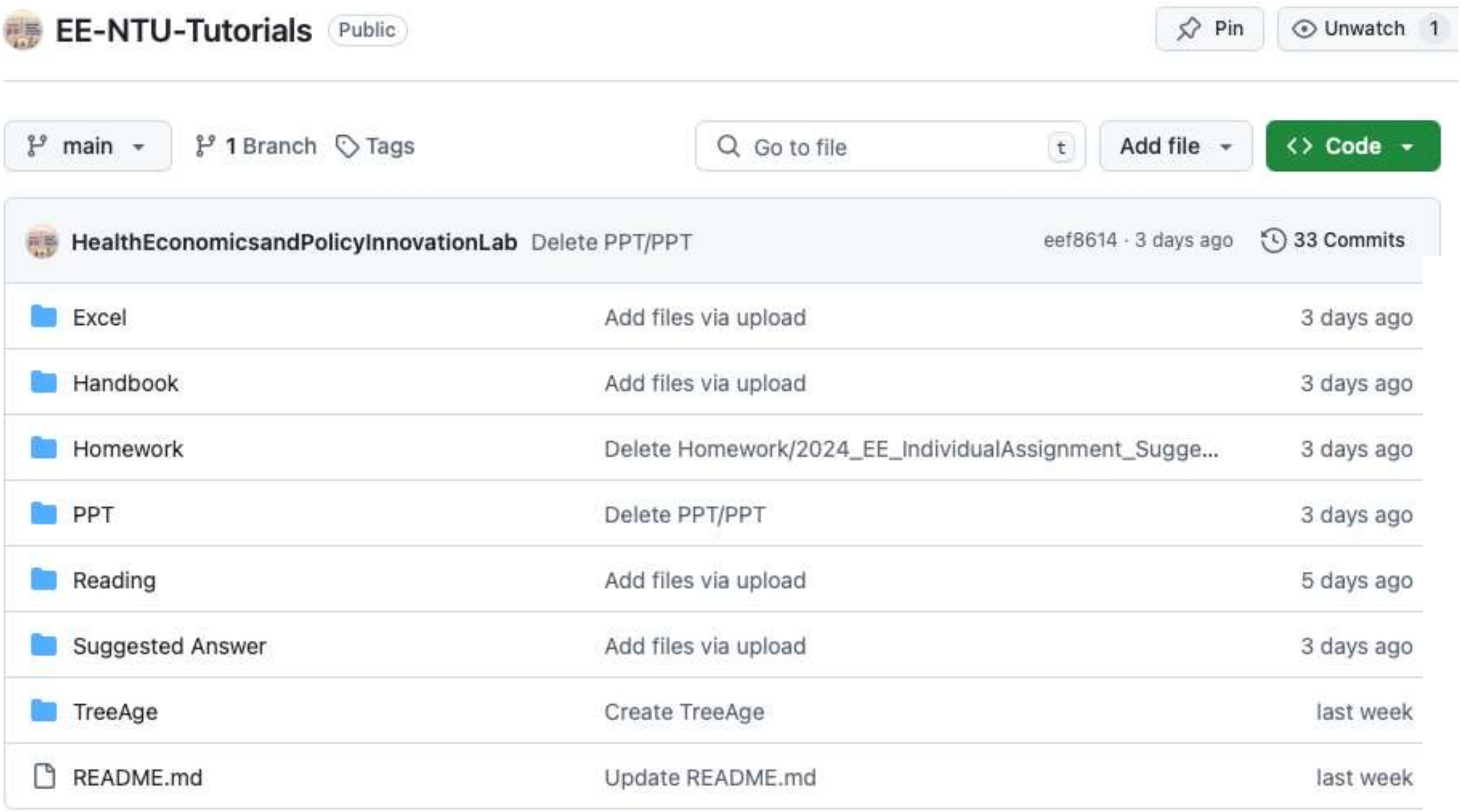
❑ 內容介紹： Material, GitHub, NTU Cool

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



❑ 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	-	• Decision tree	• Patient-level decision tree	
	Explicit time	-	• Markov model	• Patient-level Markov model	• Discrete time simulation • Discrete event simulation
Interaction among objects	Discrete or continuous time	System dynamics	• Markov chain model	• Individual event history model	• Discrete event simulation • Individual-based simulation

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

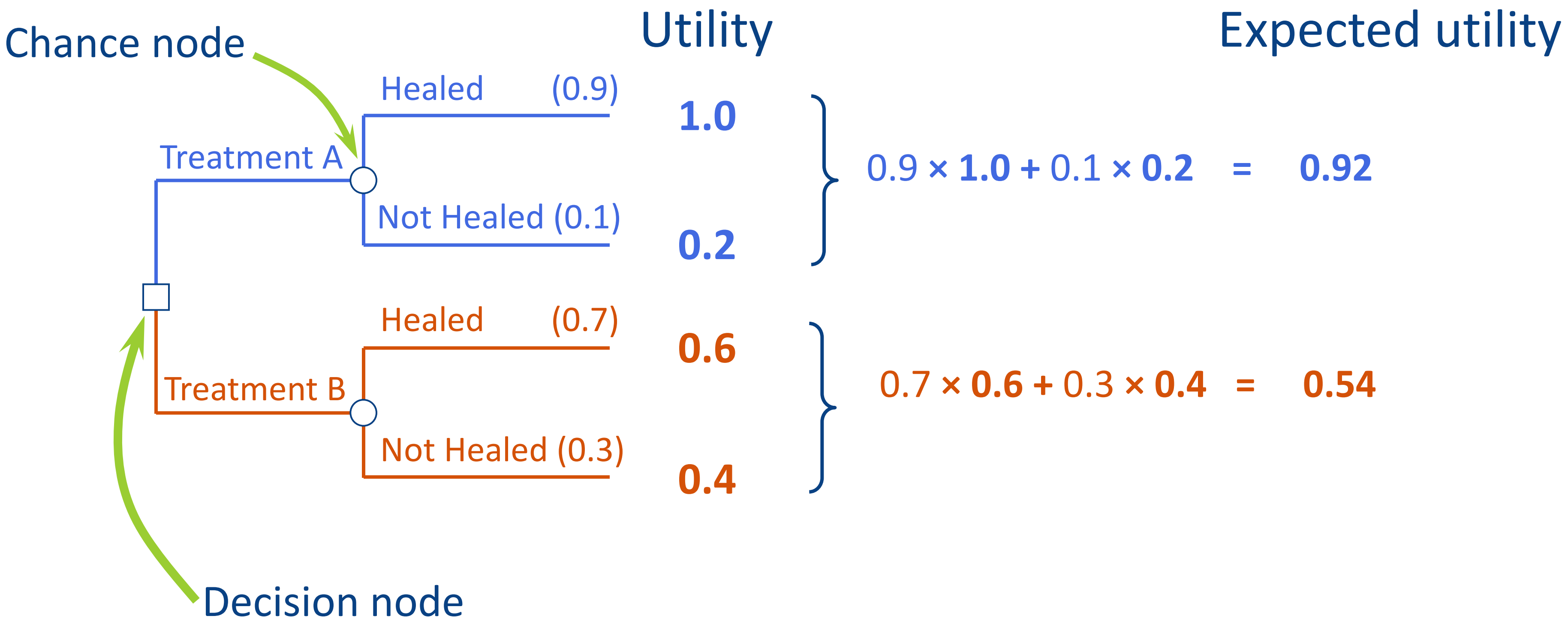
- Decision tree
    - Problem involving chance events that occur over a short time horizon
- Markov modelling
    - Problem involving risk that is on-going over time

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).



Time horizon: 6 months

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

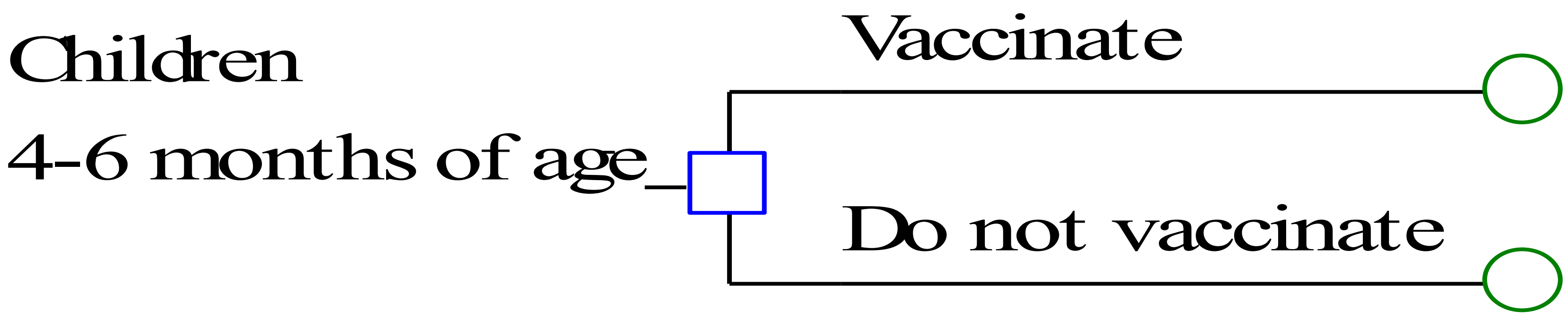
Case Study of Decision Tree: Communicable Disease

- 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

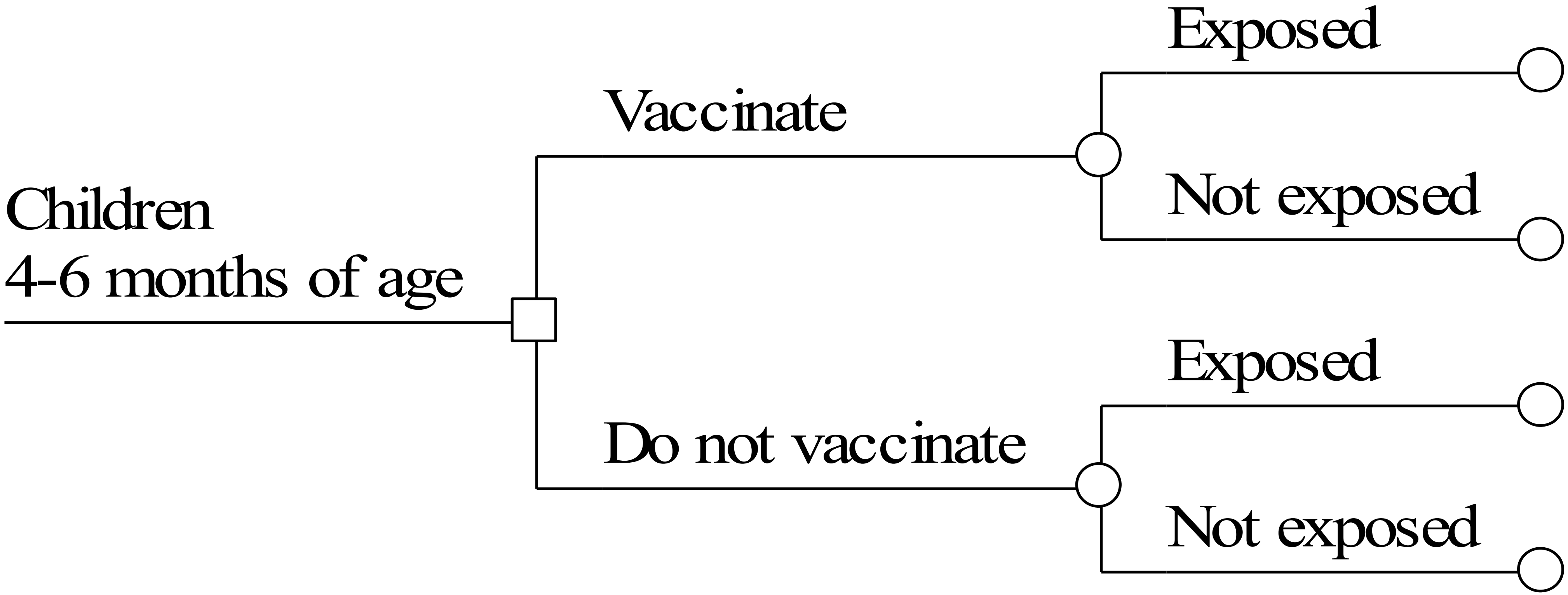
- To estimate the *potential* costs and outcomes associated of the introduction of the vaccine compared to having no vaccine in the Taiwanese setting
- The comparator is *no vaccine*
- The perspective of the analysis is *societal*
- **A short-term (1 year) decision analysis**

Building the Decision Tree

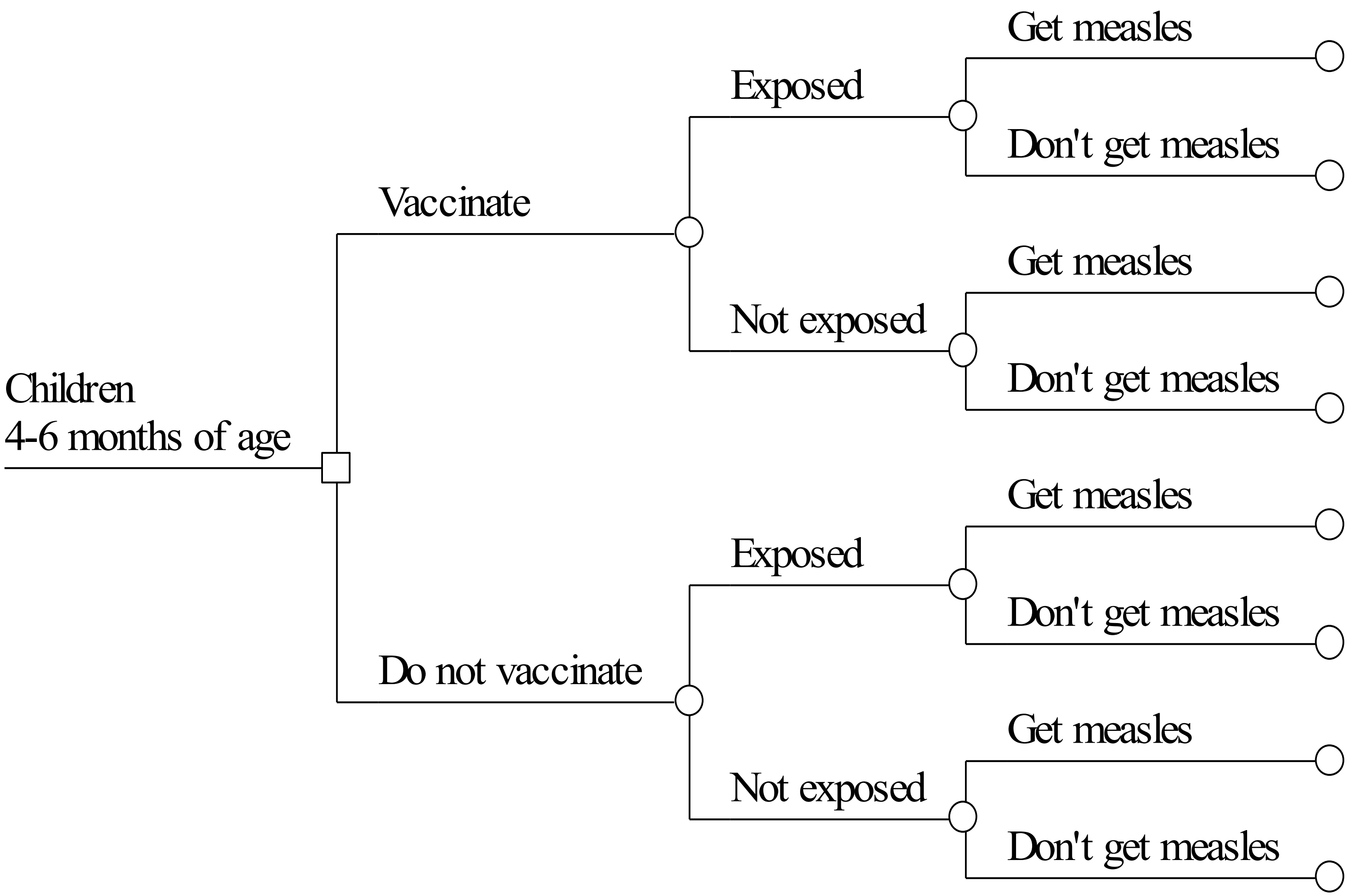


- Root node summarises patient population.
- Decision node drawn as a square (represents alternative actions under control of decision maker.
- The 2 alternatives - vaccinate and do not vaccinate - are represented as branches.

Building the Decision Tree



Building the Decision Tree



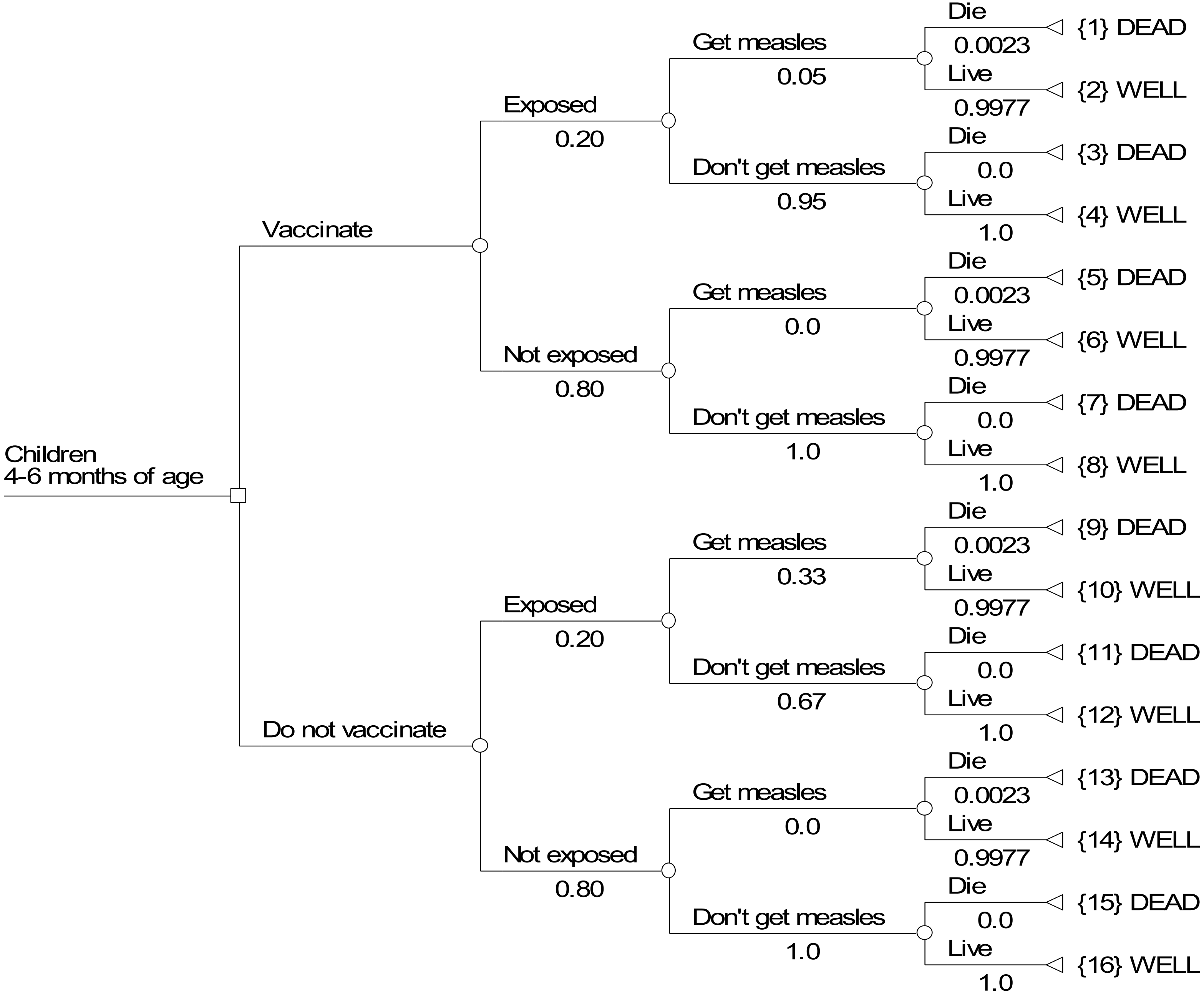
For each branch of exposed/not exposed, chance of getting measles or not is represented by a chance node

Estimating probabilities

- **Gathering information to fill the tree**

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

Estimating probabilities

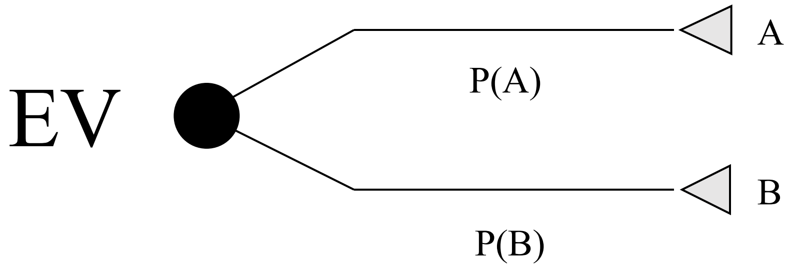


Rolling Back and Expected Values

- 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

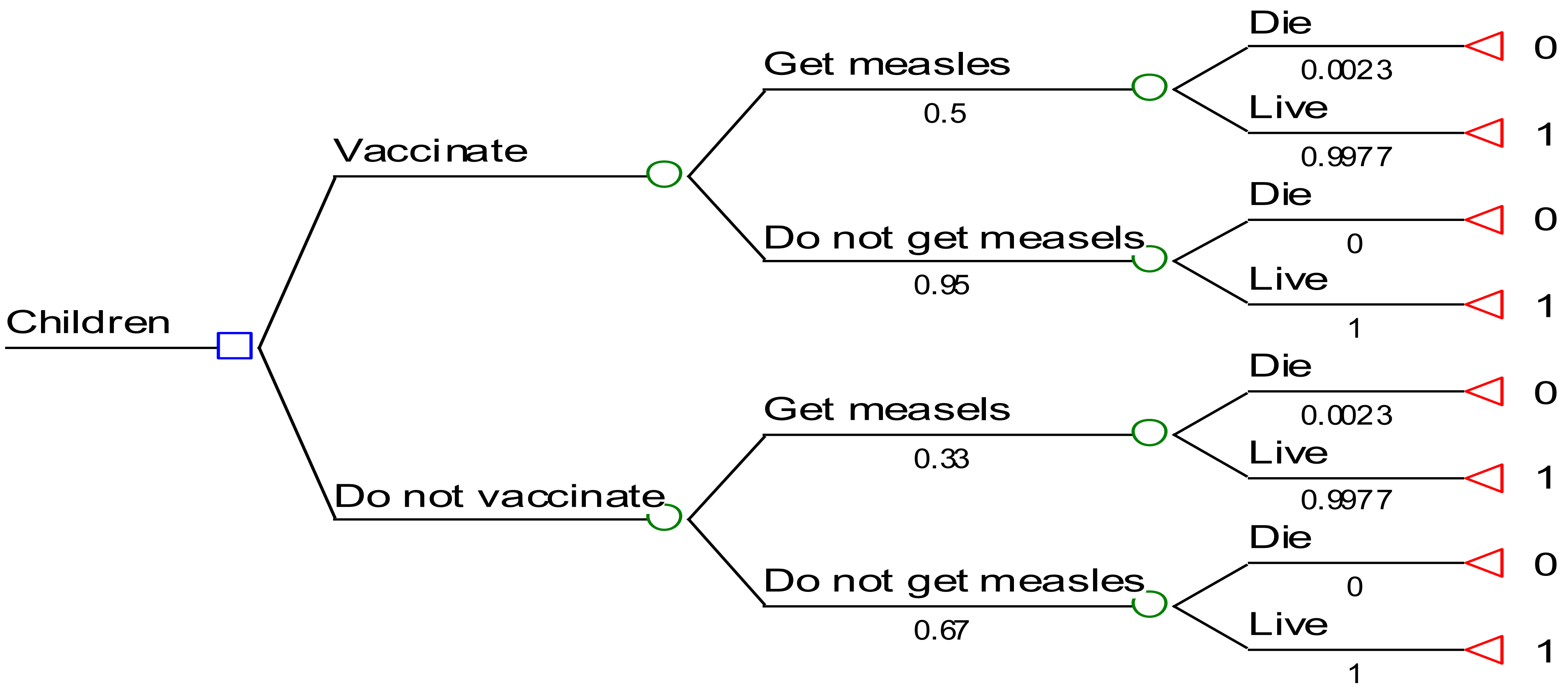
- Calculating the expected value (EV) at a particular chance node: multiply along pathways, then sum across pathways



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

Rolling Back- Estimating Expected Value (Cont'd)

Assume utility of 1 for live and 0 for die

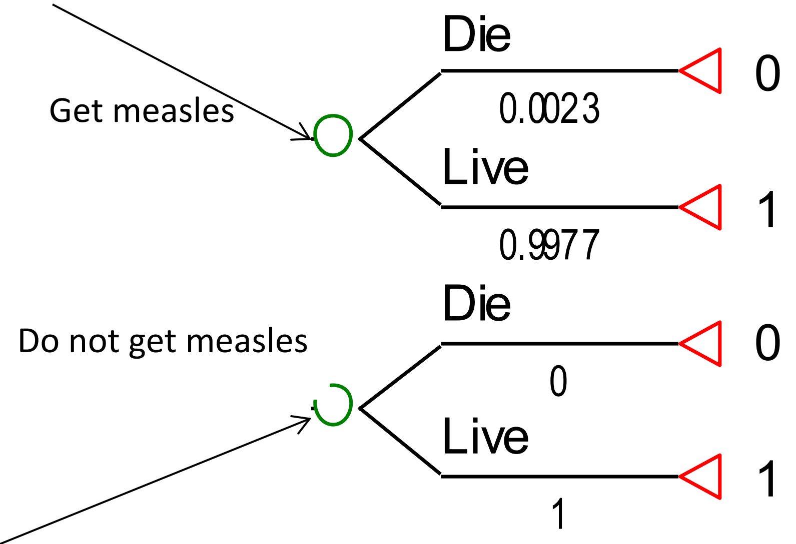


Rolling Back- Estimating Expected Value (Cont’d)

