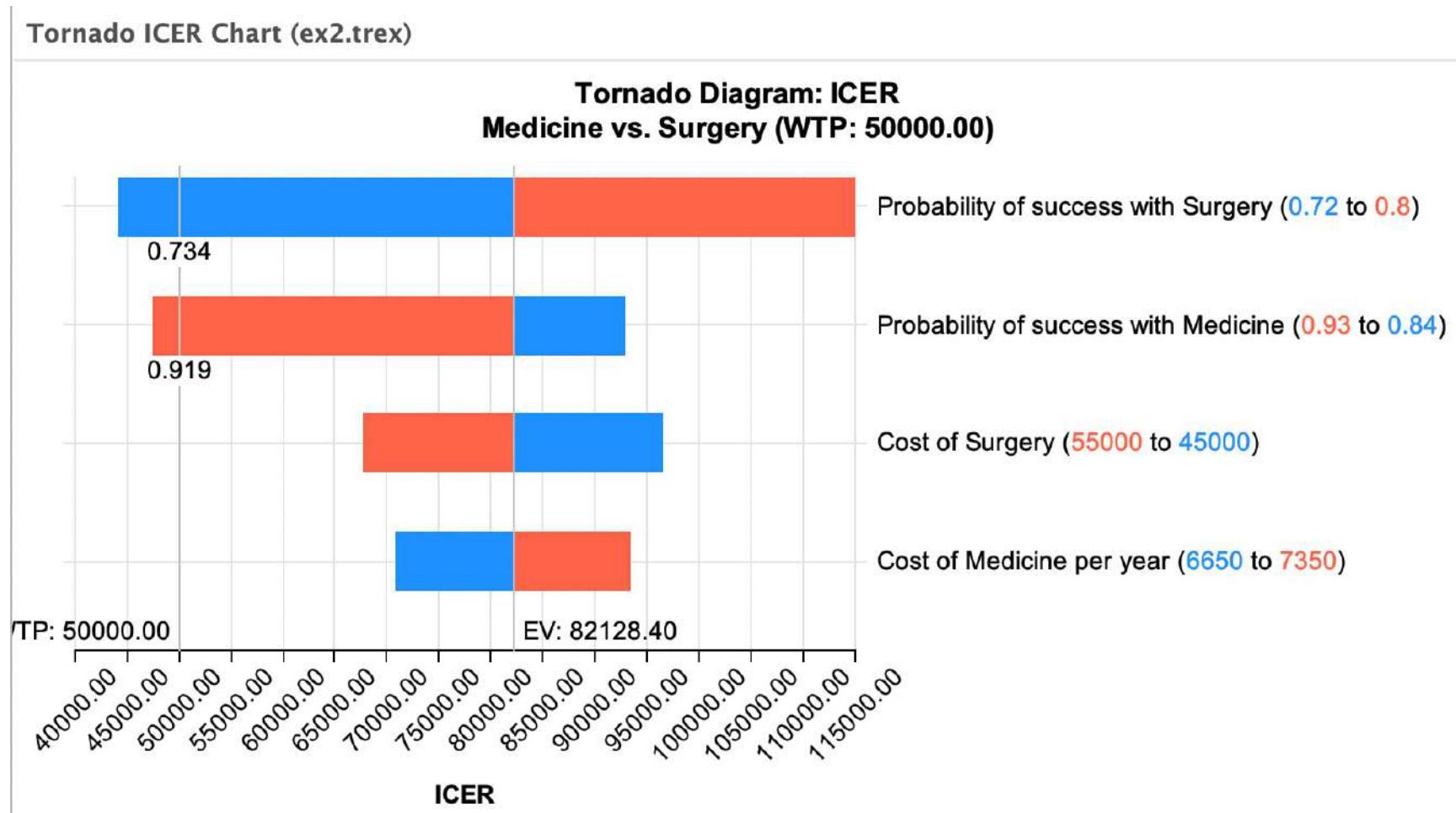


# Example 2-Tornado Diagrams



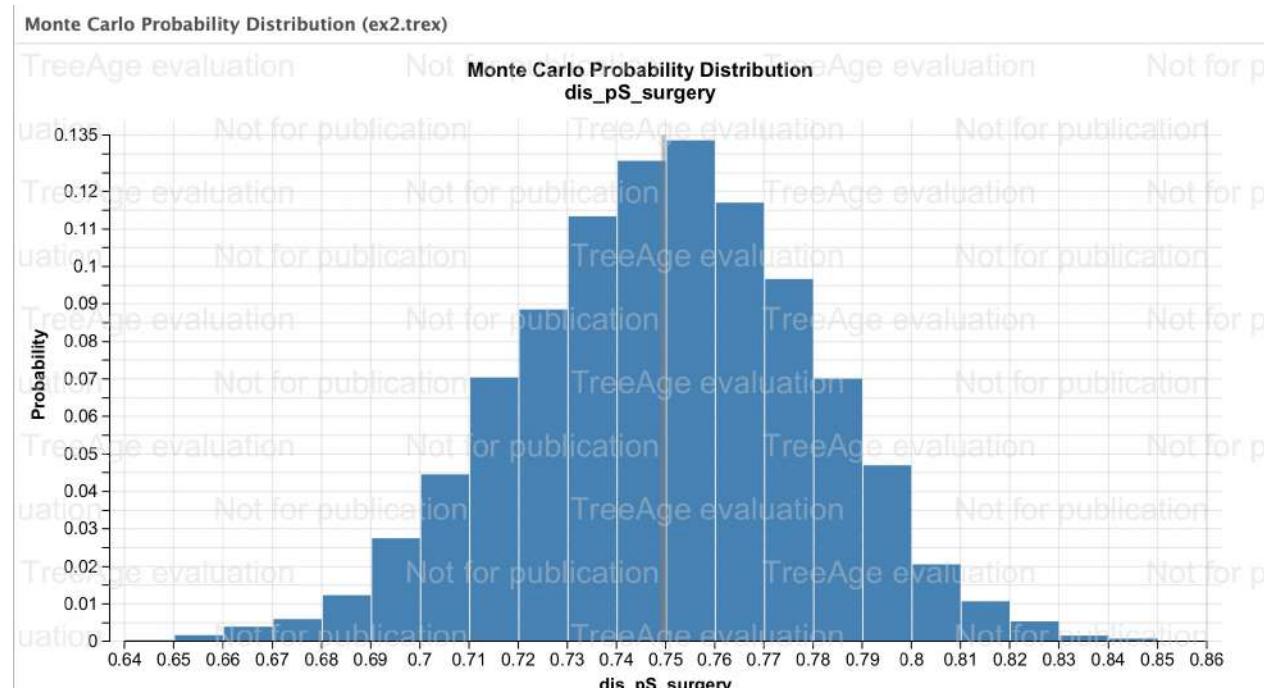
# Example 2-Tornado Diagrams

A set of one-way sensitivity analysis brought together in a single graph



## Example 2- Probabilistic Sensitivity Analysis(PSA)

- Uncertainty always exists in multiple parameters in a model



- Different parameter combinations could impact the optimal strategy
- PSA results estimate the total impact of uncertainty on the model, or the confidence that can be placed in the analysis results.

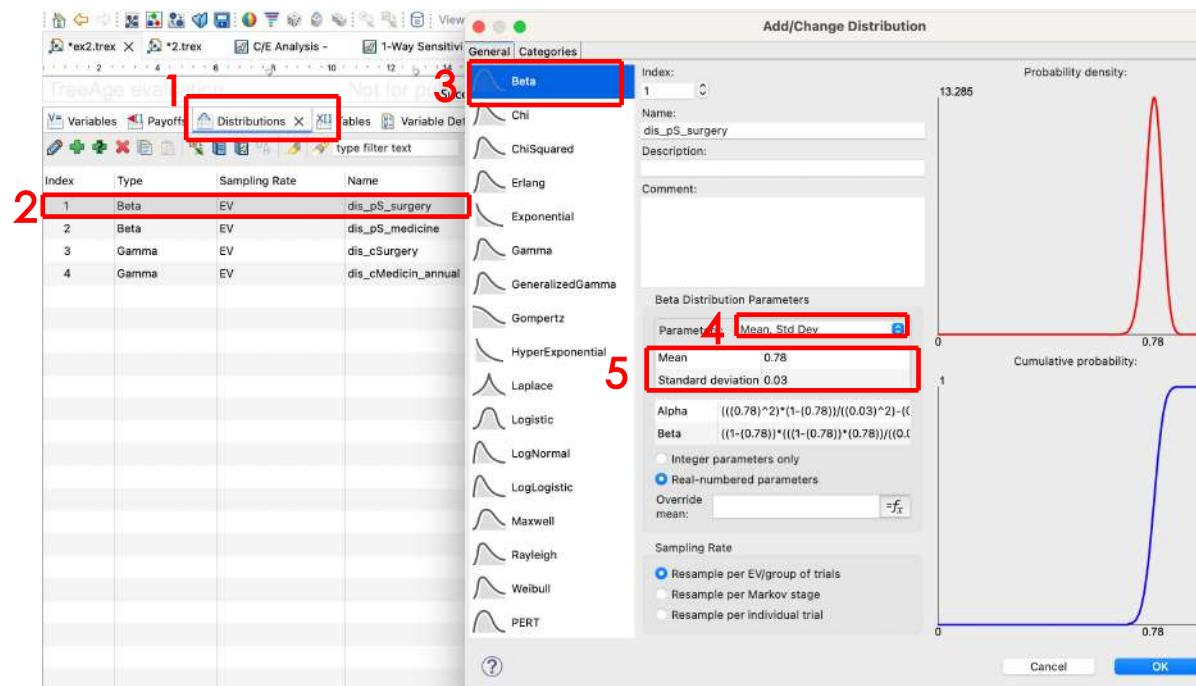
## Example 2- Probabilistic Sensitivity Analysis(PSA)

- PSA involves sampling model parameter values from **distributions** imposed on variables in the model.
- Data sources for parameter estimation
  - primary data, secondary data, and expert opinion.
- Choosing distributions for parameters

Distribution	interval	parameter
Beta distribution	[0,1]	<ul style="list-style-type: none"><li>• Transition probabilities</li><li>• utility</li></ul>
Gamma distribution	[0, $+\infty$ ]	<ul style="list-style-type: none"><li>• Cost</li><li>• disutility</li></ul>
log-normal distribution		<ul style="list-style-type: none"><li>• Cost</li><li>• Treatment effects</li><li>• disutility</li></ul>

# Example 2-PSA- Set up distributions for 4 parameters

Variable	New name	Type	Mean	SD
pS_surgery	dis_pS_surgery	Beta	0.78	0.03
pS_medicine	dis_pS_medicine	Beta	0.85	0.02
cSurgery	dis_cSurgery	Gamma	50,000	3,000
cMedicine_annual	dis_cMedicine_annual	Gamma	7,000	600



# Example 2-PSA- Set up distributions for 4 parameters

The screenshot shows the TreeAge software interface. On the left, a decision tree diagram is visible with nodes for 'Medicine' and 'Surgery'. A context menu is open over the 'Medicine' node, displaying code related to variables like `cMedicine_annual`, `dis_cMedicin_annual`, etc. On the right, a detailed dialog box titled 'Add/Change Variable or Function' is open for the variable `cMedicine_annual`. The 'General' tab is selected, showing the description 'Cost of Medicine per year'. The 'Root definition:' section contains the expression `dis_cMedicin_annual`. In the 'Add to Expression:' section, the 'Distributions' group is selected, and the element `dis_cMedicin_annual` is listed. Below this, the calculated value is set to 7000. At the bottom, there are 'Cancel' and 'Apply and Close' buttons.

Variables

Name	Root Definition	Description
<code>cMedicine_annual</code>	<code>dis_cMedicin_annual</code>	
<code>cSurgery</code>	<code>dis_cSurgery</code>	
<code>leF</code>	9	Lit
<code>leS</code>	13	Lit
<code>pS_Medicine</code>	<code>dis_pS_medicine</code>	Pr
<code>pS_Surgery</code>	<code>dis_pS_surgery</code>	Pr
<code>uF</code>	0.65	Ut
<code>uS</code>	0.83	Ut

Add/Change Variable or Function

General

cMedicine\_annual

Description: Cost of Medicine per year

Root definition:

Build Expression:

Format Text Python Array Matrix

`dis_cMedicin_annual`

Add to Expression:

Group: Recent expressions Variables Distributions Functions Operators

Element: `dis_cMedicin_annual` `dis_cSurgery` `dis_pS_medicine` `dis_pS_surgery`

Calculated value (at Select a optimal treatment): 7000

Definition info:

Comment:

Cancel Apply and Close

# Example 2-Monte Carlo Simulation

Analysis | Window | Help

Roll Back

Rankings

Cost-Effectiveness

Sensitivity Analysis

Monte Carlo Simulation

Markov Cohort

Partitioned Survival Analysis

Decision Tree Pathway Report

NMB vs. WTP...

Price Threshold...

Comparative Distributions

Stored Analyses

Expected Value

Expected Value of Perfect Information

Standard Deviation

Path Probability

Payoff Range

Over/Under Probabilities

Monte Carlo Simulation

2nd-order parameter samples (PSA)

Number of samples: 10000

Distributions...

Seeding...

Output Reports...

Identifiers...

Threading...

Report Filters...

Patient Tracking...

Downstream Decisions...

Cancel

Begin

Sampling (Probabilistic Sensitivity)...

Sampling + Trials...

EVPI Sampling...

Run Simulation Batch...

M Markov

Label

Summation

DES

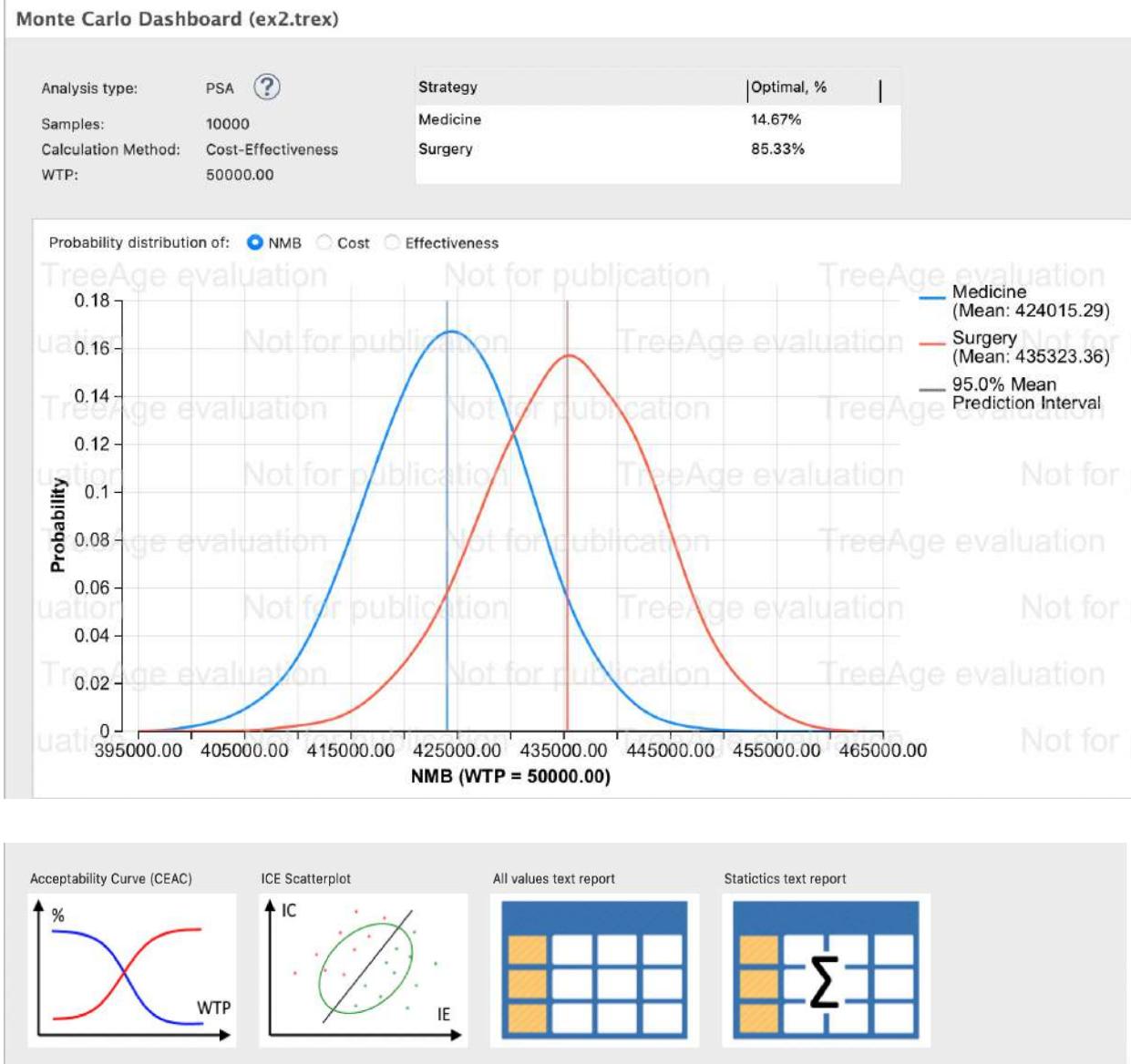
Time

Entry

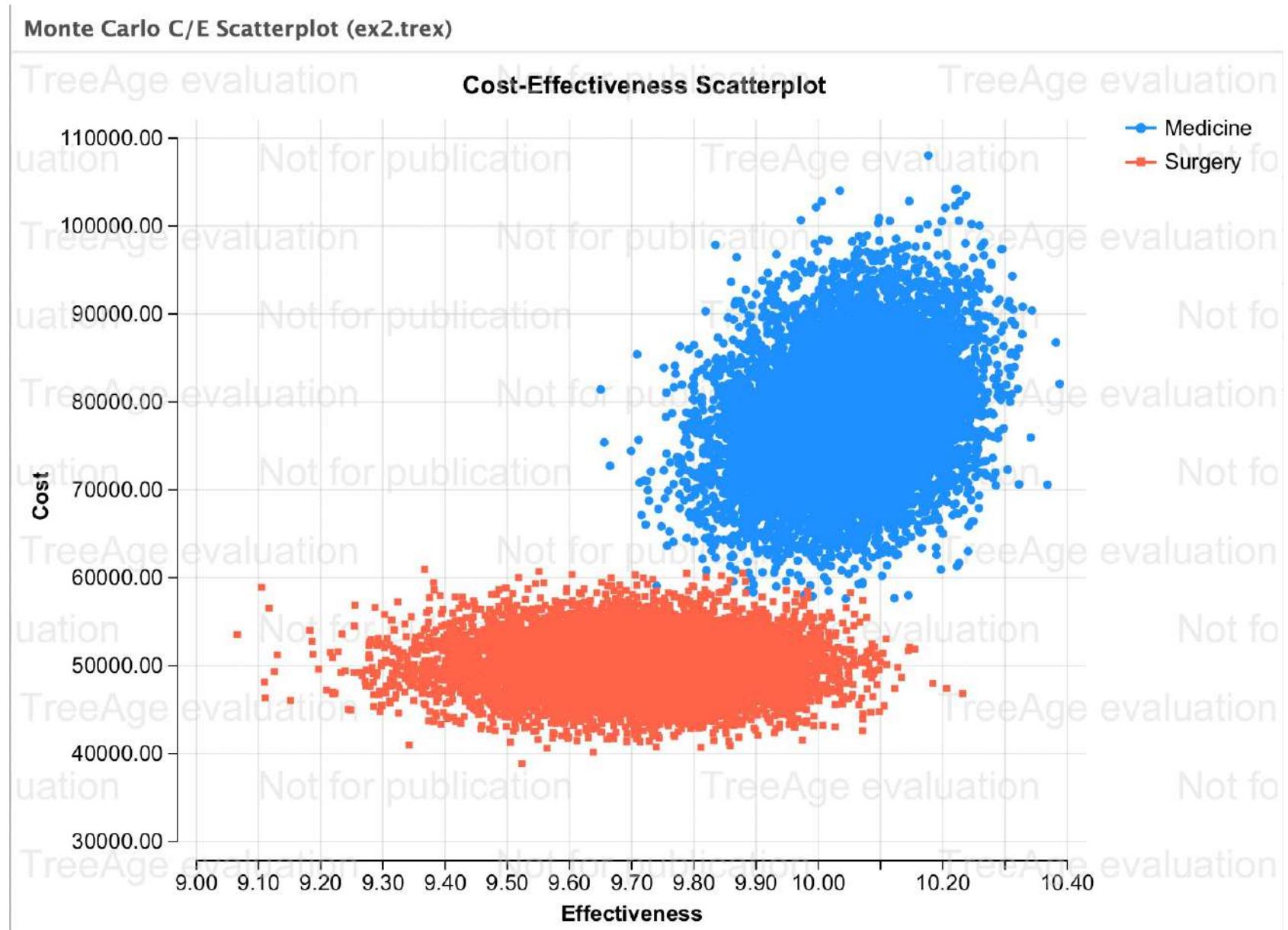
Stop

PartSA

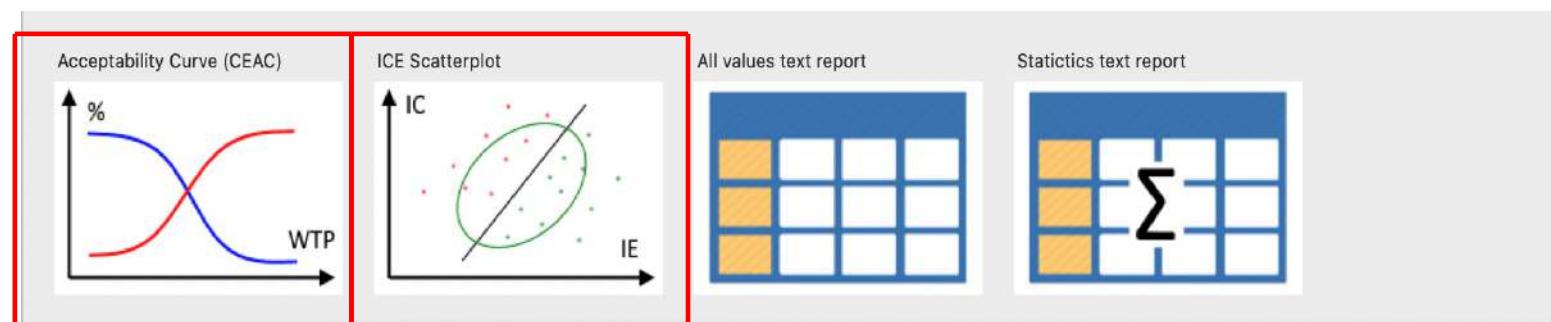
Notes and Arrows...



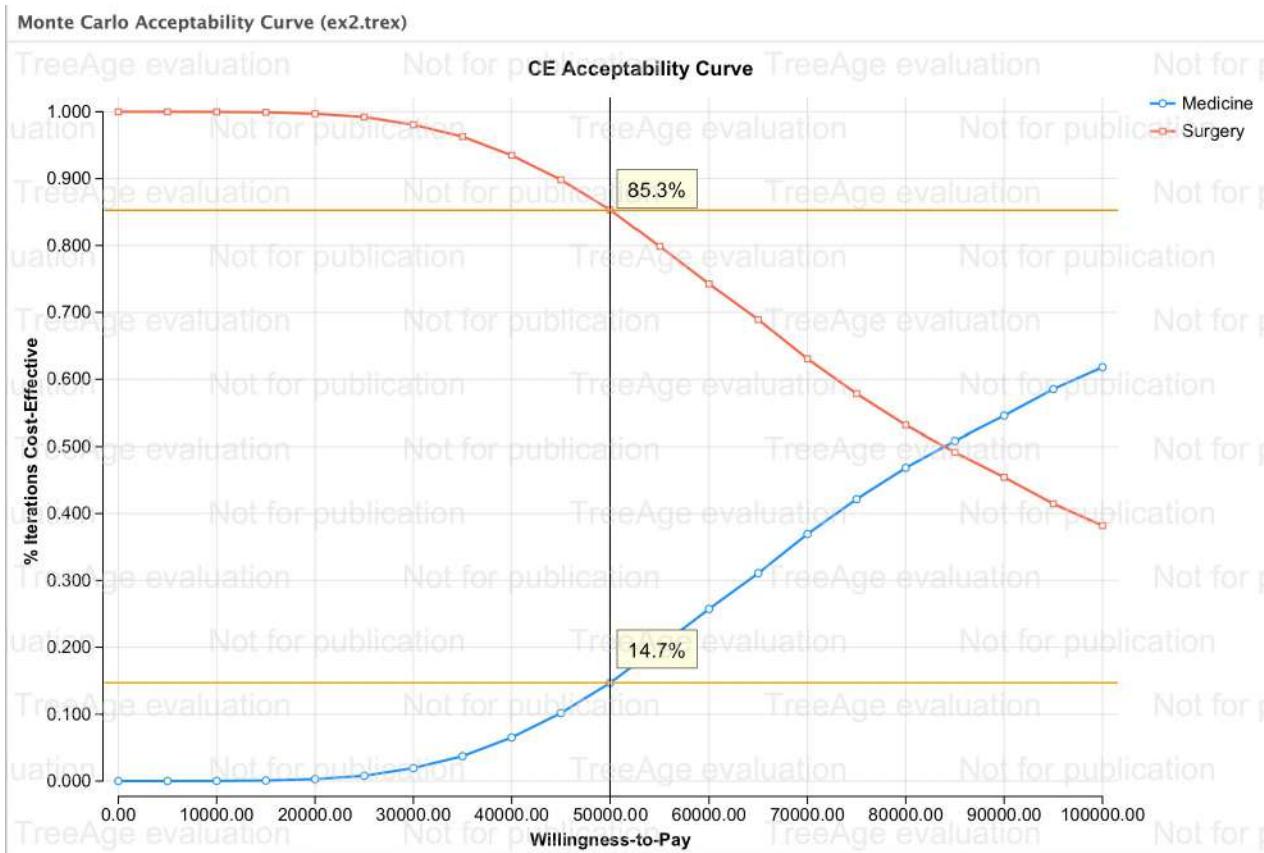
# Example 2-Monte Carlo Simulation



# Example 2-Monte Carlo Simulation



# Example 2-Monte Carlo Simulation-Acceptability Curve



Monte Carlo Acceptability Text (ex2.trex)

Willingness-to-Pay	Strategy	Acceptability
0.00	Surgery	1
0.00	Medicine	0
5000.00	Surgery	1
5000.00	Medicine	0
10000.00	Surgery	0.9998
10000.00	Medicine	0.0002
15000.00	Surgery	0.9992
15000.00	Medicine	0.0008
20000.00	Surgery	0.9971
20000.00	Medicine	0.0029
25000.00	Surgery	0.9922
25000.00	Medicine	0.0078
30000.00	Surgery	0.9806
30000.00	Medicine	0.0194
35000.00	Surgery	0.9628
35000.00	Medicine	0.0372
40000.00	Surgery	0.9348
40000.00	Medicine	0.0652
45000.00	Surgery	0.8983
45000.00	Medicine	0.1017
50000.00	Surgery	0.8533
50000.00	Medicine	0.1467
55000.00	Surgery	0.7986
55000.00	Medicine	0.2014
60000.00	Surgery	0.7426
60000.00	Medicine	0.2574
65000.00	Surgery	0.6892
65000.00	Medicine	0.3108
70000.00	Surgery	0.6306
70000.00	Medicine	0.3694
75000.00	Surgery	0.5784

# Example 2-Monte Carlo Simulation

▼ Mean Prediction Intervals

Show Mean Line

Show Prediction Interval

Confidence level (%):  

▼ Data Reports

[Dashboard Graph](#)

[Statistics](#)

[All Data](#)

[Export All Data to Excel/CSV](#)

[Text Report](#)

[Identifying Variables](#)

▼ CE Outputs

[CE Graph](#)

[CE Rankings](#)

[NMB vs. WTP...](#)

[INMB vs. WTP...](#)

▼ PSA Outputs

[Acceptability Curve...](#)

[CE Scatter Plot](#) ←

[ICE Scatterplot...](#)