Assume utility of 1 for live and 0 for die

Expected value measles =

(0.0023 x 0) + (0.9977 x 1) = 0.9977

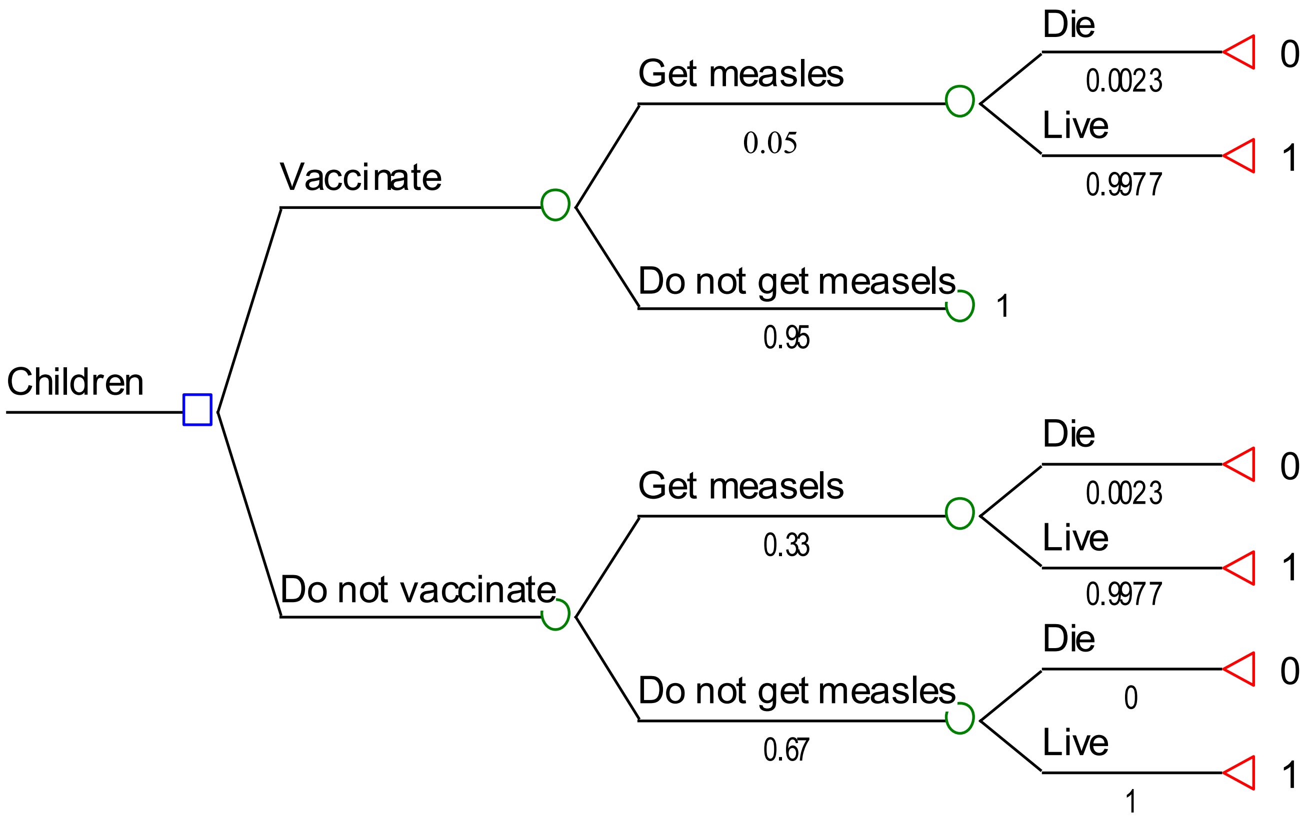


Expected value no measles =

(0.0 x 0) + (1 x 1) = 1

Rolling Back- Estimating Expected Value (Cont'd)

Assume utility of 1 for live and 0 for die



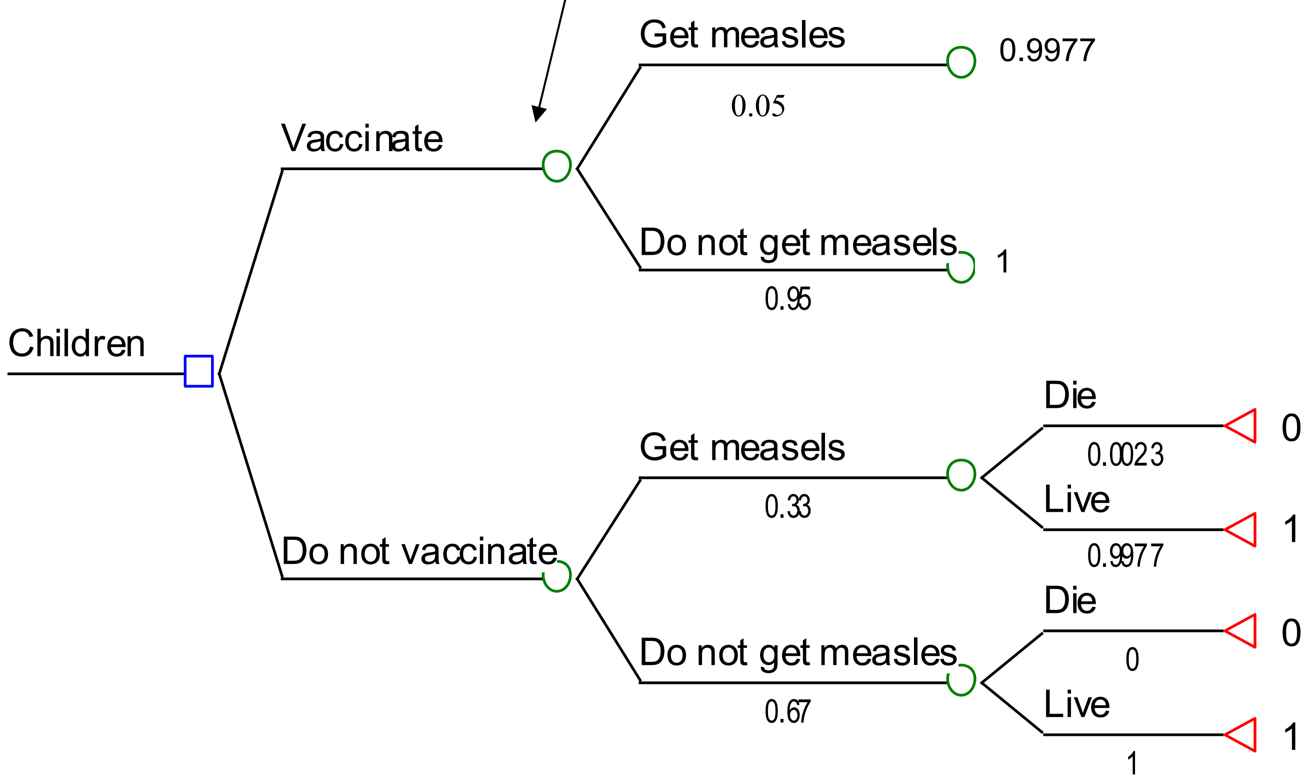
Rolling Back- Estimating Expected Value (Cont'd)

Assume utility of 1 for live and 0 for die

Expected value at this chance node =

(0.05 x 0.9977) + (0.95 x 1) = 0.99989

The expected value of vaccinating is 0.99989



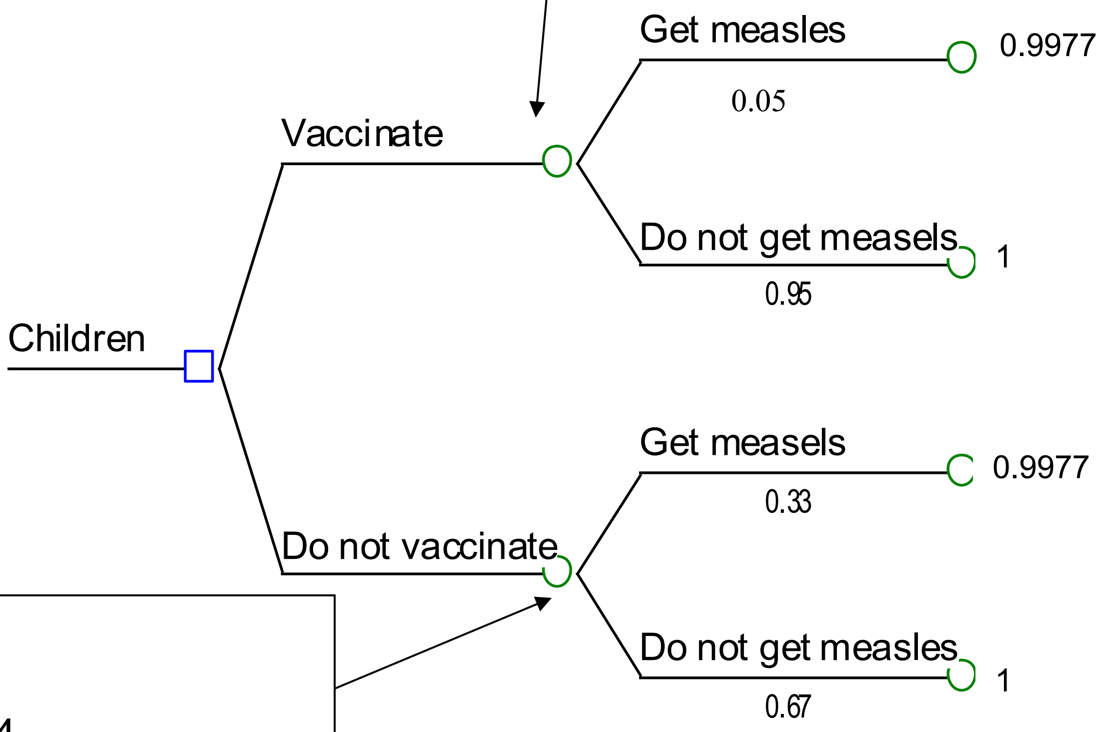
Rolling Back- Estimating Expected Value (Cont'd)

Assume utility of 1 for live and 0 for die

Expected value at this chance node =

(0.05 x 0.9977) + (0.95 x 1) = 0.99989

The expected value of vaccinating is 0.99989



Expected value at chance node:

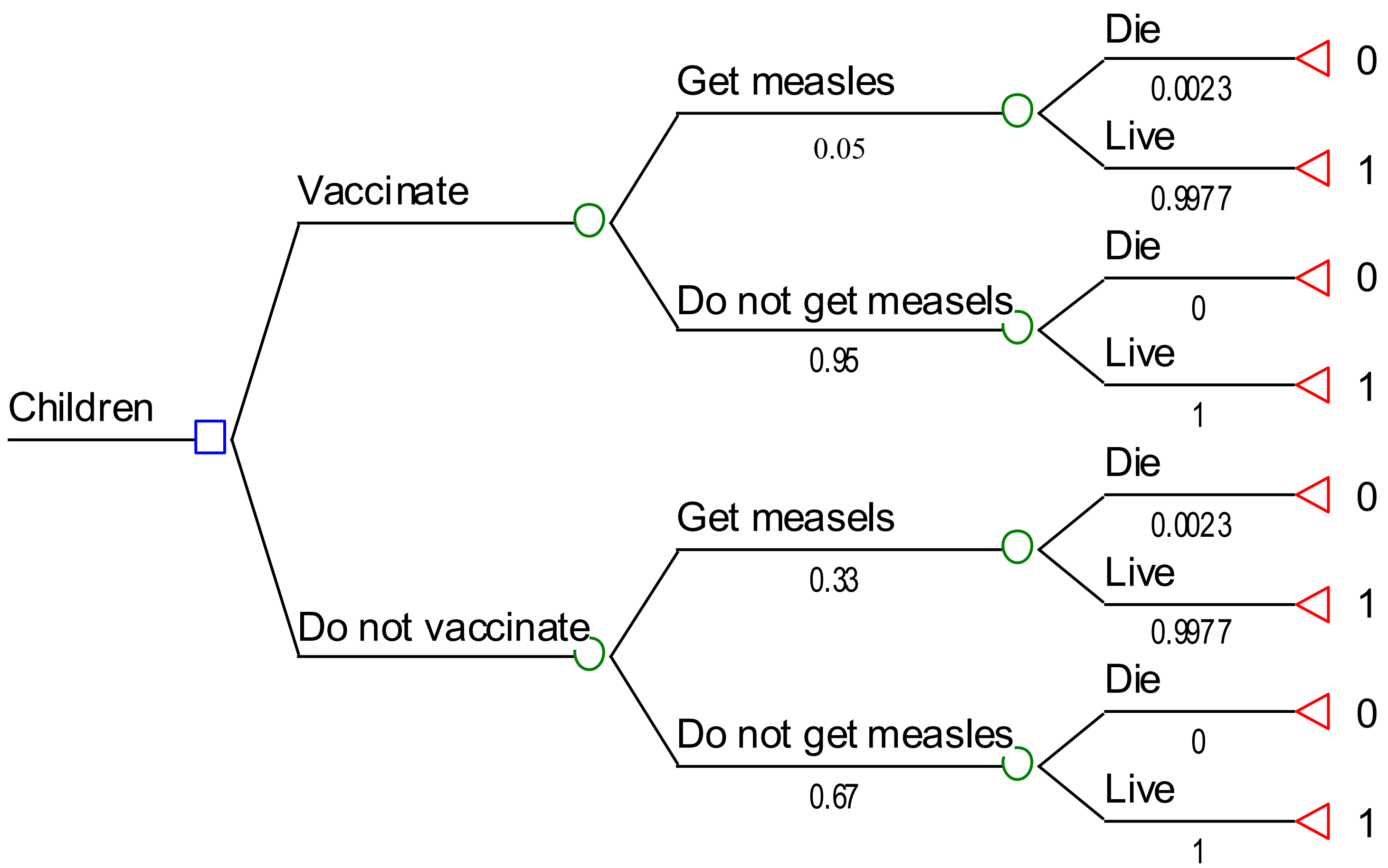
(0.33 x 0.9977) +(0.67 x 1) = 0.99924

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

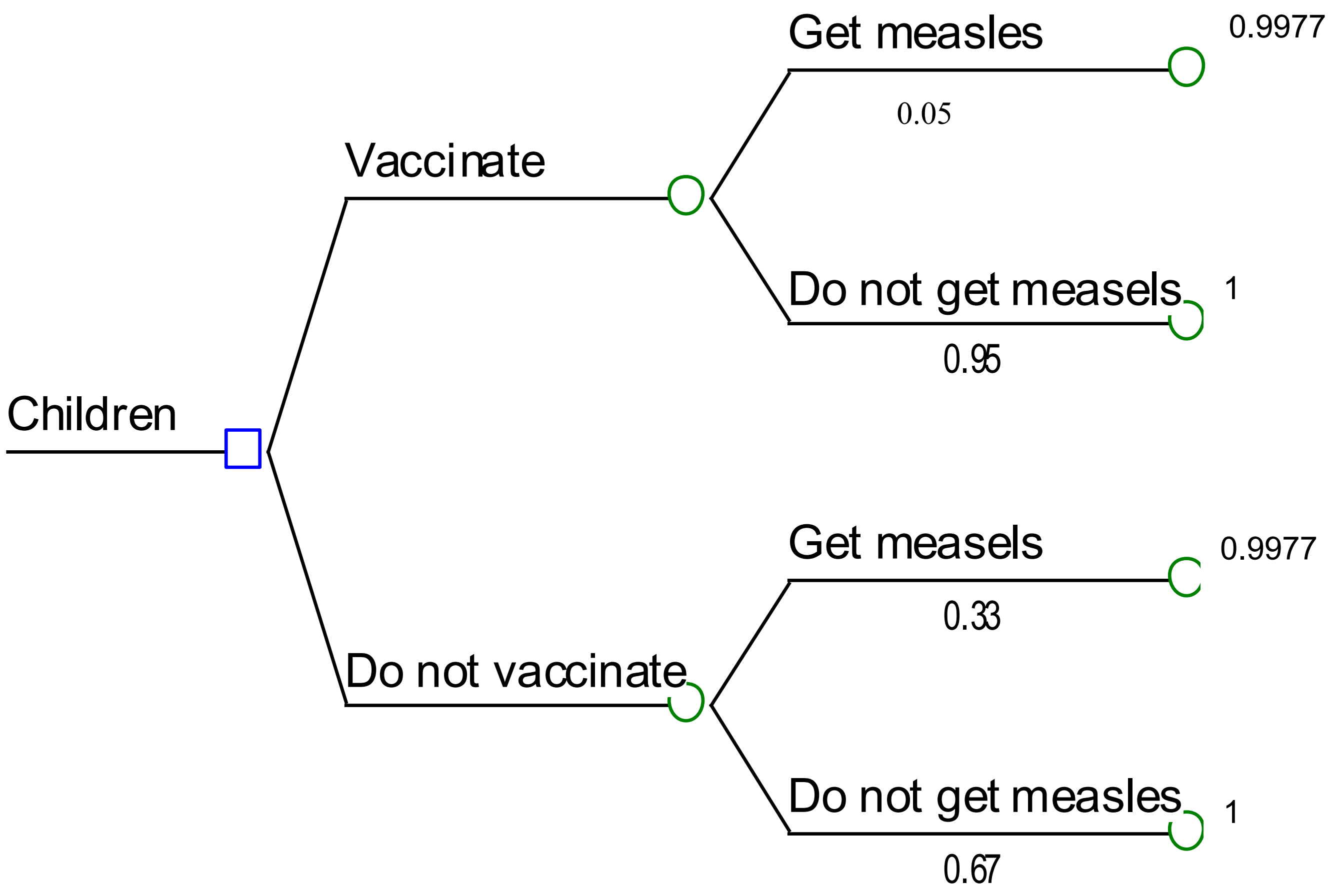
Started with this…



Rolling Back- Estimating Expected Value (Cont'd)

Assume utility of 1 for live and 0 for die

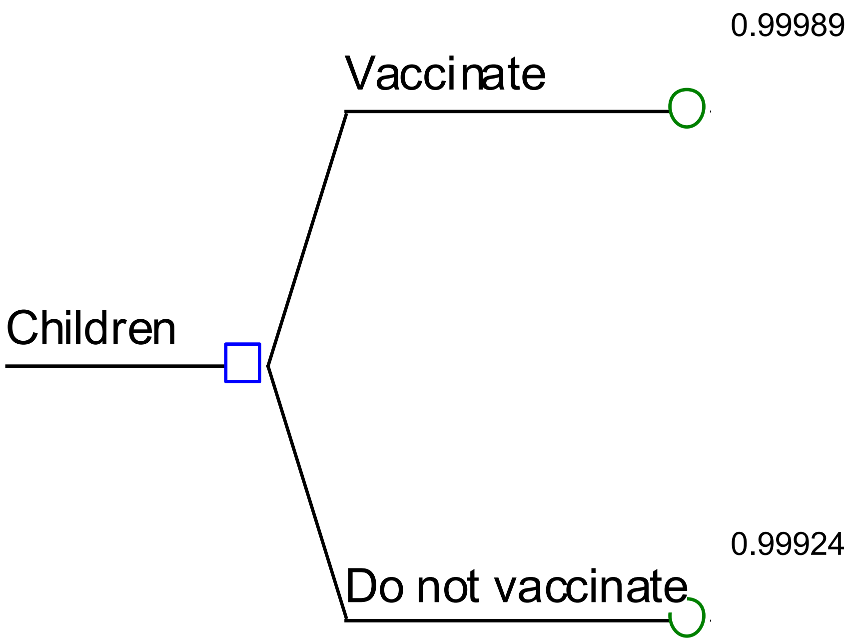
Roll back #1…



Rolling Back- Estimating Expected Value (Cont'd)

Assume utility of 1 for live and 0 for die

Roll back #2…

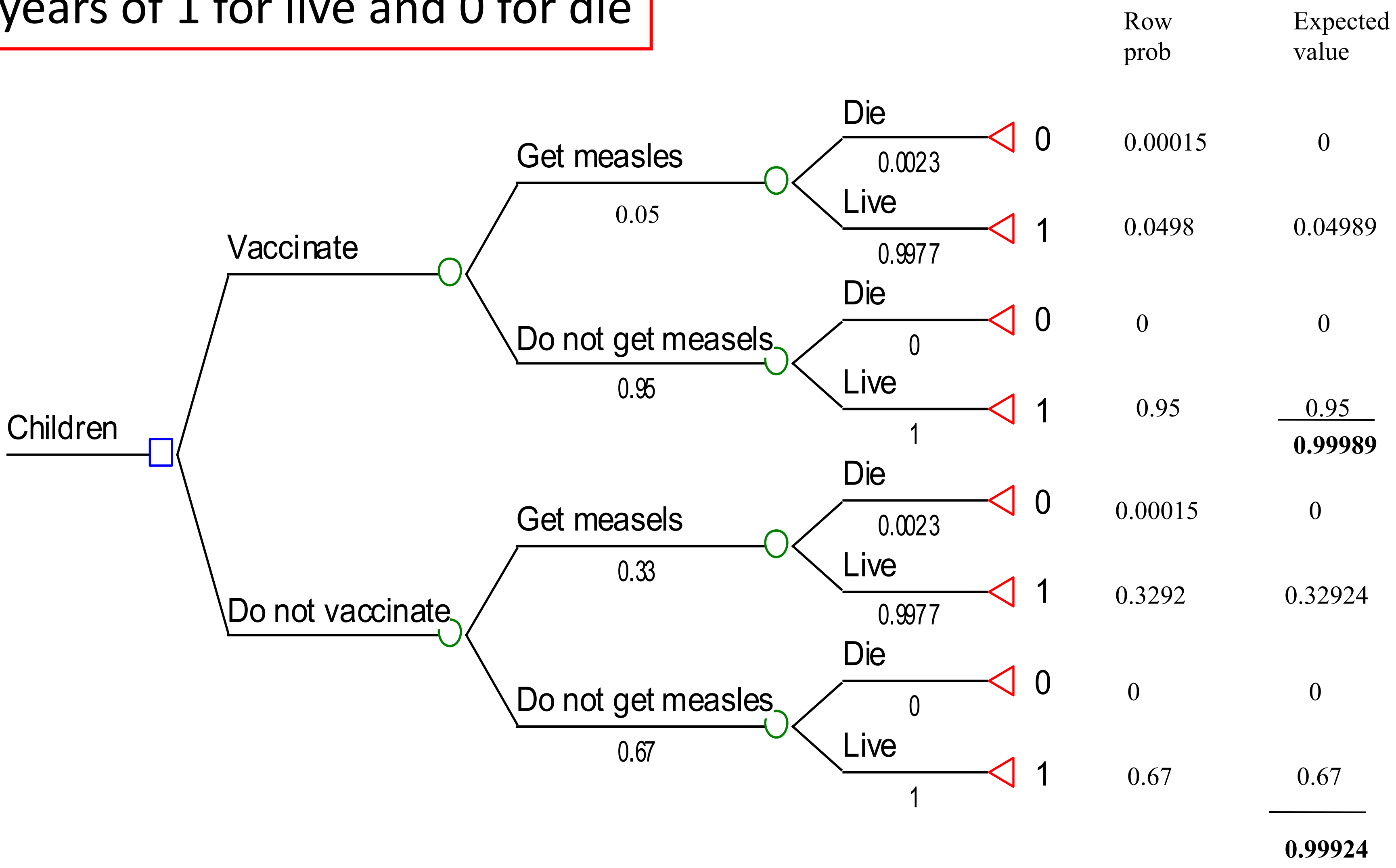


Incremental Outcomes

- 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

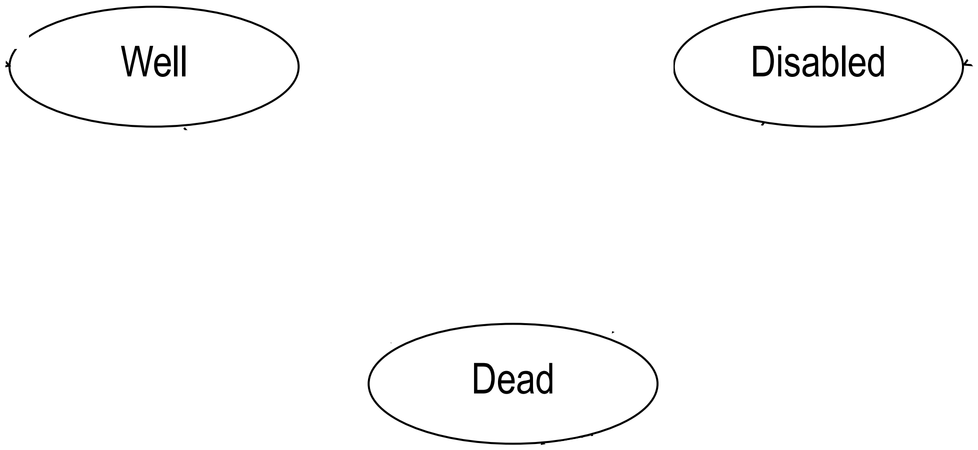
- Conventional tree describes the ways in which a patient (or cohort) in one health state might end up in other health states over a fixed time period
- Markov model is concerned with health state transitions over time
  - Repeats a series of short intervals or cycles

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

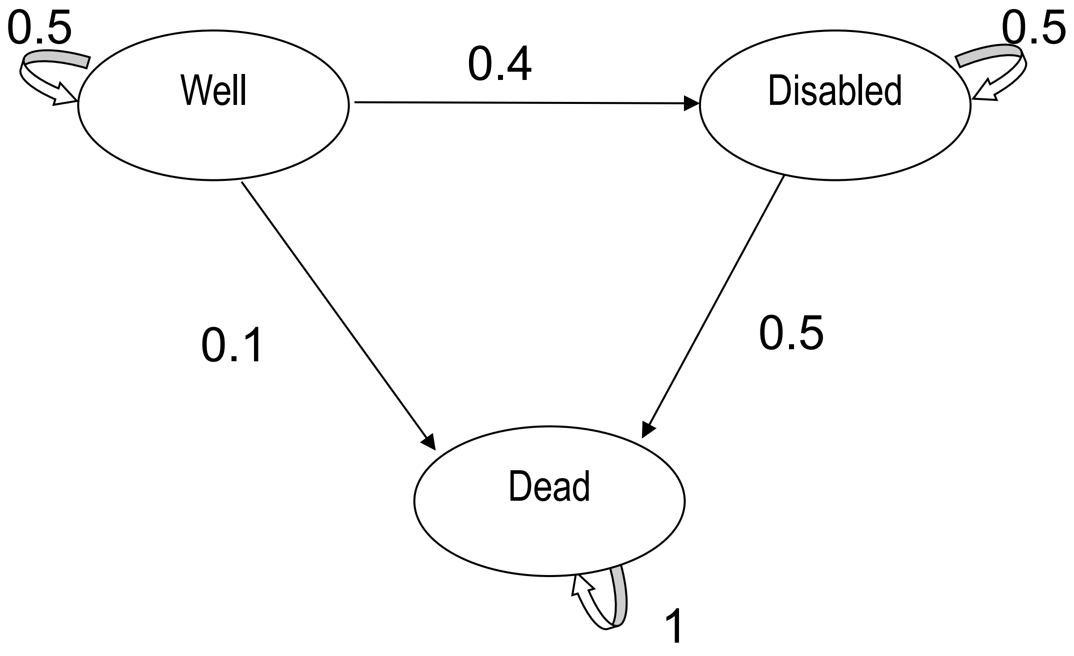
Key Elements of Markov Models

- 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.