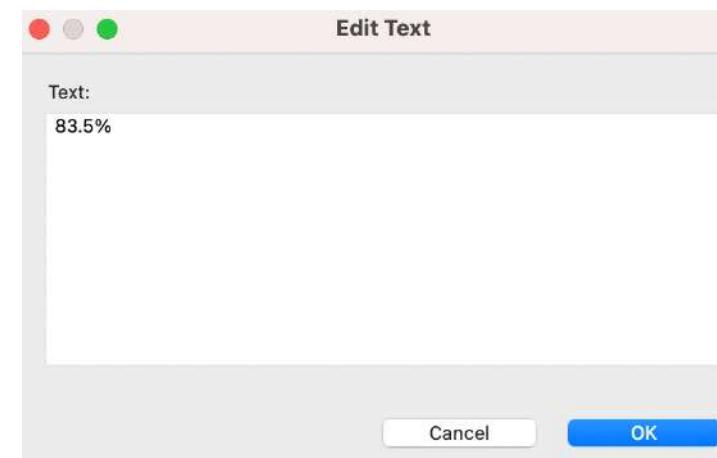
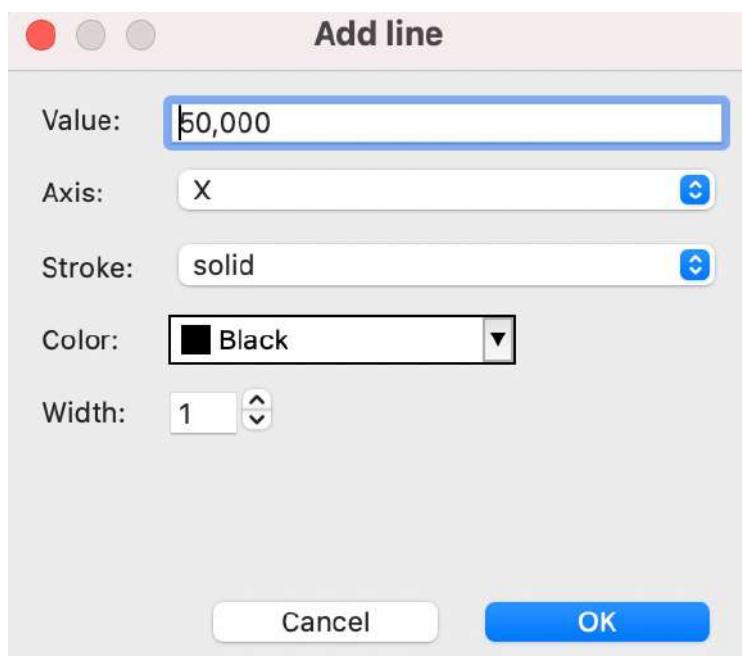
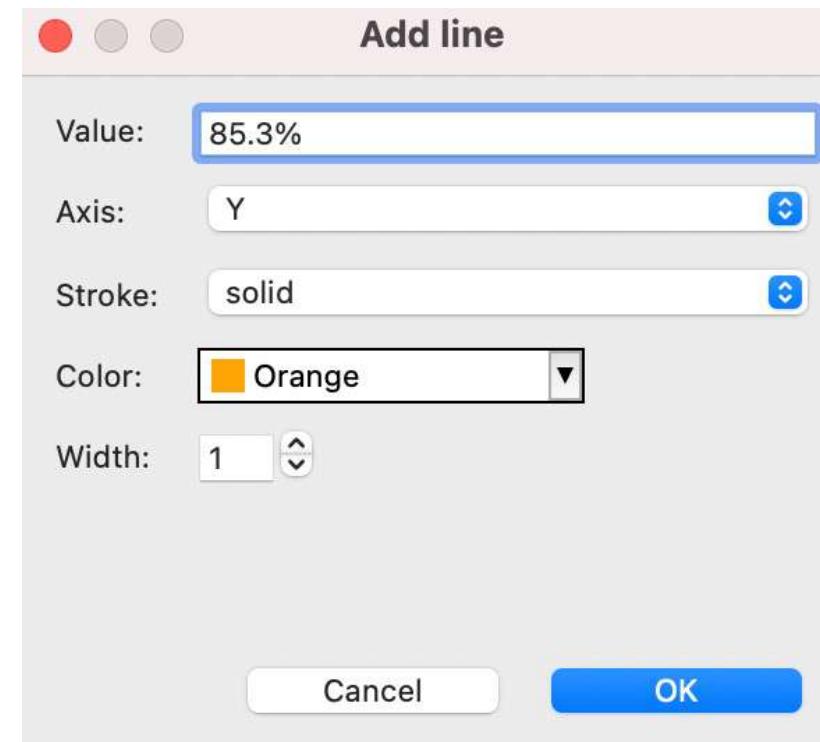
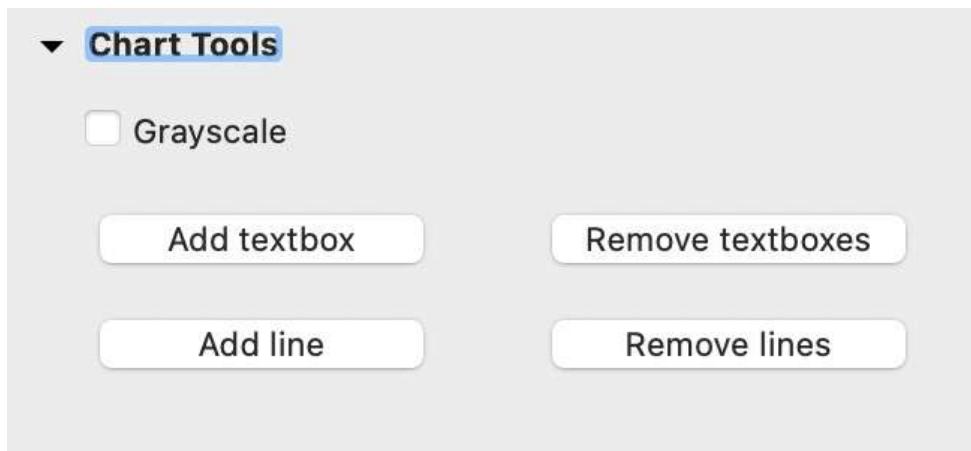
[ICER Histogram...](#)

[Acceptability at WTP...](#)

[EVPI\EVPPI Summary Report...](#)

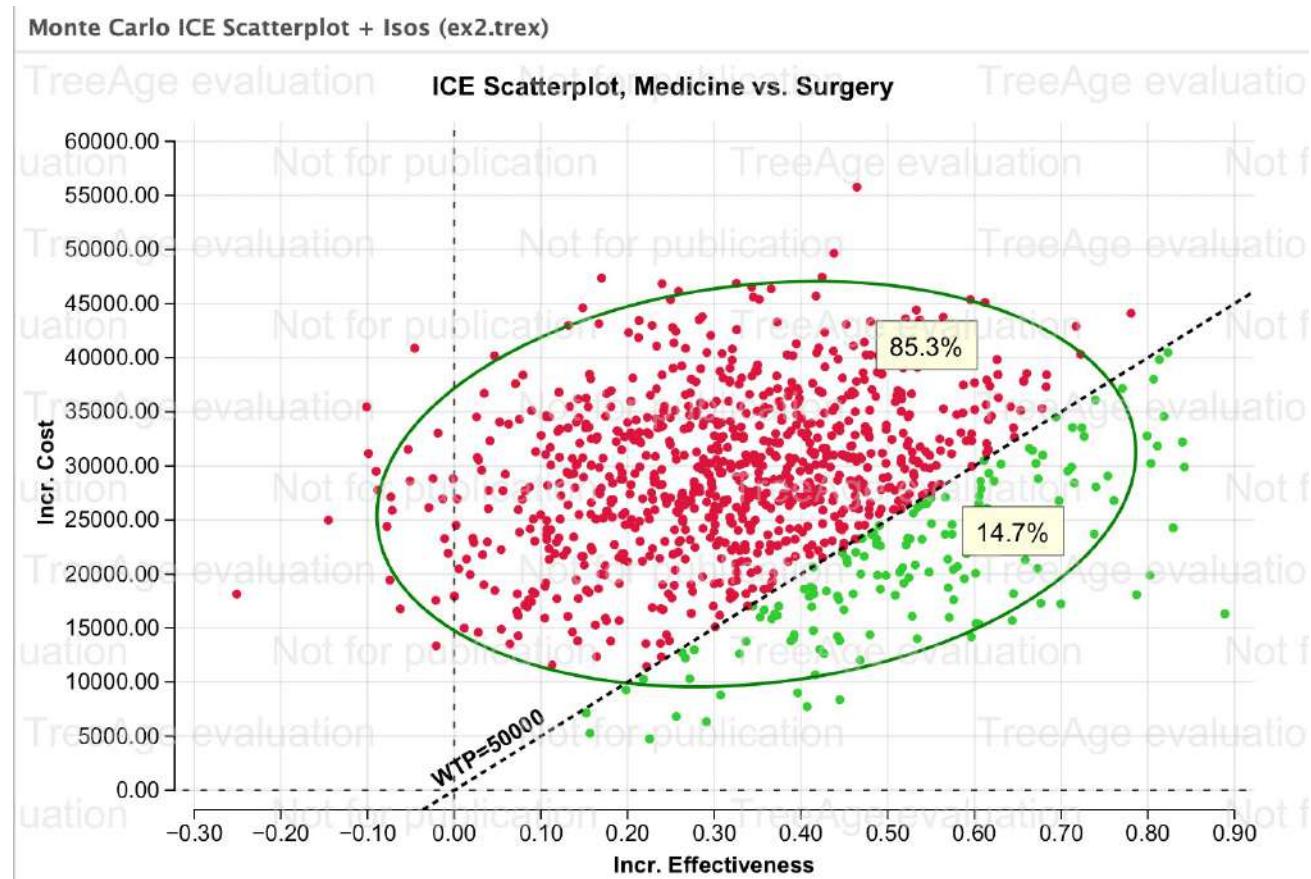
[EVPI\EVPPI vs. WTP...](#)

# Example 2-Monte Carlo Simulation- ICE Scatterplot : Medicine vs Surgery

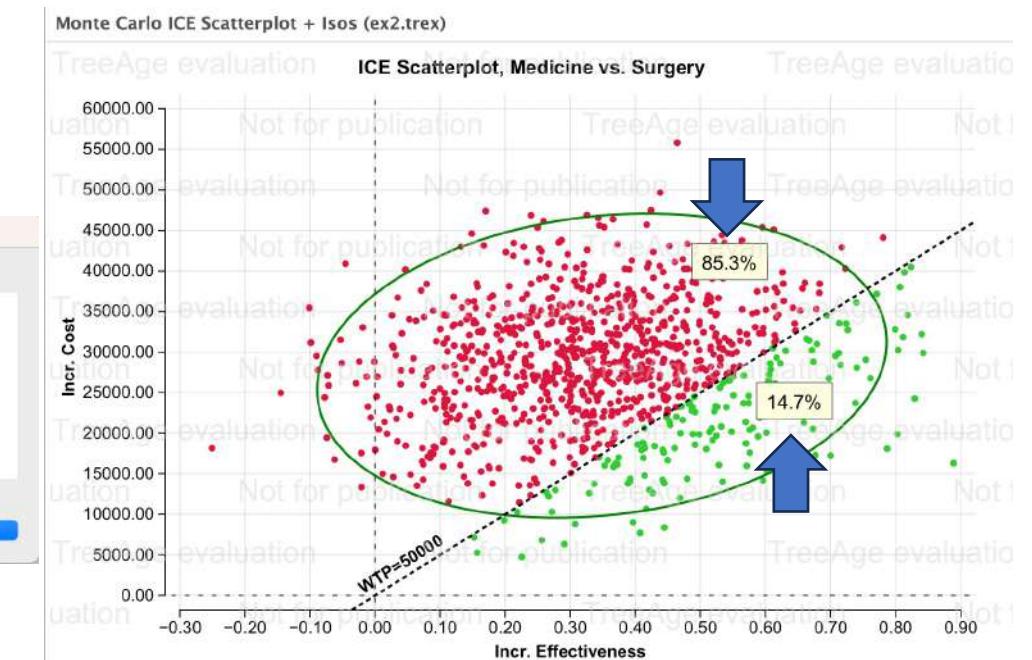
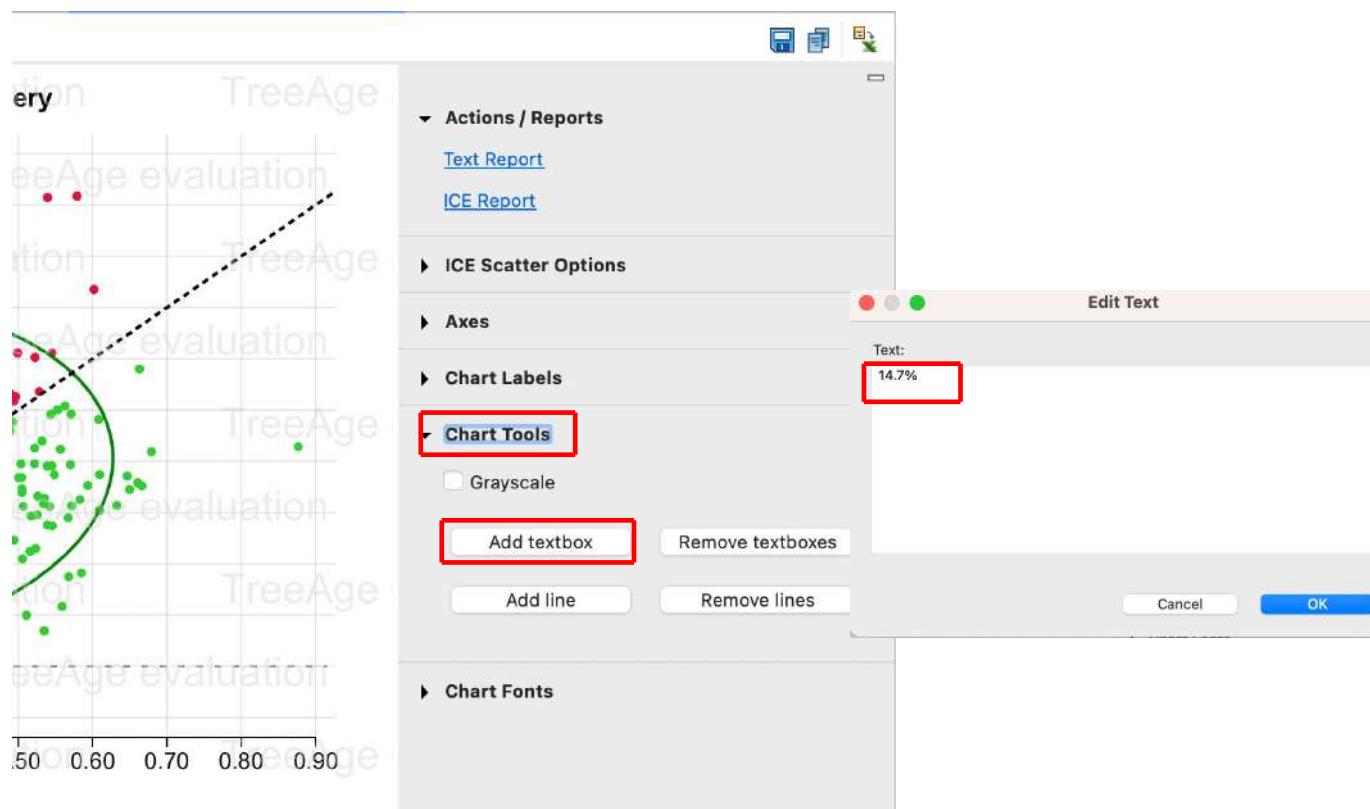


# Example 2-Monte Carlo Simulation- ICE Scatterplot : Medicine vs Surgery

-85.3% favored the less expensive strategy ,Surgery, as depicted by the dots above and to the left o the WTP line on the graph.

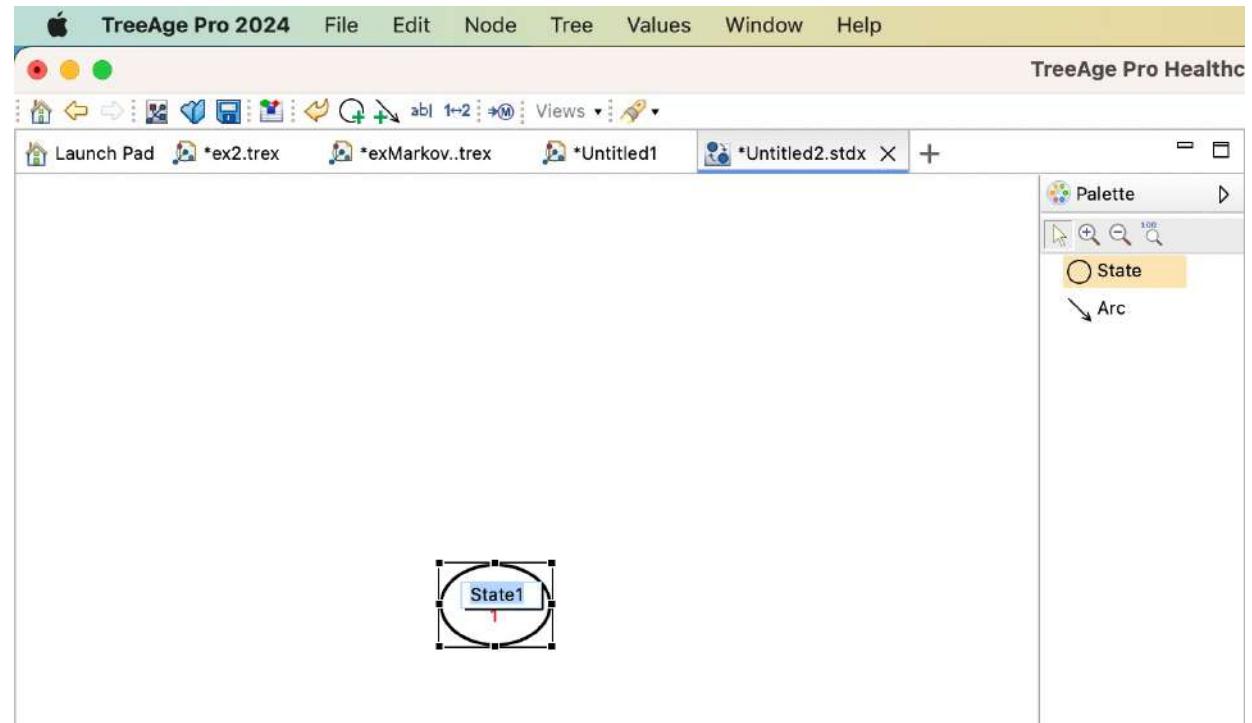
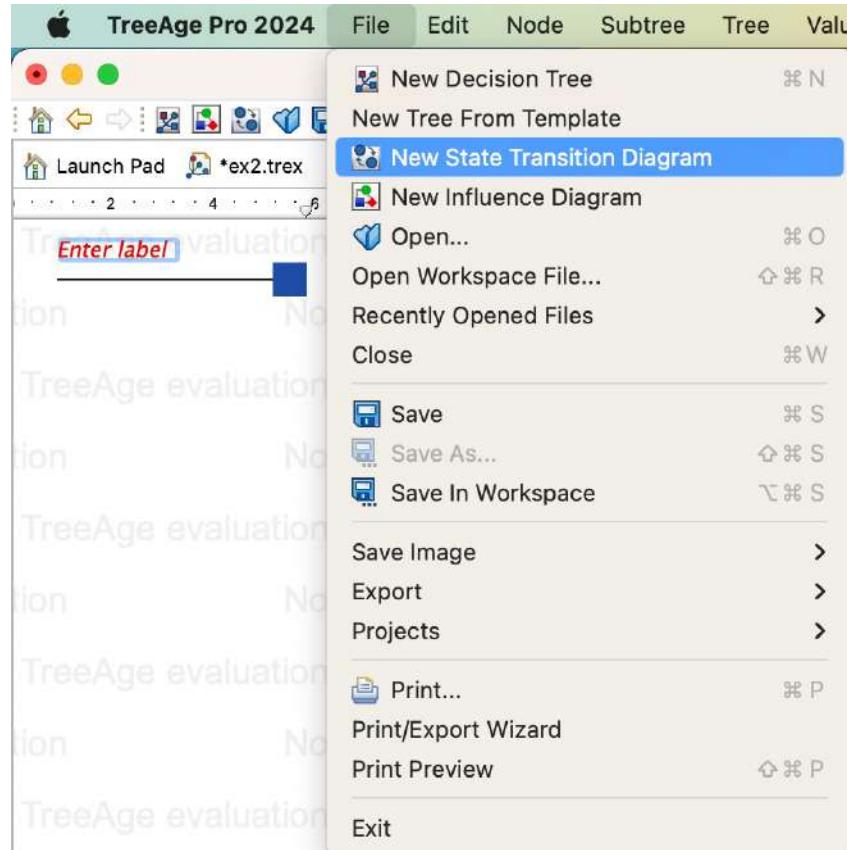


# Example 2-Monte Carlo Simulation- ICE Scatterplot : Medicine vs Surgery

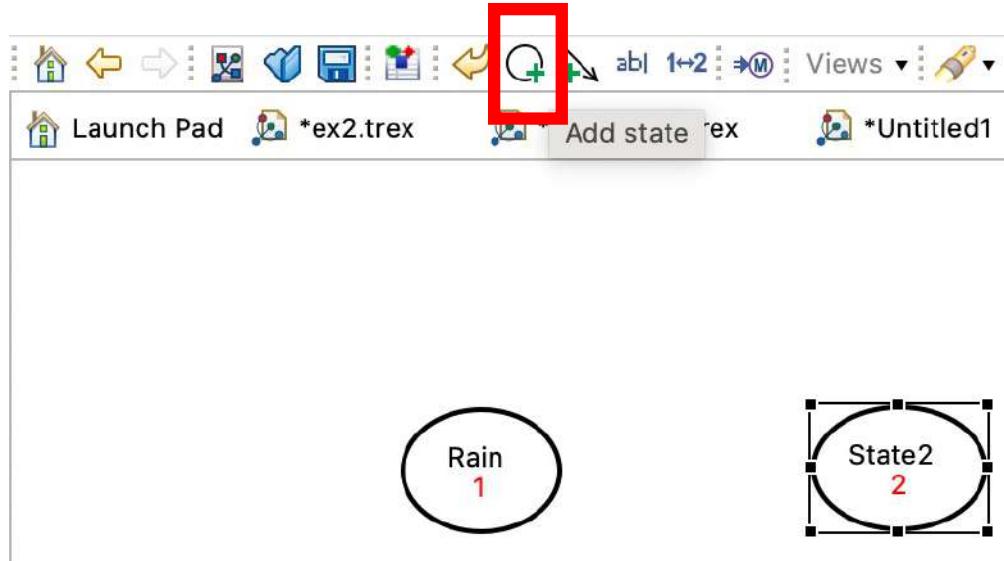


□ 單元八：  
Markov Model in TreeAge

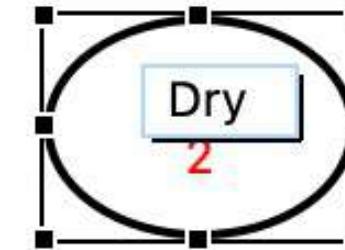
# Example 3-Markov Model



# Example 3-Markov Model



點兩下改Label



Or點這裡改Label

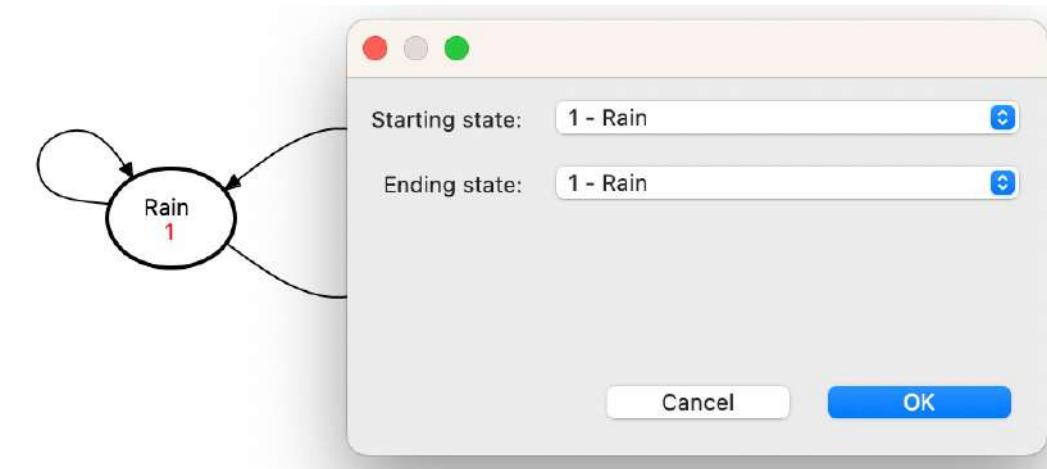


# Example 3-Markov Model

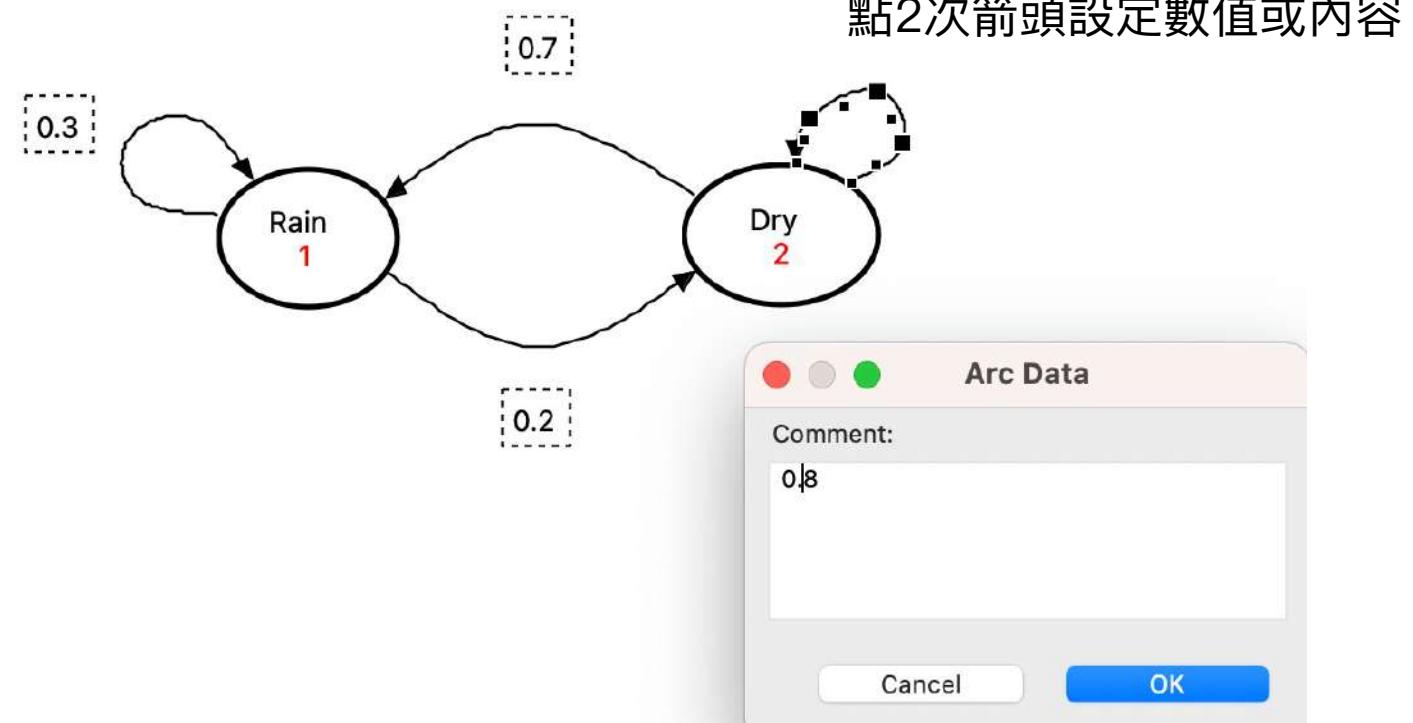
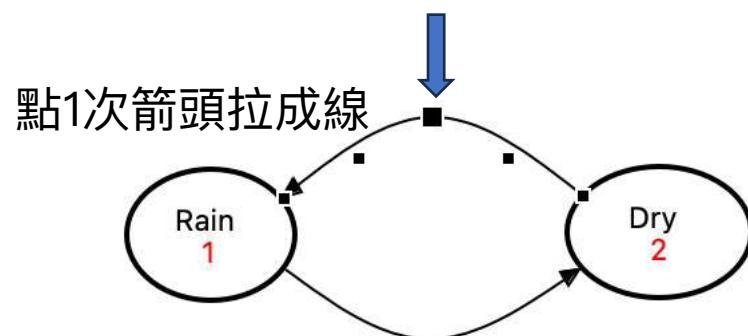
點上箭頭



設定方向

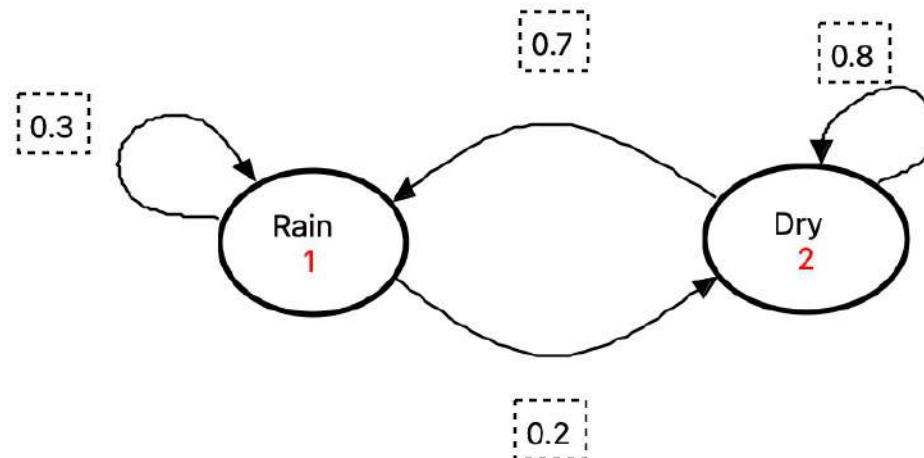


# Example 3-Markov Model



## Example 3-Markov Model

- A Markov Model is a stochastic model used to **model randomly changing systems** where it is assumed that future states depend only on the current state, not on the events that occurred before it (**Markov property or memorylessness**).