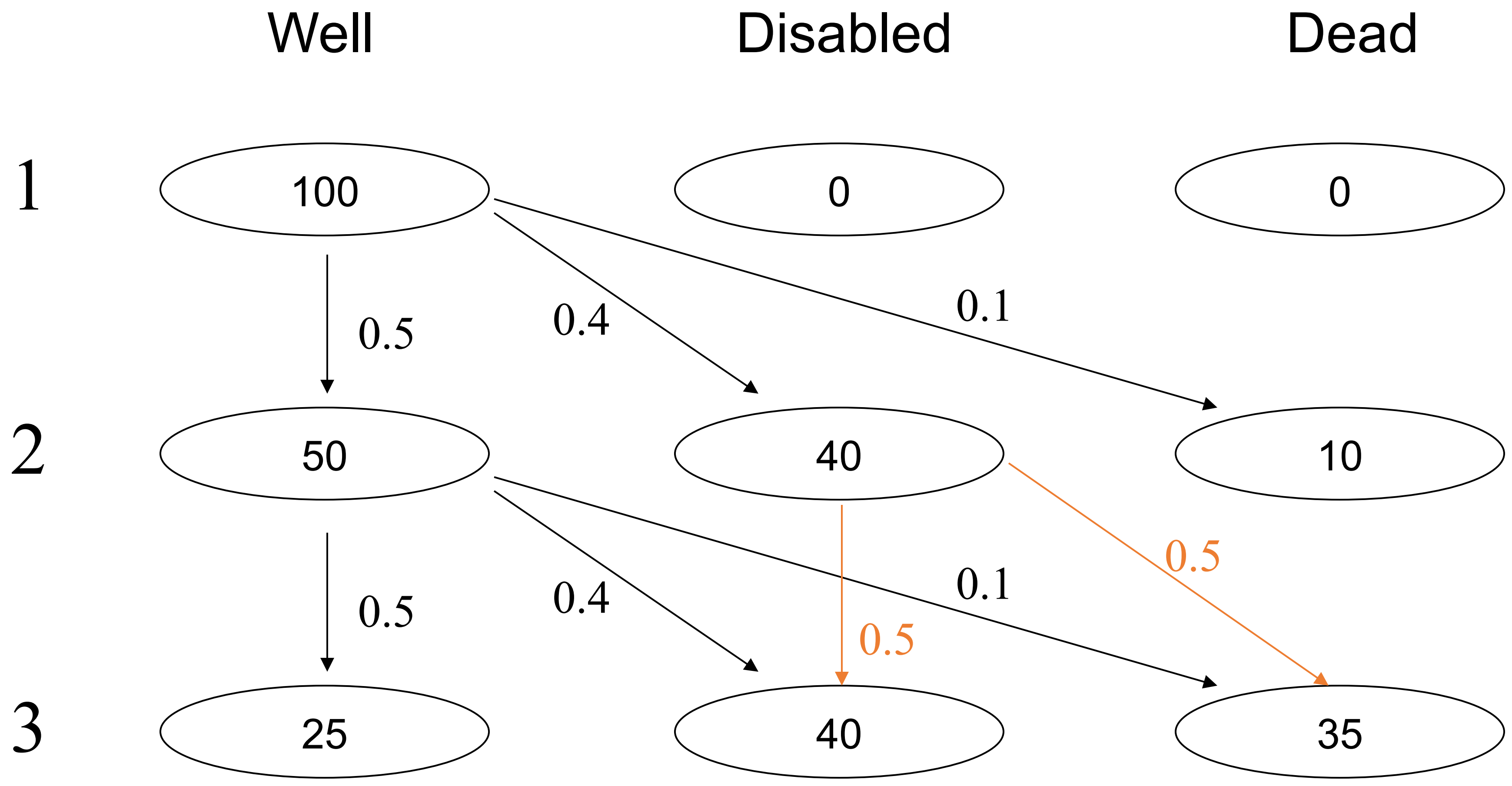
Key Elements of Markov Models

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



This is called a state transition diagram

Health State Transitions



Key Elements of Markov Models

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

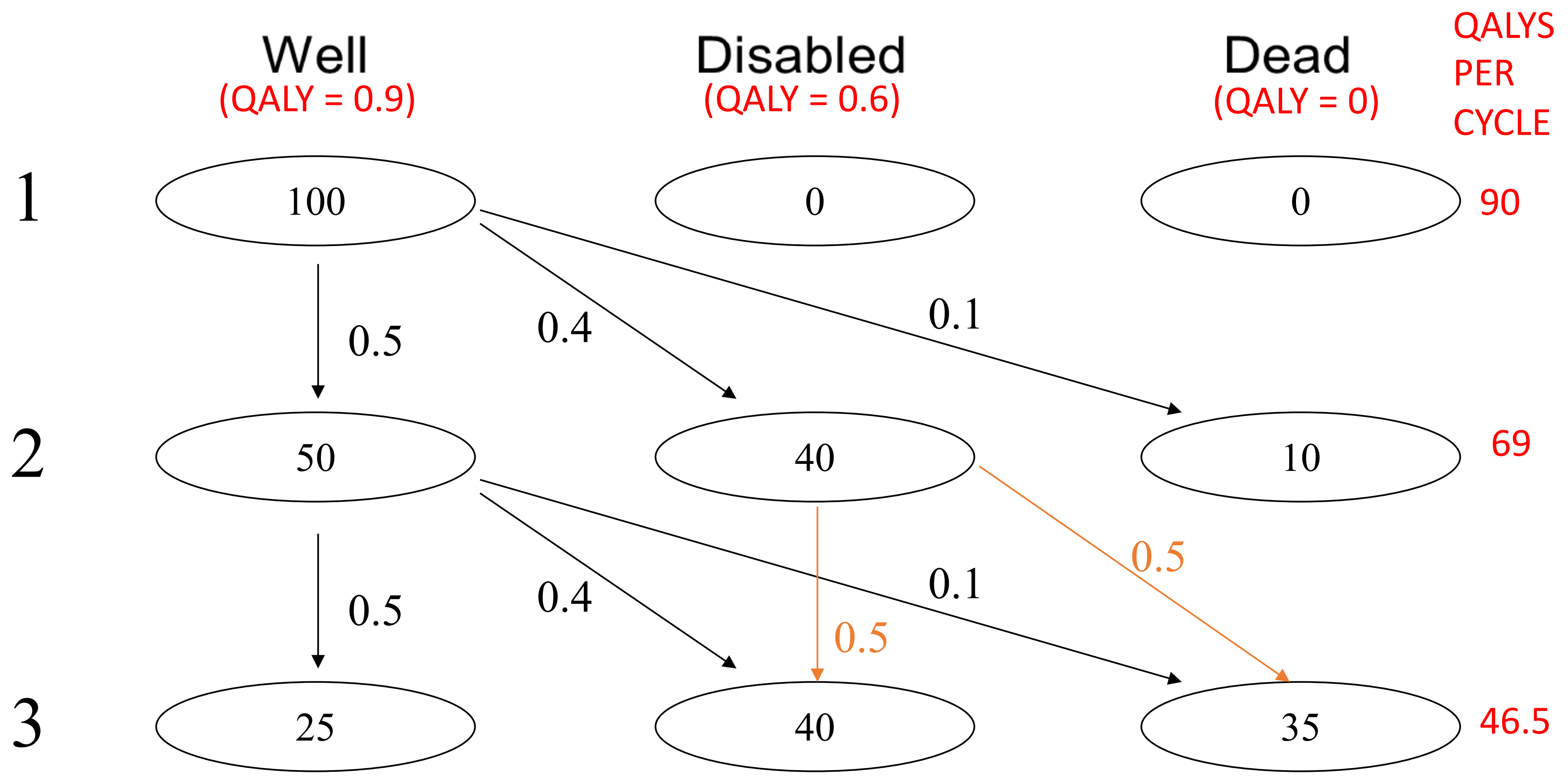
Cycle	State A	State B	State C	State D	Total
0	1000	0	0	0	1000
	1000 × 0.721	1000 × 0.202	1000 × 0.067	1000 × 0.01	
1	721	202	67	10	1000
2	520	263	181	36	1000
3	375	258	277	90	1000
4	270	226	338	166	1000
5	195	186	363	256	1000
6	140	147	361	351	1000
7	101	114	340	445	1000
8	73	87	308	532	1000
9	53	65	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

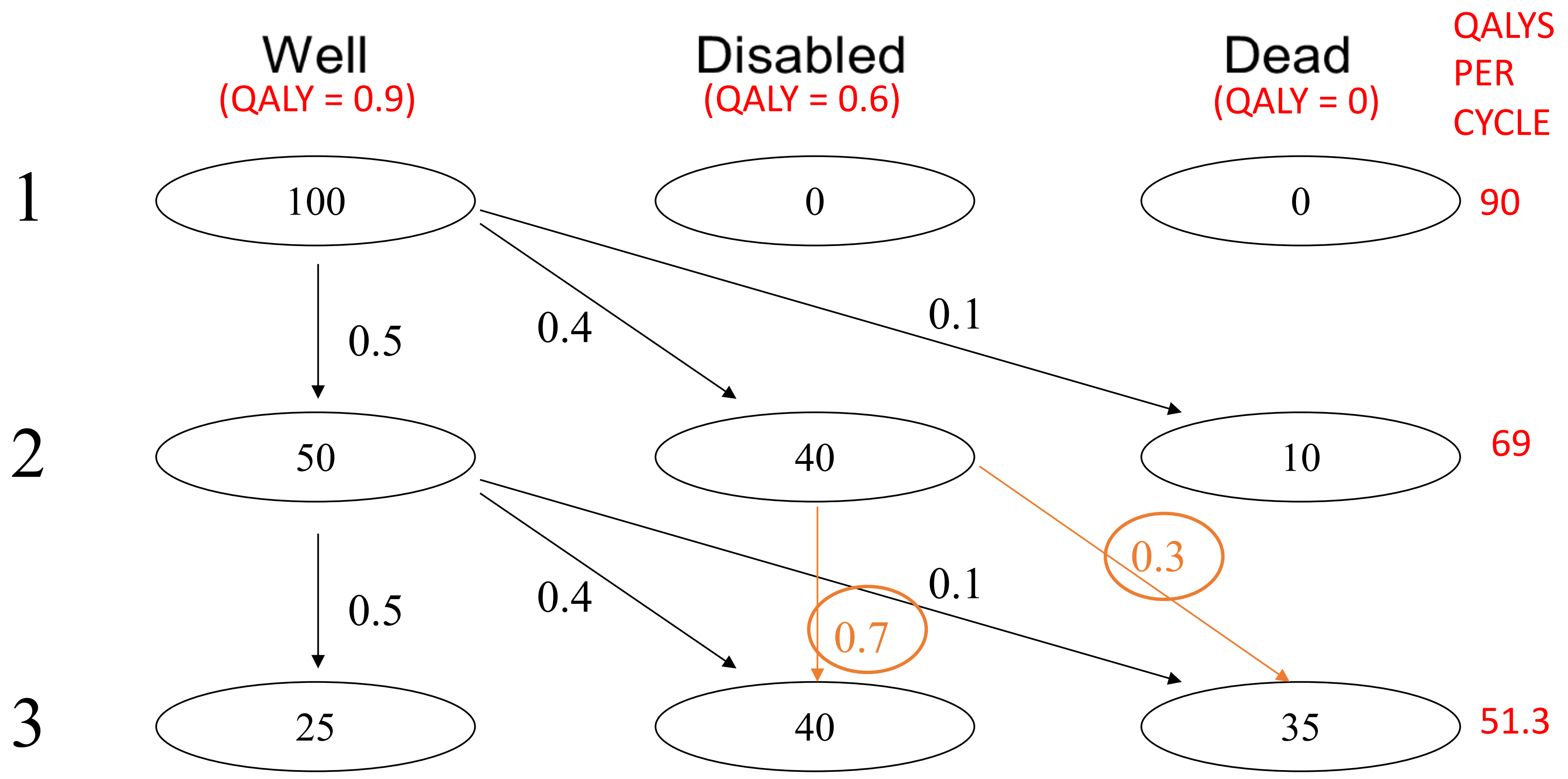
- The Markov trace tells us the proportion of patients in each health state at each time point
- From there, the expected costs and benefits accruing in each cycle can be calculated
- Summing all the costs and benefits across the cycles will provide the total expected cost/benefits
- Compare Markov outcomes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

Health State Transitions: Control



TOTAL QALYS: 205.5

Health State Transition: Treatment



Treatment reduces mortality for disabled

TOTAL QALYS: 210.3

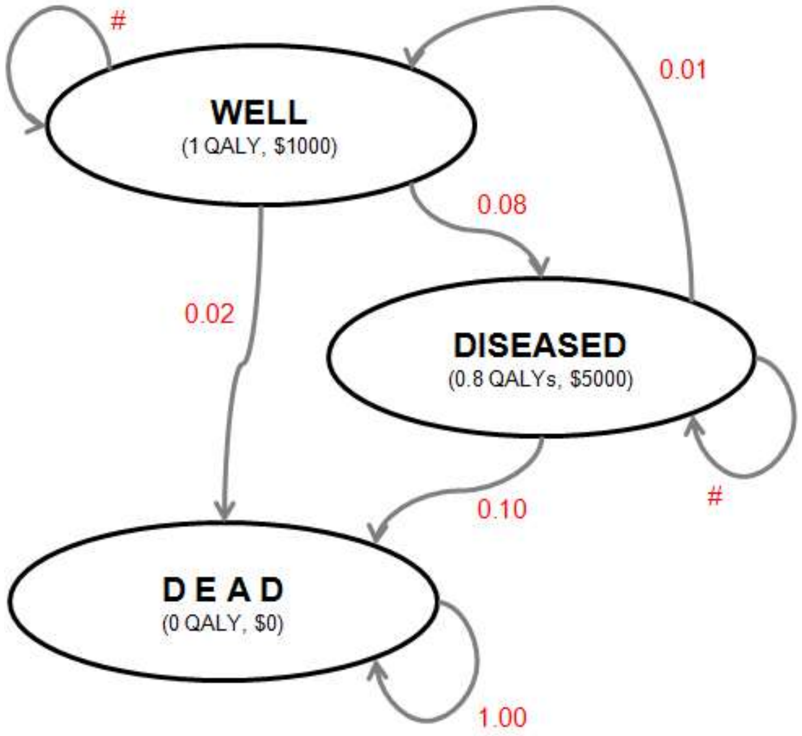
Key Practical Modeling Message

- **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



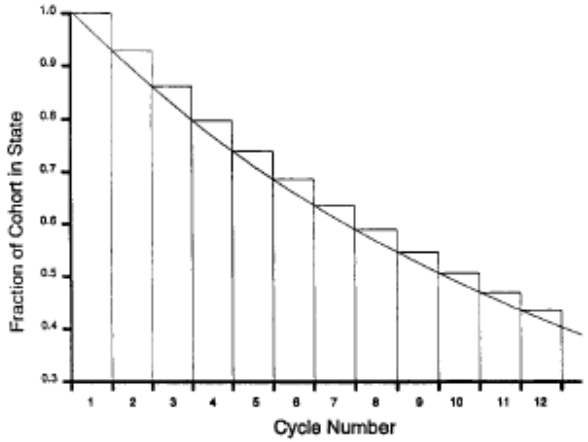
Determine Transition Probabilities

- 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:

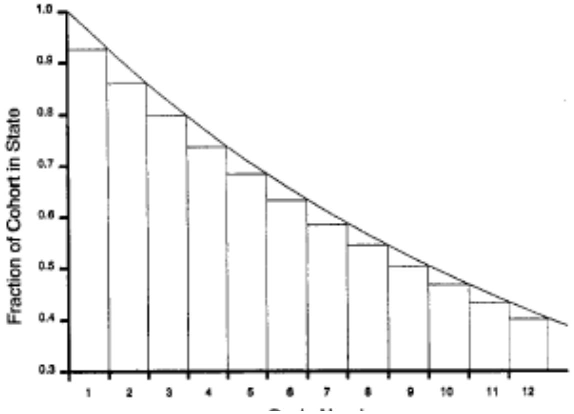
$$p = 1 - e^{-rt}$$
$$r = -\ln(1-p)/t$$

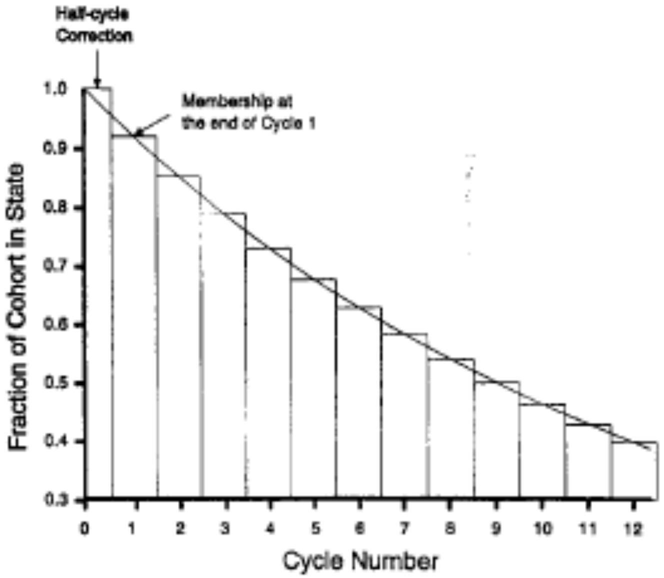
Half- Cycle Correction

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

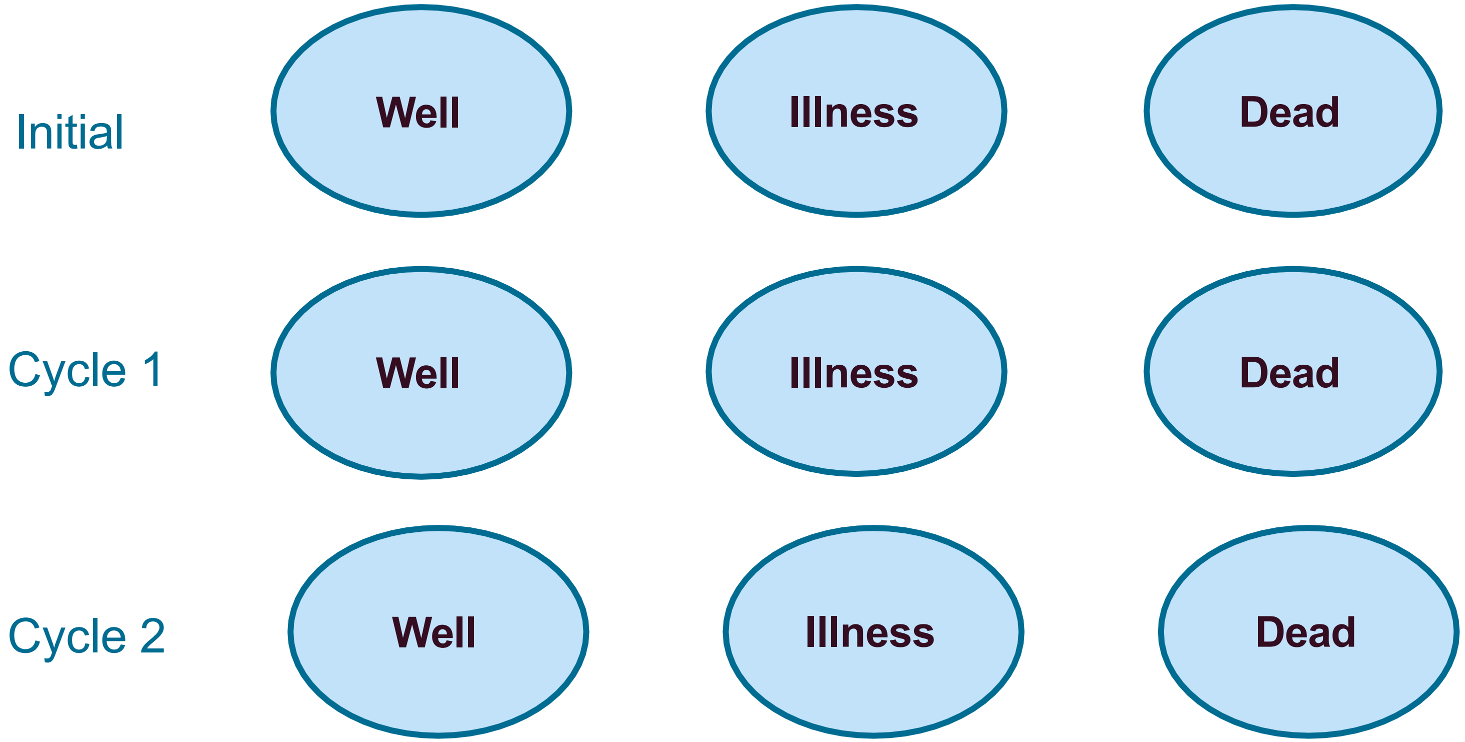
  Time for each patient can be short or long

  Computationally intensive

COHORT VERSUS MICROSIMULATIONS (1)

Cohort simulation

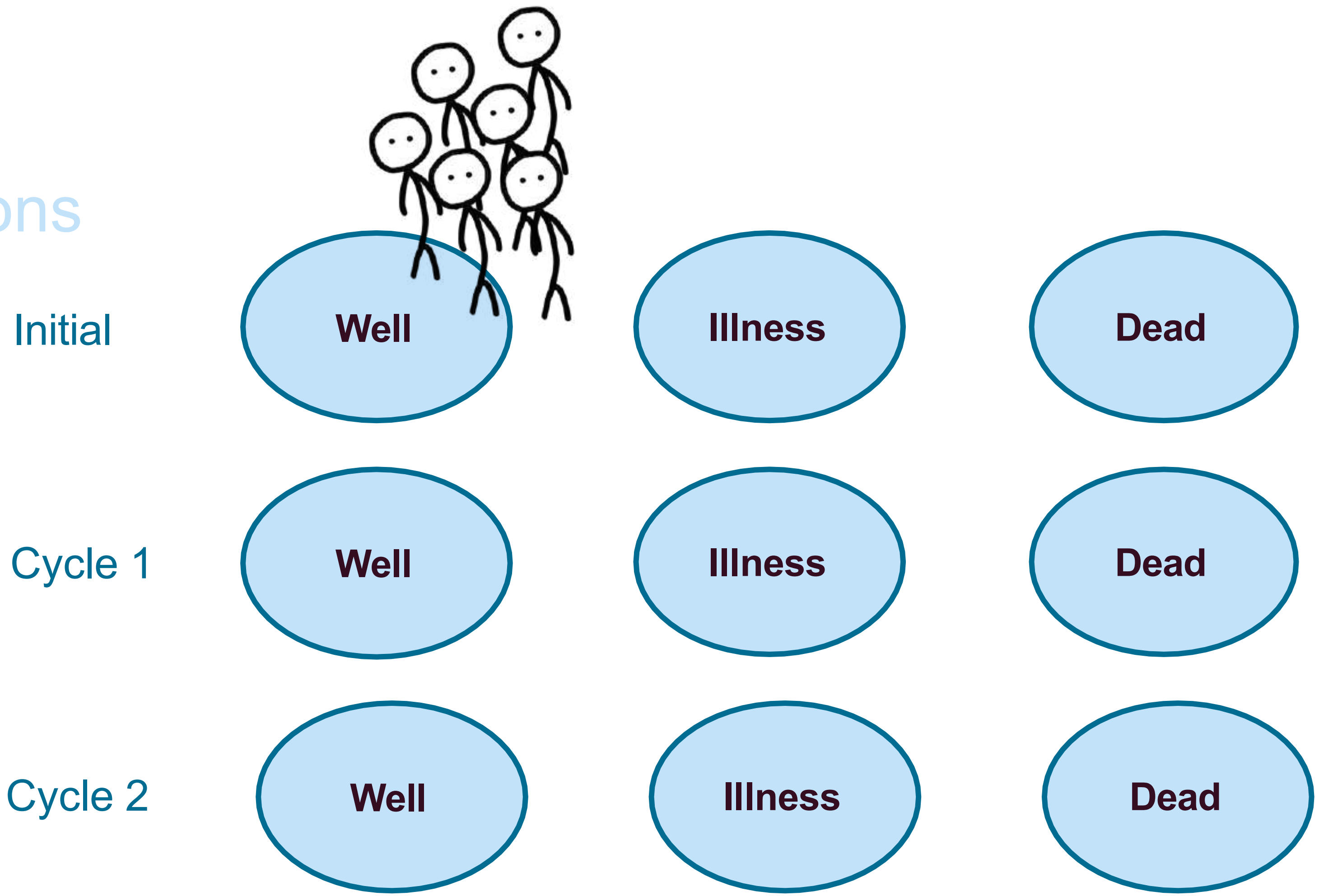
Individual or microsimulations



COHORT VERSUS MICROSIMULATIONS (2)

Cohort simulation

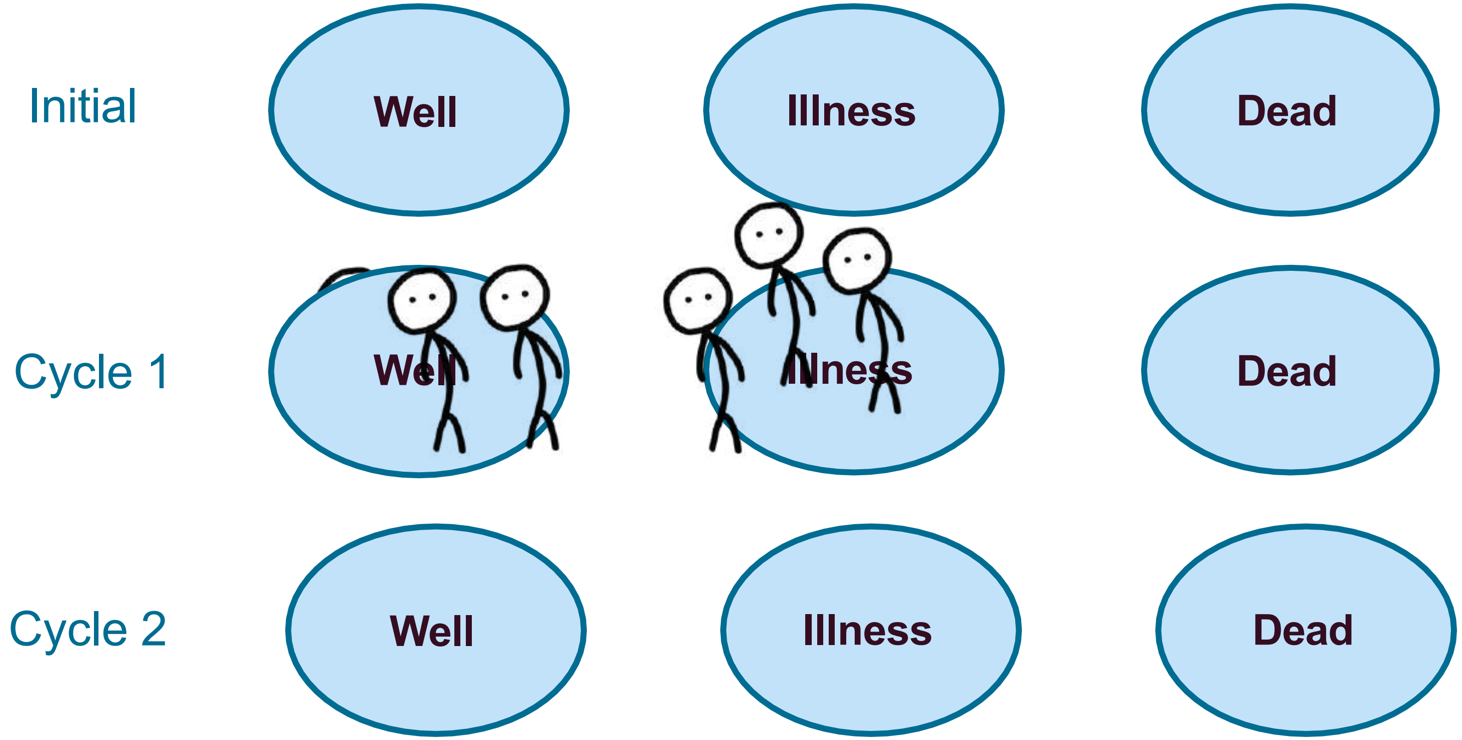
Individual or microsimulations



COHORT VERSUS MICROSIMULATIONS (3)

Cohort simulation

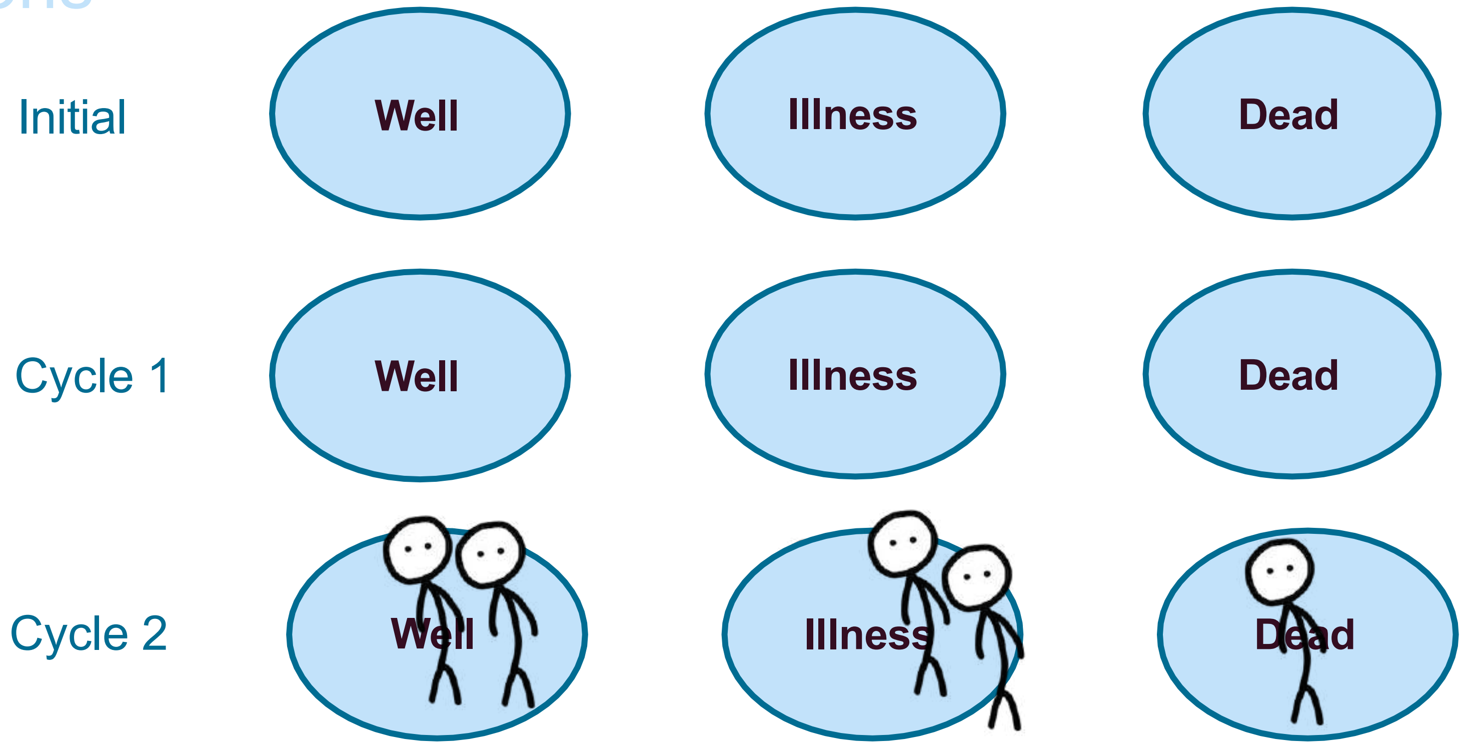
Individual or microsimulations



COHORT VERSUS MICROSIMULATIONS (4)

Cohort simulation

Individual or microsimulations

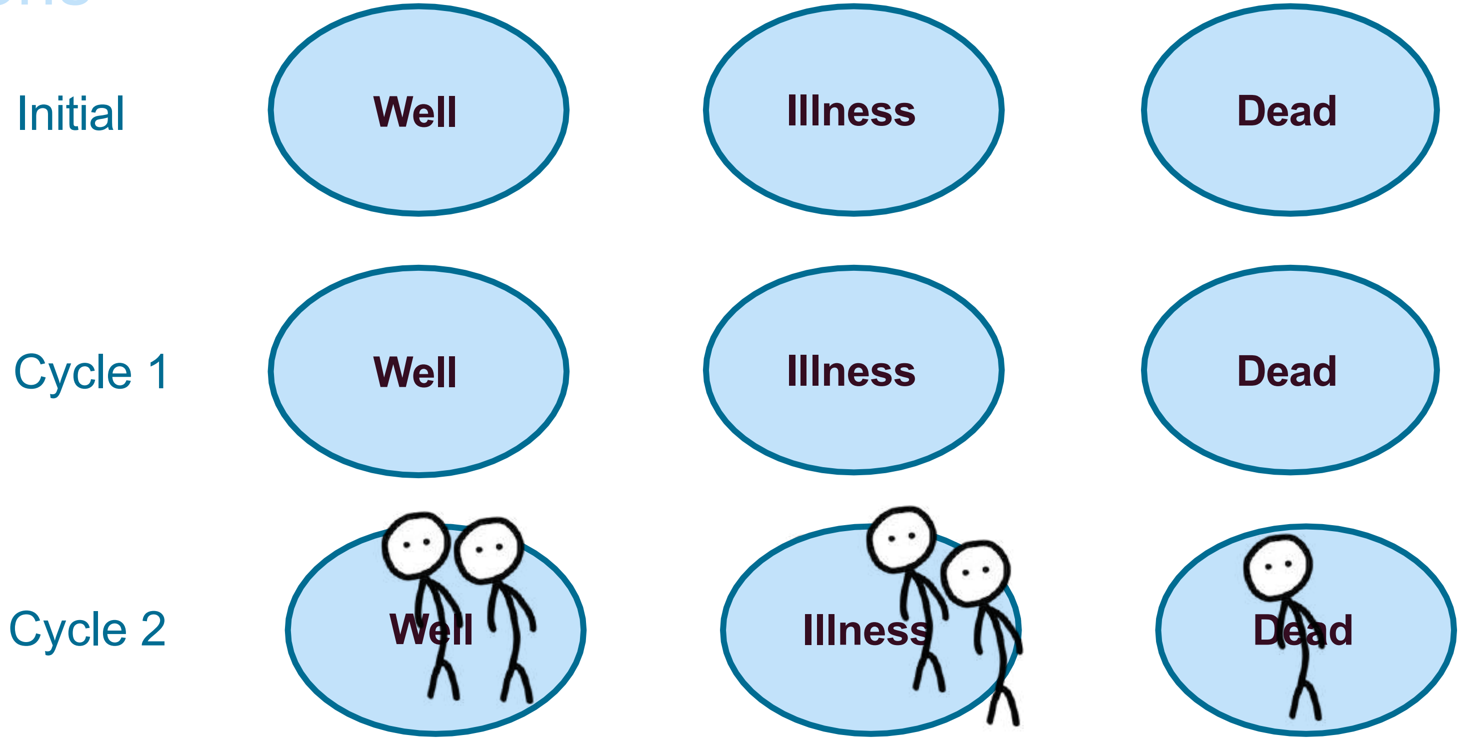


COHORT VERSUS MICROSIMULATIONS (5)

Cohort simulation

Individual or microsimulations

"Memoryless"
(Markovian Assumption)



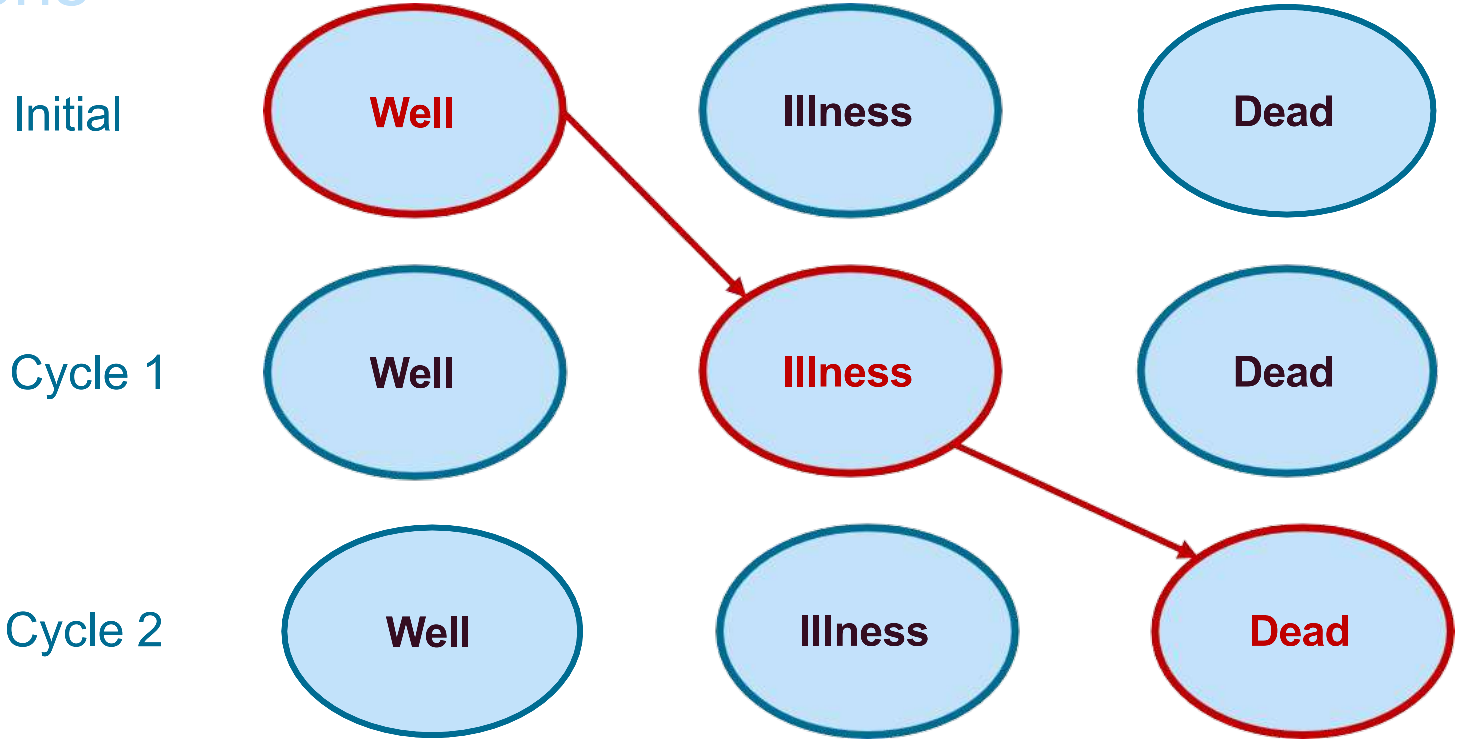
COHORT VERSUS MICROSIMULATIONS (6)

Cohort simulation

Individual or microsimulations

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

"Memoryless"
(Markovian Assumption)

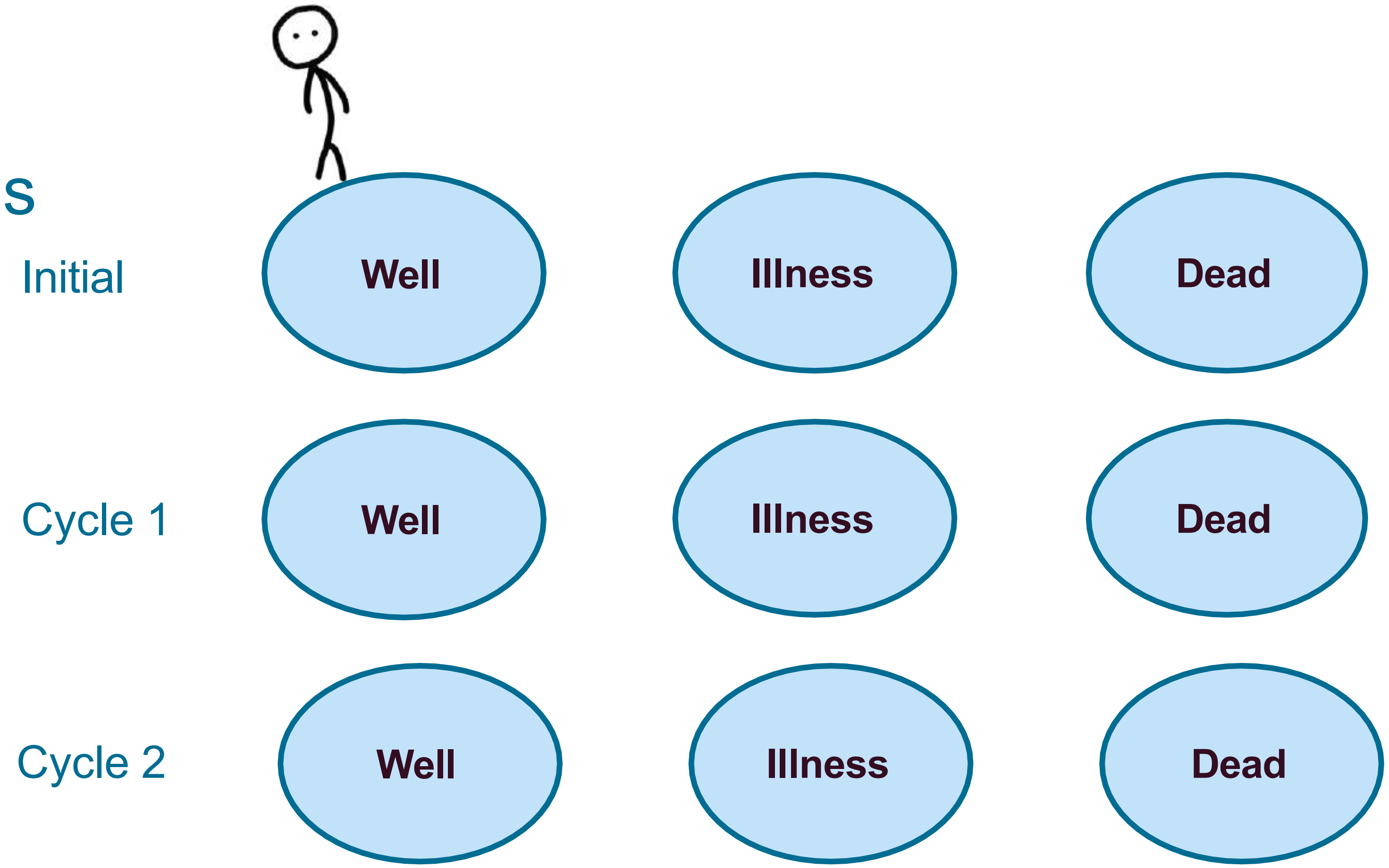


COHORT VERSUS MICROSIMULATIONS (7)

Cohort simulation

Individual or microsimulations

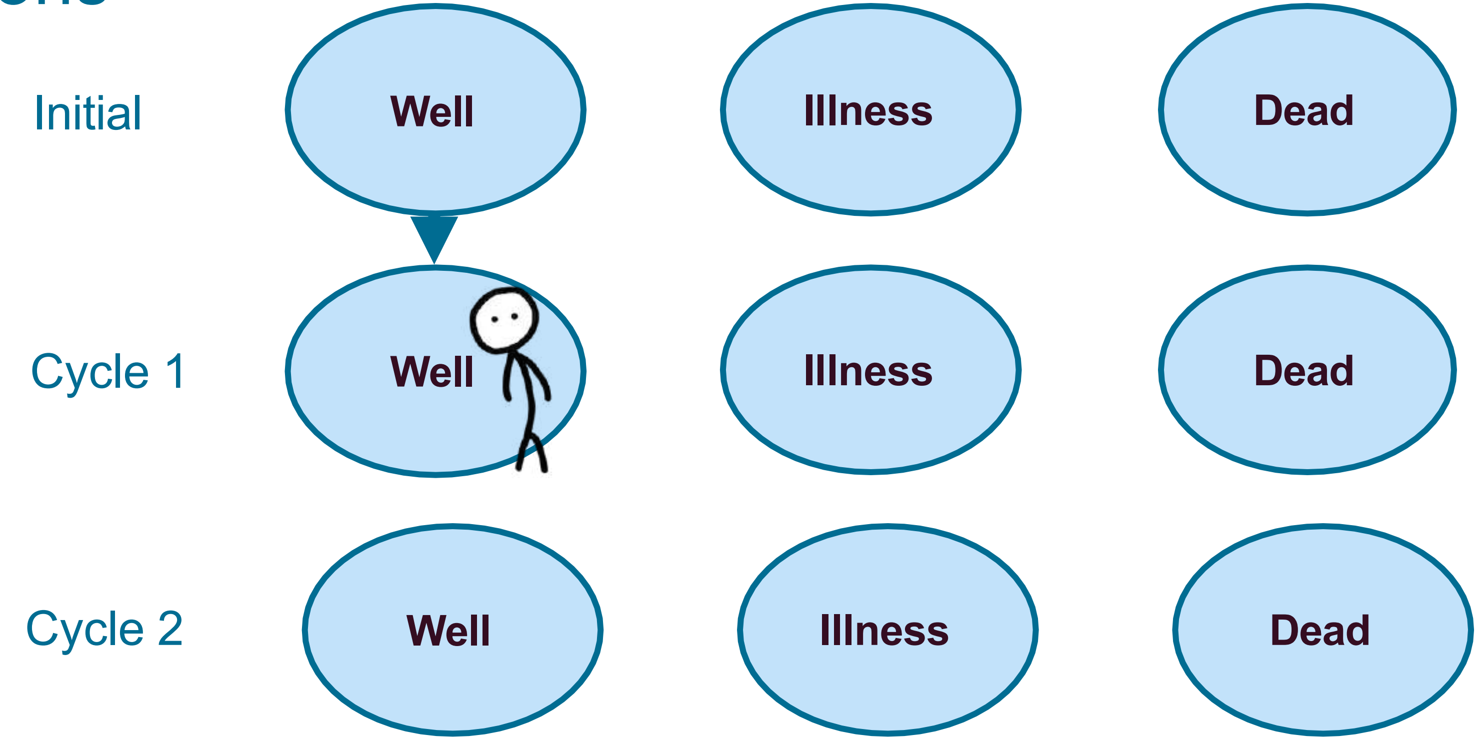
- “First order” Monte Carlo
- Generate variance around the cost and benefits



COHORT VERSUS MICROSIMULATIONS (8)

Cohort simulation

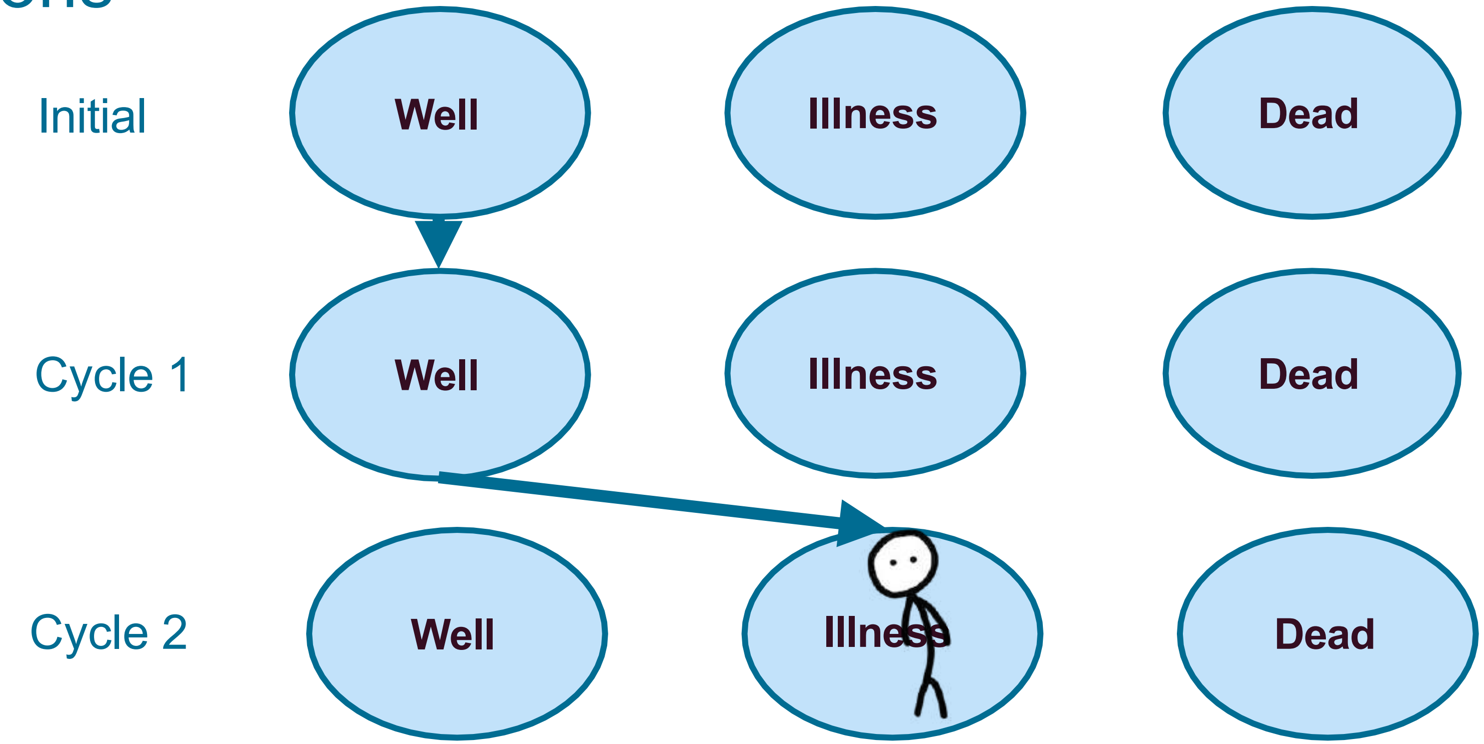
Individual or microsimulations



COHORT VERSUS MICROSIMULATIONS (9)

Cohort simulation

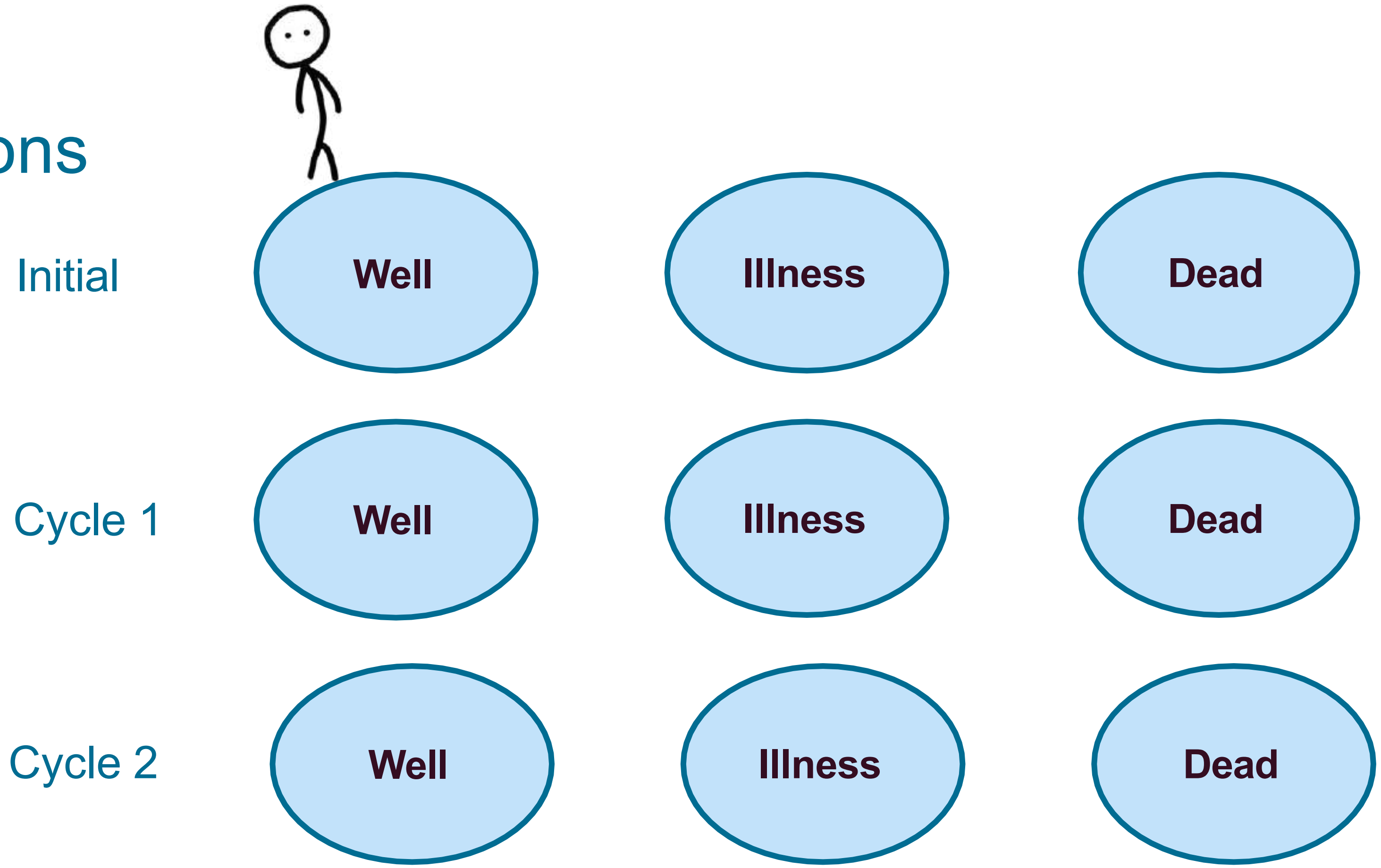
Individual or microsimulations



COHORT VERSUS MICROSIMULATIONS (10)

Cohort simulation

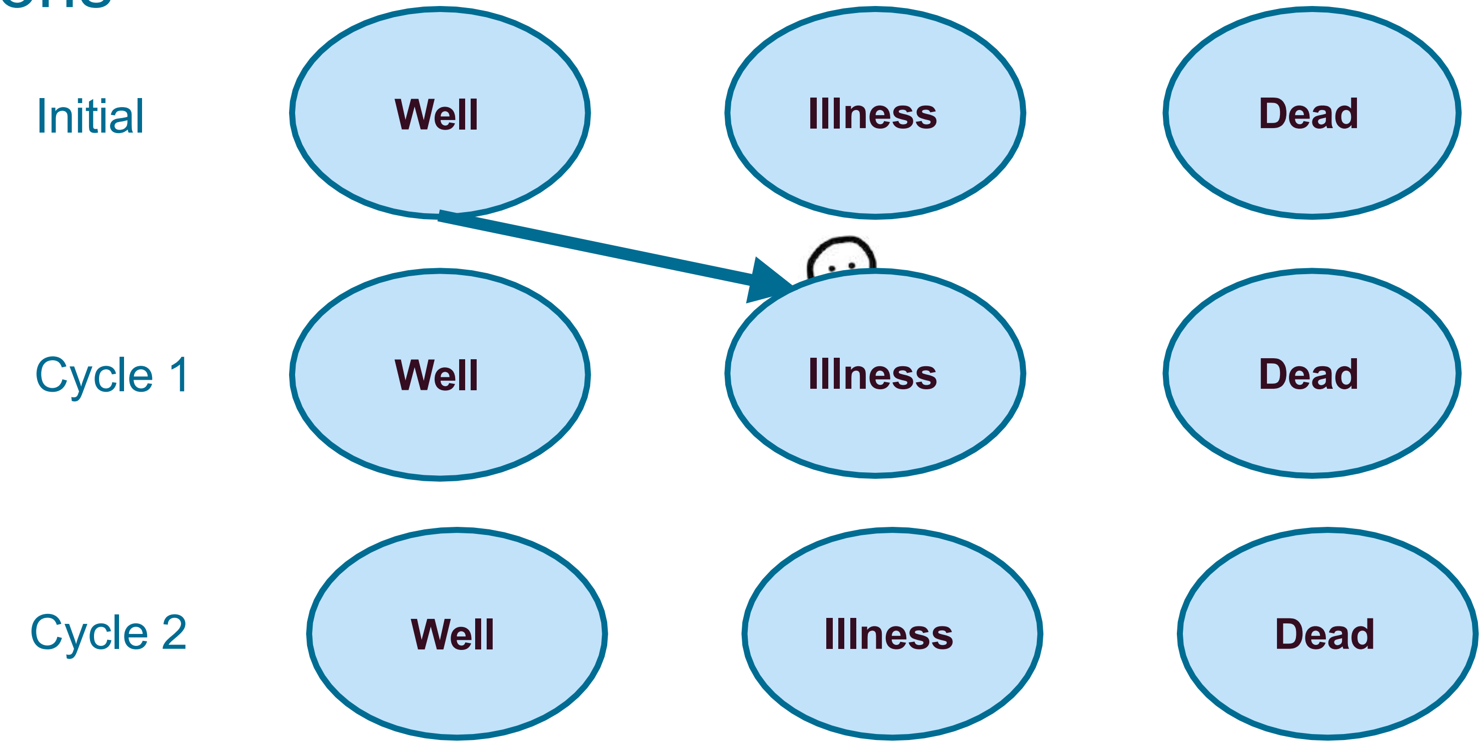
Individual or microsimulations



COHORT VERSUS MICROSIMULATIONS (11)