# Key Elements of Markov Models

- **States:** ex. well 、 ill 、 dead 、 head 、 tail 、 sunny 、 rain...)
- **Transitions :** individuals transit from one state to the another , each transition has a probability (transition probabilities /rates)
- **Cycle:** transition happen over a period of time
- **Cost & effectiveness :** each state can have a cost and /or effectiveness associated to it (called rewards in Markov model, payoffs in decision model)

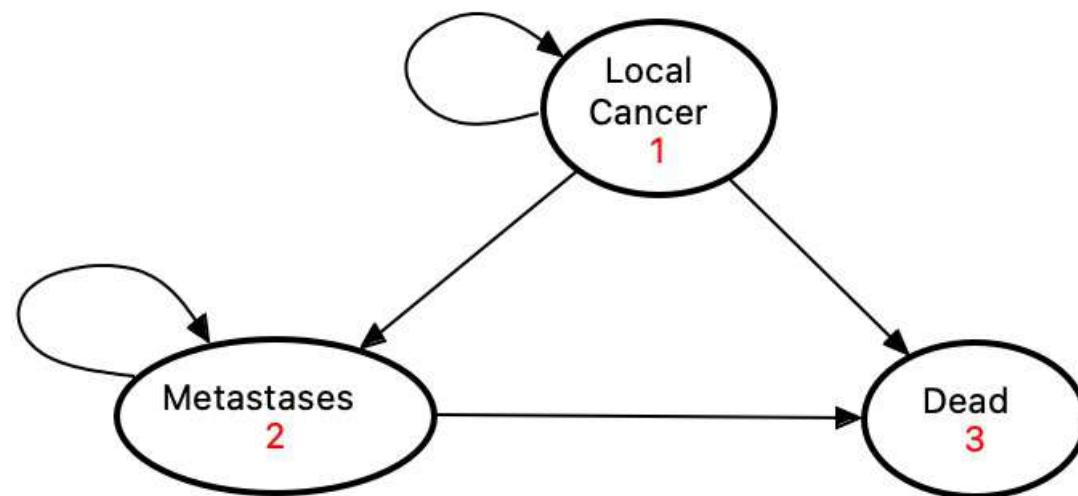
# Example 3-Markov Model

## Developing the Markov model

- **State**
- **Transitions**
- **Cycle**

Length of each cycle: 1year

Total cycles : 20 years (time horizon)



# Example 3-Markov Model-Set calculation Method as “Cost-effectiveness

## Tree\Tree Preferences\Calculation Method

The image shows two overlapping dialog boxes from the 'Tree Preferences' application.

**Left Dialog: Calculation Method**

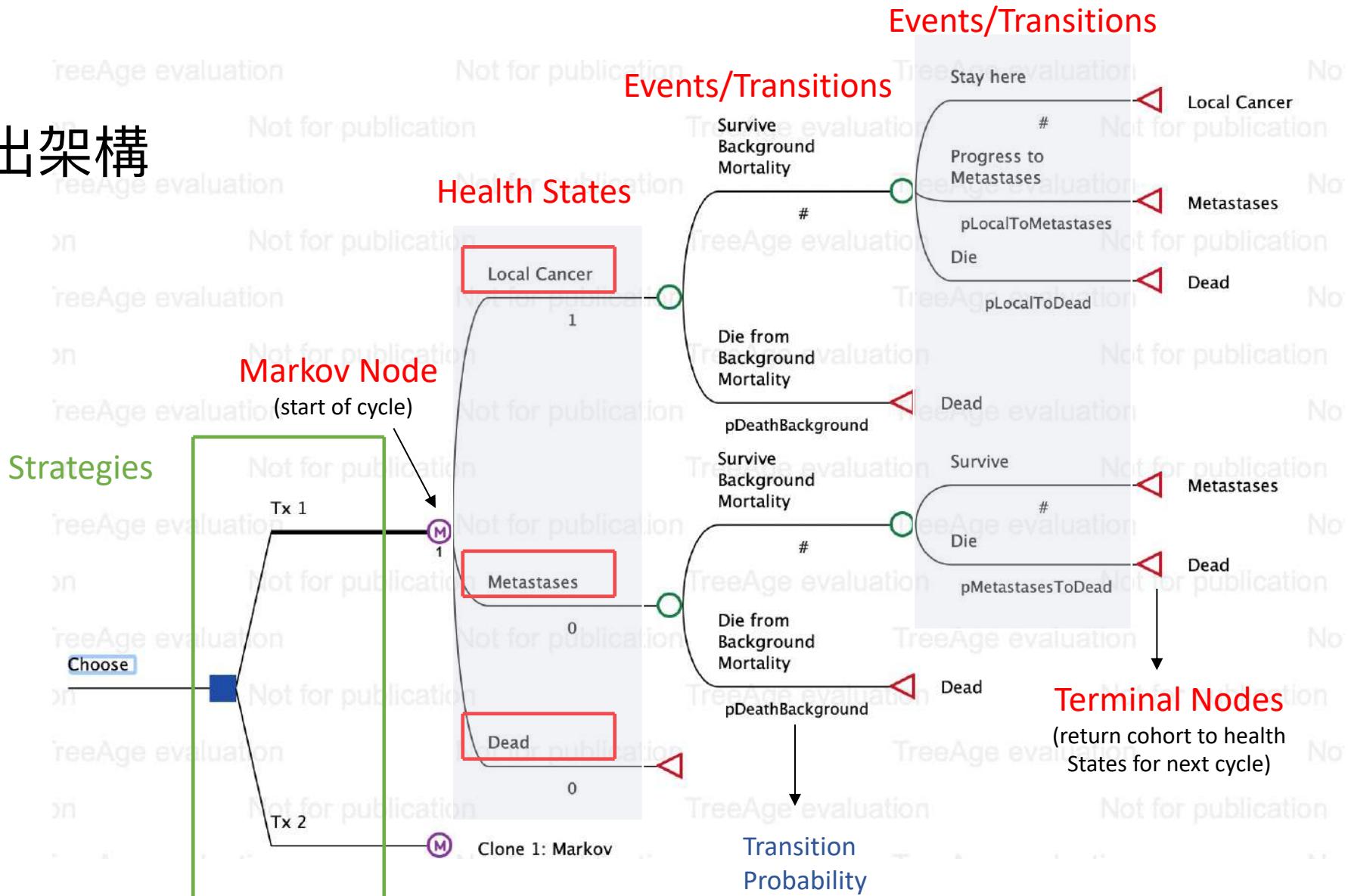
- Active Method:** Simple (radio button)
- Cost-effectiveness:** (radio button, highlighted with a red box)
- Benefit-cost:** (radio button)
- Multi-attribute:** (radio button)
- Cost payoff:** 1
- Effectiveness payoff:** 2
- CE Params:** (button)

**Right Dialog: Cost-Eff Params (WTP)**

- C-E Rollback:**
  - Willingness to pay:** 50000 (highlighted with a red box)
  - Show Net Benefits in rollback
  - Minimum effectiveness
  - 0.01
  - 20000
- Inverting Effectiveness:**
  - Do not invert:** (radio button, highlighted with a blue box)
  - Invert incremental only
  - Invert average values
  - Maximum value: 10
- Select Graph Orientation:**
  - Draw graph with cost on vertical axis:** (radio button, highlighted with a blue box)
  - Draw graph with cost on horizontal axis
- Rankings Report Options:**
  - Show average C/E
  - Show common baseline
  - Show increasing effectiveness

# Example 3-Markov Model Structure

先畫出架構



# Example 3-Markov Model Structure

Parameter	Variable name	Value
age in each cycle	Age	startAge+_stage
cost for local cancer stage	cLocal	
	TX1:cLocal1	20,000
	TX2:cLocal2	23,000
cost for metastases stage	cMetastases	50,000
QALY for local cancer state	effLocal	0.96
QALY for metastases state	effMetastases	0.88
probability of death from other causes	pDeathBackground	
probability of death from local cancer	pLocalToDead	
	TX1:pLocalToDead1	0.04
	TX2:pLocalToDead2	0.02
probability of metastases from local cancer	pLocaltoMetastases	0.16
probability of death from metastases	pMetastasesToDead	0.1
	startAge	50
number of years for model(time horizon)	totalCycles	20

# Example 3-Add variables and their value at the root node

The screenshot shows a software interface with a toolbar at the top and a main window divided into two sections. On the left, there is a table titled 'Variables' with columns for Name, Root Definition, Description, and Calculate. A red box highlights the 'Variables' tab in the toolbar. On the right, a modal dialog box is open with the title 'Add/Change Variable or Function'. The dialog has several tabs: General (selected), Sensitivity Analysis, and Categories. The 'General' tab contains fields for Name (cLocal), Description (cost for local cancer stage), and a large 'Build Expression:' area with a 'Format' button and a text input field. Below this is an 'Add to Expression:' section with a 'Group:' dropdown (Recent expressions) and a 'Variables' item highlighted with a blue box. To the right of the group are 'Element:' dropdowns showing 'age', 'cLocal', 'cLocal1', 'cLocal2', and 'cMetastases'. At the bottom of the dialog are buttons for 'Cancel' and 'Apply and Close', with the 'Apply and Close' button circled in red.

1 Variables

2 General

Name: cLocal 參數名稱

Description: cost for local cancer stage 描述/說明參數

Build Expression:

Add to Expression:

Group: Recent expressions

Variables (highlighted)

Distributions

Tables

Functions

Operators

Element: age  
cLocal  
cLocal1  
cLocal2  
cMetastases

Calculated value (at Choose):

Definition info:

Comment:

Cancel Apply and Close

## Example 3-Add variables and their value at the root node

Variables			
Payoffs Distributions Tables Variable Definitions Markov Clone Masters/Copies			
Type filter text		Clear	Variable Set: Default
Name	Root Definition	Description	Calculated Value
age	startAge + _stage		50
cLocal		QALY for Local Cancer State	
cLocal1	20000		20,000
cLocal2	23000		23,000
cMetastases	50000	QALY for Metastases State	50,000
effLocal	0.96	QALY for Local Cancer State	0.96
effMetastases	0.88	QALY for Metastases State	0.88
pDeathBackground			
pLocalToDead		Prob. of Death from Local Cancer	
pLocalToDead1	0.04		0.04
pLocalToDead2	0.02		0.02
pLocalToMetastases	0.16	Prob. of Progression from Local ...	0.16
pMetastasesToDead	0.1	Prob. of Death from Local Cancer	0.1
startAge	50		50
totalCycles	20	Number of years for model	20

## Example 3- Time-dependence variables

### Life Tables (Background Mortality)

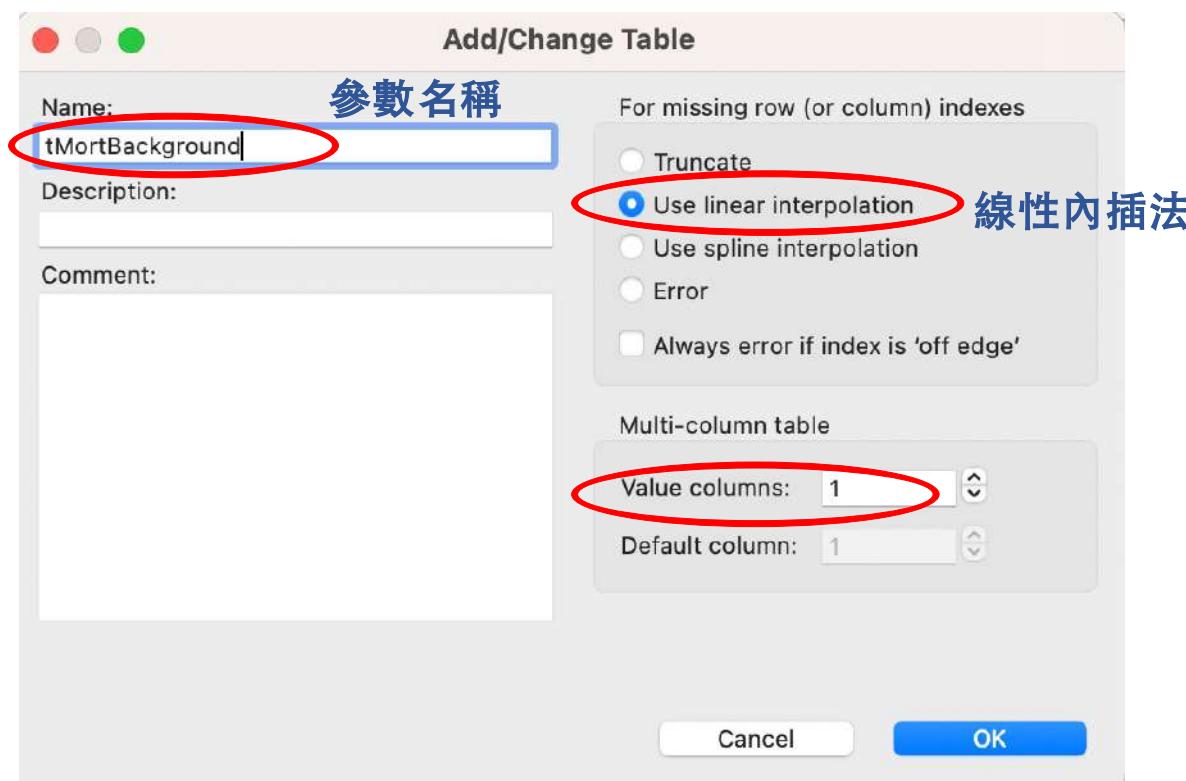
age	mortality
0	0.0080000
1	0.0003150
5	0.0001700
15	0.0008150
25	0.0010360
35	0.0020160
45	0.0043320
55	0.0094090
65	0.0225500
75	0.0546310
85	0.1459330
95	0.2500000
120	1.0000000

# Example 3-Markov Model Structure- create a Table for Background Mortality

1



2



3.到Excel 全選複製

	A	B
1	age	mortality
2	0	0.0080000
3	1	0.0003150
4	5	0.0001700
5	15	0.0008150
6	25	0.0010360
7	35	0.0020160
8	45	0.0043320
9	55	0.0094090
10	65	0.0225500
11	75	0.0546310
12	85	0.1459330
13	95	0.2500000
14	120	1.0000000
15		

# Example 3-Markov Model Structure

create a Table for Background Mortality

The screenshot shows a software interface with a toolbar at the top and a 'Tables' section. A table named 'tMortBackground' is selected, highlighted with a blue bar. To the right, a detailed view of the table rows is shown.

**4.** Step 4: The table 'tMortBackground' is selected.

**5.** Step 5: The 'New Row' button (a green plus sign) is circled in red.

**6.** Step 6: The 'Paste' button (a clipboard icon) is circled in red.

**Table Rows: tMortBackground**

age	mortality
0	0.008
1	0.000315
5	0.00017
15	0.000815
25	0.001036
35	0.002016
45	0.004332
55	0.009409
65	0.02255
75	0.054631
85	0.145933
95	0.25
120	1

# Example 3-Add value definition(pMortBackground[age] for pDeathBackground)

-startAge=50

-age= startAge+\_stage

The screenshot shows a software interface with two main windows. On the left is the 'Variables' tab of a spreadsheet-like application, and on the right is the 'Add/Change Variable or Function' dialog box.

**Variables Tab (Left):**

Name	Root Definition
age	startAge + _stage
cLocal	
cLocal1	20000
cLocal2	23000
cMetastases	50000
effLocal	0.96
effMetastases	0.88
pDeathBackground	tMortBackground[Age]
pLocalToDead	
pLocalToDead1	0.04
pLocalToDead2	2
pLocalToMetastases	0.16
pMetastasesToDead	0.1
startAge	50
totalCycles	20

**Add/Change Variable or Function Dialog (Right):**

**General Tab:**

- Variable Name: pDeathBackground
- Description: (empty)
- Root definition: (empty)

**Build Expression Tab:**

- Format: Text
- Value: tMortBackground[Age] (highlighted with a red circle)

**Add to Expression Tab:**

- Group: Recent expressions
- Variables: (empty)
- Tables: (highlighted with a red circle)
- Functions: (empty)
- Operators: (empty)

**Calculated value (at Choose):** 0.0068705

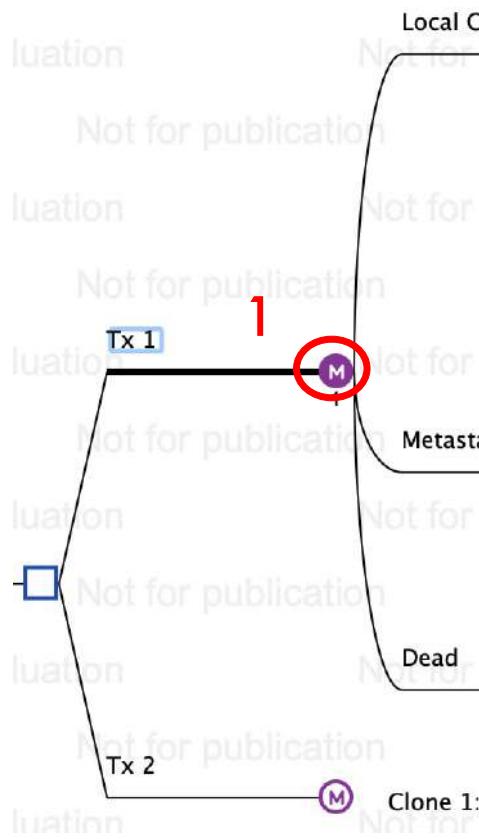
**Definition info:** (empty)

**Comment:** (empty)

**Buttons:** Cancel, Apply and Close (highlighted with a red circle)

# Example 3-Markov Model Structure

- The half-cycle correction ( $0.5 * \text{outcome}$ ) can improve the accuracy of the results.
  - Set termination: `_stage=totalCycles`



2

Variables Payoffs Distributions Tables Variable Definitions **Markov** X DES PartSA Clone Masters/Copies Comm

3

Markov Node Health States Transition Rewards PartSA

4

Markov node: Tx 1

Element Local Cancer Metastases Dead

▼ Rewards (Active Sets)

Init Cost	0.5 * ( cLocal )	0.5 * ( cMetastases )	0
Incr Cost	cLocal	cMetastases	0
Final Cost	0.5 * ( cLocal )	0.5 * ( cMetastases )	0
Init Effectiveness	0.5 * ( effLocal )	0.5 * ( effMetastases )	0
Incr Effectiveness	effLocal	effMetastases	0
Final Effectiveness	0.5 * ( effLocal )	0.5 * ( effMetastases )	0

➤ Rewards (Additional Sets)

➤ Initial Probabilities and Tunnel Max

5

Markov Node Health States Transition Rewards PartSA

Markov node: Tx 1

Element Markov node

▼ Termination Condition Active

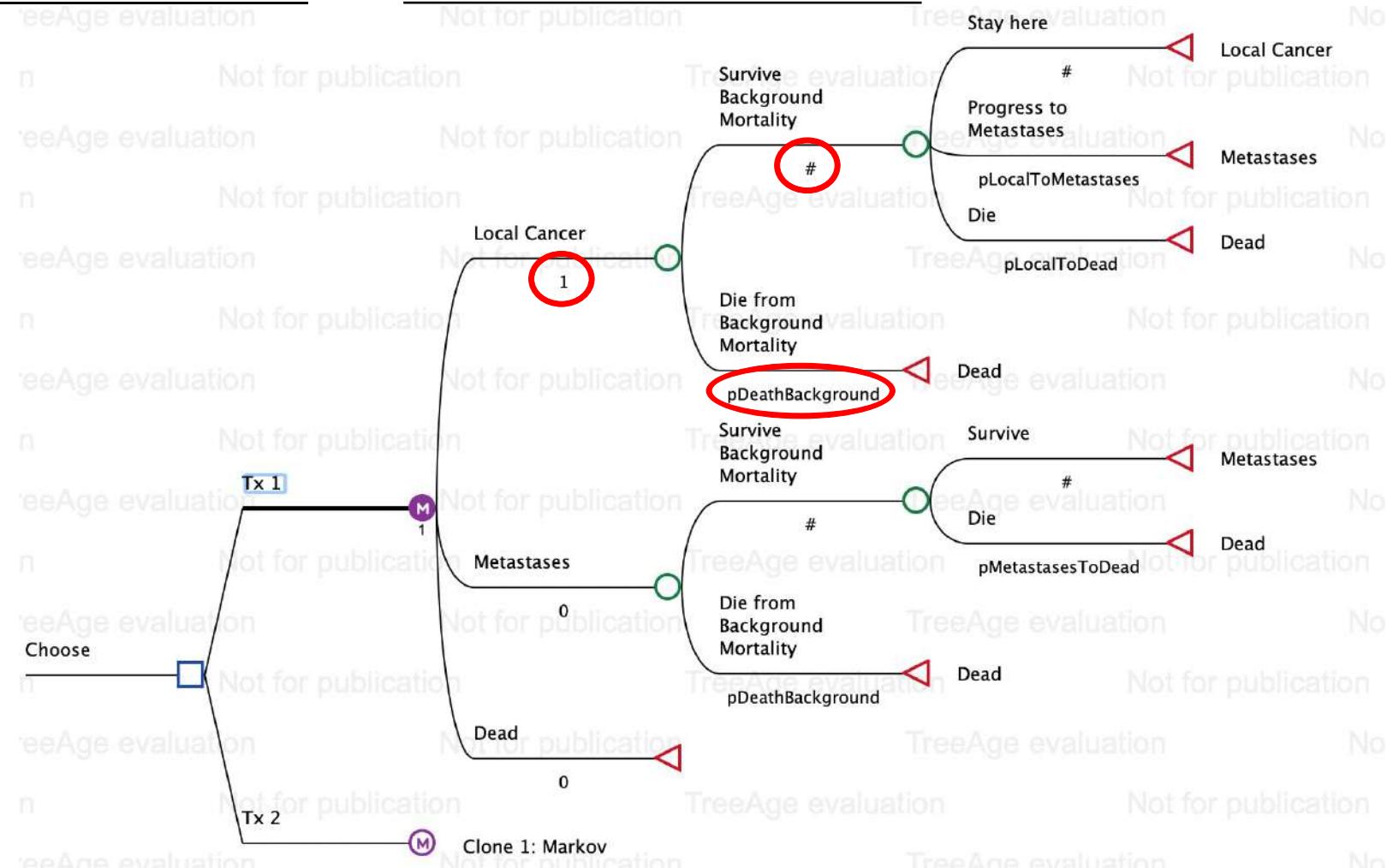
6

Term Cost-Eff \_stage = totalCycles

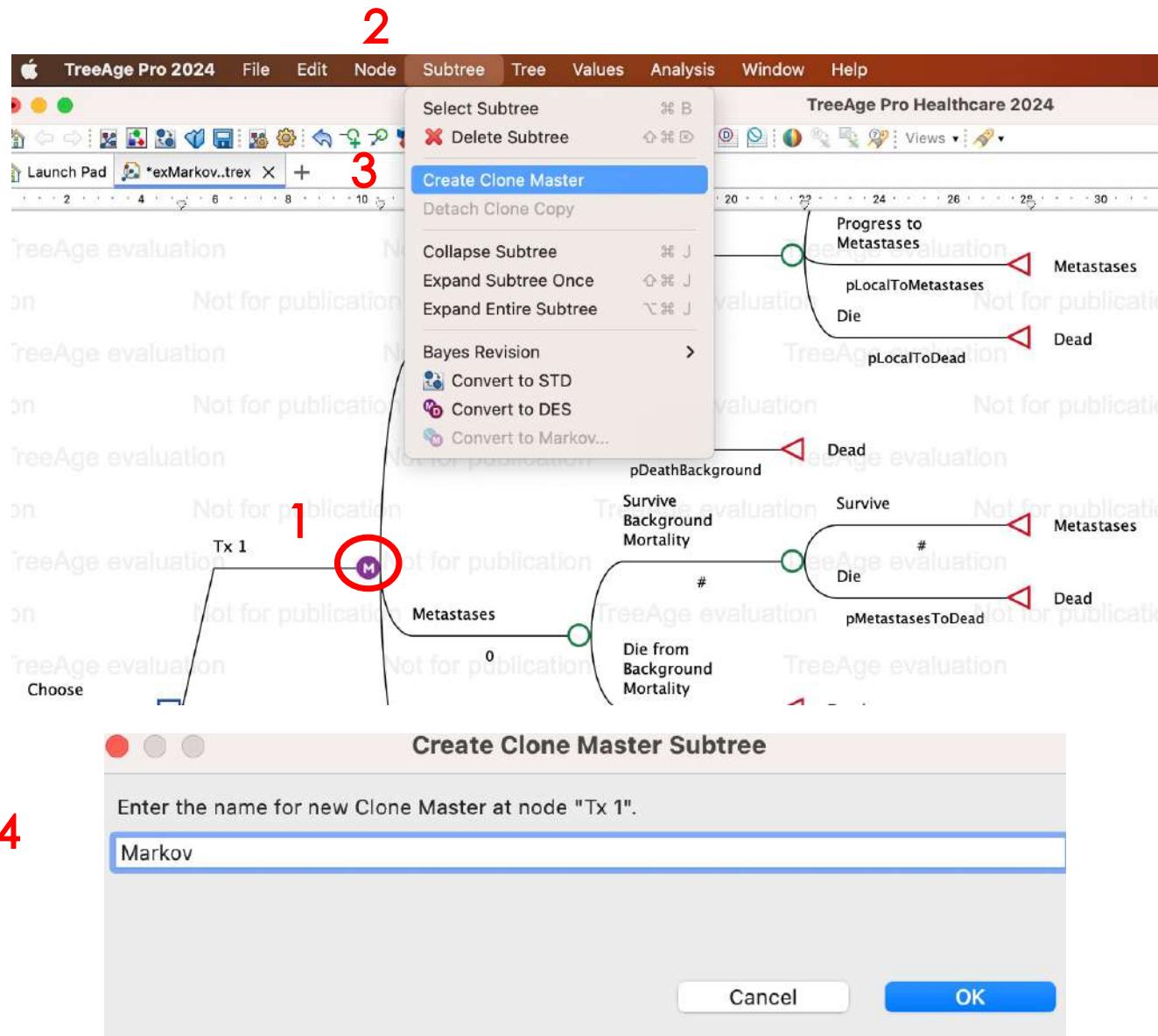
Termination Condition Inactive

# Example 3-Markov Model Structure

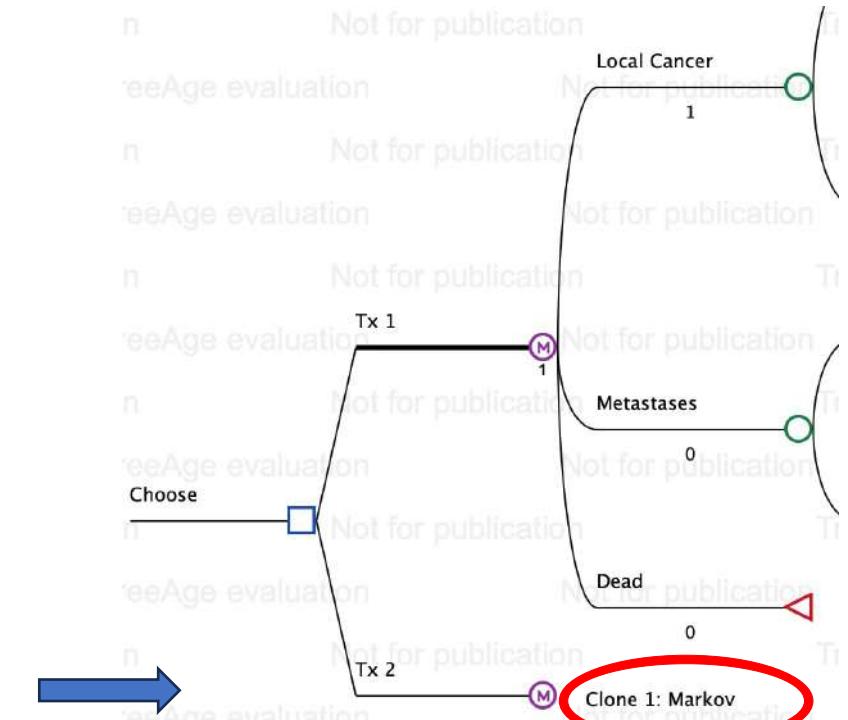
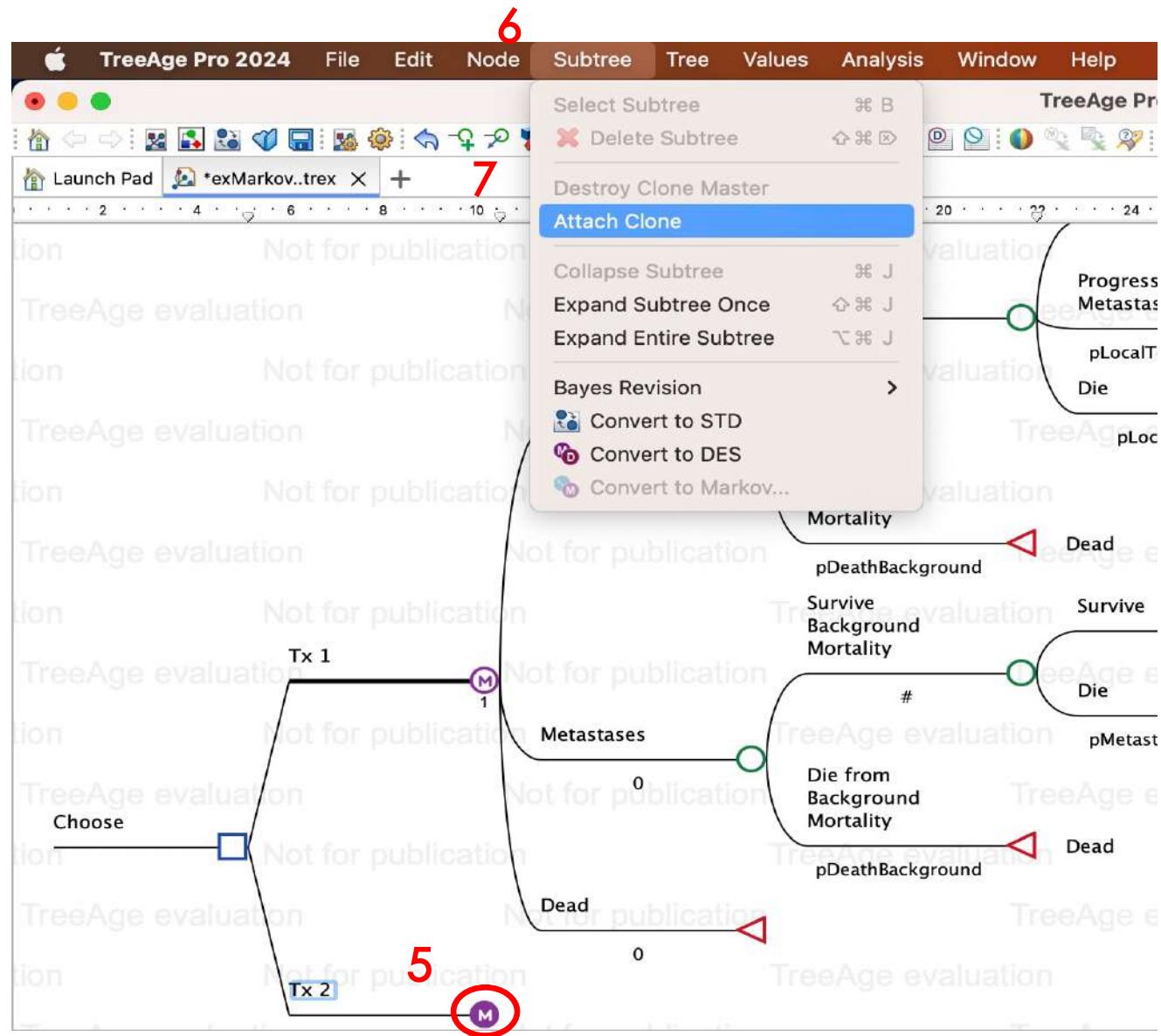
- Add **initial probabilities** and **transition probabilities**



# Example 3-Markov Model Structure-Create clone master



# Example 3-Markov Model Structure-Attach clone to the Markov node of Tx2



# Example 3-Markov Model Structure-Define variables

-Tx1: cLoocal= cLoocal1, pLocalToDead=pLocalToDead1

The screenshot shows the TreeAge Pro software interface. On the left, a decision tree diagram is displayed. A node labeled 'Tx 1' has two branches: one leading to a purple circle labeled 'M' (Metastases) and another leading to a green circle labeled '0' (Death). A red circle with the number '1' highlights the transition from 'Tx 1' to the 'M' node. Below the tree, the menu bar shows 'Variables' (highlighted with a red box), 'Payoffs', 'Distributions', 'Tables', 'Variable Definitions', and 'Matrix'. The 'Variable Definitions' tab is active, showing a table of variables:

Name	Root Definition	Description
age	startAge + _stage	
cLocal	$=f_x$	QALY for Local Cancer Stat
cLocal1	20000	
cLocal2	23000	
cMetastases	50000	QALY for Metastases State
effLocal	0.95	QALY for Local Cancer Stat
effMetastases	0.9	QALY for Metastases State
pDeathBackground	tMortBackground[age]	
pLocalToDead		Prob. of Death from Local C
pLocalToDead1	0.02	

A red box with the number '2' highlights the 'Variables' tab. A red circle with the number '3' highlights the 'cLocal' row in the table.