Cohort simulation

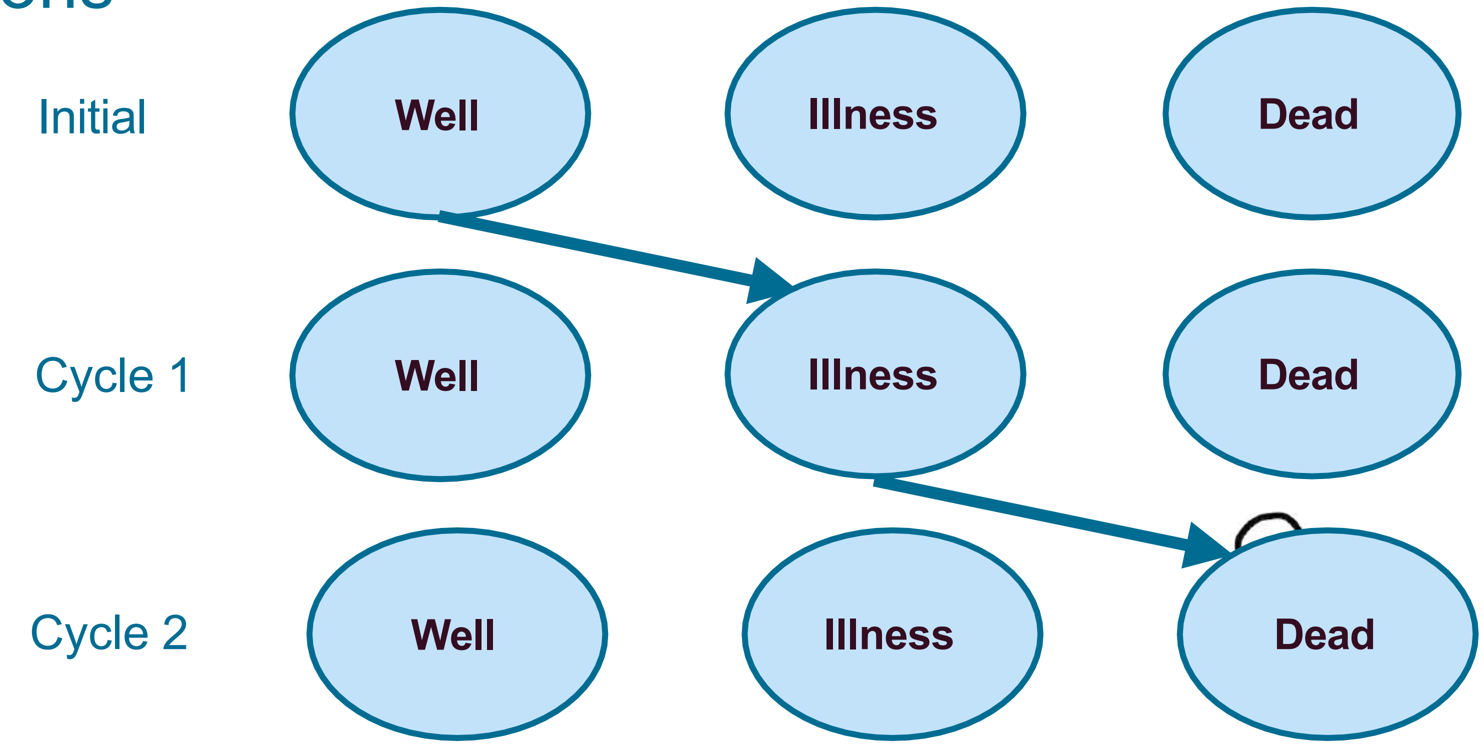
Individual or microsimulations



COHORT VERSUS MICROSIMULATIONS (12)

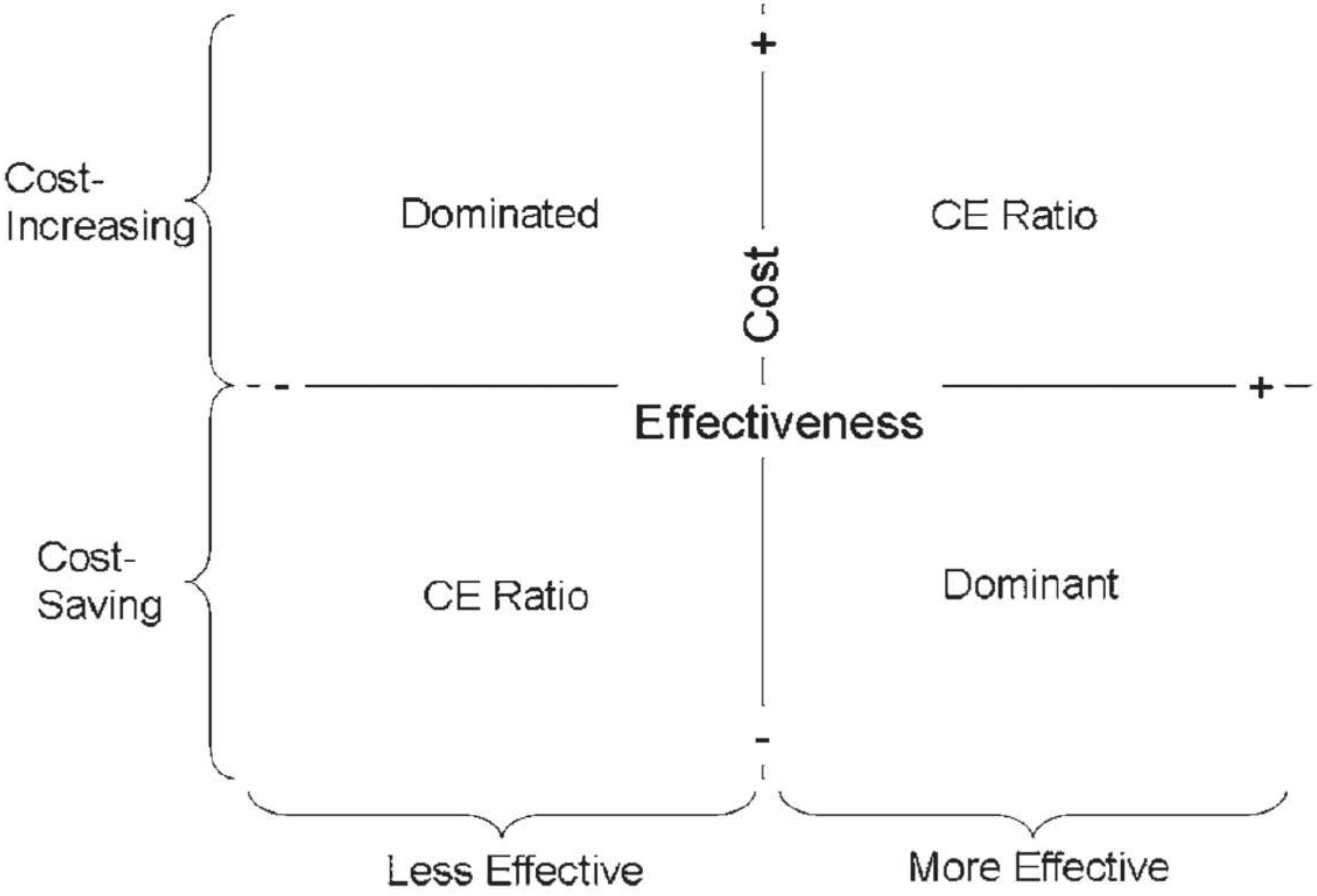
Cohort simulation

Individual or microsimulations



❑ 單元二：Presentation of Results

實例 1- Decision Tree Diagram/ Schematic



Source: Cohen et al (2008) J Am Coll Cardiol.

實例 1- Decision Tree Diagram/ Schematic

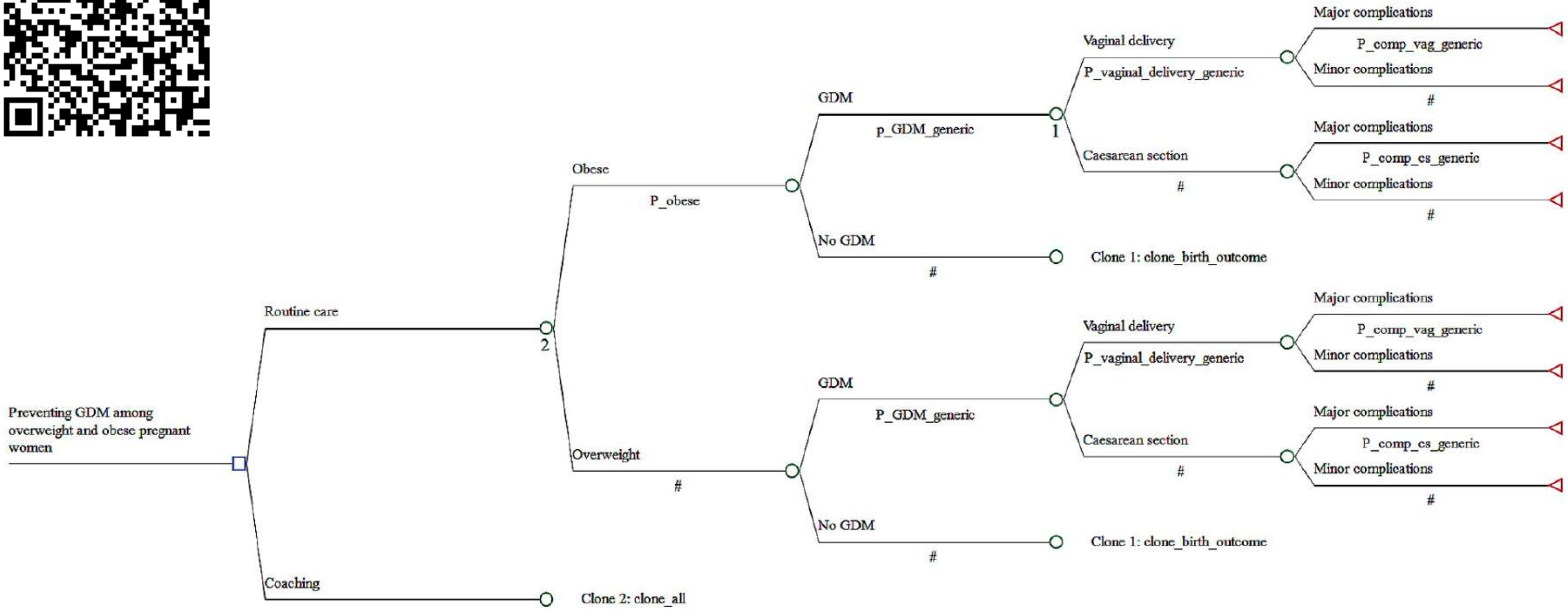


Fig. 1 Simplified diagram of the decision tree model used to analyze the cost-effectiveness of coaching to prevent GDM

Source: de Jersey et al (2024) Cost Effectiveness and Resource Allocation

實例 2- Markov Model Diagram/ Schematic

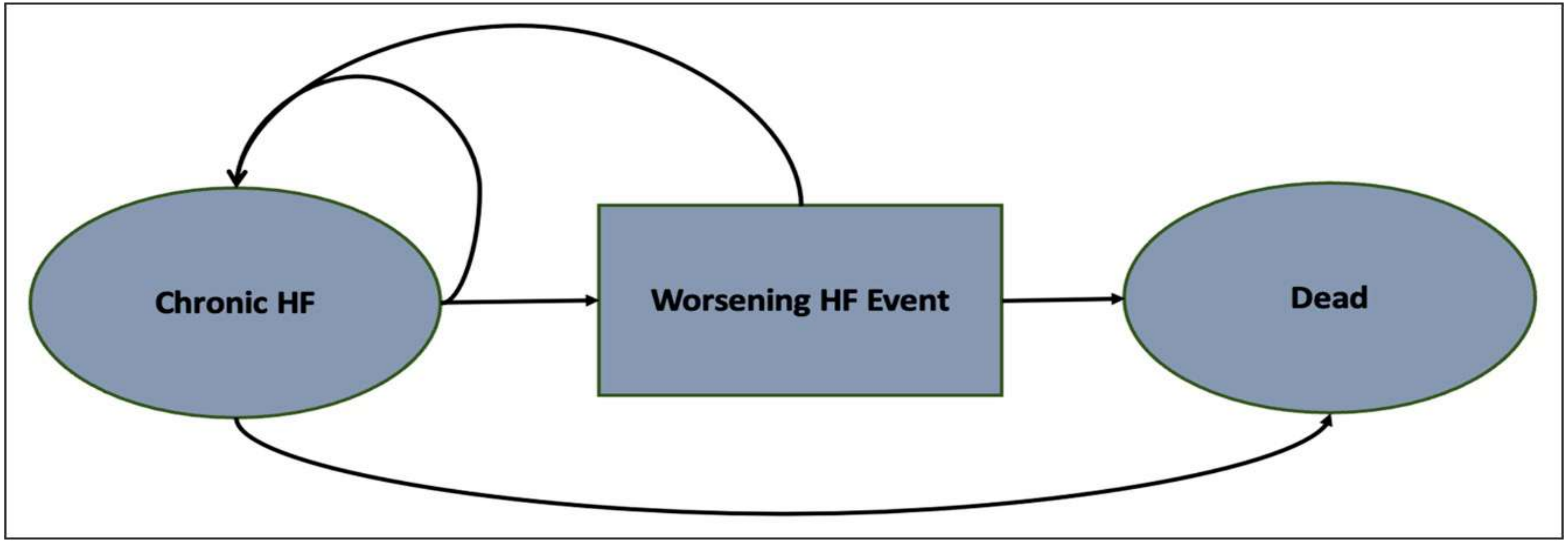
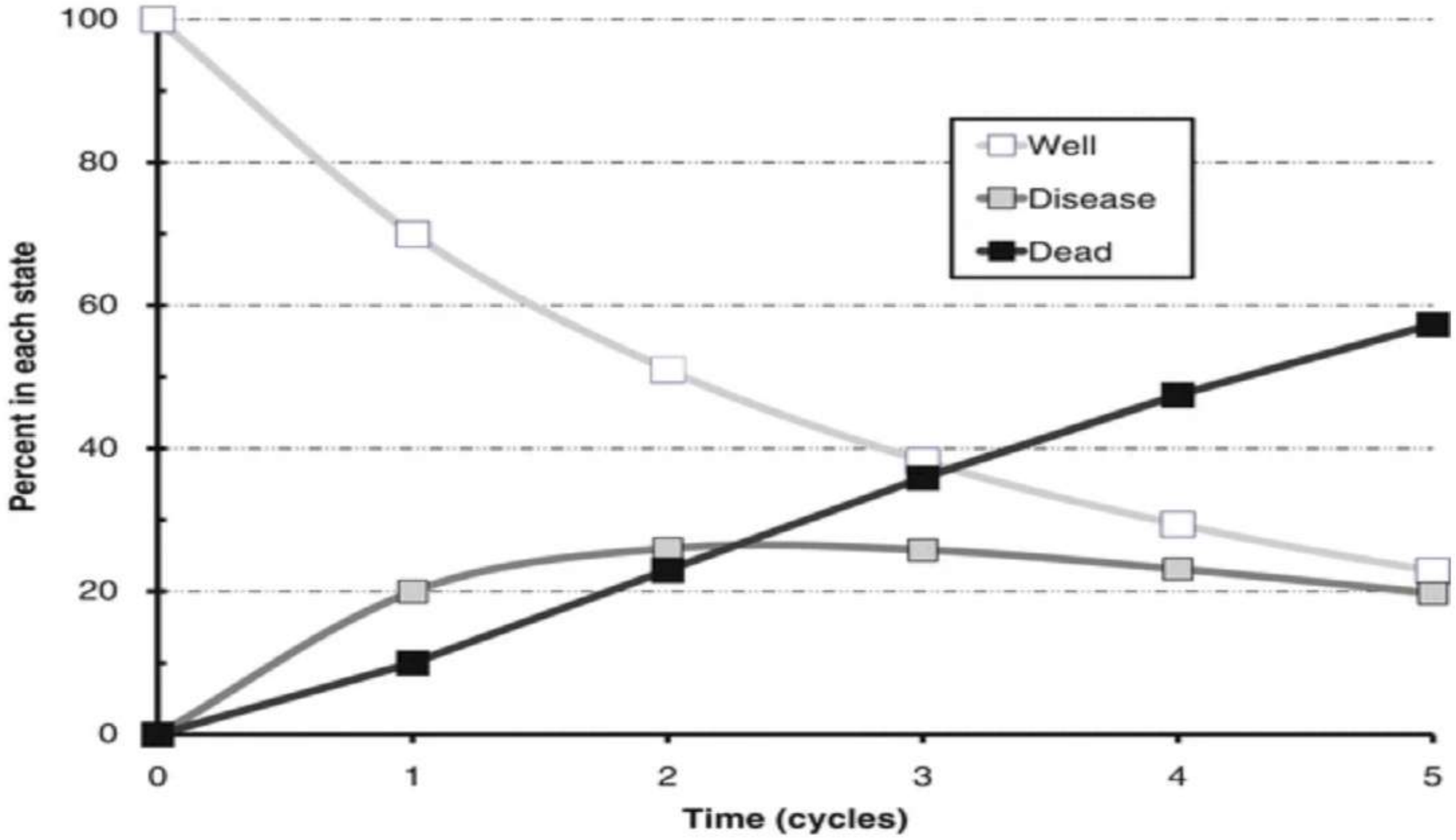


Figure 1. Diagram of the Markov model.
Patients occupy health states, shown in the ovals and boxes. Patients transition from different health states represented as arrows based on transition probabilities derived from participant-level data from DAPA-HF and DELIVER. Worsening HF events include hospitalization 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.

Source: Bhatt et al, (2024) Journal of the American Heart Association

實例 3- Markov Trace

Fig. 5.3



Graphical depiction of the Markov trace for a simple Markov model

Source: Cost-effectiveness modelling for health technology assessment. Adis publisher (2015)

實例 4- ICER

Table 3 Within-trial cost-effectiveness analysis

Cost-effectiveness	Costs (95% CI) [P(most costly)]	QALYs (95% CI) [P(most effective)]	Inc Costs (95% CI)	Inc QALY (95% CI)	ICER
Dyad					
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
Primary carer					
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
Child					
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

Source: Cox et al, (2022) BMC Health Service Research

實例 5- Net Monetary Benefit

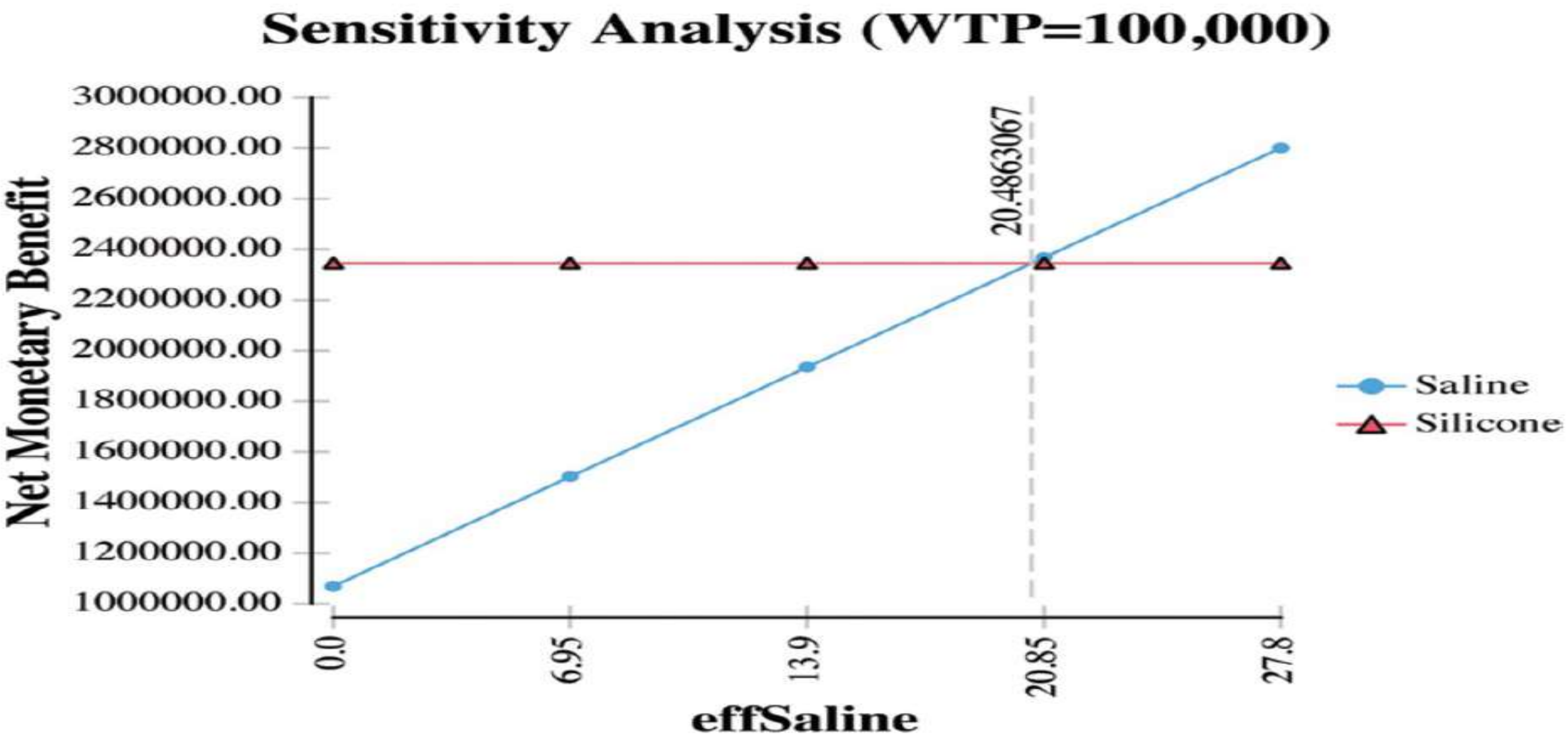


Fig. 2. Sensitivity analysis by differential effectiveness showing the BREAST-Q–adjusted life-year threshold (20.5) at which saline yields a greater net monetary benefit. The net monetary benefit calculation combines cost, effectiveness (*eff*), and willingness-to-pay (*WTP*) (set at $100,000) into a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

Source: Siotos et al, (2019) Plastic and Reconstructive Surgery

實例 6- Tornado Diagram

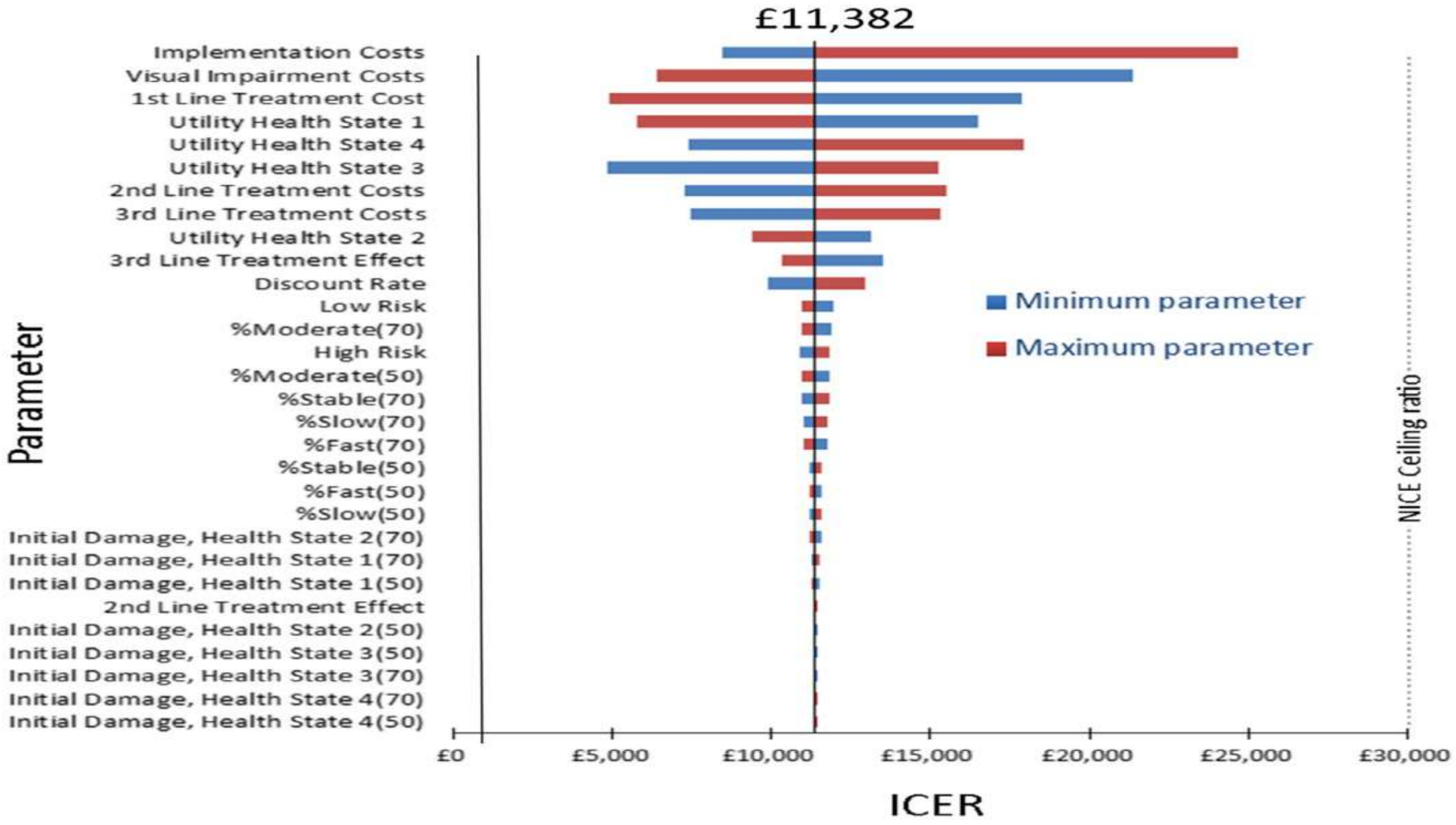


Fig. 4 Tornado Diagram measuring the impact in variation in parameters for the health economic model with included visual impairment costs (ICER = £11,382). Maximum and minimum limits for parameters were identified. ICERs were derived and ordered in terms of impact (greatest to lowest ICER variation)

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

實例 7- Cost-Effectiveness Scatterplot

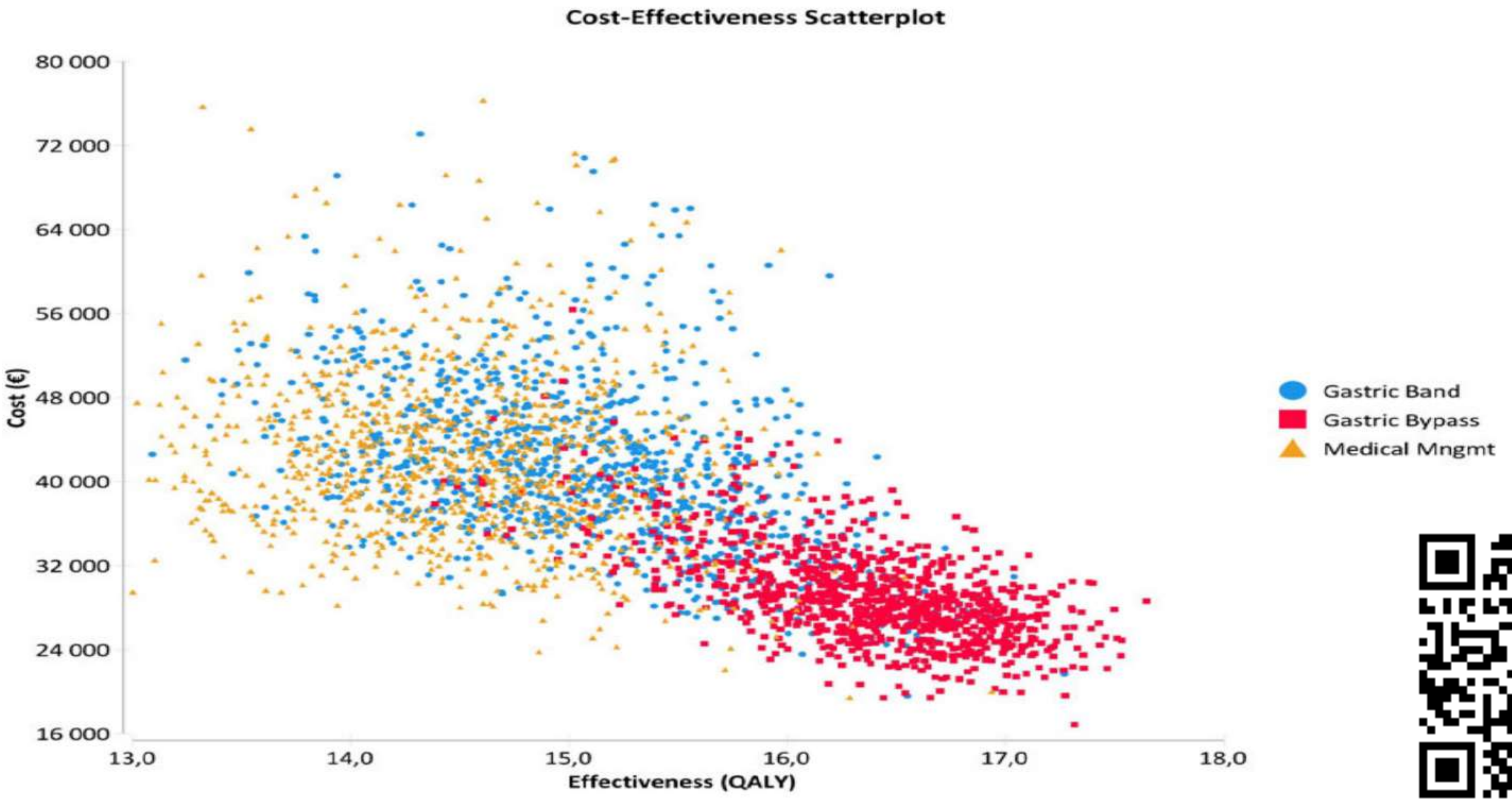
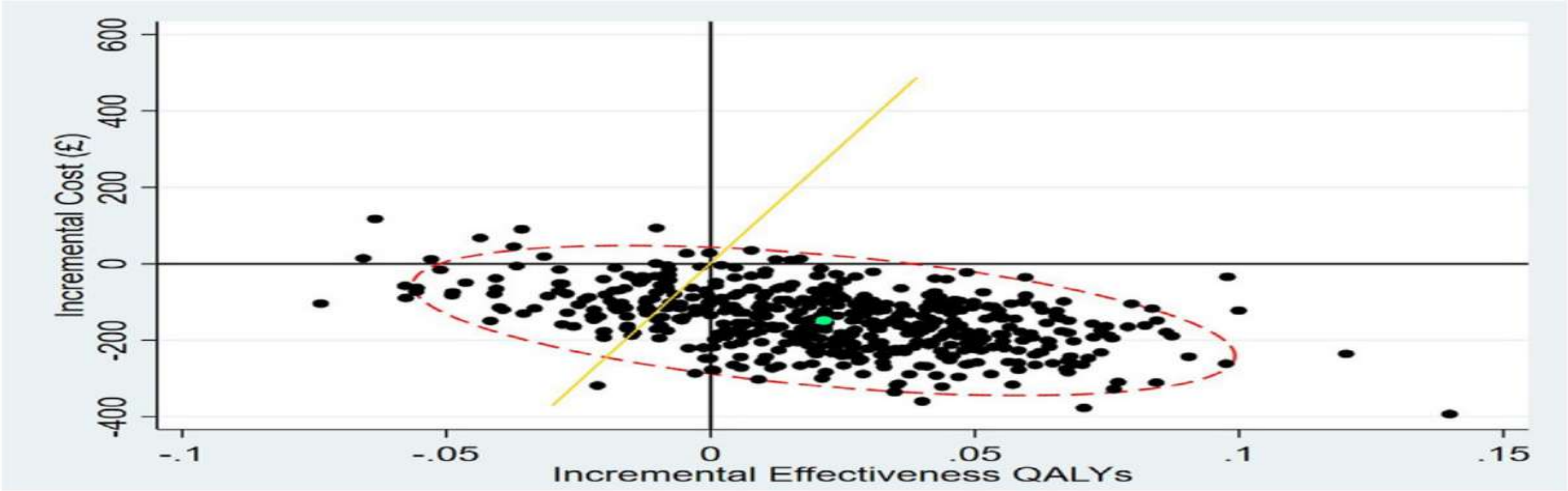


Fig. 2 Cost-effectiveness scatter plot

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.



Source: Manoukian et al (2024) Value in Health

實例 9- Monte Carlo Simulation of Incremental Cost-Effectiveness

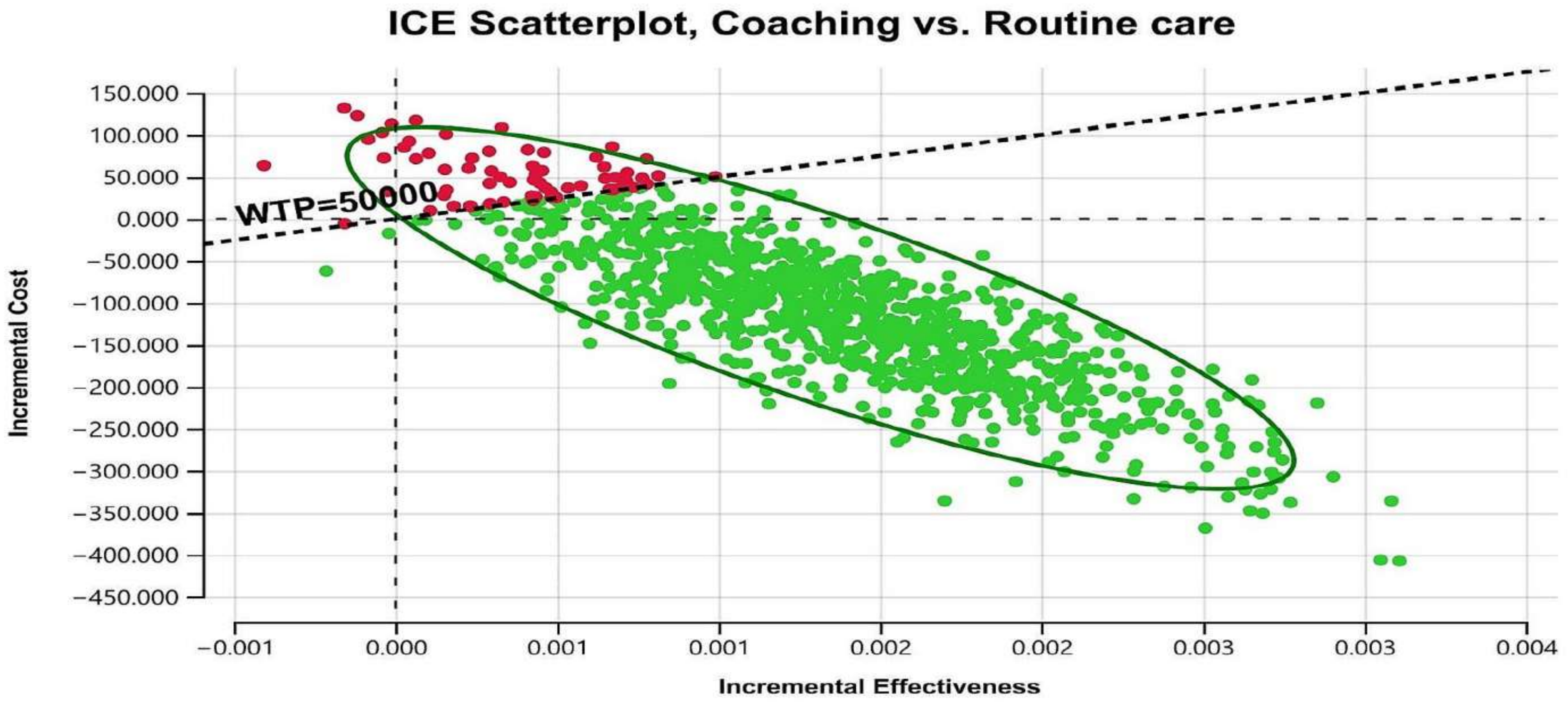


Fig. 4 Monte Carlo simulations scatter plot of incremental cost-effectiveness of coaching compared with routine care with a willingness to pay (WTP) of AUD50, 000

Source: de Jersey et al (2024) Cost Effectiveness and Resource Allocation

實例 10- Cost-Effectiveness Acceptance Curve(s)

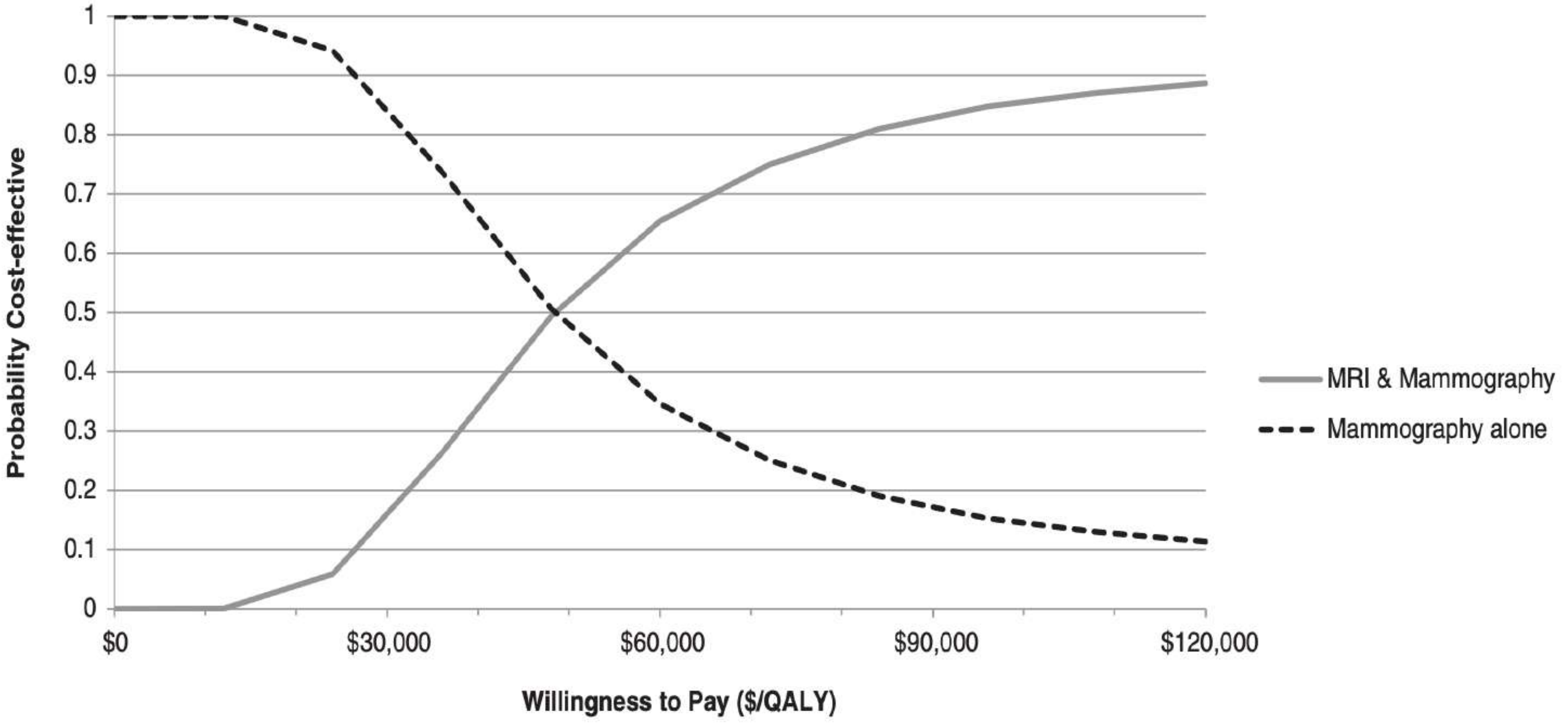


Figure 3 Cost effectiveness acceptability curve. Abbreviations: MRI, magnetic resonance imaging; QALY, quality-adjusted life-year.

Source: Pataky et al (2013) BMC Cancer

實例 11- Cost-Effectiveness Acceptance Curve(s)

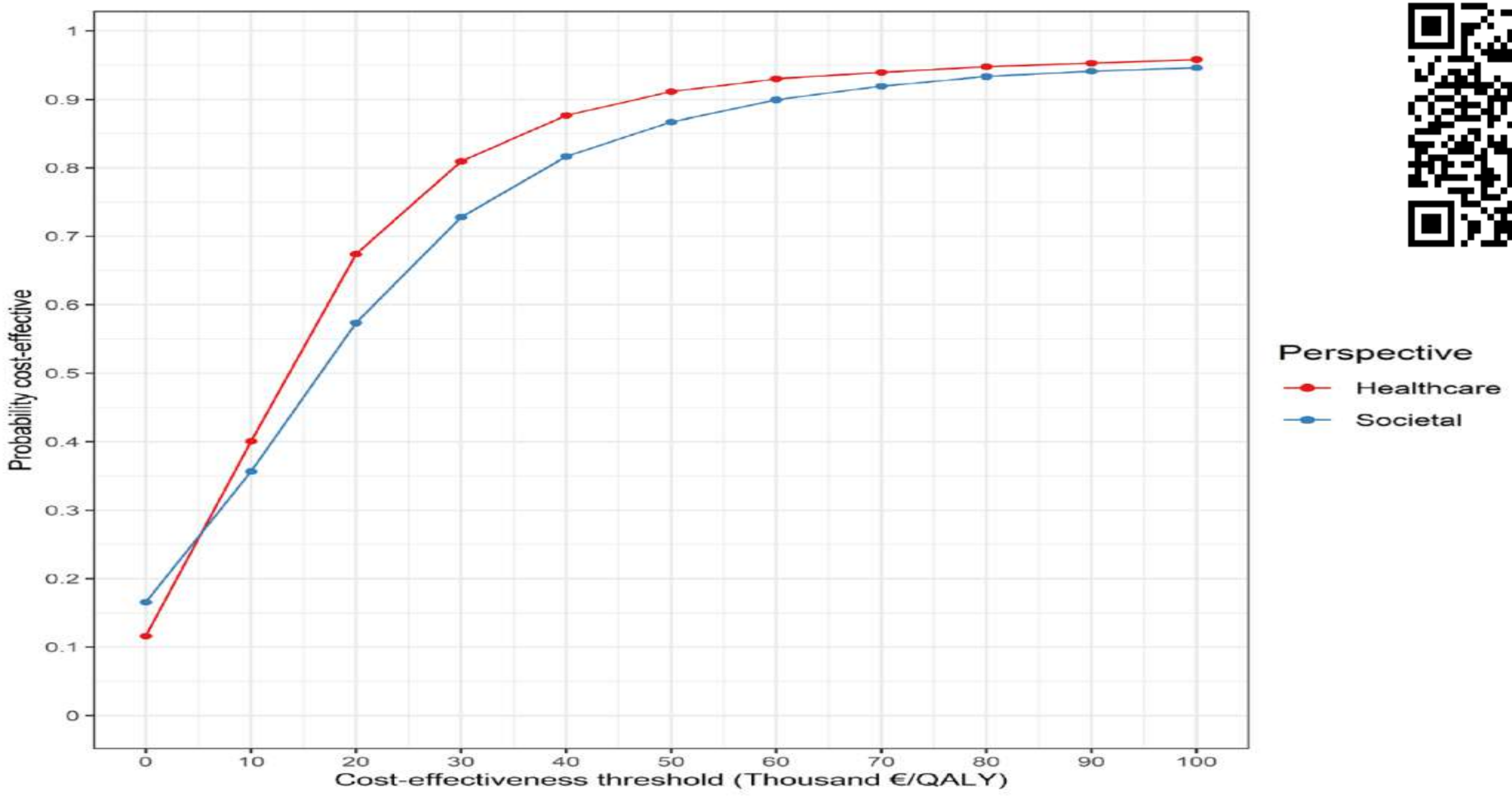


Figure 3. Cost-effectiveness acceptability curve. At a cost-effectiveness threshold of €50,000/QALY, EVT was cost-effective in 87% of replications from a societal perspective, and in 91% of replications from a healthcare perspective.

Source : Pinckaers et al (2024) European Stroke Journal

實例 12- Cost-Effectiveness Acceptance Curve(s)

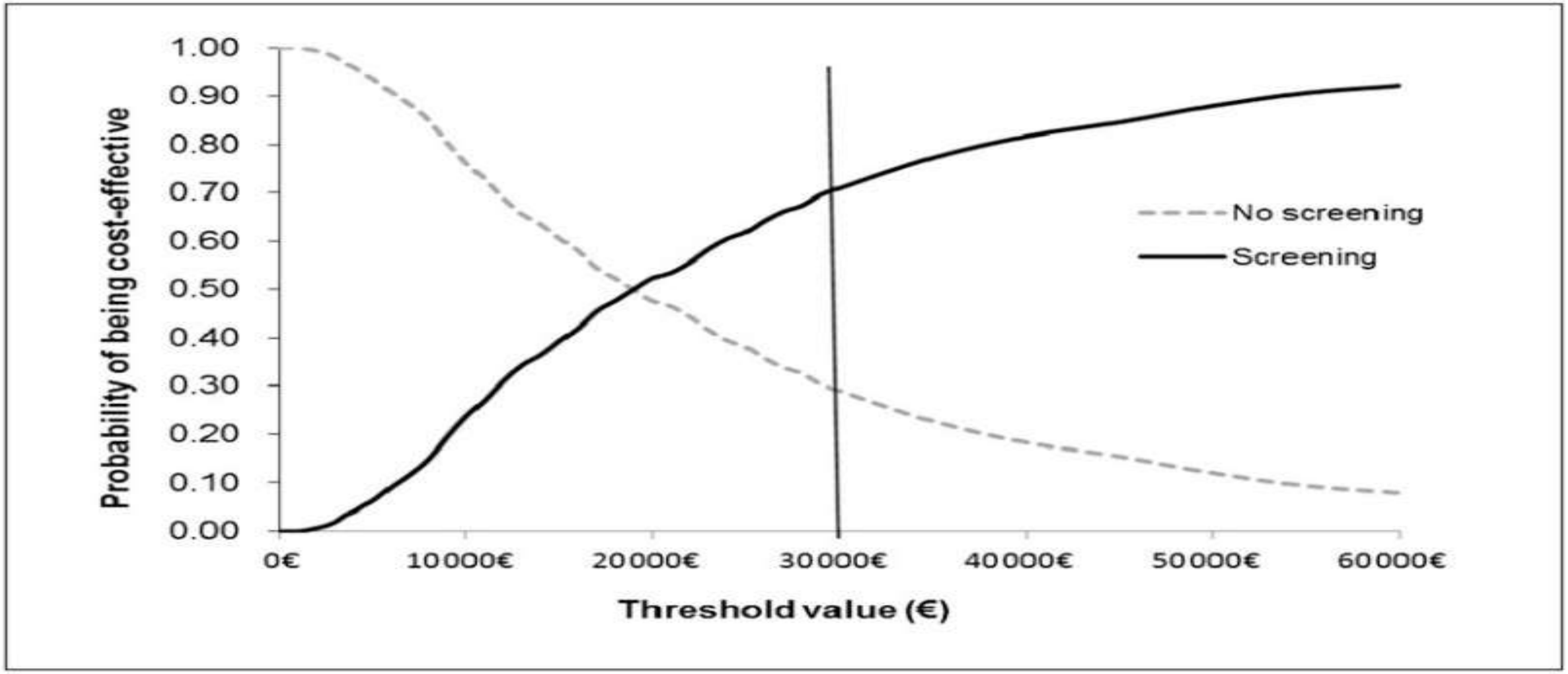
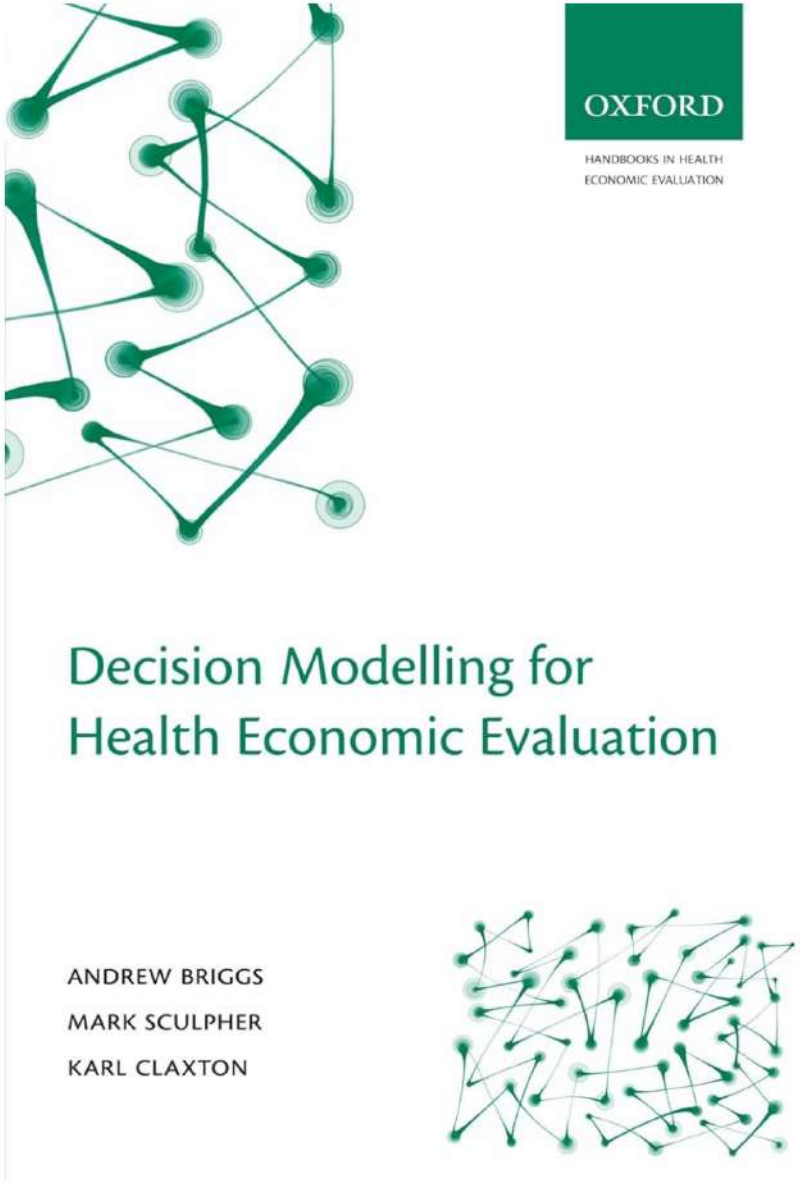


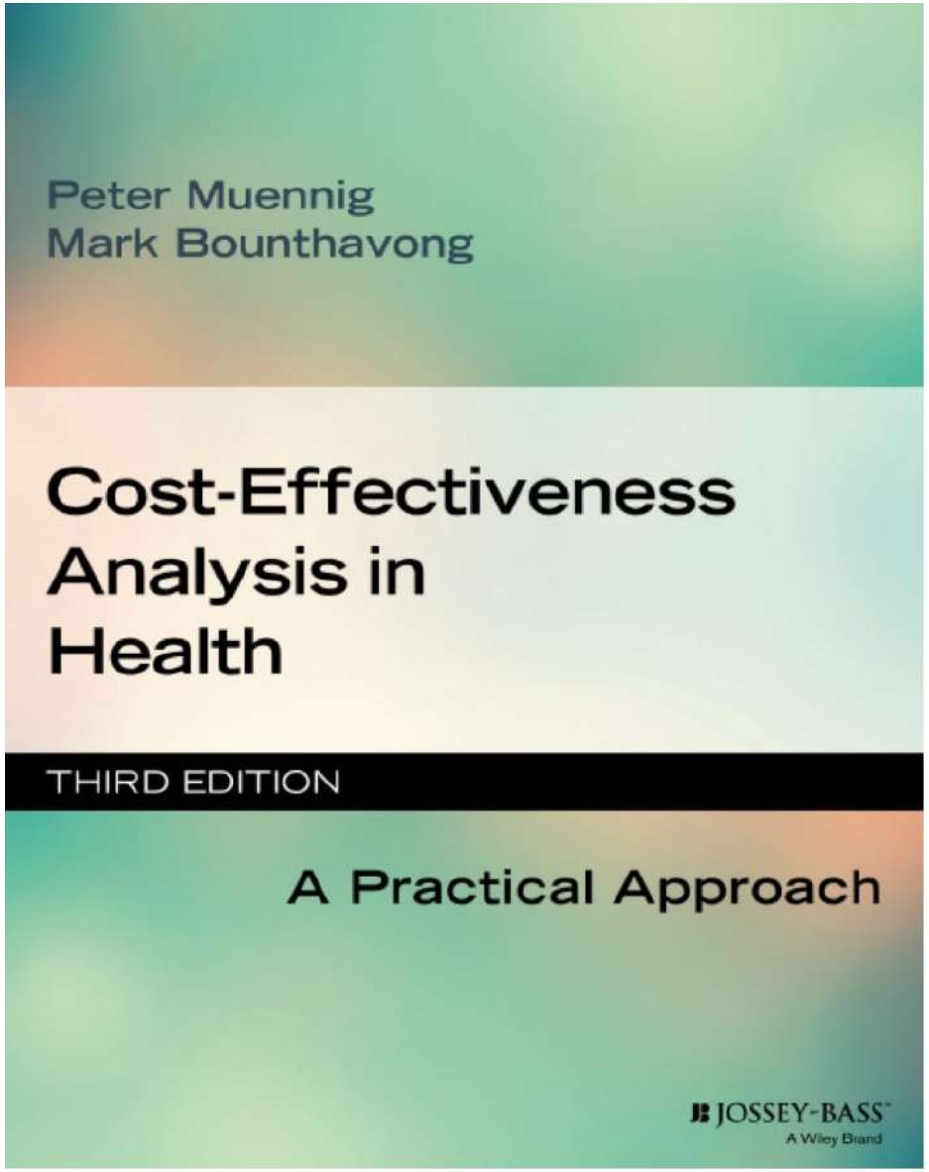
FIGURE 2
Cost-effectiveness acceptability curves. Note: Threshold value of €30 000 = US$40 000.