On the right, the 'Add/Change Variable or Function' dialog box is open. It shows the 'General' tab with the following details:

- Name: cLocal
- Description: QALY for Local Cancer State
- Root definition: cLocal1
- Build Expression: Format: Text, Python, Array, Matrix. Value: cLocal1

The 'Add to Expression' section shows the 'Recent expressions' group with 'Variables' selected. The 'Variables' list contains 'age', 'cLocal', 'cLocal1' (highlighted with a red box), 'cLocal2', and 'cMetastases'. A red circle with the number '4' highlights the 'Recent expressions' group, and a red circle with the number '5' highlights 'cLocal1' in the list. A red circle with the number '6' highlights the 'Apply and Close' button at the bottom right of the dialog.

# Example 3-Markov Model Structure-Define variables

-Tx2: **cLocal= cLocal2, pLocalToDead=pLocalToDead2**

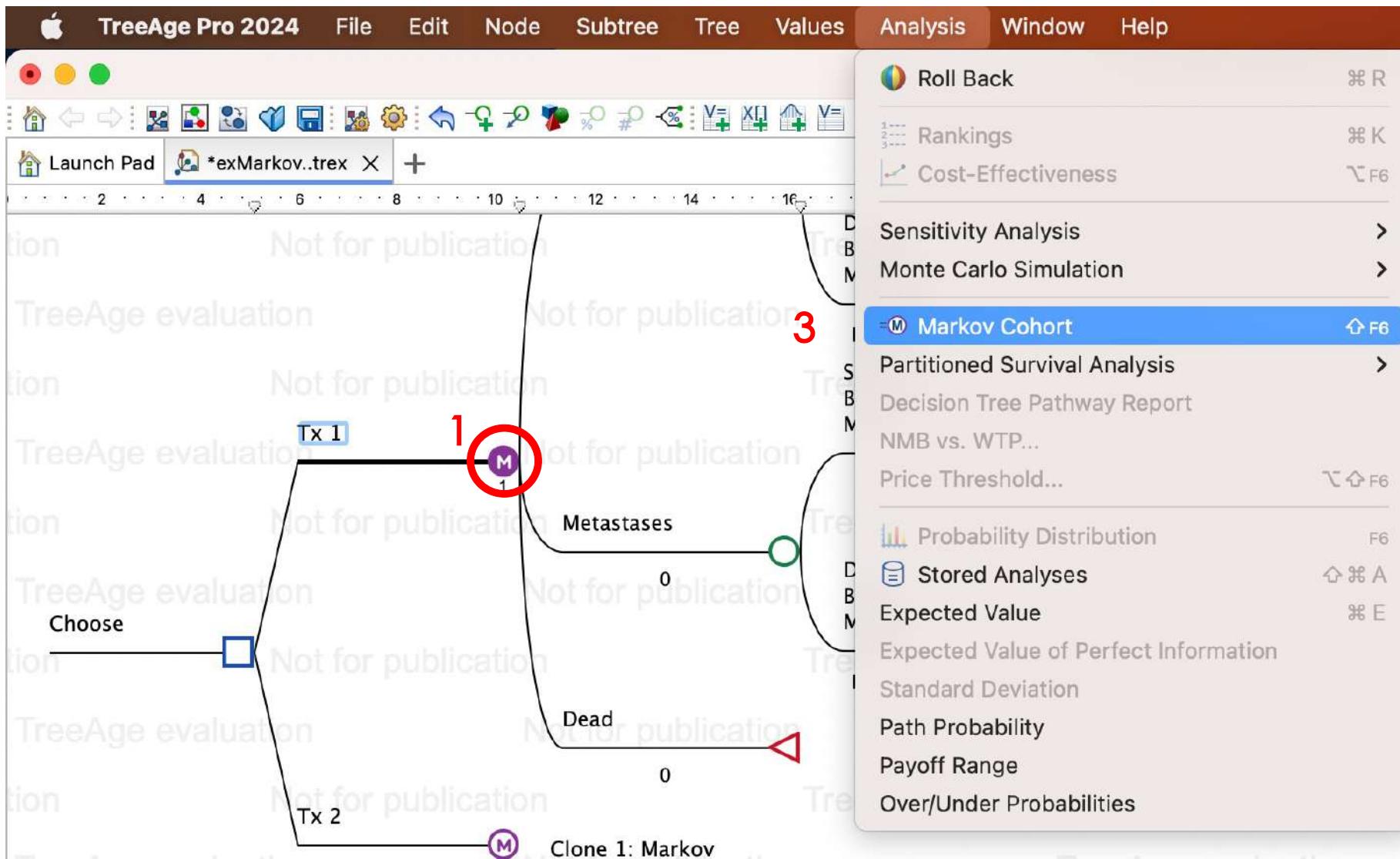
The screenshot shows the TreeAge software interface. At the top, there is a flowchart diagram representing a decision tree. A 'Choose' node branches into 'Tx 2' and 'Not for publication'. 'Tx 2' leads to a 'Clone 1: Markov' state, which then branches into 'Dead' and '0'. 'Dead' is labeled 'BACKGROUND Mortality' with 'pDeathBack'. Below the diagram is a toolbar with various icons. A red box highlights the 'Variables' icon (V=), and a red number '2' is placed to its left. The main workspace contains a table of variables:

Name	Root Definition	Description
age	startAge + _stage	
cLocal	3	QALY for Local Cancer State
cLocal1	20000	
cLocal2	23000	
cMetastases	50000	QALY for Metastases State
effLocal	0.95	QALY for Local Cancer State
effMetastases	0.9	QALY for Metastases State
pDeathBackground	tMortBackground[age]	
pLocalToDead		Prob. of Death from Local Cancer
pLocalToDead1	0.02	

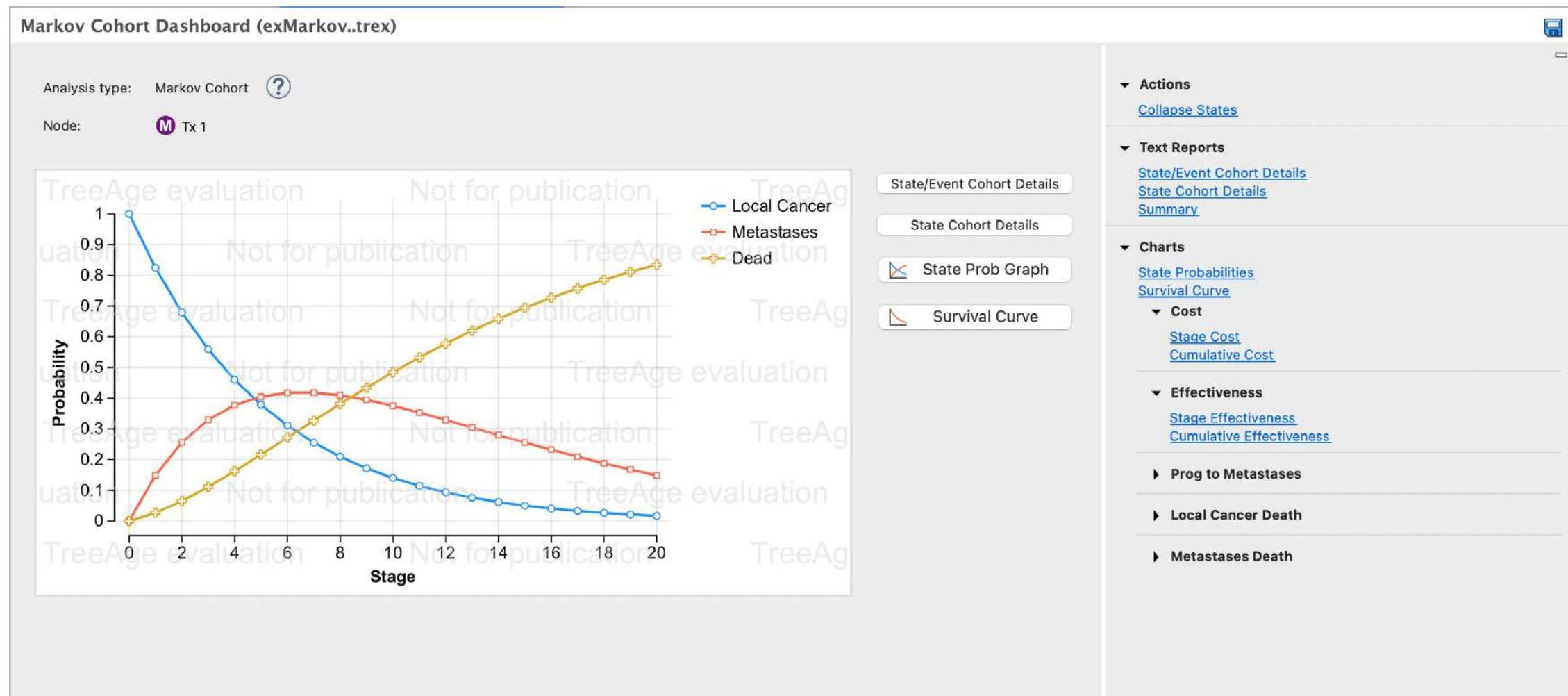
The screenshot shows the 'Add/Change Variable or Function' dialog box. The 'General' tab is selected. The variable name is 'cLocal', with a description 'QALY for Local Cancer State'. The 'Root definition' field contains 'cLocal2'. The 'Build Expression' section shows 'cLocal2'. The 'Add to Expression' section lists 'Recent expressions' and 'Variables' (cLocal, cLocal1, cLocal2, cMetastases). A red box highlights 'cLocal2', and a red number '5' is placed to its right. The 'Calculated value (at Choose):' field shows '22000', and the 'Definition info:' field is empty. A red number '6' is placed at the bottom right of the dialog.

# Example 3-Markov Model Structure-Check the model

2



## Example 3-Markov Model Structure-Check the model

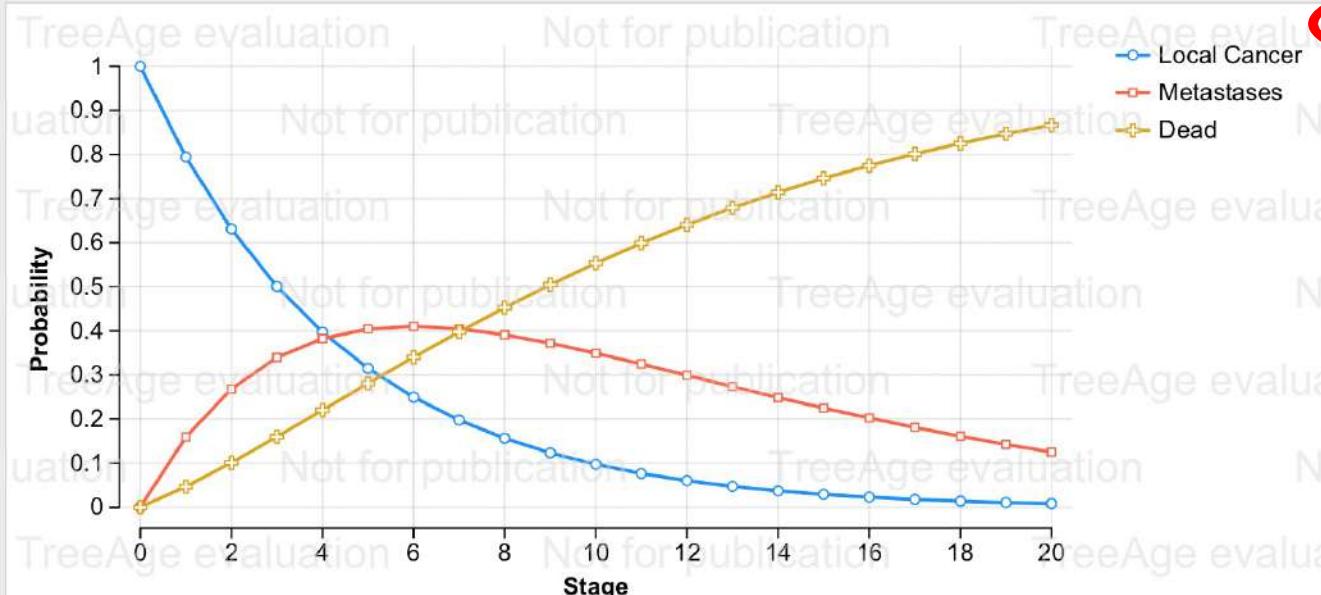


# Example 3-Markov Model Structure-State/Event Cohort Details

## Markov Cohort Dashboard (exMarkov.trex)

Analysis type: Markov Cohort [?](#)

Node: Tx 1



[State/Event Cohort Details](#)

[State Cohort Details](#)

[State Prob Graph](#)

[Survival Curve](#)

Actions

[Collapse States](#)

Text Reports

[State/Event Cohort Details](#)

[State Cohort Details](#)

[Summary](#)

Charts

[State Probabilities](#)

[Survival Curve](#)

Cost

[Stage Cost](#)

[Cumulative Cost](#)

Effectiveness

[Stage Effectiveness](#)

[Cumulative Effectiveness](#)

Prog to Metastases

Local Cancer Death

Metastases Death

# Example 3-Markov Model Structure-State/Event Cohort Details

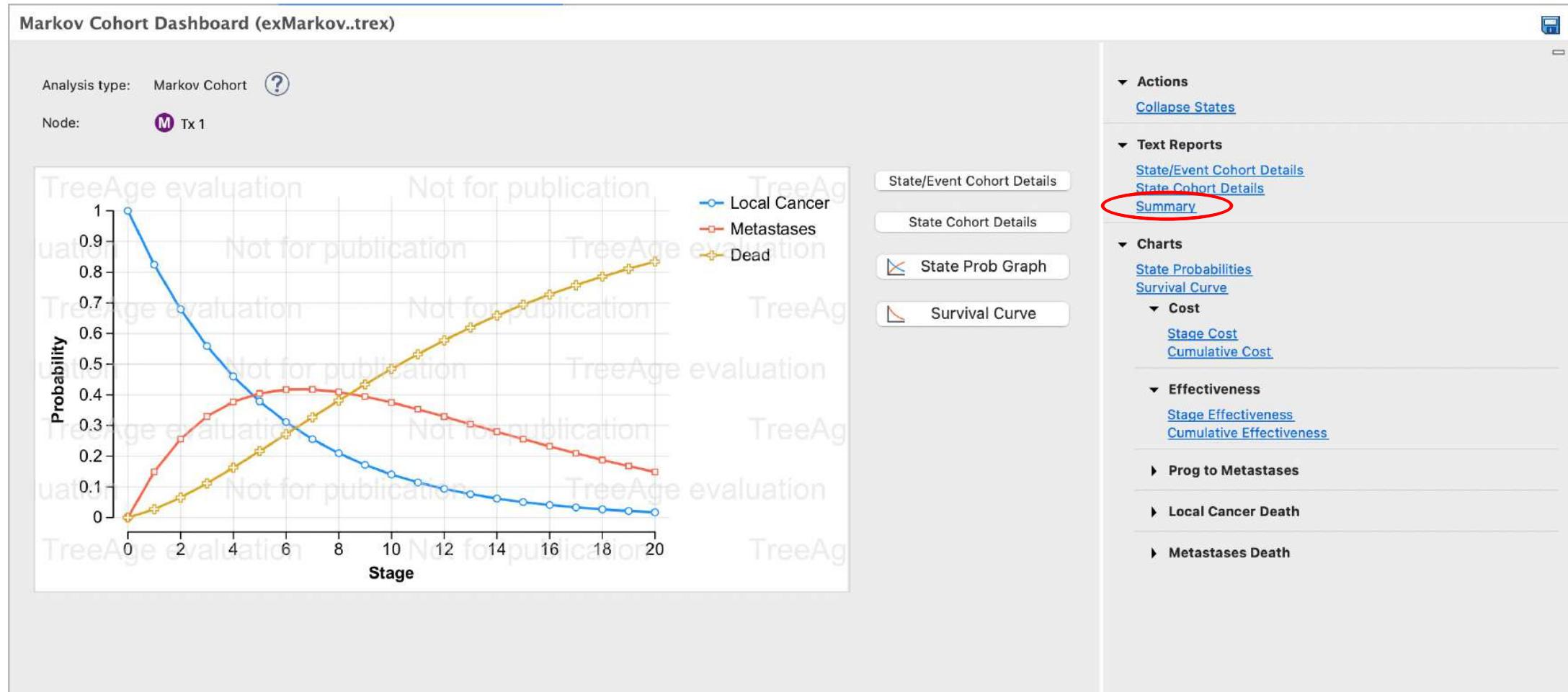
50yr background mortality=0.007

**Markov Cohort Extended Report C/E (exMarkov..trex)**

The table shows the following data summary:

Stage	Cohort %	Cost Entry	Cost	Cum Cost	Effectiveness Entry	Effectiveness	Cum Effectiveness	Prog to Metastases Entry	Prog to Metastases	Cum Prog to Metastases	Local Cancer Death Entry	Local Cancer Death	Cum Local Cancer Death	Metastases Death Entry
0	1.000	10,000	10,000	10,000	0.48	0.48	0.48	0.159	0.159	0.159	0.040	0.040	0.040	
1	0.795	20,000	15,890	33,835	0.96	0.76	0.90	0.000	0.000	0.285	0.032	0.071		
2	0.631	20,000	12,618	59,860	0.96	0.61	0.84	0.000	0.000	0.385	0.025	0.096		
3	0.501	20,000	10,015	86,854	0.96	0.48	0.78	3.00	0.079	0.465	0.020	0.116		
4	0.397	20,000	7,945	113,923	0.96	0.38	0.72	3.72	0.063	0.528	0.016	0.132		
5	0.315	20,000	6,299	140,431	0.96	0.30	0.66	4.38	0.050	0.578	0.012	0.144		
6	0.250	20,000	4,992	165,936	0.96	0.24	0.60	4.98	0.040	0.617	0.010	0.154		

# Example 3-Markov Model Structure-Summary

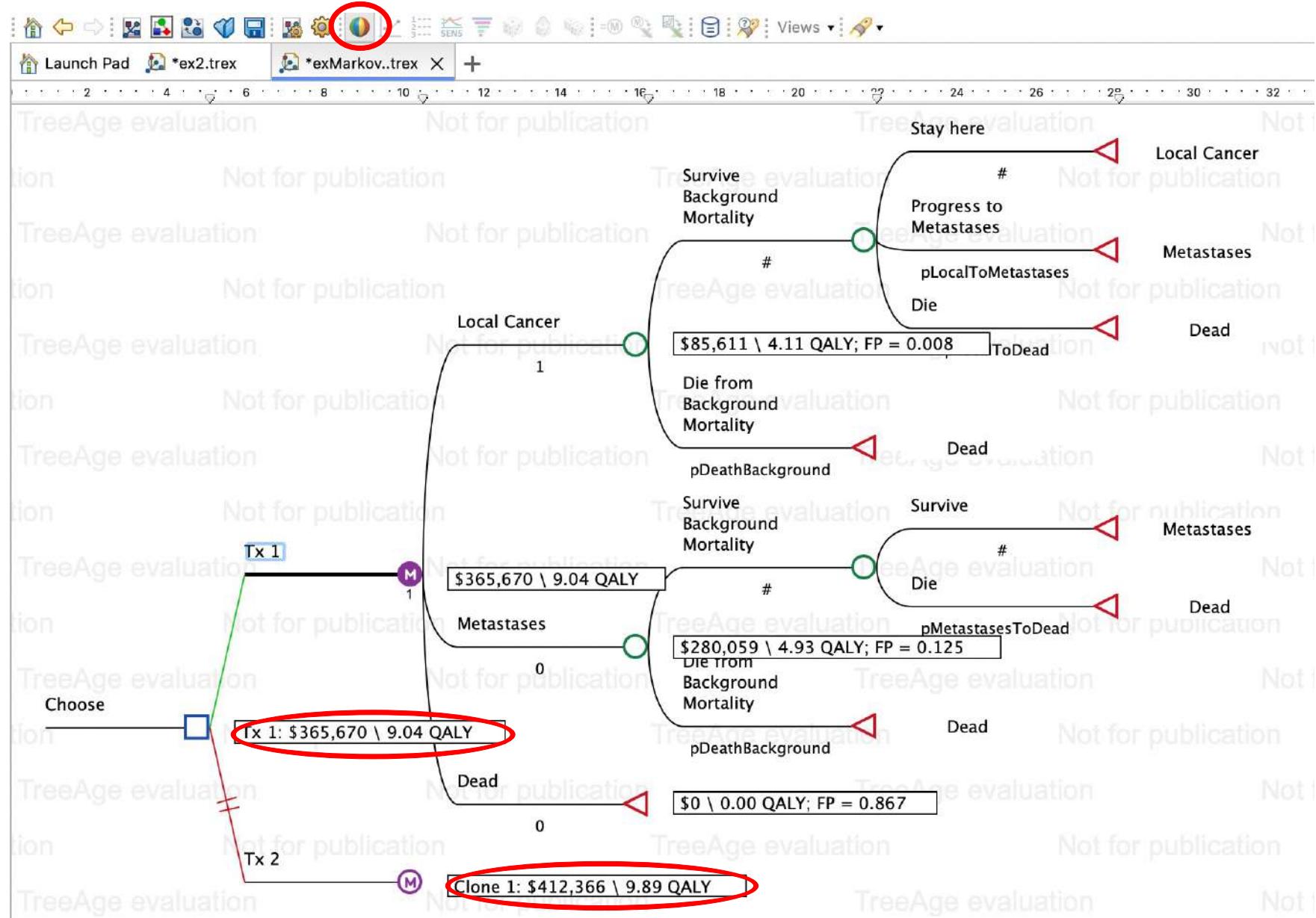


# Example 3-Markov Model Structure-Summary

Markov Cohort Summary Report (exMarkov..trex)

Stage	% - Local Cancer	% - Metastases	% - Dead	Cost	Cum Cost	Effectiveness	Cum Effectiveness	Prog to Metastases	Cum Prog to Metastases	Local Cancer Death	Cum Local Cancer Death	Metastases Death	Cum Metastases Death
0	1.000	0.000	0.000	10,000	10,000	0.48	0.48	0.159	0.159	0.040	0.040	0.000	0.000
1	0.795	0.159	0.047	23,835	33,835	0.90	1.38	0.126	0.285	0.032	0.071	0.016	0.016
2	0.631	0.268	0.101	26,025	59,860	0.84	2.22	0.100	0.385	0.025	0.096	0.027	0.042
3	0.501	0.340	0.160	26,994	86,854	0.78	3.00	0.079	0.465	0.020	0.116	0.034	0.076
4	0.397	0.382	0.220	27,070	113,923	0.72	3.72	0.063	0.528	0.016	0.132	0.038	0.114
5	0.315	0.404	0.281	26,508	140,431	0.66	4.38	0.050	0.578	0.012	0.144	0.040	0.154
6	0.250	0.410	0.340	25,505	165,936	0.60	4.98	0.040	0.617	0.010	0.154	0.041	0.195
7	0.198	0.405	0.398	24,190	190,126	0.55	5.53	0.031	0.648	0.008	0.162	0.040	0.235
8	0.156	0.391	0.453	22,680	212,805	0.49	6.02	0.025	0.673	0.006	0.168	0.039	0.273
9	0.123	0.372	0.505	21,063	233,869	0.45	6.47	0.019	0.692	0.005	0.173	0.037	0.310
10	0.097	0.349	0.554	19,408	253,276	0.40	6.87	0.015	0.708	0.004	0.177	0.034	0.344
11	0.076	0.325	0.599	17,761	271,037	0.36	7.23	0.012	0.720	0.003	0.180	0.032	0.376
12	0.060	0.299	0.641	16,160	287,197	0.32	7.55	0.009	0.729	0.002	0.182	0.029	0.405
13	0.047	0.274	0.679	14,627	301,824	0.29	7.83	0.007	0.737	0.002	0.184	0.027	0.432
14	0.037	0.249	0.714	13,180	315,004	0.25	8.09	0.006	0.742	0.001	0.186	0.024	0.457
15	0.029	0.225	0.746	11,827	326,831	0.23	8.31	0.005	0.747	0.001	0.187	0.022	0.479
16	0.023	0.202	0.775	10,574	337,405	0.20	8.51	0.004	0.750	0.001	0.188	0.020	0.498
17	0.018	0.181	0.801	9,404	346,809	0.18	8.69	0.003	0.753	0.001	0.188	0.018	0.516
18	0.014	0.161	0.825	8,321	355,131	0.15	8.84	0.002	0.755	0.001	0.189	0.016	0.531
19	0.011	0.142	0.847	7,328	362,459	0.14	8.98	0.002	0.757	0.000	0.189	0.014	0.545
20	0.008	0.125	0.867	3,212	365,670	0.06	9.04	0.000	0.757	0.000	0.189	0.000	0.545

# Example 3-Markov Model Structure-Roll Back



# Example 3-Markov Model Structure-Ranking

- 取消Roll Back/Analysis/Ranking

Cost-Effectiveness Rankings Report (exMarkov..trex)										
Category	Strategy	Cost	Incr. Cost	Effectiveness	Incr. Effectiveness	ICER (IC/IE)	NMB	Prog to Metastases	Local Cancer Death	Metastases Death
All (no dominance)										
undominated	Tx 1	\$365,670		9.04 QALY			\$86,248	0.757	0.189	0.545
undominated	Tx 2	\$412,366	\$46,695	9.89 QALY	0.86 QALY	\$54,515	\$82,381	0.831	0.104	0.589