Source : Vallejo-Torres et al (2015) Pediatrics

❑ 單元三：
Decision Tree Modelling in Excel

Decision Tree Modelling in Excel (1)





Decision Tree Modelling in Excel (2)

ORIGINAL RESEARCH ARTICLE

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

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

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2 Department of Economics, University of Regina, Regina, Saskatchewan, Canada
3 Department of Health, Government of Canada, Vancouver, British Columbia, Canada
4 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) Pharmacoeconomics

Decision Tree Modelling in Excel (3)

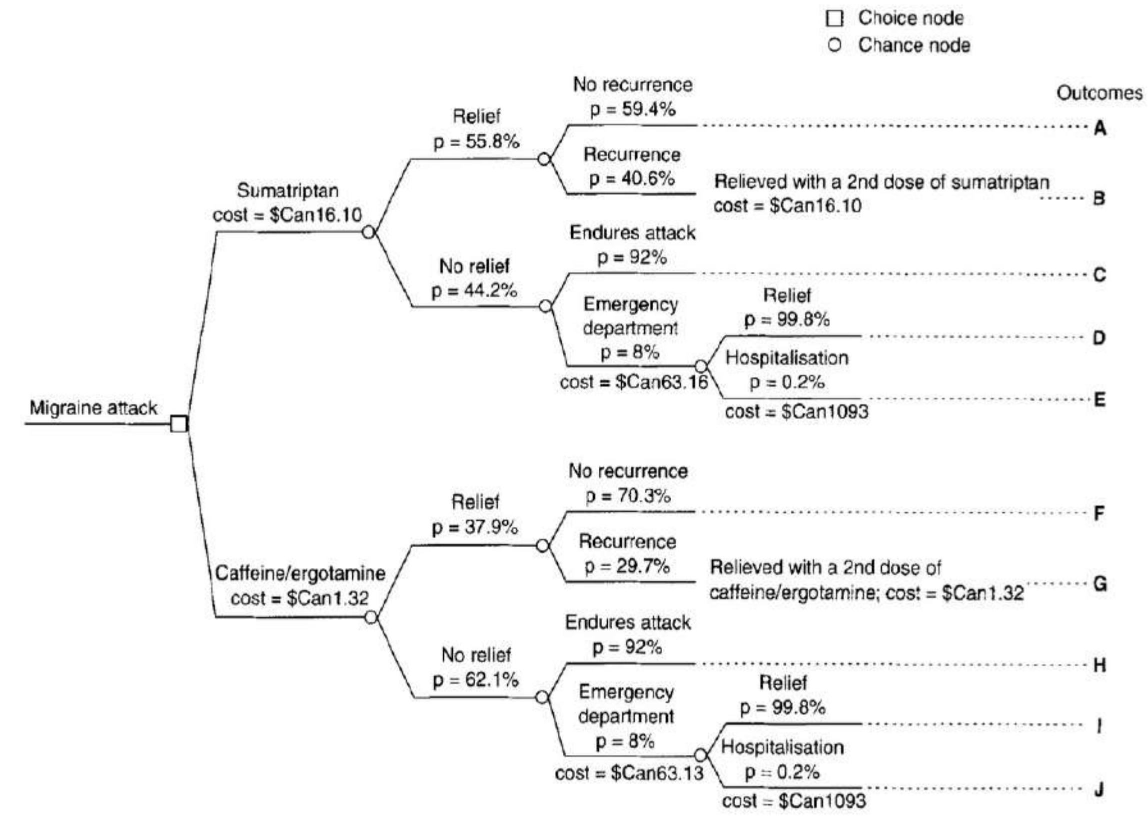


Fig. 1. Decision tree used in the model.

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
Sumatriptan					
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
Total	**100**		**22.06**		**0.42**
Caffeine/ergotamine					
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
Total	**100**		**4.71**		**0.20**

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.

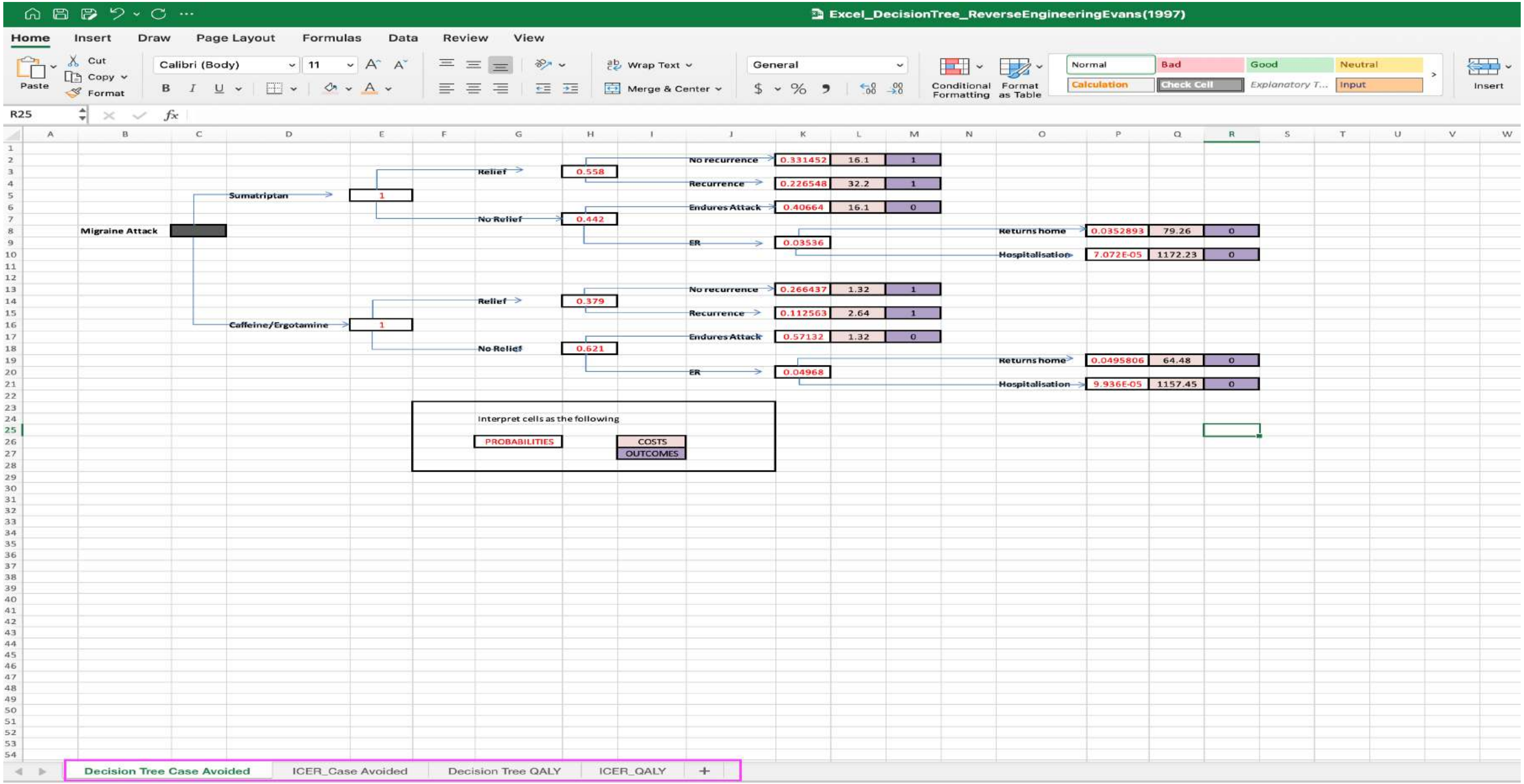
From the societal perspective, the use of oral sumatriptan resulted in net savings as well as improved health outcomes, as evidenced by the negative cost-effectiveness and cost-utility ratios and the positive net economic benefit.

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.[34] (table IV).

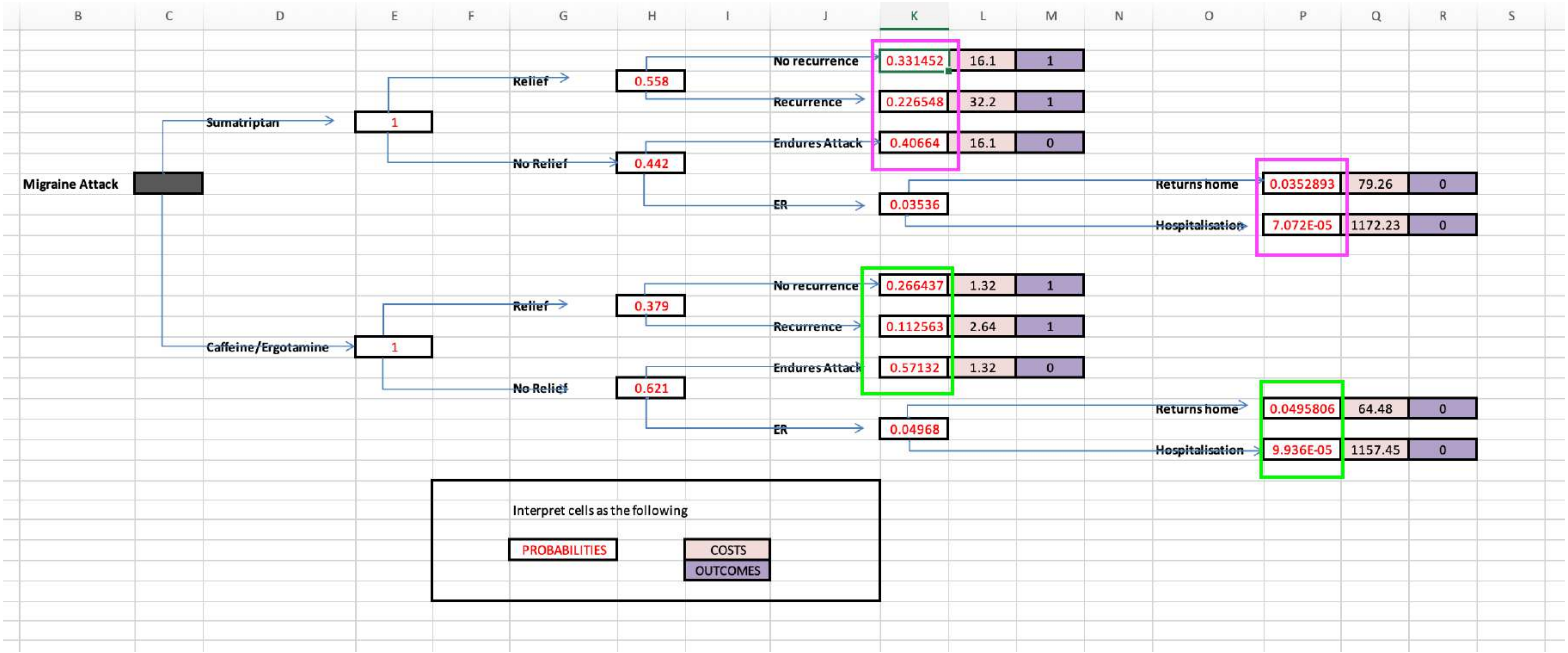
Sensitivity Analyses

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

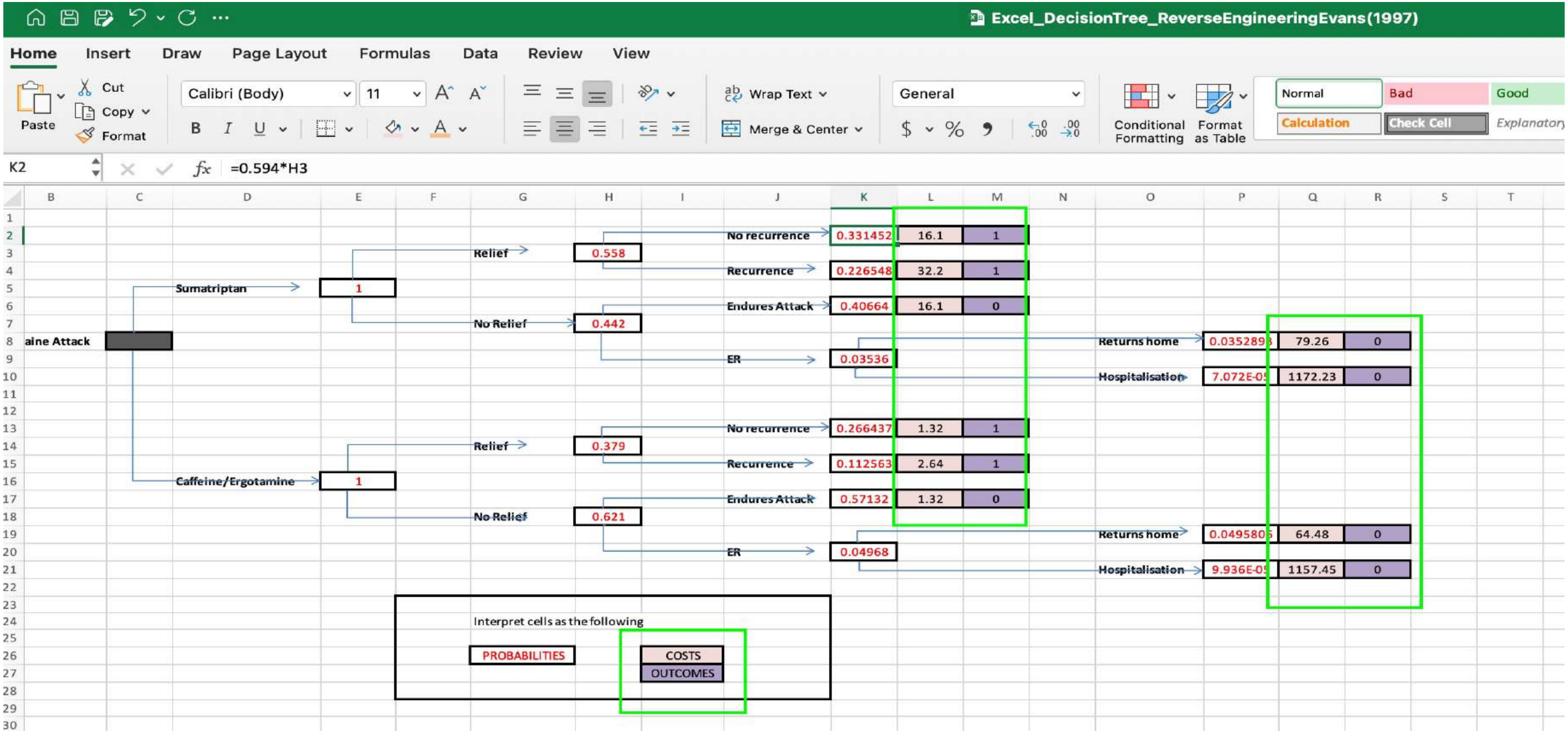
Decision Tree Modelling in Excel (4)



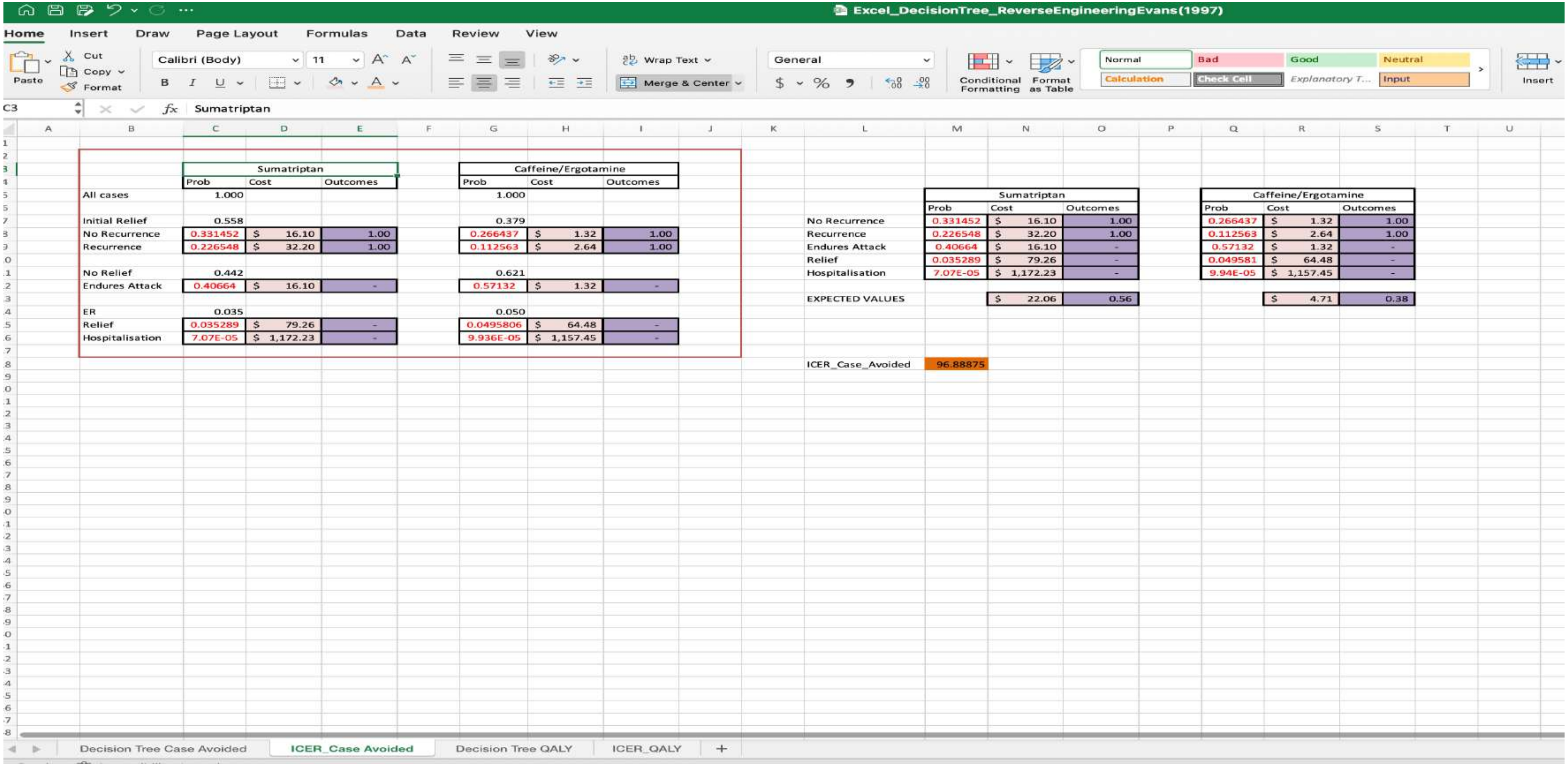
Decision Tree Modelling in Excel (5)



Decision Tree Modelling in Excel (6)



Decision Tree Modelling in Excel (7)

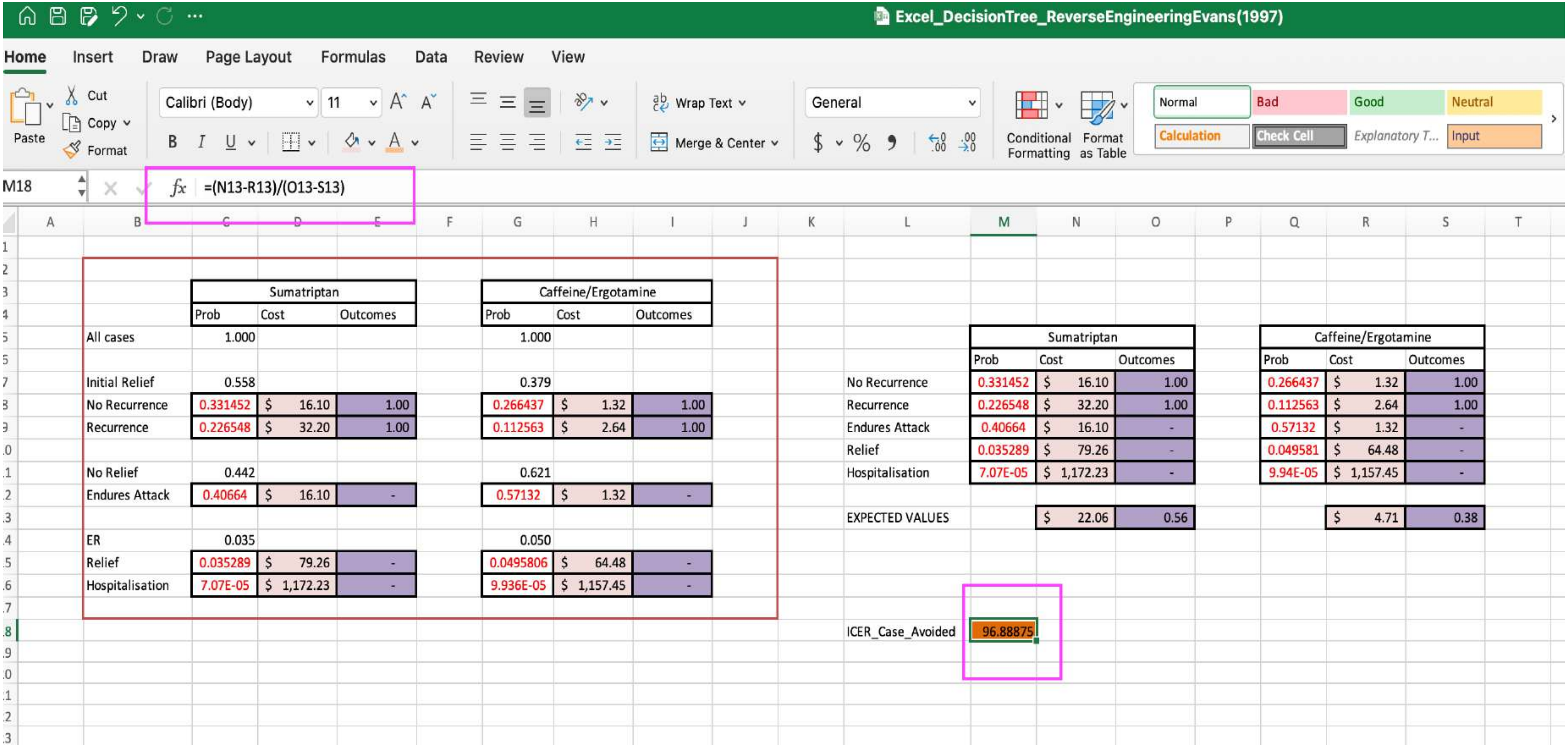


	Sumatriptan			Caffeine/Ergotamine		
	Prob	Cost	Outcomes	Prob	Cost	Outcomes
All cases	1.000			1.000		
Initial Relief	0.558			0.379		
No Recurrence	0.331452	$ 16.10	1.00	0.266437	$ 1.32	1.00
Recurrence	0.226548	$ 32.20	1.00	0.112563	$ 2.64	1.00
No Relief	0.442			0.621		
Endures Attack	0.40664	$ 16.10	-	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 (8)



	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)

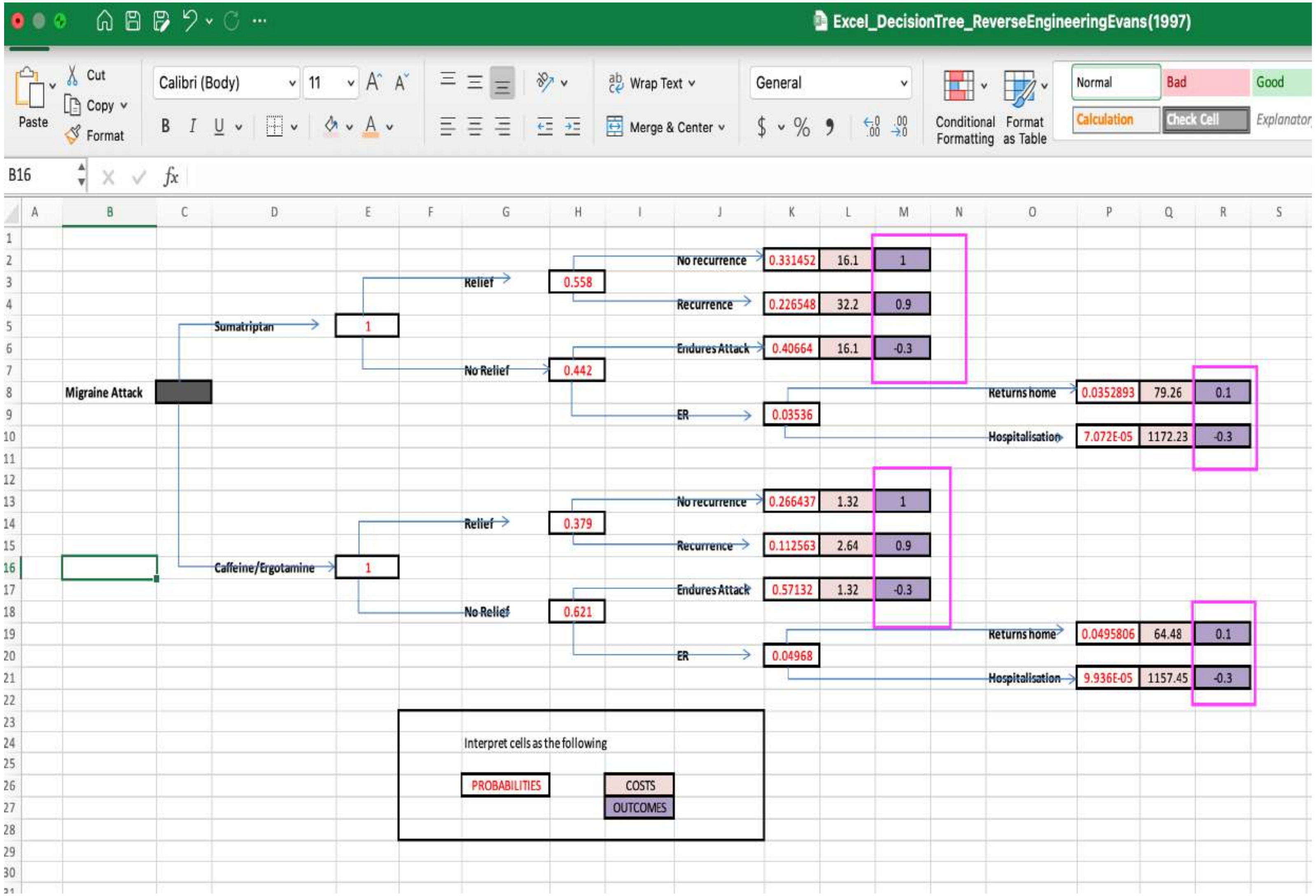


Table II. Table of utilities (outcomes are shown in figure 1)