Willingness to Pay (WTP) for a unit of benefit = 50,000

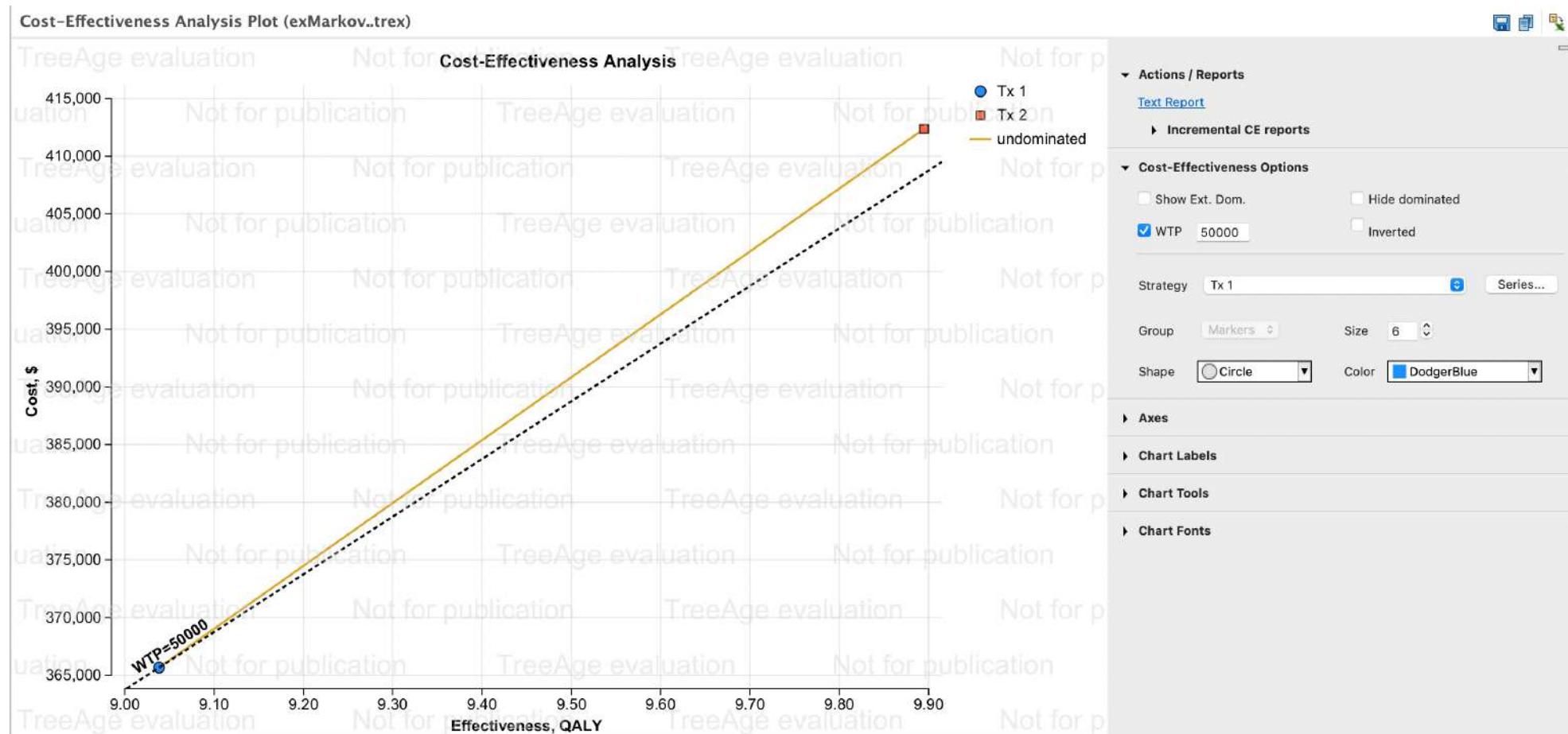
Net Monetary Benefits (NMB) = Effectiveness \* WTP - Cost 淨貨幣效益

(Tx1: 9.04\*50,000-365,670)

Net Health Benefits (NHB) = Effectiveness - Cost / WTP 淨健康效益

# Example 3-Markov Model Structure-Results of cost-effectiveness

- Results of cost-effectiveness  
Analysis / cost-effectiveness/WTP



# Example 3-Markov Model Structure-One way Sensitive analysis

- One way Sensitive analysis  
Define low/ high value

variable	value
cLocal1	20000(+/-20%)
cLocal2	23000(+/-20%)
cMetastases	50000(+/-20%)

The screenshot shows a software interface for managing variables and performing sensitivity analysis. On the left, a list of variables is displayed in a table format. On the right, a 'Sensitivity Analysis' dialog box is open, allowing users to define ranges for specific variables.

1. The 'Variables' tab is selected in the main interface.

2. The variable 'cLocal' is highlighted in the list.

3. The 'Sensitivity Analysis' tab is selected in the dialog box.

4. The 'Low value' and 'High value' fields are highlighted with red boxes, both set to 0.2.

5. The 'Range type' section is highlighted with a red box, showing the 'Adj %' radio button selected.

Detailed Variable List:

Name	Root Definition	Description
age	startAge + stage	
cLocal	cLocal	QALY for Local Cancer State
cLocal1	20000	=f_X
cLocal2	23000	
cMetastases	50000	QALY for Metastases State
effLocal	0.96	QALY for Local Cancer State
effMetastases	0.88	QALY for Metastases State
pDeathBackground	tMortBackground[Age]	
pLocalToDead	pLocalToDead1	Prob. of Death from Local Cancer
pLocalToDead1	0.04	
pLocalToDead2	0.02	
pLocalToMetastases	0.16	Prob. of Progression from Local ...
pMetastasesToDead	0.1	Prob. of Death from Local Cancer
startAge	50	
totalCycles	20	Number of years for model

# Example 3-Markov Model Structure-One way Sensitive analysis

The screenshot shows a software application window with a menu bar and a central workspace.

**Menu Bar:**

- Analysis
- Window
- Help

**Toolbar:**

- Roll Back
- Rankings
- Cost-Effectiveness
- Sensitivity Analysis
- Monte Carlo Simulation
- Markov Cohort
- Partitioned Survival Analysis
- Decision Tree Pathway Report
- NMB vs. WTP...
- Price Threshold...
- Comparative Distributions
- Stored Analyses
- Expected Value
- Expected Value of Perfect Information
- Standard Deviation
- Path Probability
- Payoff Range
- Over/Under Probabilities

**Central Workspace:**

A modal dialog titled "One-Way Sensitivity Analysis Setup" is open. It contains a table with the following data:

Variable	Type	Low entry	High entry	Intervals	Low value	High value	Definitions	Correlations
cLocal1	Adj %	20%	20%	4	16,000	24,000	[Choose: 20000]	

Below the table is a checkbox labeled "Run microsimulation rather than EV".

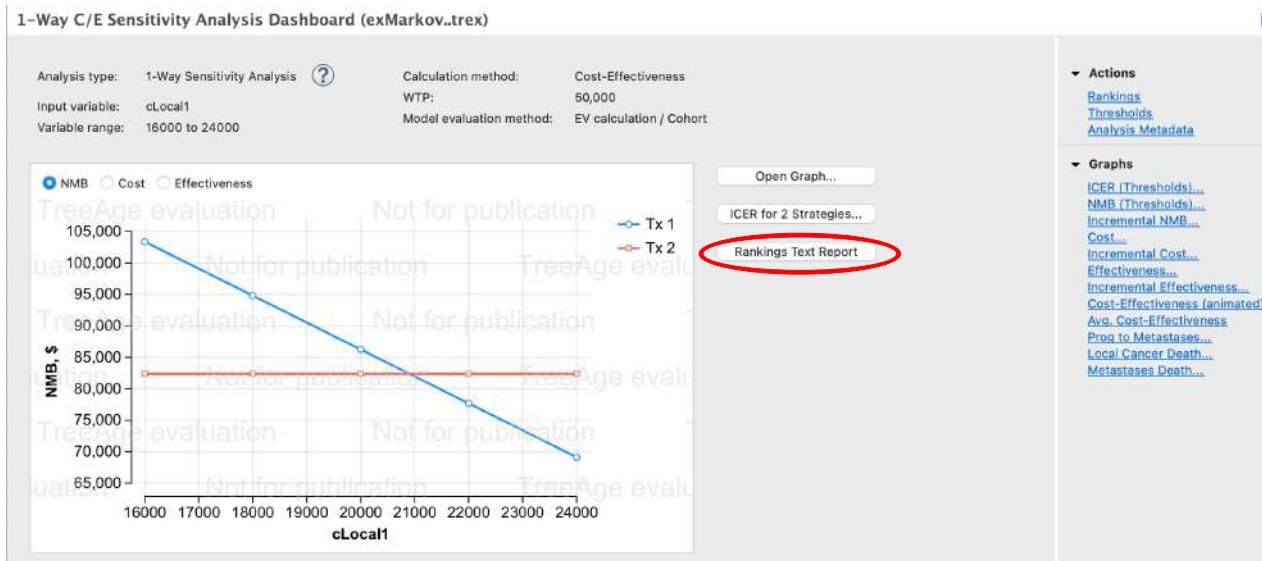
**Bottom Right:**

- Cancel
- OK

**Red Number:**

6

# Example 3-Markov Model Structure-One way Sensitive analysis



WTP=50,000

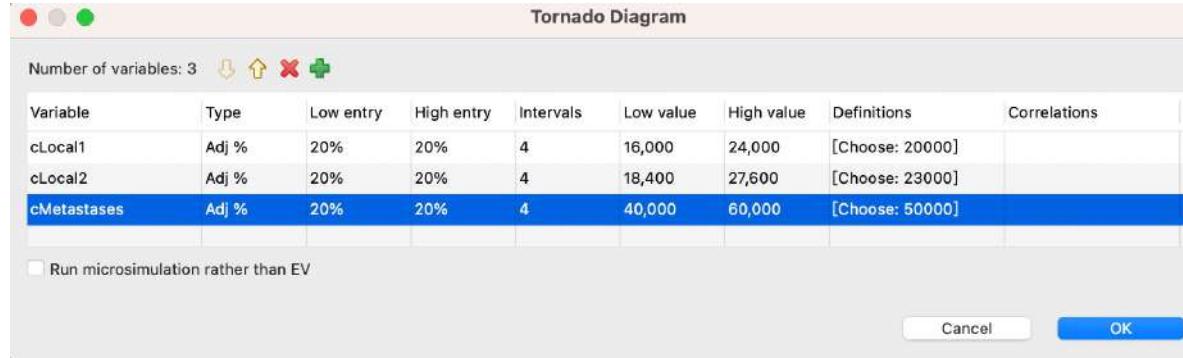
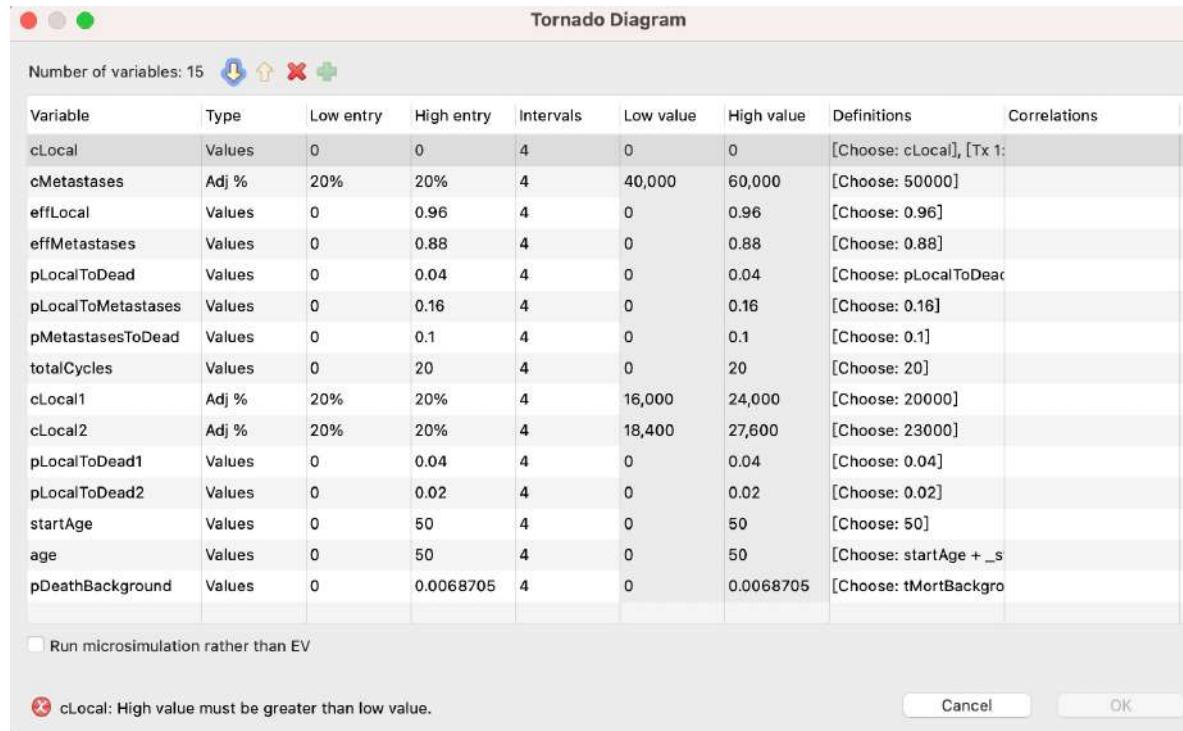
Tx1 is the optimal strategy

Tx2 is the optimal strategy

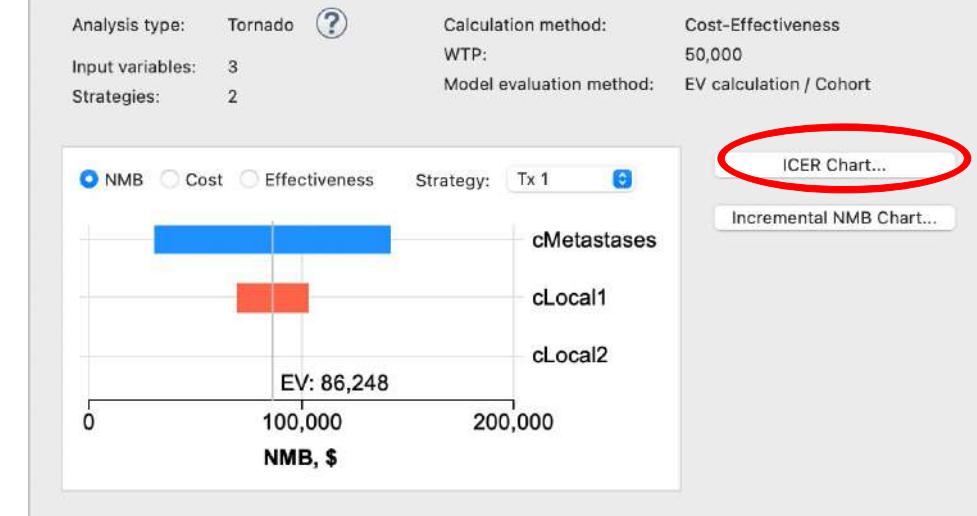
cLocal1	Strategy	Cost	Incr. Cost	Effectiveness	Incr. Effectiveness	ICER	NMB	C/E	Dominance	Prog to Metastases	Local Cancer Death	Metastases Death
16,000												
16,000	Tx 1	348,548	0	9.04	0.00	0	103,370	38,563		0.757	0.189	0.545
16,000	Tx 2	412,366	63,818	9.89	0.86	74,504	82,381	41,674		0.831	0.104	0.589
18,000												
18,000	Tx 1	357,109	0	9.04	0.00	0	94,809	39,510		0.757	0.189	0.545
18,000	Tx 2	412,366	55,256	9.89	0.86	64,510	82,381	41,674		0.831	0.104	0.589
20,000												
20,000	Tx 1	365,670	0	9.04	0.00	0	86,248	40,458		0.757	0.189	0.545
20,000	Tx 2	412,366	46,695	9.89	0.86	54,515	82,381	41,674		0.831	0.104	0.589
22,000												
22,000	Tx 1	374,231	0	9.04	0.00	0	77,687	41,405		0.757	0.189	0.545
22,000	Tx 2	412,366	38,134	9.89	0.86	44,520	82,381	41,674		0.831	0.104	0.589
24,000												
24,000	Tx 1	382,792	0	9.04	0.00	0	69,126	42,352		0.757	0.189	0.545
24,000	Tx 2	412,366	29,573	9.89	0.86	34,525	82,381	41,674		0.831	0.104	0.589

# Example 3-Markov Model Structure-Tornado Diagrams

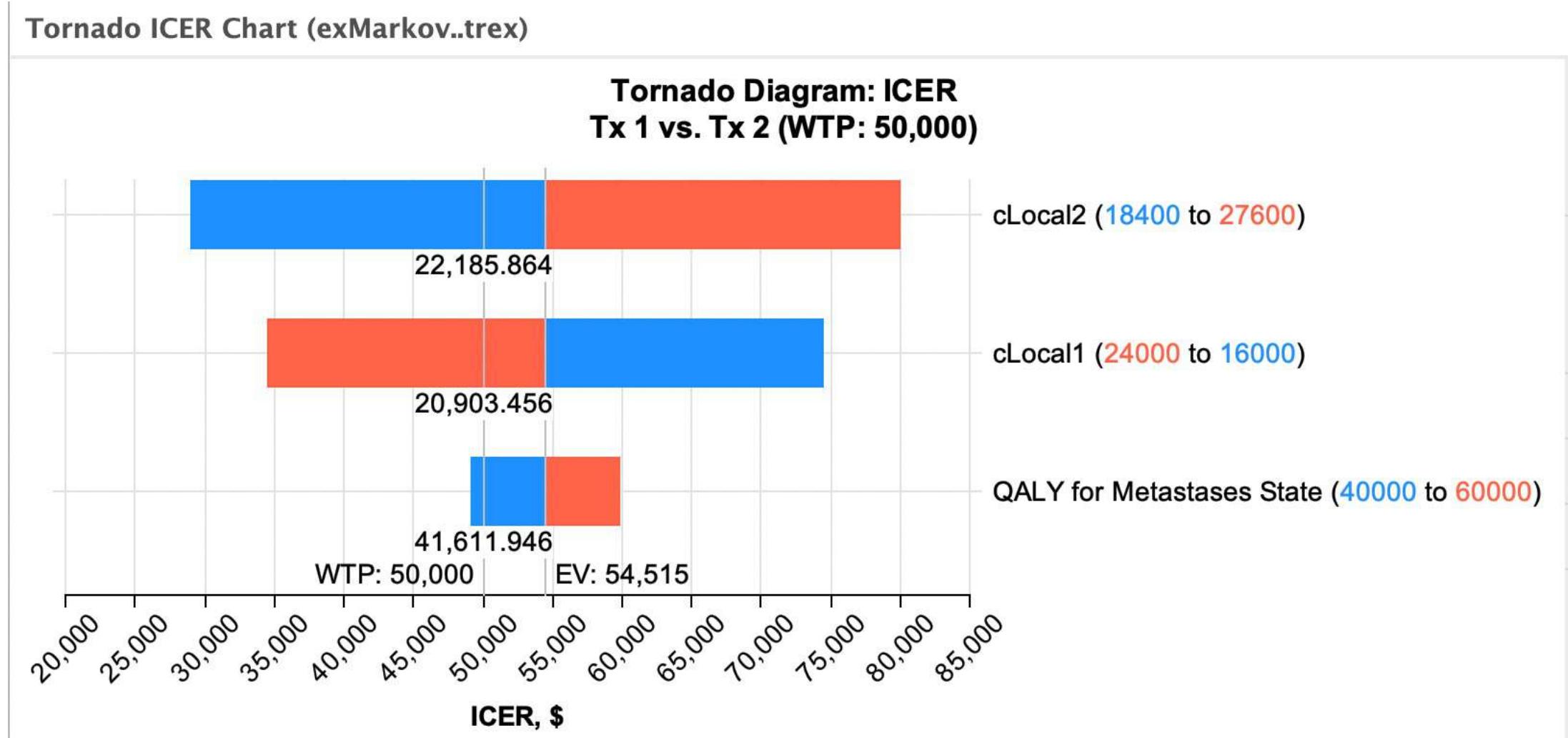
1



**Tornado C/E Sensitivity Analysis Dashboard (exMarkov.trex)**



# Example 3-Markov Model Structure-Tornado Diagrams



# Example 3-PSA-Set up distribution for 5 variables

Variable	New name	distribution	parameters
StartAge	distStartAge	Uniform	Min=5 ,Max=30
effLocal	disteffLocal	Beta	Mean=0.96,SD=0.03
effMetastases	disteffMetastases	Beta	Mean=0.88, SD=0.02
cLocal1	distcLocal1	Triangular	min=10,000 ,Likeliest=20,000,Max=30,000
cLocal2	distcLocal2	Triangular	min=16,000, Likeliest=23,000,Max=34,000

The screenshot shows the @RISK software interface. At the top, there is a menu bar with tabs: Variables, Payoffs, Distributions (which is highlighted with a red box and has a red number '1' above it), Tables, Variable Definitions, Markov, and DES. Below the menu is a toolbar with various icons. A red circle with the number '2' is placed over the first icon in the toolbar, which is a green plus sign inside a circle. The main area displays a table of distributions:

Index	Type	Sampling Rate	Name	Description
1	Uniform	EV	distStartAge	
2	Beta	EV	disteffLocal	
3	Beta	EV	disteffMetastases	
4	Triangular	EV	distcLocal1	
5	Triangular	EV	distcLocal2	

# Example 3-PSA-Set up distribution for 5 variables

Screenshot of the Add/Change Distribution dialog box in a software application for setting up distributions for 5 variables.

The dialog box is titled "Add/Change Distribution".

**General Tab:**

- Index: 4
- Name: distcLocal1
- Description:
- Comment:

**Probability density:** A red triangular distribution curve peaking at 20,000 with a value of 1e-4.

**Cumulative probability:** A blue S-shaped cumulative distribution function curve starting at 10,000 and approaching 1 at 30,000.

**Triangular Distribution Parameters:**

Min	10000
Likeliest	20000
Max	30000
Override mean:	<input type="text"/> $=f_x$

**Sampling Rate:**

- Resample per EV/group of trials
- Resample per Markov stage
- Resample per individual trial

**Buttons:** Cancel, OK

**Left Panel:** Shows a table of variables with columns: Index, Type, Sampling Rate, Name. The rows are:

Index	Type	Sampling Rate	Name
1	Uniform	EV	distStartAge
2	Beta	EV	disteffLocal
3	Beta	EV	disteffMetastases
4	Triangular	EV	distcLocal1
5	Triangular	EV	distcLocal2

**Categories Tab:** Shows a list of distribution types with icons: Beta, Chi, ChiSquared, Erlang, Exponential, Gamma, GeneralizedGamma, Gompertz, HyperExponential, Laplace, Logistic, LogNormal, LogLogistic. The "Triangular" icon is highlighted.

# Example 3-PSA-Change 5 variable's root definition

Variable	New name
StartAge	distStartAge
effLocal	disteffLocal
effMetastases	disteffMetastases
cLocal1	distcLocal1
cLocal2	distcLocal2

1

Name	Root Definition
age	startAge + _stage
cLocal	cLocal
cLocal1	distcLocal1
cLocal2	distcLocal2
cMetastases	50000
effLocal	diseffLocal
effMetastases	2 diseffMetastases
pDeathBackground	tMortBackground[Age]
pLocalToDead	pLocalToDead1
pLocalToDead1	0.04
pLocalToDead2	0.02
pLocalToMetastases	0.16
pMetastasesToDead	0.1
startAge	disStartAge
totalCycles	20

2

3

4

Add/Change Variable or Function

General

Sensitivity Analysis

Categories

effMetastases

Description: QALY for Metastases State

Root definition:

Build Expression:

Format Text Python Array Matrix

diseffMetastases

Add to Expression:

Group: Recent expressions Variables Distributions Tables Functions

Element: distcLocal1 distcLocal2 diseffLocal diseffMetastases distStartAge

Calculated value (at Choose): 0.9

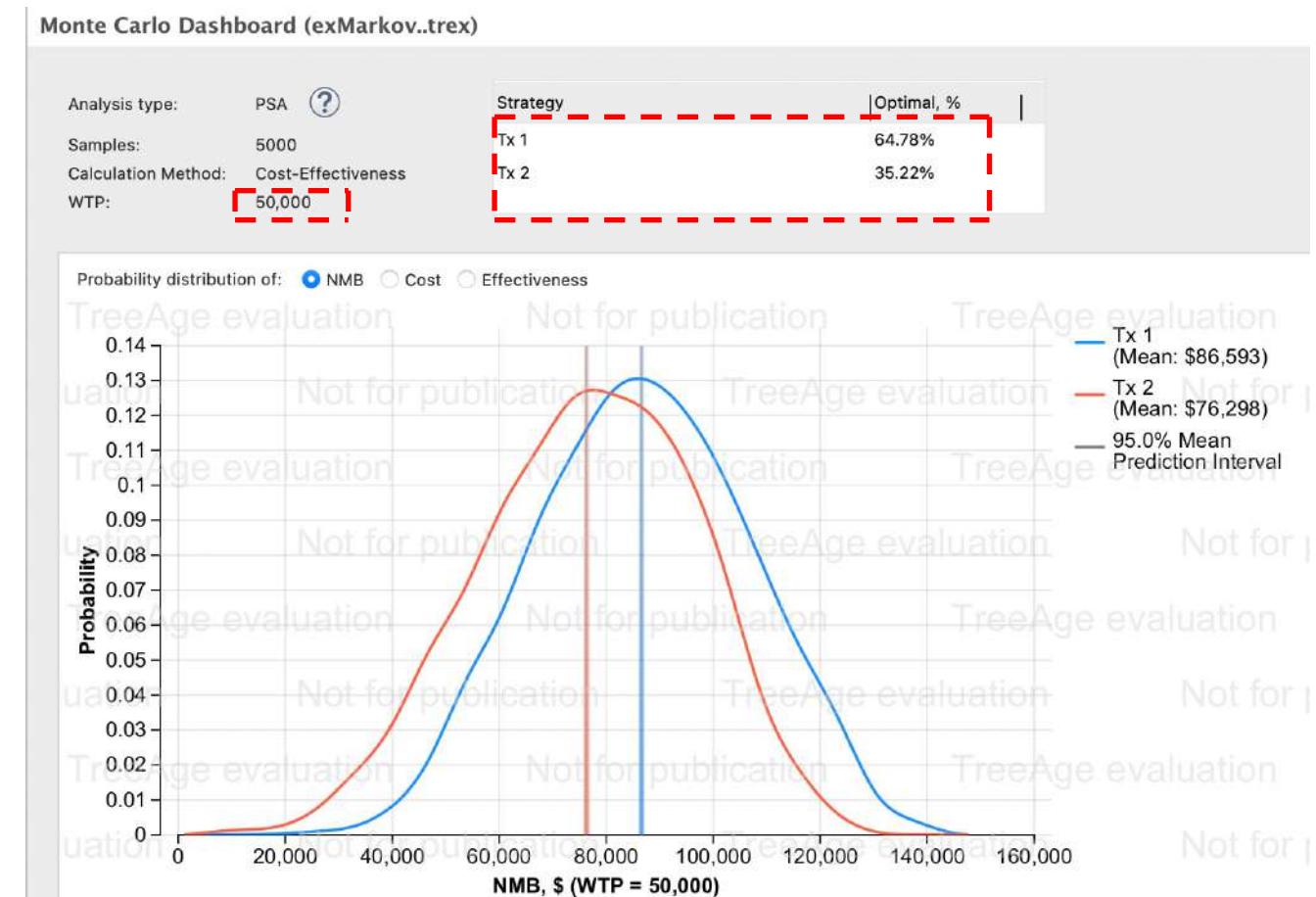
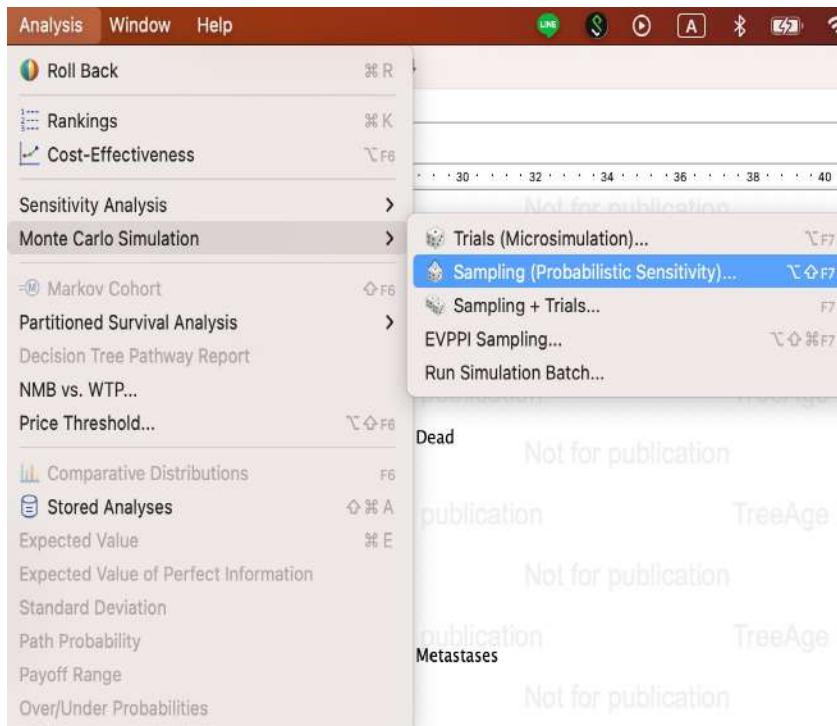
Definition info:

Comment:

Cancel Apply and Close

# Example 3-PSA-Monte Carlo Dashboard

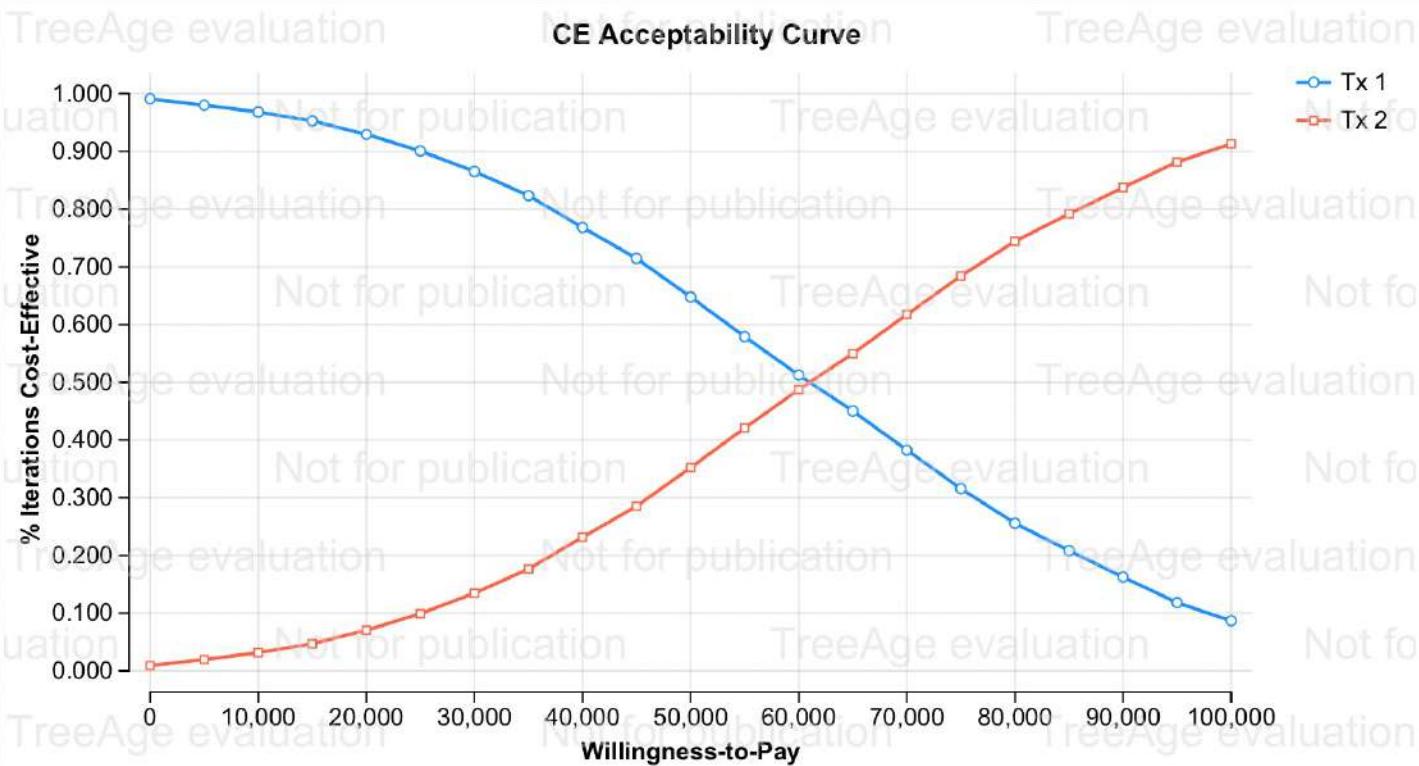
## Analysis/Monte Carlo Simulation/ Sampling/sample:5000



# Example 3-PSA-Monte Carlo Acceptability Curve

## CEAC/Text Report

Monte Carlo Acceptability Curve (exMarkov..trex)

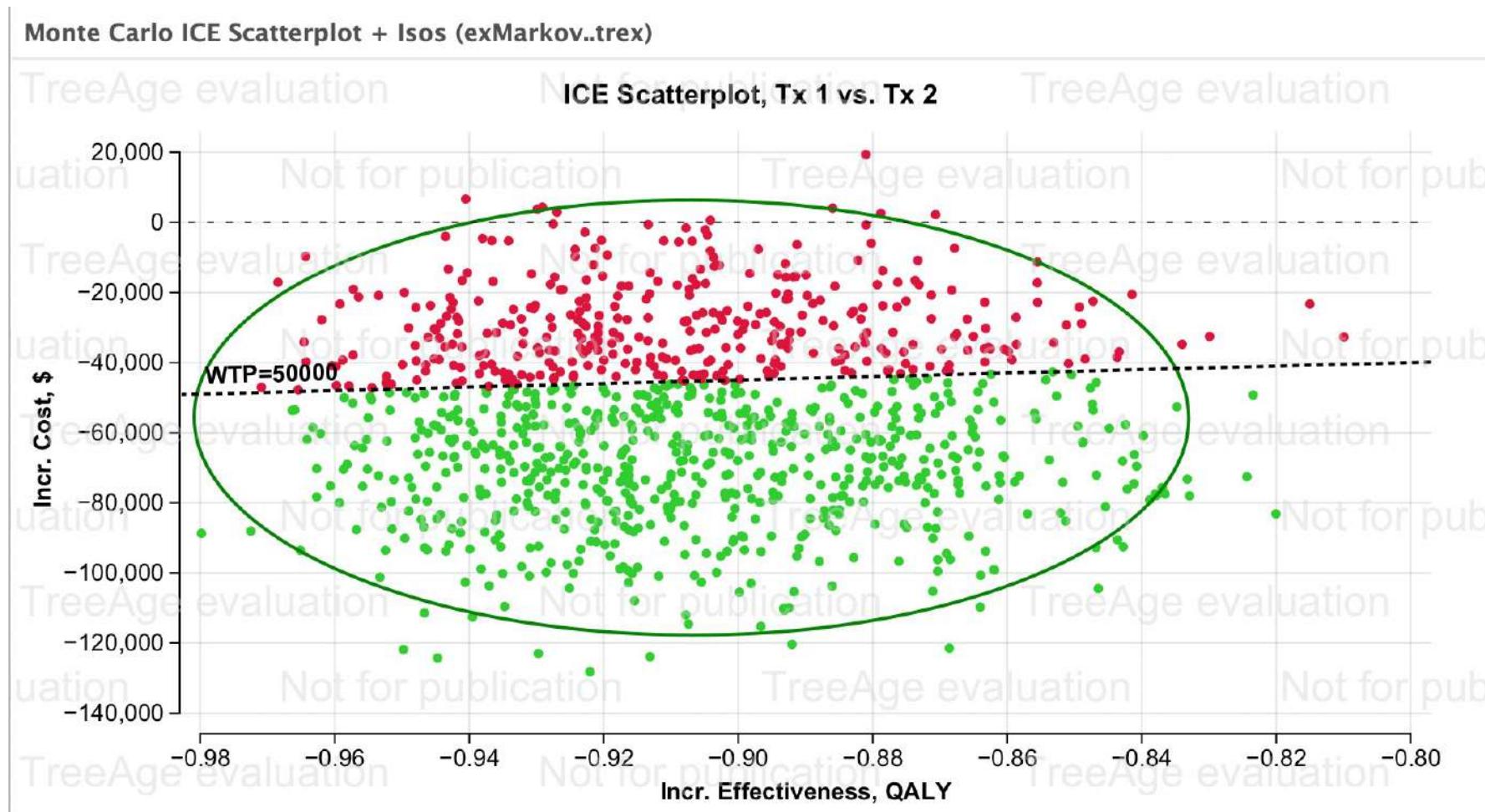


Monte Carlo Acceptability Text (e)

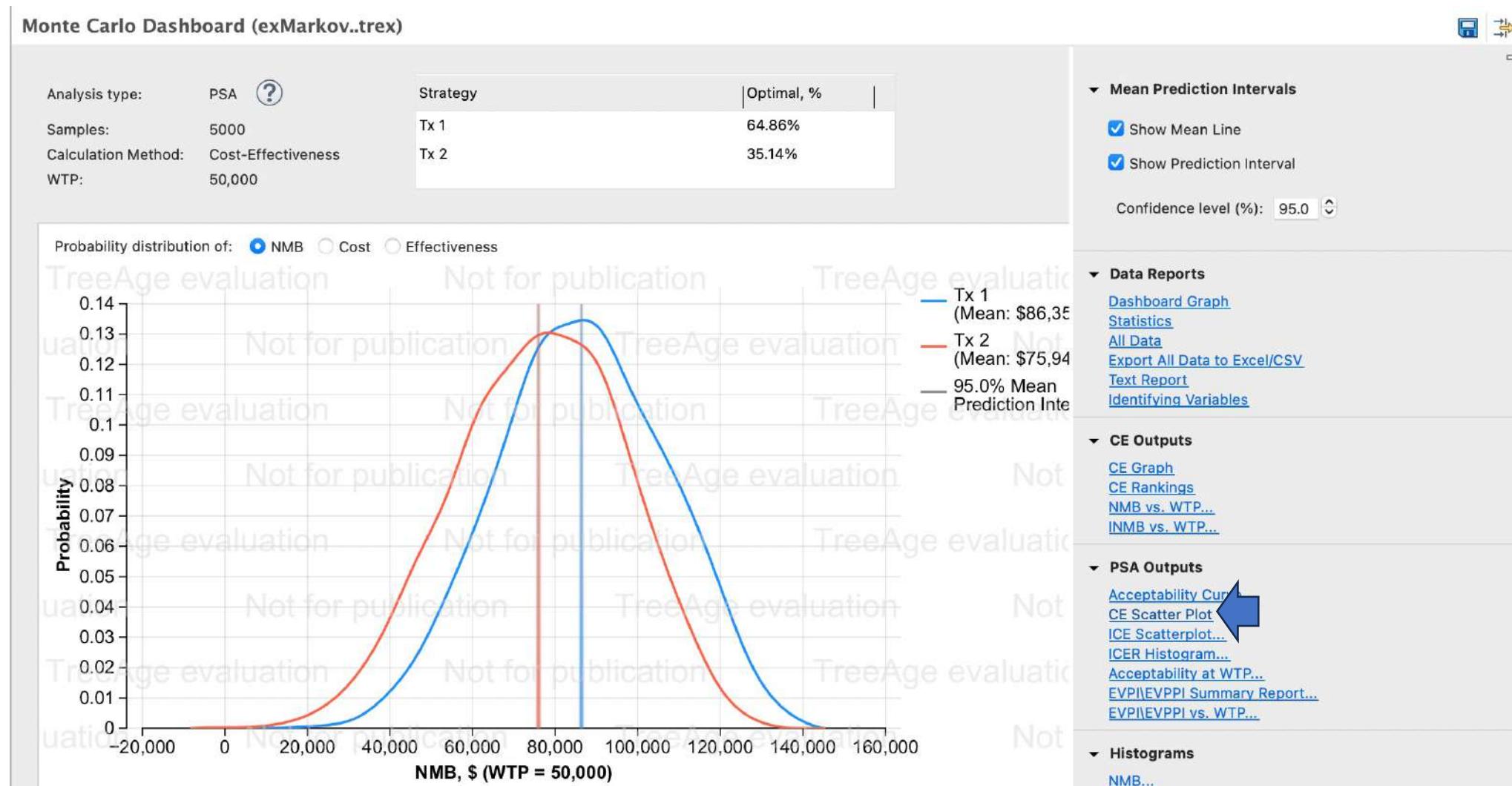
Willingness-to-Pay	Strategy	Acceptability
0	Tx 1	0.991
0	Tx 2	0.009
5,000	Tx 1	0.9802
5,000	Tx 2	0.0198
10,000	Tx 1	0.9684
10,000	Tx 2	0.0316
15,000	Tx 1	0.953
15,000	Tx 2	0.047
20,000	Tx 1	0.9296
20,000	Tx 2	0.0704
25,000	Tx 1	0.9008
25,000	Tx 2	0.0992
30,000	Tx 1	0.8654
30,000	Tx 2	0.1346
35,000	Tx 1	0.8234
35,000	Tx 2	0.1766
40,000	Tx 1	0.7684
40,000	Tx 2	0.2316
45,000	Tx 1	0.7146
45,000	Tx 2	0.2854
50,000	Tx 1	0.6478
50,000	Tx 2	0.3522
55,000	Tx 1	0.5792
55,000	Tx 2	0.4208
60,000	Tx 1	0.5126
60,000	Tx 2	0.4874
65,000	Tx 2	0.5496
65,000	Tx 1	0.4504
70,000	Tx 2	0.6174
70,000	Tx 1	0.3826
75,000	Tx 2	0.6842

# Example 3-PSA-Monte Carlo ICE Scatterplot : Tx1 vs.Tx2

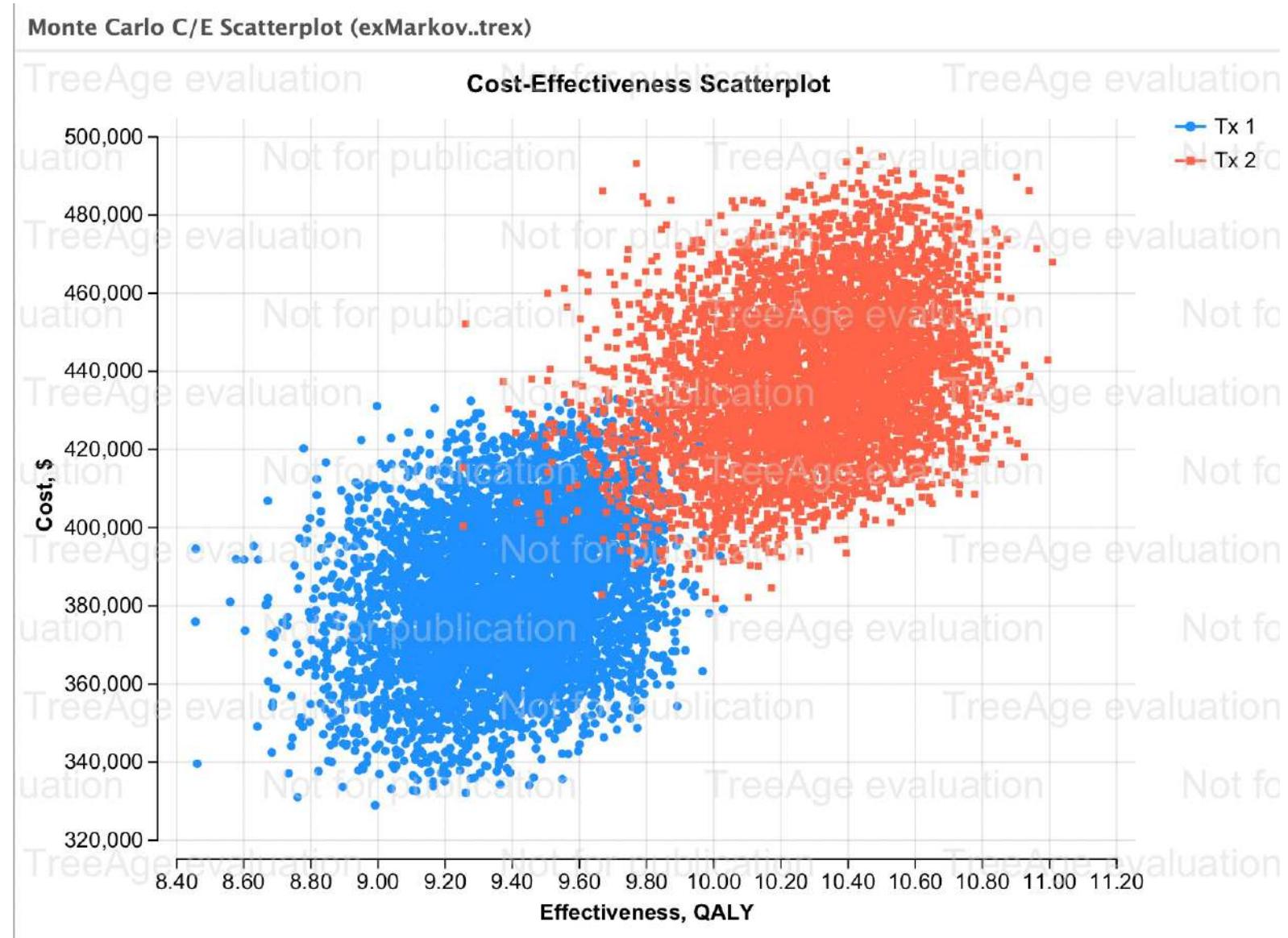
64.78% favored Tx1



## Example 3-PSA



# Example 3-PSA-C/E Scatterplot



## Example 3- Discount

The Global Discounting worksheet has the discount rate which needs to be applied to each payoff, each cycle (\_stage). The discount rate formula is given below:

$$\frac{1}{(1+rate)^{\text{time}}}$$

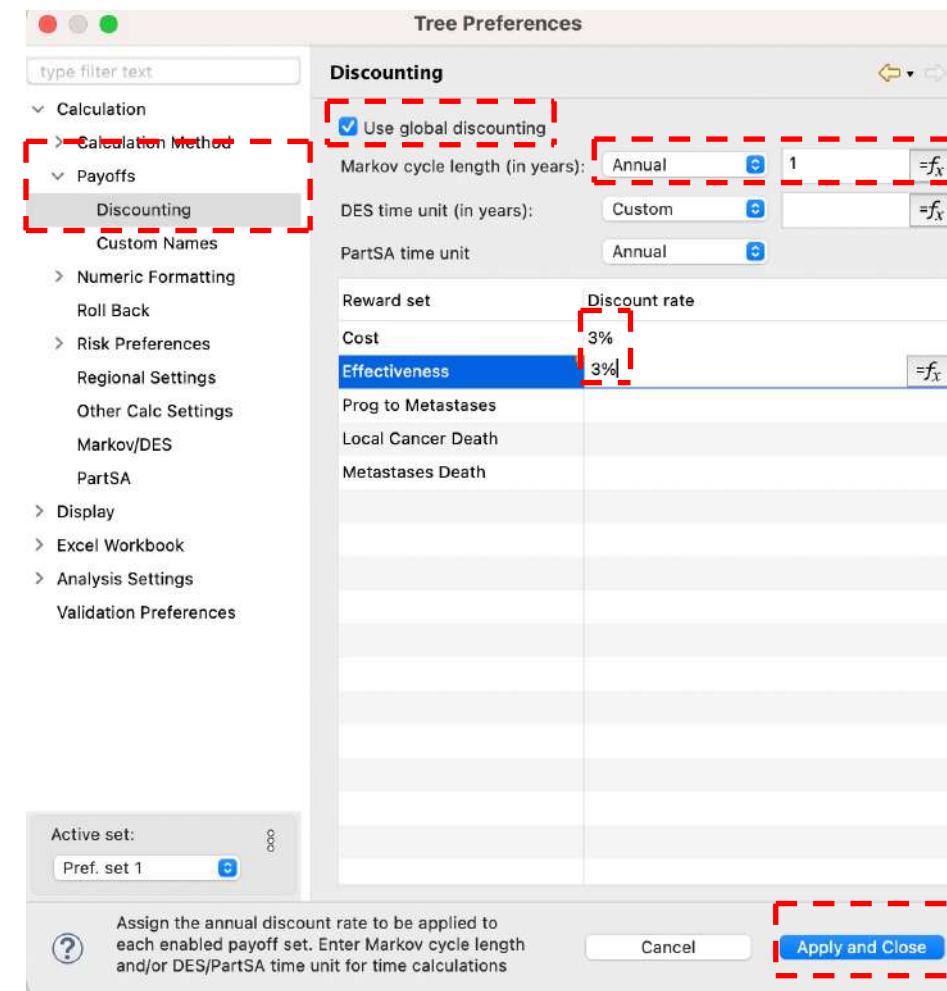
- **No Discount:** The value of the payoff before discounting based on State Details worksheets. All payoffs will have a No Discount column.
- **Discounted:** This only appears if the payoff is discounted. It is the payoff amount for this cycle with discounting applied.
- **Cum Disc:** This is the cumulative value of the payoffs as the cycle (\_stage) increases. If the payoff has been discounted it uses the discounted values.

# Example 3- Discount

If the Markov Model has Global Discounting turned on, then the *Strategy Results* worksheet changes and there is an additional *Global Discounting* worksheet.

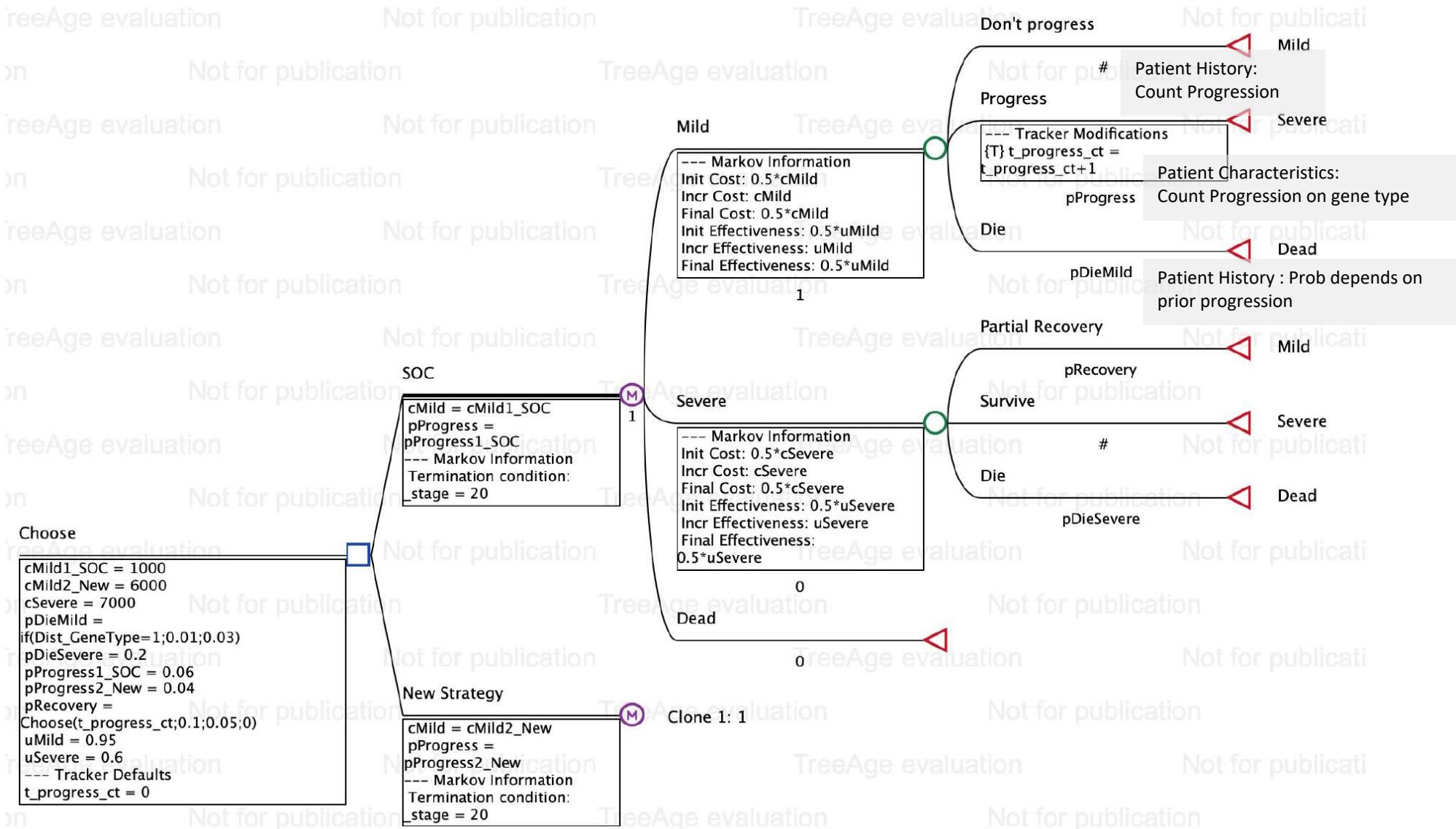
In the Health Care Tutorial Example, Markov Conversion Model Discounting .trex, global discounting is already setup on for the cost and effectiveness payoffs with a discount rate of 3% through the variable integrate. See below.

## Tree/TreePreferences/Payoffs/Discounting



□ 單元九：  
TreeAge Microsimulation

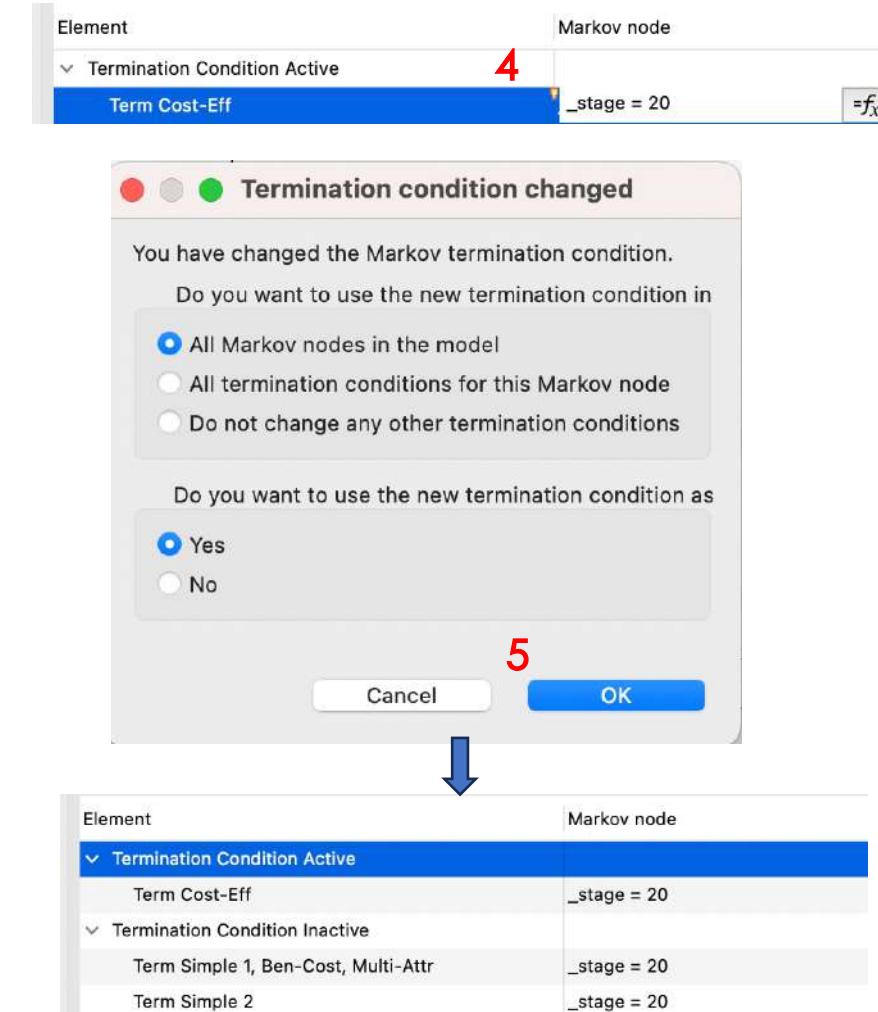
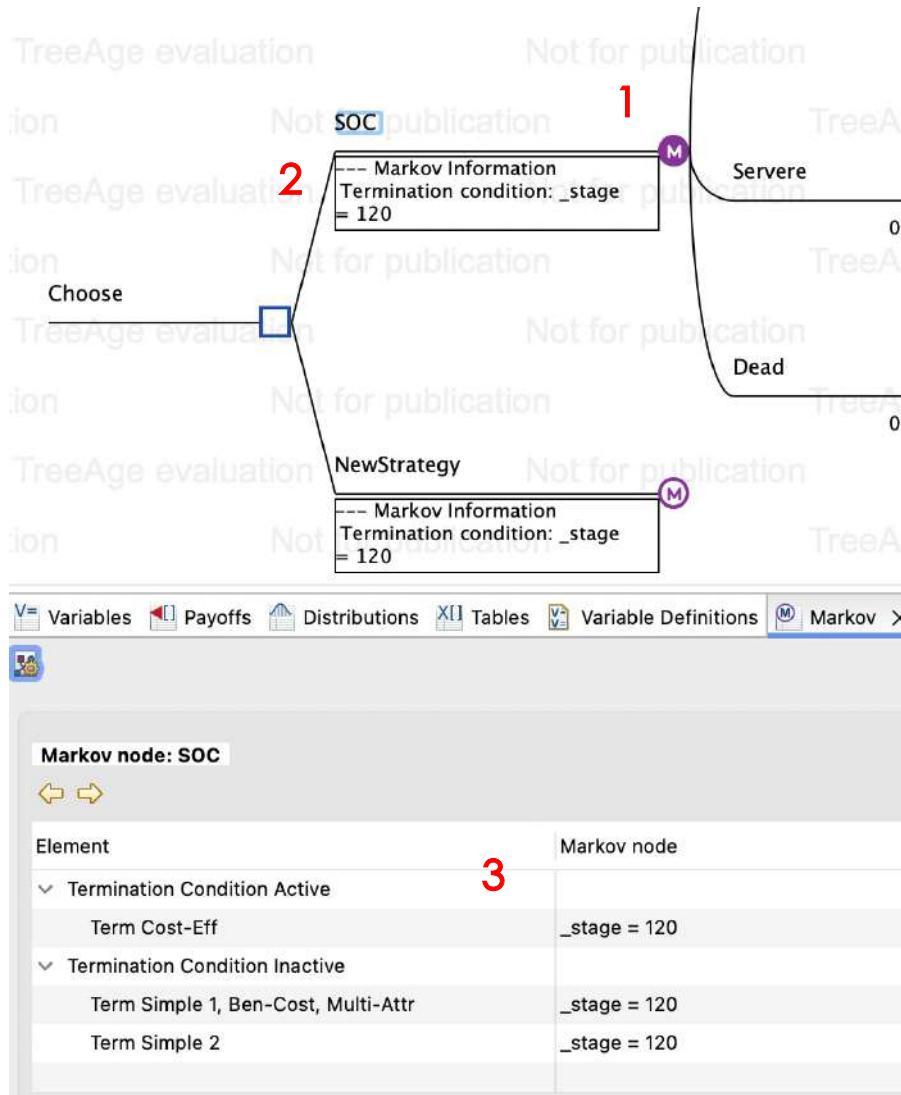
# Example 4-Patient Level Simulation



## Example 4-Patient Level Simulation

Variable name	Variable
cMild	
cMild1_SOC	1000
cMild2_New	6000
cSevere	7000
pDieMild	0.02
pDieSevere	0.2
pProgress	
pProgress1_SOC	0.06
pProgress2_New	0.04
pRecovery	0.1
uMild	0.95
pSevere	0.6

# Example 4-Patient Level Simulation



# Example 4-Patient Level Simulation

SOC	NewStrategy
cMild=cMild1_SOC	cMild=cMild1_New
pProgress=pProgress1_SOC	pProgress=pProgress2_New

TreeAge evaluation

Not for publication

Choose

```

cMild1_SOC = 1000
cMild2_New = 6000
cSevere = 7000
pDieMild = 0.02
pDieSevere = 0.2
pProgressive1_SOC = 0.06
pProgressive2_New = 0.04
pRecovery = 0.1
uMild = 0.95

```

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Define Variable: cMild

Node: SOC

Build Expression:

Format Text Python Array Matrix

cMild1\_SOC

Add to Expression:

Group: Recent expressions Variables Functions Operators Keywords

Element: cMild cMild1\_SOC cMild2\_New cSevere pDieMild pDieSevere

Calculated value (at SOC): 1000

Definition info:

Variable Info

Description: Comment:

Cancel OK

The screenshot shows a decision tree model in the background. A variable definition dialog is open on the right, titled 'Define Variable: cMild'. The 'Build Expression' field contains 'cMild1\_SOC'. The 'Add to Expression' section lists variables under the 'Variables' group. The calculated value at SOC is 1000. The 'Definition info' field is empty. The 'OK' button is highlighted.

# Example 4-Patient Level Simulation

The screenshot shows a Markov model in TreeAge Pro. The model starts at a state labeled "SOC". From "SOC", there are two branches: "Mild" (probability  $p_{Mild} = 0.5$ ) and "Severe" (probability  $p_{Severe} = 0.5$ ). The "Mild" branch leads to a "Progress" state, which then leads to either "Die" or "Partial Recovery". The "Severe" branch leads to a "Survive" state, which then leads to either "Die" or "Partial Recovery".

The "Edit Payoff" dialog is open, showing the expression  $0.5*cMild$ . The calculated value at the Mild state is 500.

**Markov Node: SOC**

Element	Mild	Severe	Dead
<b>Rewards (Active Sets)</b>			
Init Cost	$0.5*cMild$	$0.5*cSevere$	0
Incr Cost	$cMild$	$cSevere$	0
Final Cost	$0.5*cMild$	$0.5*cSevere$	0
Init Effectiveness	$0.5*uMild$	$0.5*uSevere$	0
Incr Effectiveness	$uMild$	$uSevere$	0
Final Effectiveness	$0.5*uMild$	$0.5*uSevere$	0
<b>Rewards (Additional Sets)</b>			

**Edit Payoff**

Build Expression:

Format:  $0.5*cMild$

Add to Expression:

Group: Recent expressions

Element:  $cMild$

Variables:  $cMild1\_SOC$

Functions:  $cMild2\_New$

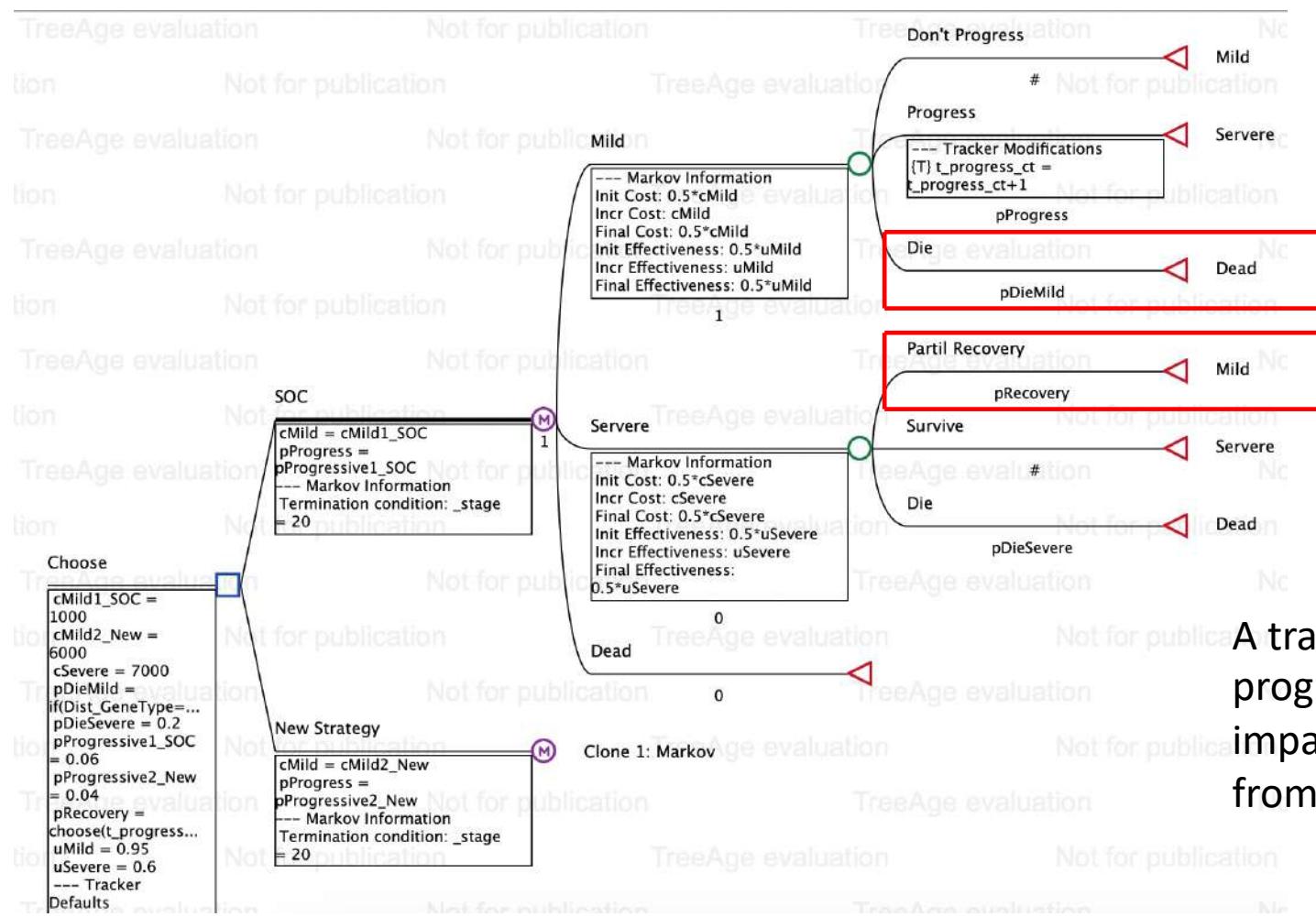
Operators:  $cSevere$

Keywords:  $pDieMild$

Calculated value (at Mild): 500

Cancel OK

# Example 4-Patient Level Simulation



The model includes demographic data on gene types, affecting probabilities like death risk.

A tracker counts how often a patient progresses through different stages, impacting probabilities like recovery from severe states.

# Example 4-Patient Level Simulation

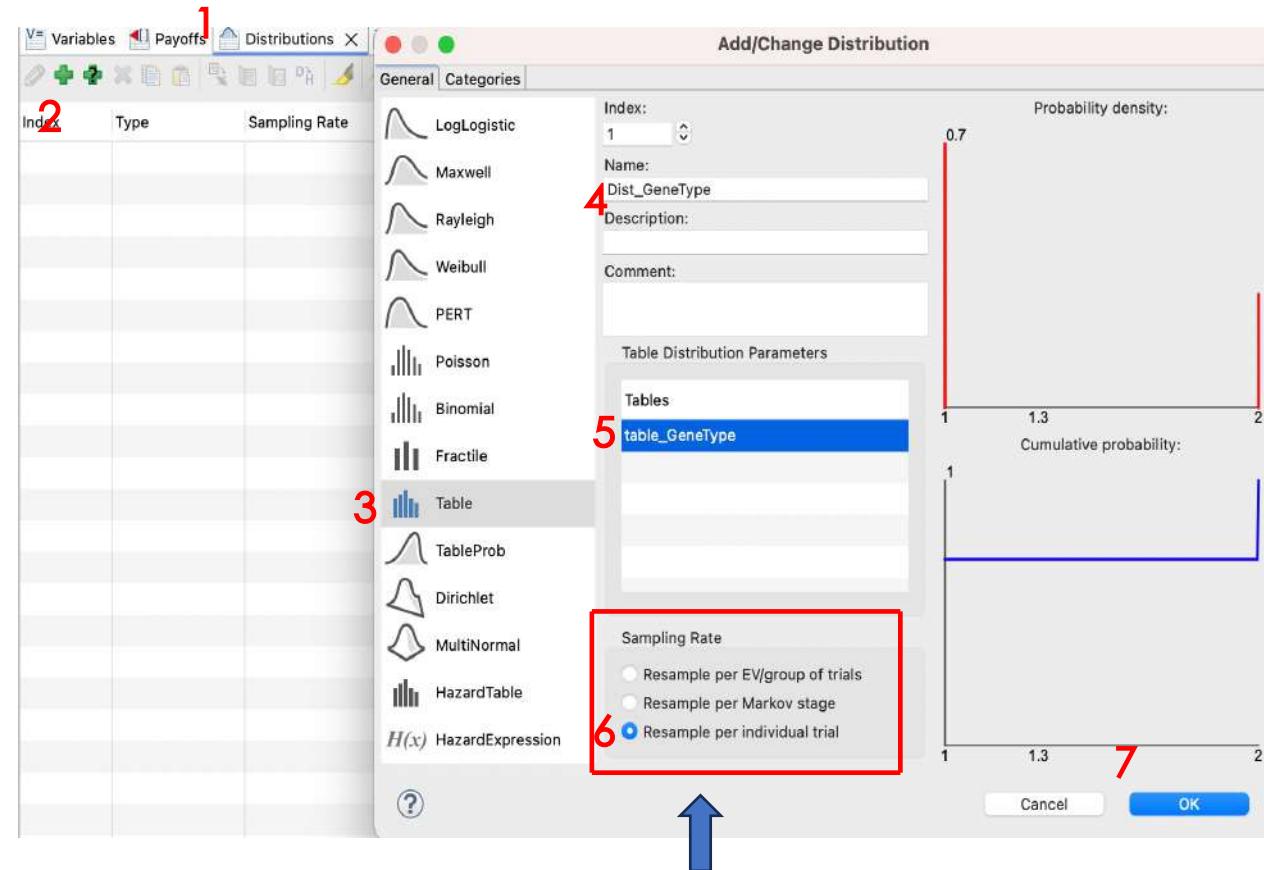
This is loaded in a table seventy percent of the population have gene type one and thirty percent of the population have gene type two the table gene type stores the demographic data in the model.

The screenshot shows a simulation software interface with three main windows:

- Top Bar:** Shows tabs for Variables, Payoffs, Distributions, Tables (highlighted with a red box and number 1), and Variable D.
- Left Panel:** Shows a 'Tables' section with a red box and number 2 containing a green plus sign icon, and a 'Description' section.
- Middle Panel:** An 'Add/Change Table' dialog box with a red box and number 3. It has fields for Name (table\_GeneType), Description, and Comment. It includes options for handling missing row/column indexes (Truncate, Use linear interpolation, Use spline interpolation, Error) and settings for a multi-column table (Value columns: 1, Default column: 1). Buttons for Cancel and OK are at the bottom.
- Right Panel:** A 'Table Rows: table\_GeneType' view with a red box and number 5. It shows a table with an Index column (1, 2) and a Value 1 column (0.7, 0.3). A red box and number 6 highlights the value 0.7.

# Example 4-Patient Level Simulation

根據人口統計數據中基因類型的分佈，使用一個分佈來為每位患者分配一個特定的基因類型。我們使用的分佈來源於一張表格，該表格總結並表示了適當的基因類型分佈。



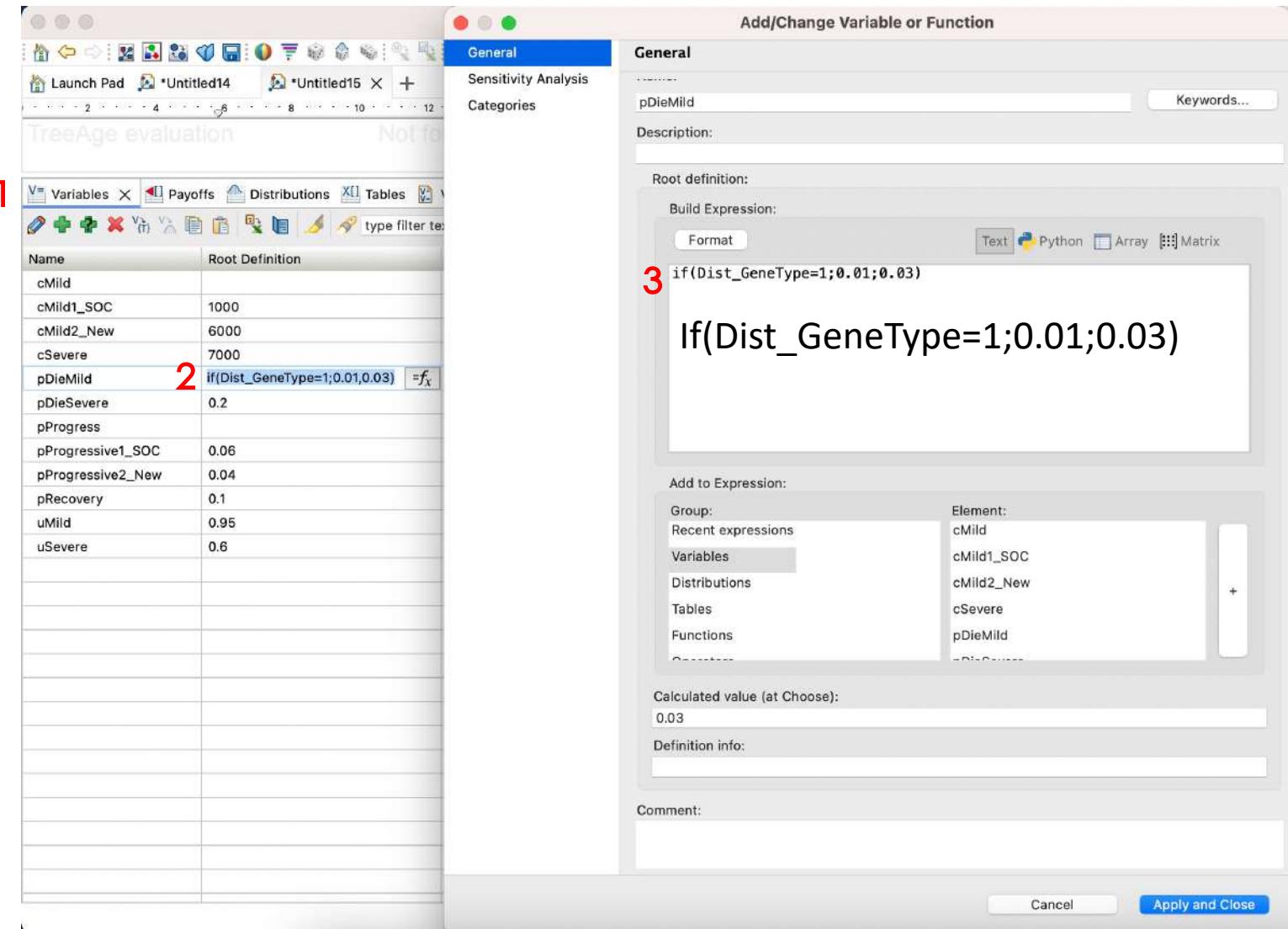
當模型運行時，將根據分佈為每位模擬患者分配一個基因類型。隨後，每當基因類型在模型中對患者產生影響時，就可以參照該分佈。

# Example 4-Patient Level Simulation

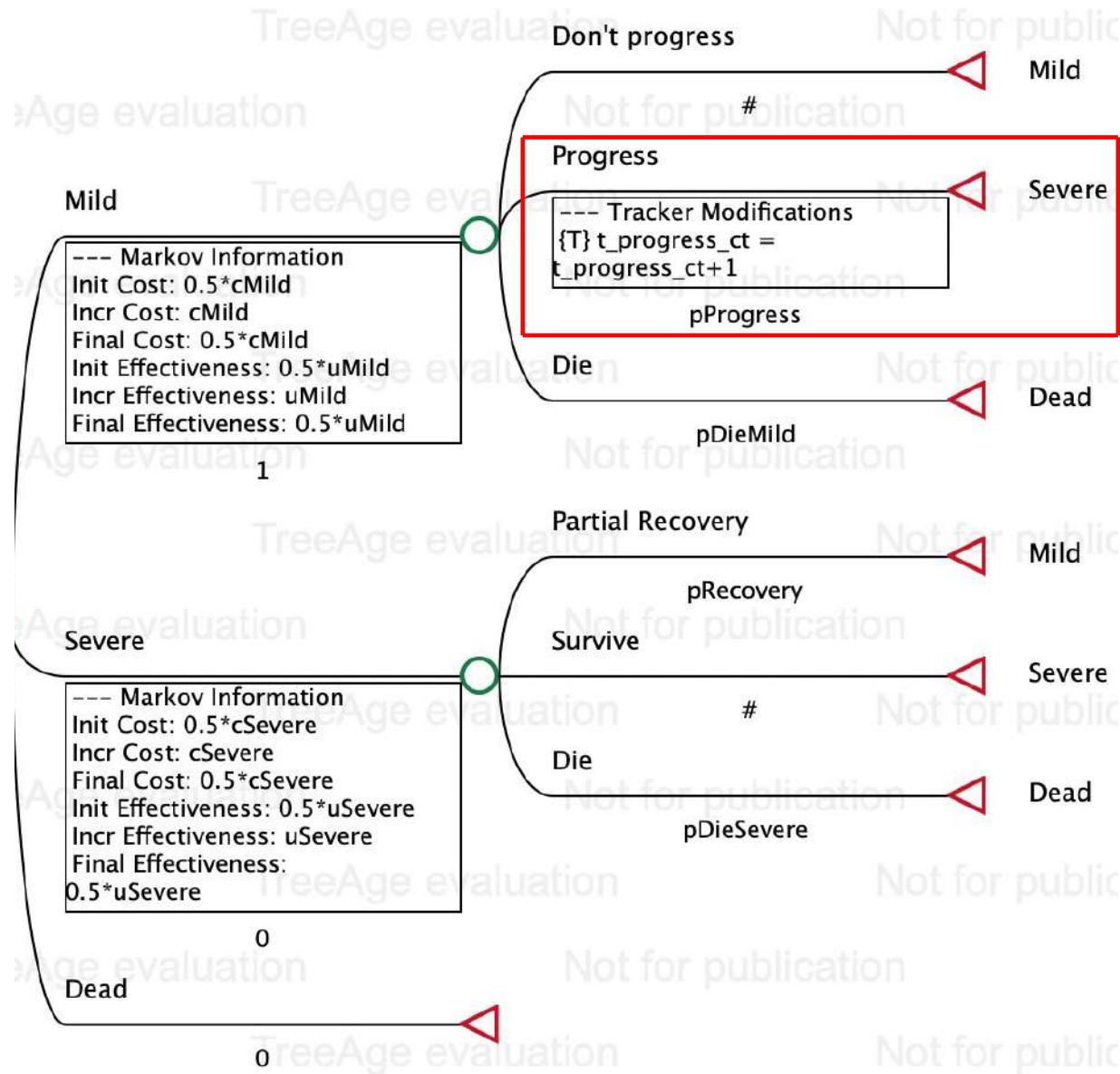
在模型中，如果要根據患者特徵（如基因類型）動態調整某個事件（如死亡）的機率，可以使用條件語句 if函數來改變機率。這樣可以根據不同的基因類型或特徵設定不同的機率數值。

GeneType=1,pDieMild=0.01

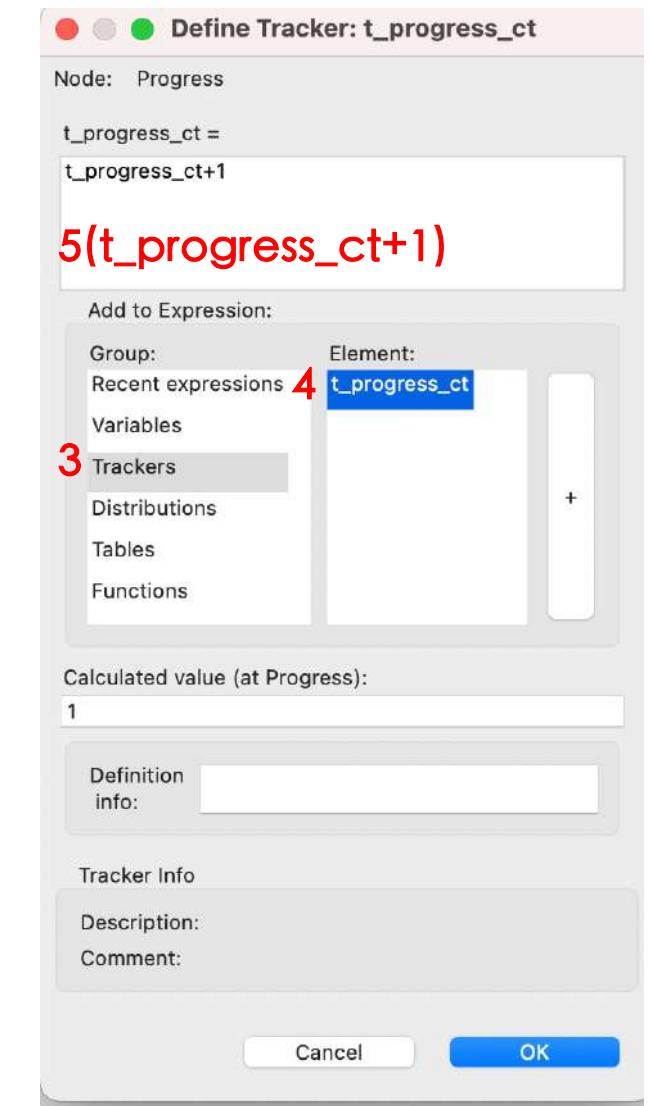
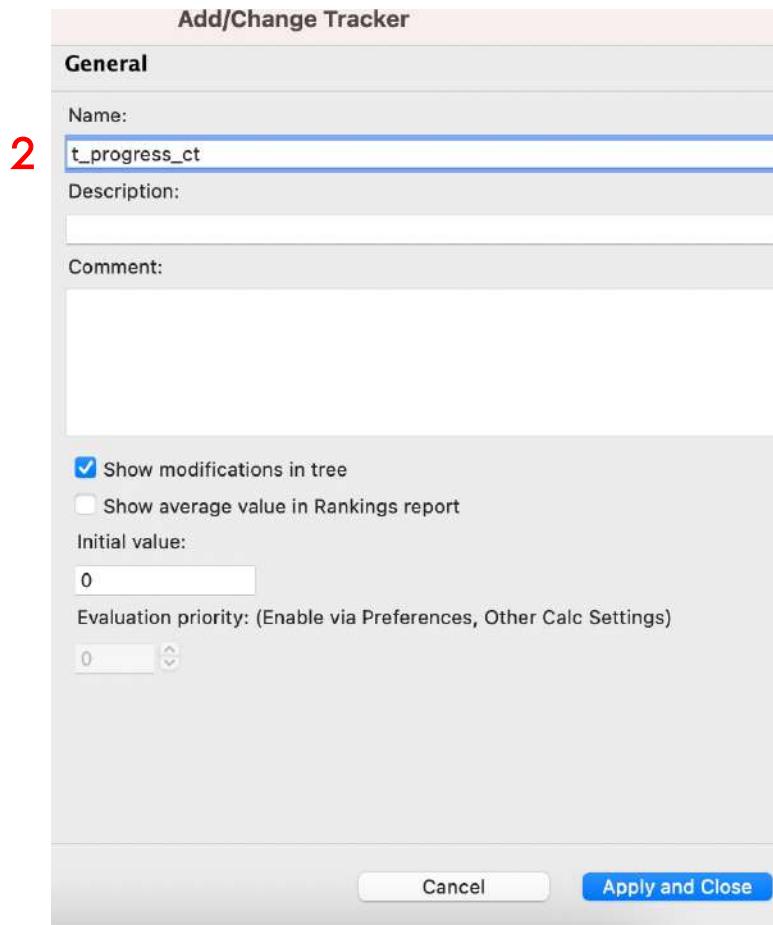
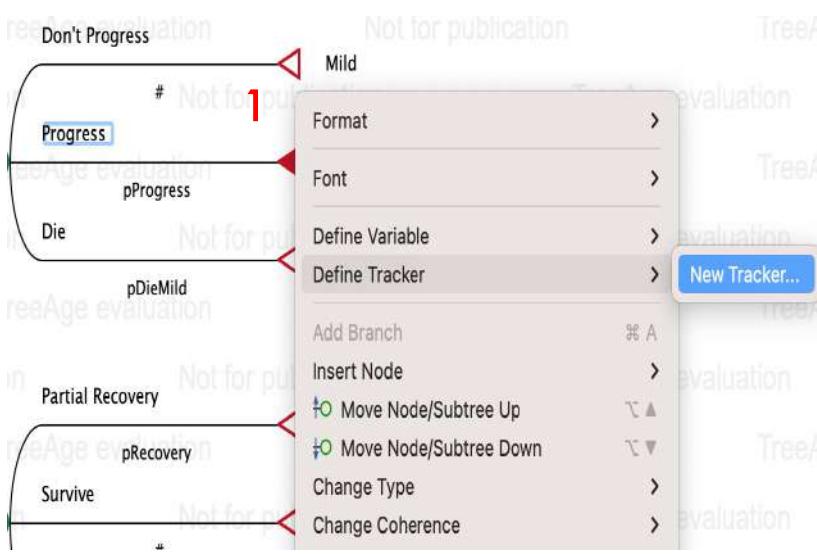
GeneType=2,pDieMild=0.03



# Example 4-Patient Level Simulation-The Tracker

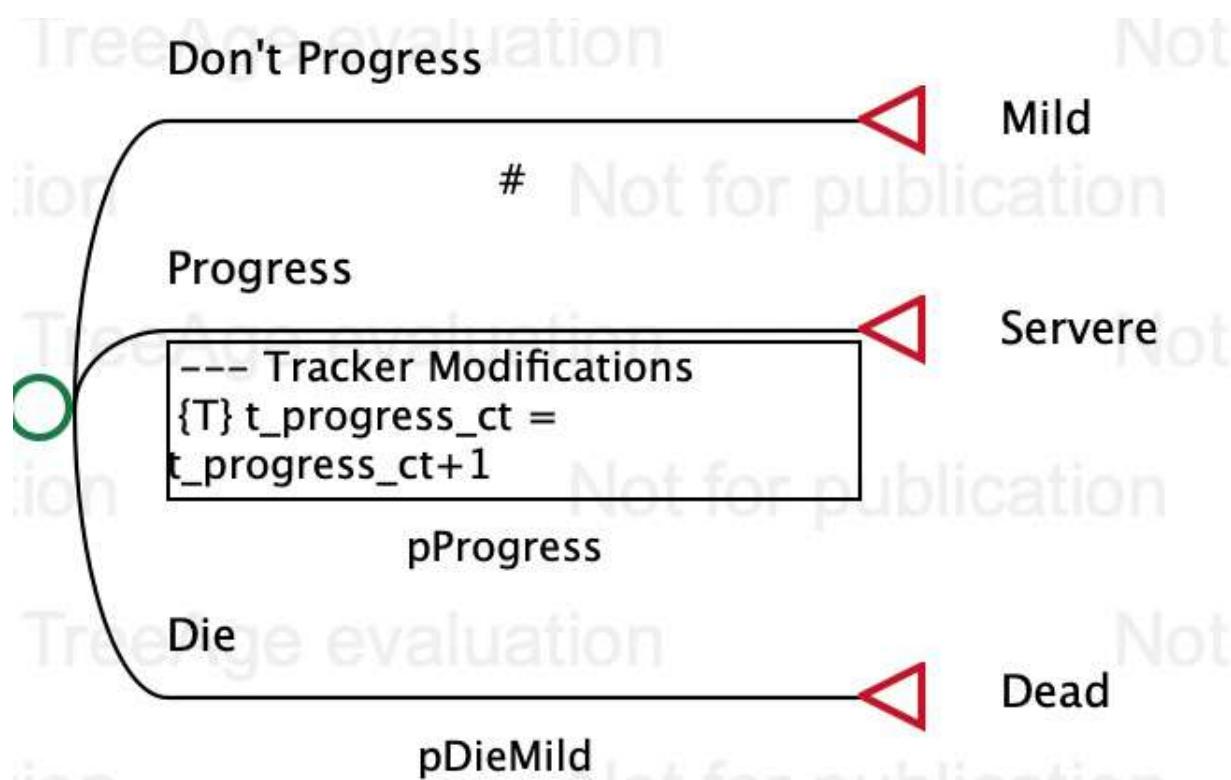


# Example 4-Patient Level Simulation-The Tracker



# Example 4-Patient Level Simulation-The Tracker

Trackers record progression history, increasing by one each time a patient progresses. The progression count is referenced to adjust recovery probabilities, with limits set as progression increases.



# Example 4-Patient Level Simulation-The Tracker

```
t_progress_ct=1,pRecovery=0.1  
t_progress_ct=2,pRecovery=0.05  
t_progress_ct=3,pRecovery=0
```

當追蹤器為1時，將返回值0.1；  
當追蹤器為2時，將返回值0.05；  
當追蹤器進展計數為3時，恢復率將為0，且不再可能恢復。

The screenshot shows the AnyLogic software interface. On the left, the 'Variables' tab of the workspace is selected, displaying a list of variables and their root definitions. A variable named 'pRecovery' is highlighted with a red box and a red number '2' placed over it. On the right, the 'Add/Change Variable or Function' dialog box is open, specifically the 'General' tab. The variable 'pRecovery' is defined with the root definition: `Choose(t_progress_ct;0.1;0.05;0)`. The 'Variables' group in the 'Add to Expression' section is also highlighted with a red box and a red number '3' placed over it.

1

2

3

Name	Root Definition
cMild	
cMild1_SOC	1000
cMild2_New	6000
cSevere	7000
pDieMild	If(Dist_GeneType=1;0.01;0.03)
pDieSevere	0.2
pProgress	
pProgressive1_SOC	0.06
pProgressive2_New	0.04
pRecovery	0.1
uMild	0.95
uSevere	0.6

Add/Change Variable or Function

General

Sensitivity Analysis

Categories

pRecovery

Description:

Root definition:

Build Expression:

Format Text Python Array Matrix

Choose(t\_progress\_ct;0.1;0.05;0)

Add to Expression:

Group: Recent expressions Variables Trackers Distributions Tables Calculations

Element: cMild cMild1\_SOC cMild2\_New cSevere pDieMild pDieSevere

Calculated value (at Choose): 0

Definition info:

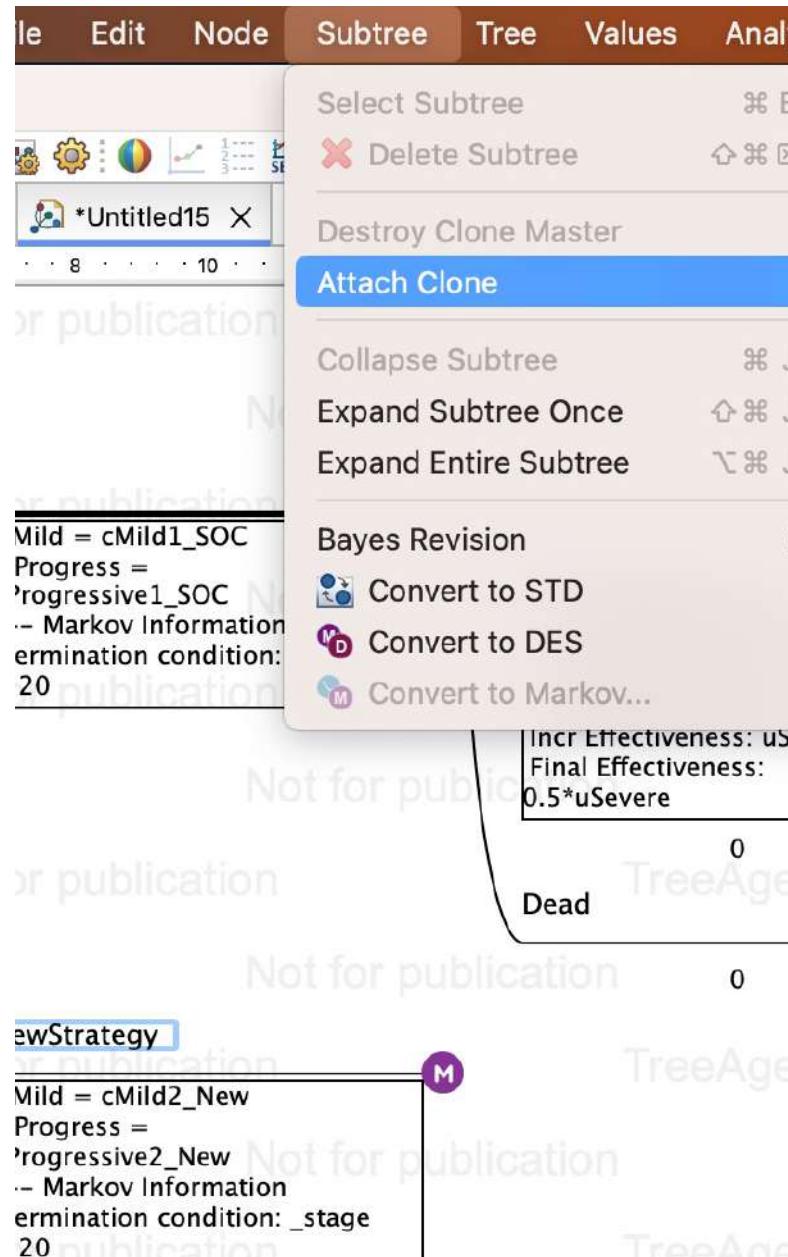
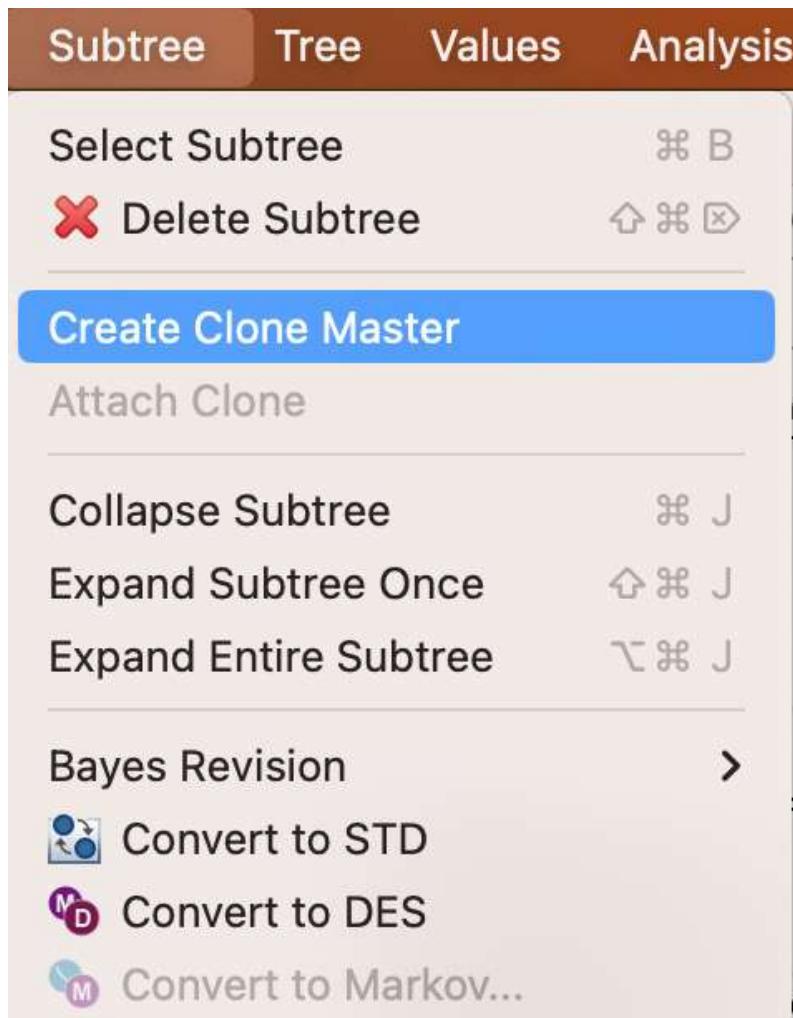
Comment:

Cancel Apply and Close

# Example 4-Patient Level Simulation

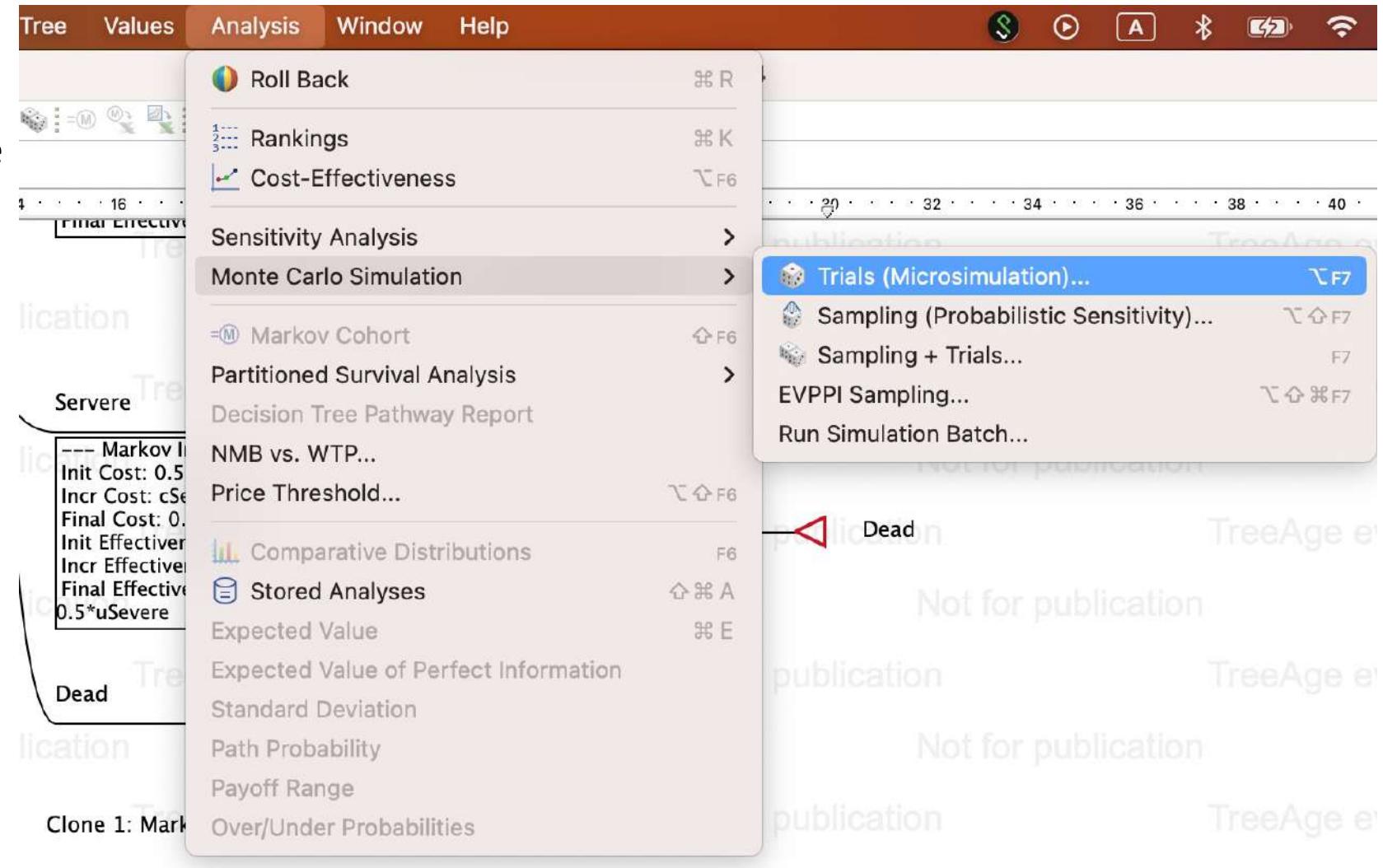
1.Clone SOC

2.Attach NewStrategy



# Example 4-Patient Level Simulation

Simulated patients go through the model, with pathways chosen based on probabilities. Monte Carlo simulations with 10,000 trials generate average cost and effectiveness data for comparison between strategies.



# Example 4-Patient Level Simulation

Monte Carlo Summary Text Report (Untitled15)

Attribute	Statistic	SOC	NewStrategy
Cost	Mean	26805.80	89637.45
Cost	Std Deviation	18408.36	39026.75
Cost	Minimum	500.00	3000.00
Cost	2.5%	1500.00	9000.00
Cost	10%	7500.00	27000.00
Cost	Median	20000.00	118000.00
Cost	90%	51500.00	122000.00
Cost	97.5%	77000.00	126500.00
Cost	Maximum	137000.00	137000.00
Cost	Sum	268058000.00	896374500.00
Cost	Size (n)	10000.00	10000.00
Cost	Variance	338867786.36	1523087082.50
Cost	Variance/Size	33886.78	152308.71
Cost	SQRT[Variance/Size]	184.08	390.27
Cost	95% Lower Bound	26445.00	88872.54
Cost	95% Upper Bound	27166.60	90402.36
Eff	Mean	12.21	13.37
Eff	Std Deviation	6.25	6.20
Eff	Minimum	0.47	0.47
Eff	2.5%	1.07	1.07
Eff	10%	2.98	3.33
Eff	Median	13.57	16.52
Eff	90%	19.00	19.00
Eff	97.5%	19.00	19.00
Eff	Maximum	19.00	19.00
Eff	Sum	122063.30	133685.63
Eff	Size (n)	10000.00	10000.00
Eff	Variance	39.05	38.48
Eff	Variance/Size	0.00	0.00
Eff	SQRT[Variance/Size]	0.06	0.06
Eff	95% Lower Bound	12.08	13.25

每位患者將經過模型並累積總成本和效果值，然後將每位患者的結果彙總為平均值，以提供每位患者的平均成本和效果。在微觀模擬模型中，我們仍然需要做出最佳決策。

Monte Carlo C/E Rankings Report (Untitled15)

Category	Strategy	Cost	Incr. Cost	Effectiveness	Incr. Effectiveness	ICER (IC/IE)	NMB
All (no dominance)							
undominated	SOC	26805.80		12.21			-26805.80
undominated	NewStrategy	89637.45	62831.65	13.37	1.16	54061.17	-89637.45

# Example 4-Patient Level Simulation

The screenshot shows the 'Tree Preferences' dialog box, which is a modal window overlaid on the main application interface. The title bar of the dialog box reads 'Tree Preferences'. The main content area is titled 'Patient Tracking Reporting'. Under this section, there is a checked checkbox labeled 'Activate patient tracking for your simulation model'. Below this is an unchecked checkbox labeled 'Skip records without data updates (not recommended)'. A section titled 'Choose which values to track:' contains several checked checkboxes corresponding to different data types and variables. At the bottom of the dialog box, there is a note: 'Activate patient tracking reporting for your simulation model. Choose which values to track.' followed by 'Cancel' and 'Apply and Close' buttons.

Tree Values Analysis Window Help

Select Root ⌘ 不

Find... ⌘ F

Select Nodes If

Compare With Another Tree

Tree Properties

Values Lists >

Build Model Outputs

Expand Table for Sensitivity Analysis

Add PSA For Variable

**Tree Preferences** ⌘ F11

Model Setup Wizard...

✓ Run Model Setup Wizard for New Models

Web Sharing Options ⌘ W

Node ID Report

Export Model Scenarios to Excel...

Convert Markov Tree to Excel Model...

Tree Preferences

Patient Tracking Reporting

Activate patient tracking for your simulation model

Skip records without data updates (not recommended)

Choose which values to track:

Payoffs

Payoff 1 (Cost)

Payoff 2 (Effectiveness)

Distributions

Dist\_GeneType

Trackers

t\_progres\_ct

t\_progress\_ct

Active set: Pref. set 1

Activate patient tracking reporting for your simulation model. Choose which values to track.

Cancel Apply and Close

# Example 4-Patient Level Simulation

1

Mean Prediction Intervals

Show Mean Line

Show Prediction Interval

Confidence level (%): 95.0

Data Reports

[Dashboard Graph](#)

[Statistics](#)

[All Data](#)

[Export All Data to Excel/CSV](#)

[Text Report](#)

[Patient tracking reports...](#)

[Identifying Variables](#)

CE Outputs

[CE Graph](#)

[CE Rankings](#)

[NMB vs. WTP...](#)

[INMB vs. WTP...](#)

Histograms

[NMB...](#)

[Cost...](#)

[Effectiveness...](#)

[t\\_progres\\_ct \(tracker\)...](#)

[t\\_progress\\_ct \(tracker\)...](#)

[Dist\\_GeneType \(distribution\)](#)

2

Patient tracking parameters

Report type

Trial

Cohort

All Data - Time/Node by Data Item

Trial - Data Items by Time Period

Data Item - Trials by Time Period

Strategy

SOC

Cancel OK

Monte Carlo Summary Text Report (Untitled15)

Attribute	Statistic	%	NewStrategy
Cost	Mean	26436.35	89371.75
Cost	Std Deviation	18026.31	39011.60
Cost	Minimum	500.00	3000.00
Cost	2.5%	1500.00	9000.00
Cost	10%	7500.00	27000.00
Cost	Median	20000.00	117000.00
Cost	90%	51500.00	122000.00
Cost	97.5%	74000.00	126000.00
Cost	Maximum	137000.00	139500.00
Cost	Sum	264363500.00	893717500.00
Cost	Size (n)	10000.00	10000.00
Cost	Variance	324948023.68	1521905026.94
Cost	Variance/Size	32494.80	152190.50
Cost	SQRT[Variance/Size]	180.26	390.12
Cost	95% Lower Bound	26083.04	88607.14
Cost	95% Upper Bound	26789.66	90136.36
Eff	Mean	12.20	13.36
Eff	Std Deviation	6.28	6.23
Eff	Minimum	0.47	0.47
Eff	2.5%	1.07	1.42
Eff	10%	2.98	3.33
Eff	Median	13.57	16.55
Eff	90%	19.00	19.00
Eff	97.5%	19.00	19.00
Eff	Maximum	19.00	19.00
Eff	Sum	122038.32	133554.17
Eff	Size (n)	10000.00	10000.00
Eff	Variance	39.48	38.81
Eff	Variance/Size	0.00	0.00
Eff	SQRT[Variance/Size]	0.06	0.06
Eff	95% Lower Bound	12.08	13.23

Data

Patient Tracking Reports

All Data - Time/Node by Data Item

All Data (Export to Excel/CSV)

3 Trial - Data Items by Time Period

Data Item - Trials by Time Period

Strategy Values

Identifying Variables

Trackers

Distributions

Report Options...

Decimal format

Analysis Comment

# Example 4-Patient Level Simulation

Individual trials unique paths through the model

Monte Carlo Patient Tracking Trial Report (Untitled15)									
Trial: 1 of 10000		Go to trial:		Go					
State/Transition	Stage	Cost	Cum Cost	Effectiveness	Cum Effectiveness	Distribution	Tracker t_progres_ct	Tracker t_progress_ct	
[+]	Mild	0	500.00	500.00	0.47	0.47	2	0	0
◀	Dont Progress	0	0.00	500.00	0.00	0.47	2	0	0
[+]	Mild	1	1000.00	1500.00	0.95	1.42	2	0	0
◀	Dont Progress	1	0.00	1500.00	0.00	1.42	2	0	0
[+]	Mild	2	1000.00	2500.00	0.95	2.38	2	0	0
◀	Dont Progress	2	0.00	2500.00	0.00	2.38	2	0	0
[+]	Mild	3	1000.00	3500.00	0.95	3.33	2	0	0
◀	Dont Progress	3	0.00	3500.00	0.00	3.33	2	0	0
[+]	Mild	4	1000.00	4500.00	0.95	4.28	2	0	0
◀	Dont Progress	4	0.00	4500.00	0.00	4.28	2	0	0
[+]	Mild	5	1000.00	5500.00	0.95	5.23	2	0	0
◀	Dont Progress	5	0.00	5500.00	0.00	5.23	2	0	0
[+]	Mild	6	1000.00	6500.00	0.95	6.18	2	0	0
◀	Progress	6	0.00	6500.00	0.00	6.18	2	0	1
[+]	Servere	7	7000.00	13500.00	0.60	6.78	2	0	1
◀	Survive	7	0.00	13500.00	0.00	6.78	2	0	1
[+]	Servere	8	7000.00	20500.00	0.60	7.38	2	0	1
◀	Survive	8	0.00	20500.00	0.00	7.38	2	0	1
[+]	Servere	9	7000.00	27500.00	0.60	7.97	2	0	1
◀	Survive	9	0.00	27500.00	0.00	7.97	2	0	1
[+]	Servere	10	7000.00	34500.00	0.60	8.57	2	0	1
◀	Survive	10	0.00	34500.00	0.00	8.57	2	0	1
[+]	Servere	11	7000.00	41500.00	0.60	9.17	2	0	1
◀	Survive	11	0.00	41500.00	0.00	9.17	2	0	1
[+]	Servere	12	7000.00	48500.00	0.60	9.77	2	0	1
◀	Survive	12	0.00	48500.00	0.00	9.77	2	0	1
[+]	Servere	13	7000.00	55500.00	0.60	10.37	2	0	1
◀	Die	13	0.00	55500.00	0.00	10.37	2	0	1
◀	Dead	14	0.00	55500.00	0.00	10.37	2	0	1

# Example 4-Patient Level Simulation

**Patient tracking parameters**

Report type

- Trial
- Cohort
- All Data - Time/Node by Data Item
- Trial - Data Items by Time Period
- Data Item - Trials by Time Period

Strategy

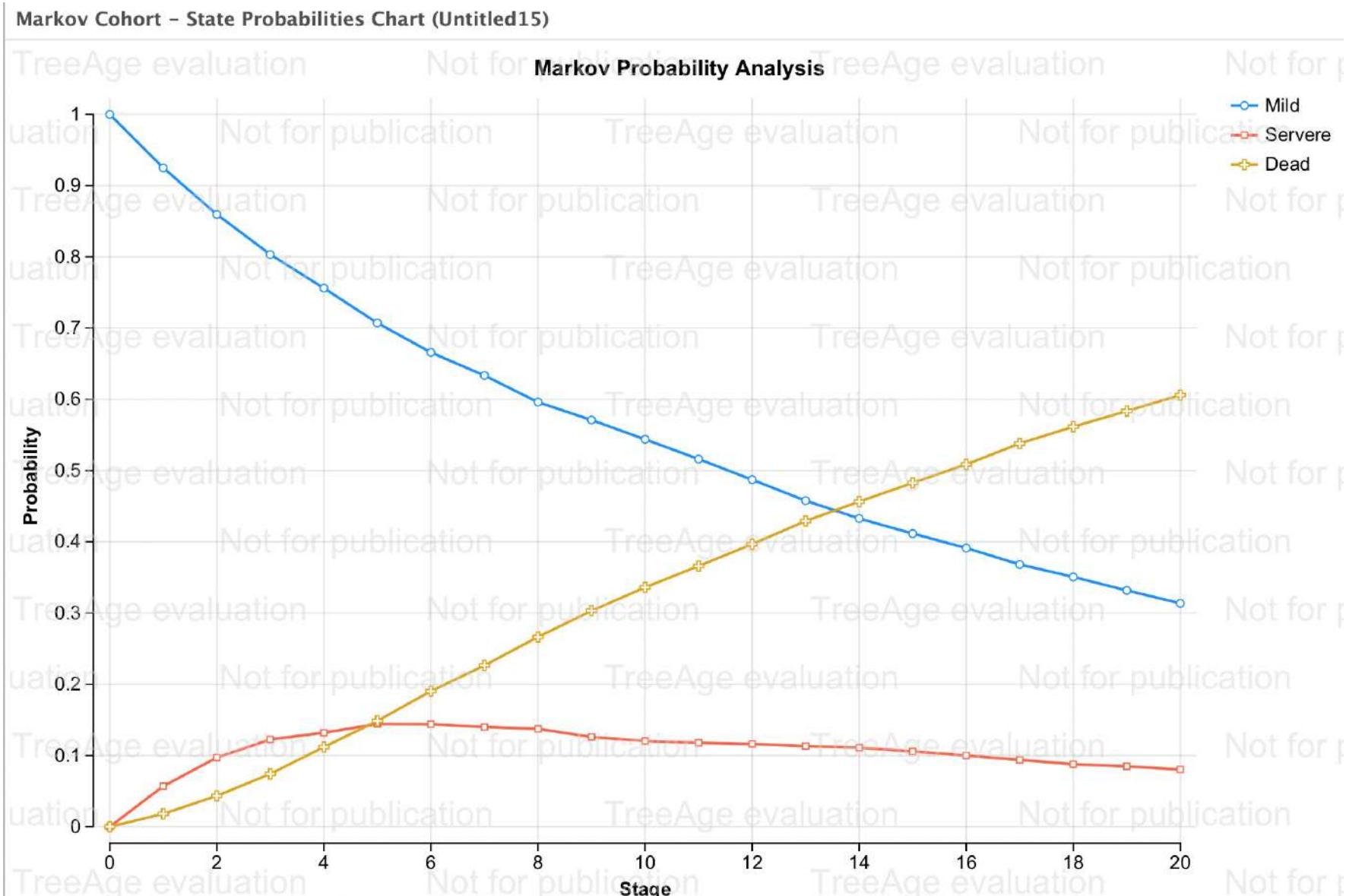
Cancel      OK

Cohort report for patient level simulation model

Monte Carlo Patient Tracking Cohort Report (Untitled15)

State/Transition	Stage	Cohort %	Cost	Cum Cost	Effectiveness	Cum Effectiveness	Tracker t_progress_ct	Tracker t_progress_ct
Summary	0		500.00	500.00	0.47	0.47	0	0.0569
Mild	0	1.000	500.00		0.47			
Servere	0	0.000	0.00		0.00			
Dead	0	0.000	0.00		0.00			
Summary	1		1323.20	1823.20	0.91	1.39	0	0.1125
Mild	1	0.925	924.90		0.88			
Servere	1	0.057	398.30		0.03			
Dead	1	0.018	0.00		0.00			
Summary	2		1539.30	3362.50	0.87	2.26	0	0.1657
Mild	2	0.860	859.60		0.82			
Servere	2	0.097	679.70		0.06			
Dead	2	0.043	0.00		0.00			
Summary	3		1661.40	5023.90	0.84	3.10	0	0.2123
Mild	3	0.803	803.20		0.76			
Servere	3	0.123	858.20		0.07			
Dead	3	0.074	0.00		0.00			
Summary	4		1680.10	6704.00	0.80	3.90	0	0.2639
Mild	4	0.756	756.10		0.72			
Servere	4	0.132	924.00		0.08			
Dead	4	0.112	0.00		0.00			
Summary	5		1717.20	8421.20	0.76	4.66	0	0.3071
Mild	5	0.707	707.10		0.67			
Servere	5	0.144	1010.10		0.09			
Dead	5	0.149	0.00		0.00			
Summary	6		1673.70	10094.90	0.72	5.37	0	0.3444
Mild	6	0.666	665.70		0.63			
Servere	6	0.144	1008.00		0.09			
Dead	6	0.190	0.00		0.00			
Summary	7		1614.20	11709.10	0.69	6.06	0	0.3841
Mild	7	0.633	633.50		0.60			
Servere	7	0.110	980.70		0.09			

# Example 4-Patient Level Simulation-Patient Tracking



# Congratulations

🎉 恭喜！你成功完成了這本內容精實的手冊！ 🎉

你現在已經是成本效益分析的模型高手了！  
能看懂文獻中絕大部分的模型，走路都有風～

📊💪 未來的你：  
當別人提到 Markov 模型、決策樹或敏感度分析時，  
你可以自信滿滿地說：「這些我都懂！」

👏为自己鼓掌吧，學習過程辛苦了！ 👏



Source: Shiba Says