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%=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%=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	Healthy	Sick	Dead
2		Healthy	Sick	Dead		1	1000	0	0
3	Healthy	0.91	0.07	0.02		2	=MMULT(G2:I2,$B$3:$D$5)		
4	Sick	0	0.95	0.05		3			
5	Dead	0	0	1		4			
6						5			
7						6			
8						7			
9						8			

1. 建立每個不同健康狀態的轉移機率的列聯表

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

Markov Model in Excel (8) – 生(老)病死

情境：

<u>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：</u>

- 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			
14			
15	Discount Rate	3%	

1.建立表格1

表格2

M2 =G2*$B$11

	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

Cost這樣算

參照上一張表格Cycle 2的人數：
- Healthy = 910*50 = 45,500
- Sick = 70*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

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*50 = 45,500
- Sick = 70*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	QALY
11	Healthy	50	0.9
12	Sick	1000	0.6
13			
14			
15	Discount Rate	3%	

1.保留表格1

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

QALY這樣算

例：參照Cycle 2的人數
- Healthy = 910*0.9 =819
- Sick = 70*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

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	QALY
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*0.9 =819
- Sick = 70*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 =G2*$C$11

	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	0.888487048				668.4702193
7	0.862608784		252970.3721		620.0994041
8	0.837484257		268860.1505		
9	0.813091511		279375.4261		
10	0.789409234		285416.0065		

1.在V2輸入
=POWER(1/(1+$B$15),$F2-1)

2.在X2輸入
Cycle 1的Total cost* V 2
（ =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：

<u>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：</u>

- 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	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	=MMULT(AK2:AM2,$AF$3:$AH$5)		
4	Sick	0	0.95	0.05		3			
5	Dead	0	0	1		4			
6						5			
7						6			
8						7			

1. 建立每個不同健康狀態的轉移機率的列聯表

2. 初始值是1000位健康的人，AK2:AM2分別輸入1000,0,0
3. 接著在AK3這格輸入上列公式 =MMULT(AK2:AM2,$AF$3:$AH$5)
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%	

1.建立表格1

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

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

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%	

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

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

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			
14			
15	Discount Rate	3%	

1.保留表格1

	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

QALY這樣算

例：參照Cycle 2的人數
- Healthy = 950*0.9 =855
- Sick = 30*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

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%	

QALY這樣算

例：參照Cycle 2的人數

- Healthy = 910*0.9 =819
- Sick = 70*0.6 =42
- Total QALY = 861

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

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

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%	

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		[illegible]		706.1576222
7	0.862608784		[illegible]		663.9572326
8	[illegible]		[illegible]		624.0522672
9	[illegible]		[illegible]		586.3407338
10	[illegible]		420346.3365		550.7226363

1.在AZ2輸入
=POWER(1/(1+$AF$15),$AJ2-1)

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%	

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			

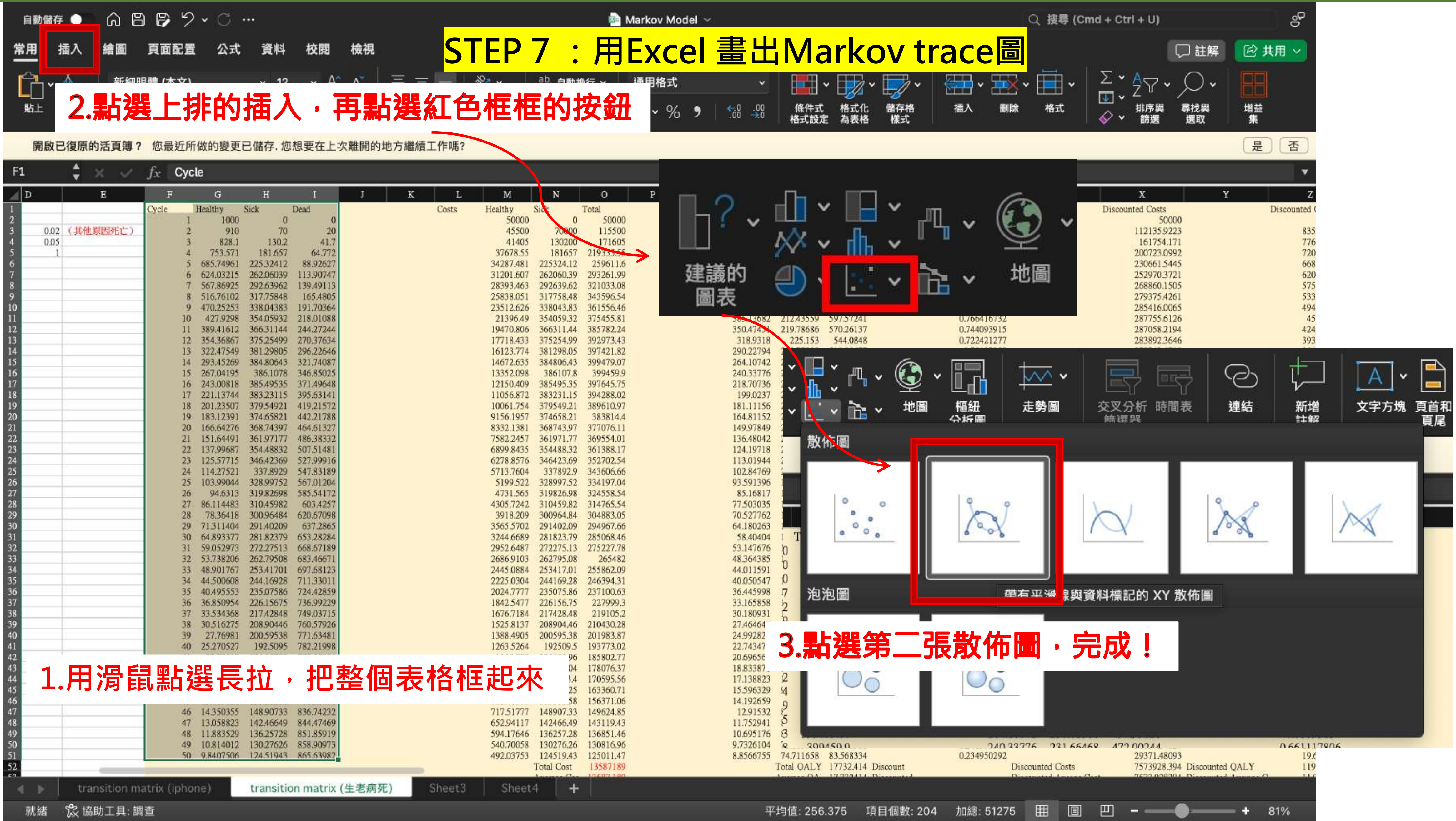
ICER：
Incremental成本 / Incremental QALY
=(D58/E58)

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

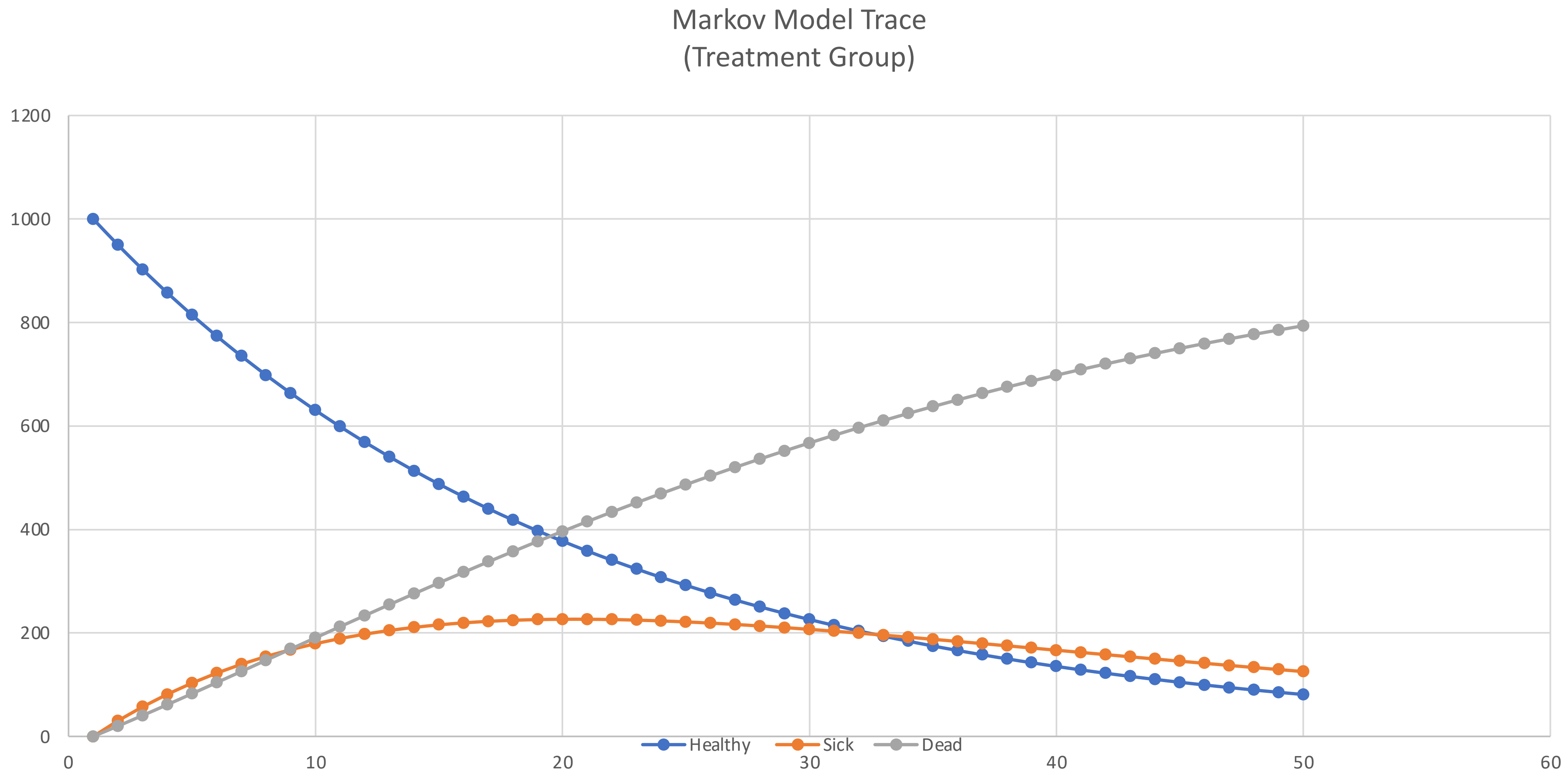


Markov Model in Excel (28) – 生(老)病死

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：

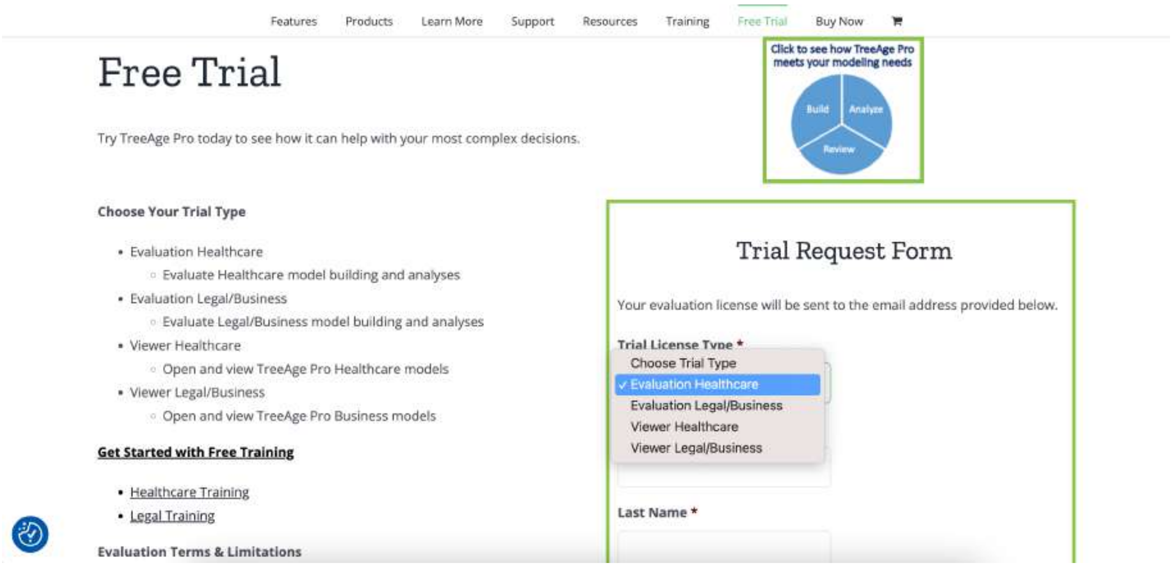


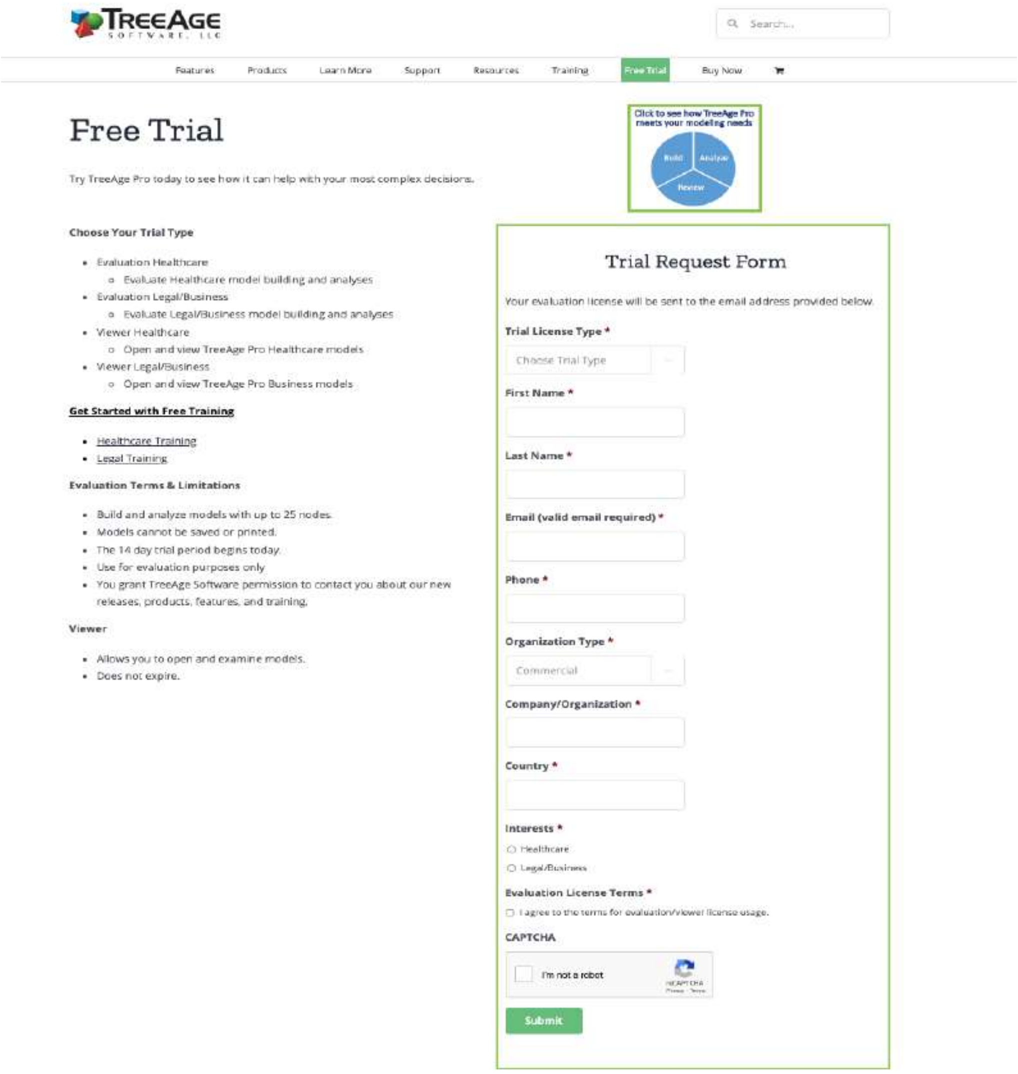
❑ 單元五:
TreeAge Workbench

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/





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>

寄給 我

翻譯成中文（繁體）

10月15日 週二 下午10:47

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.

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

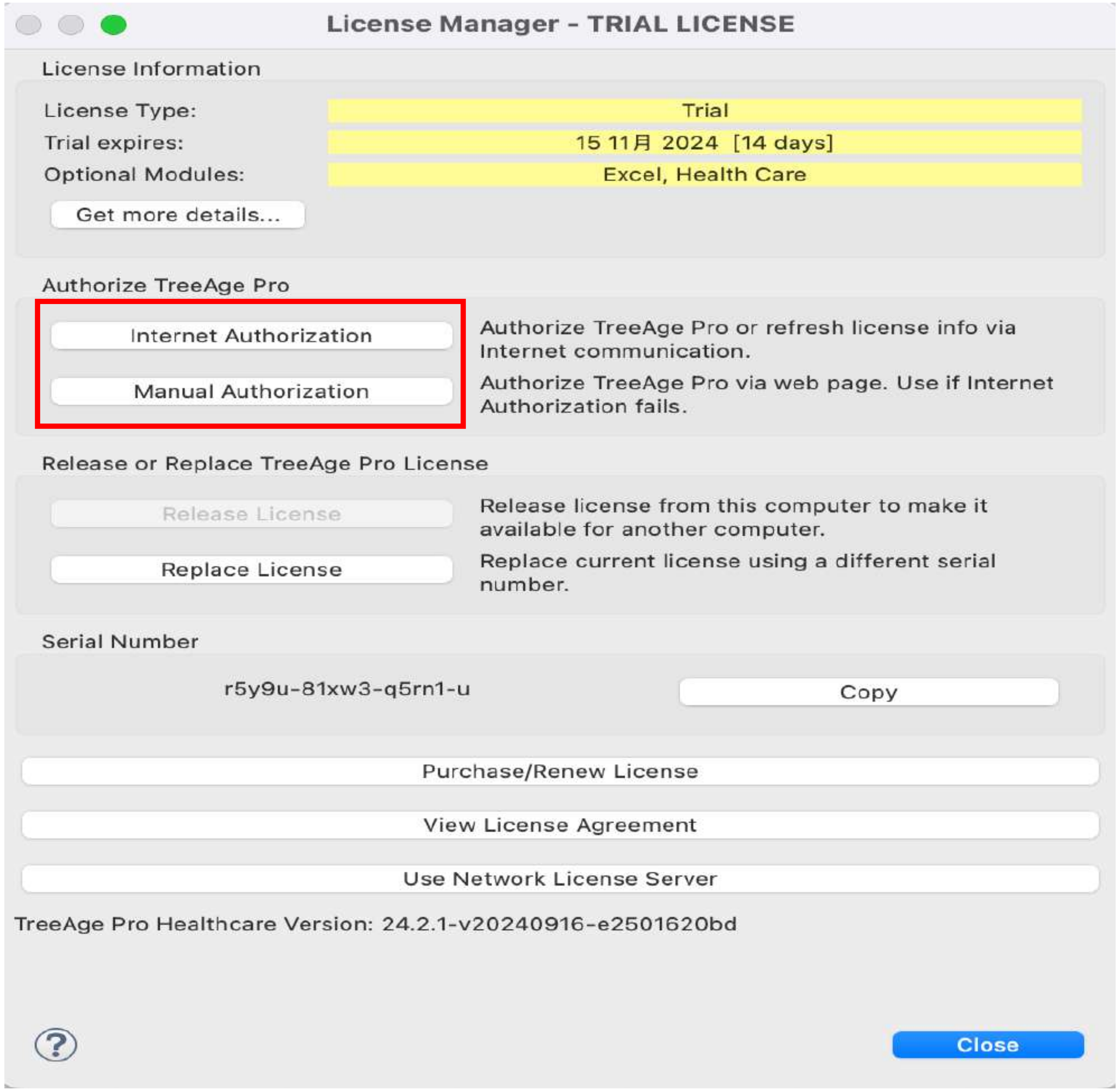
You can install directly over older versions of TreeAge Pro.

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.

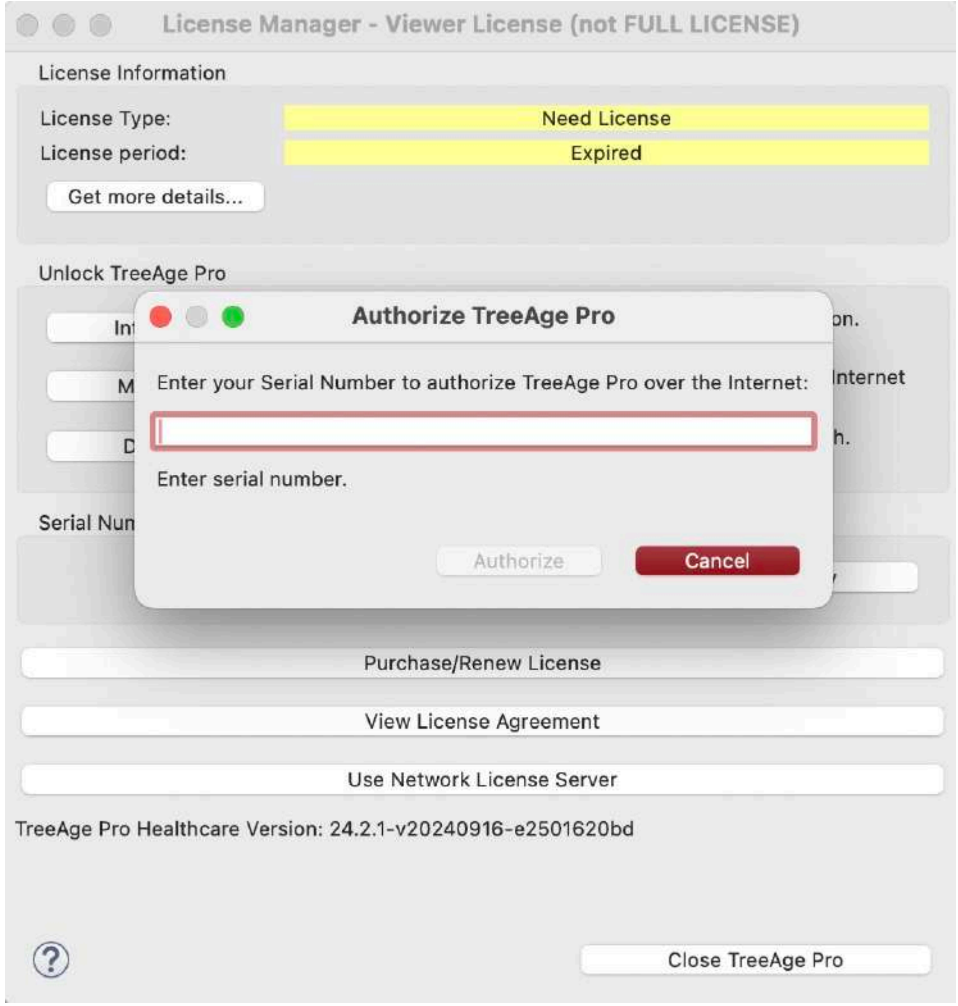
TreeAge 下載

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



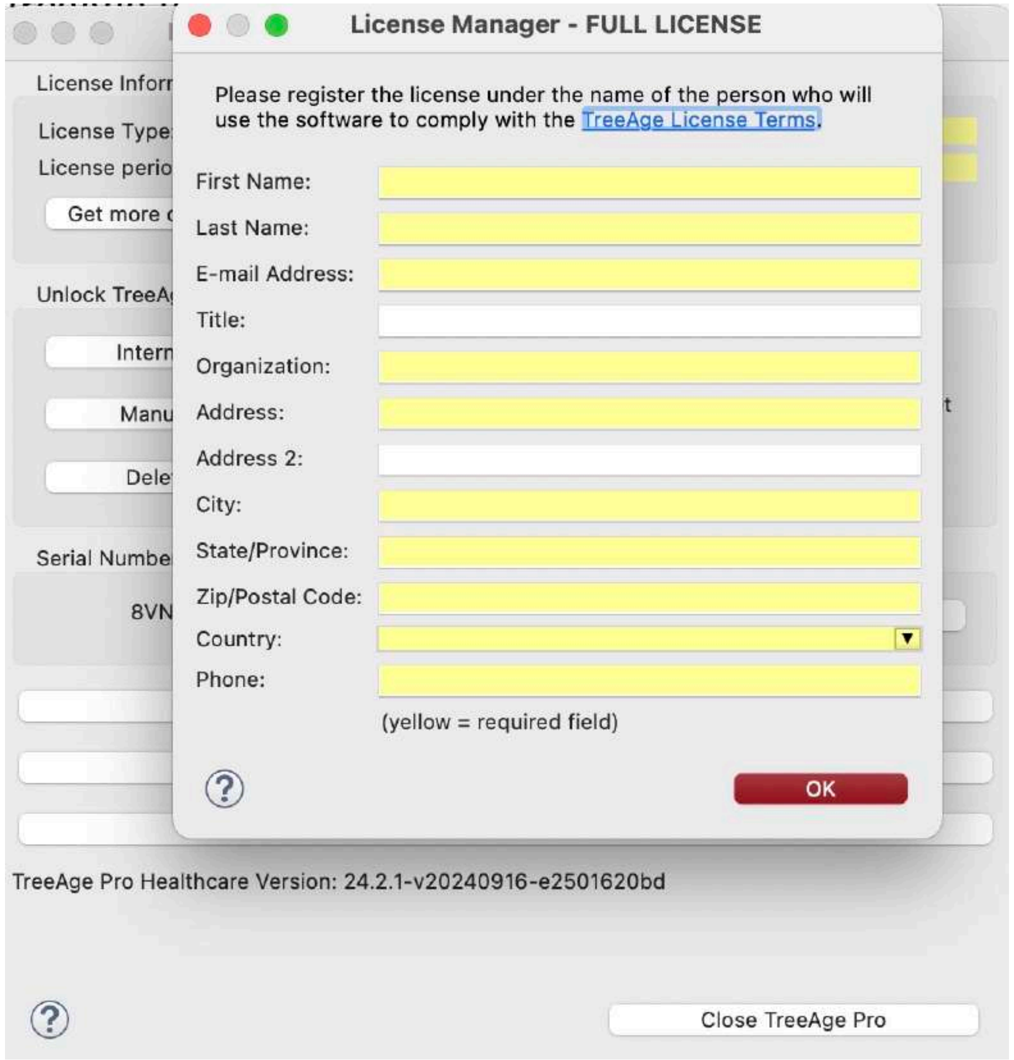
TreeAge 下載

5. 複製Serial Number並貼上

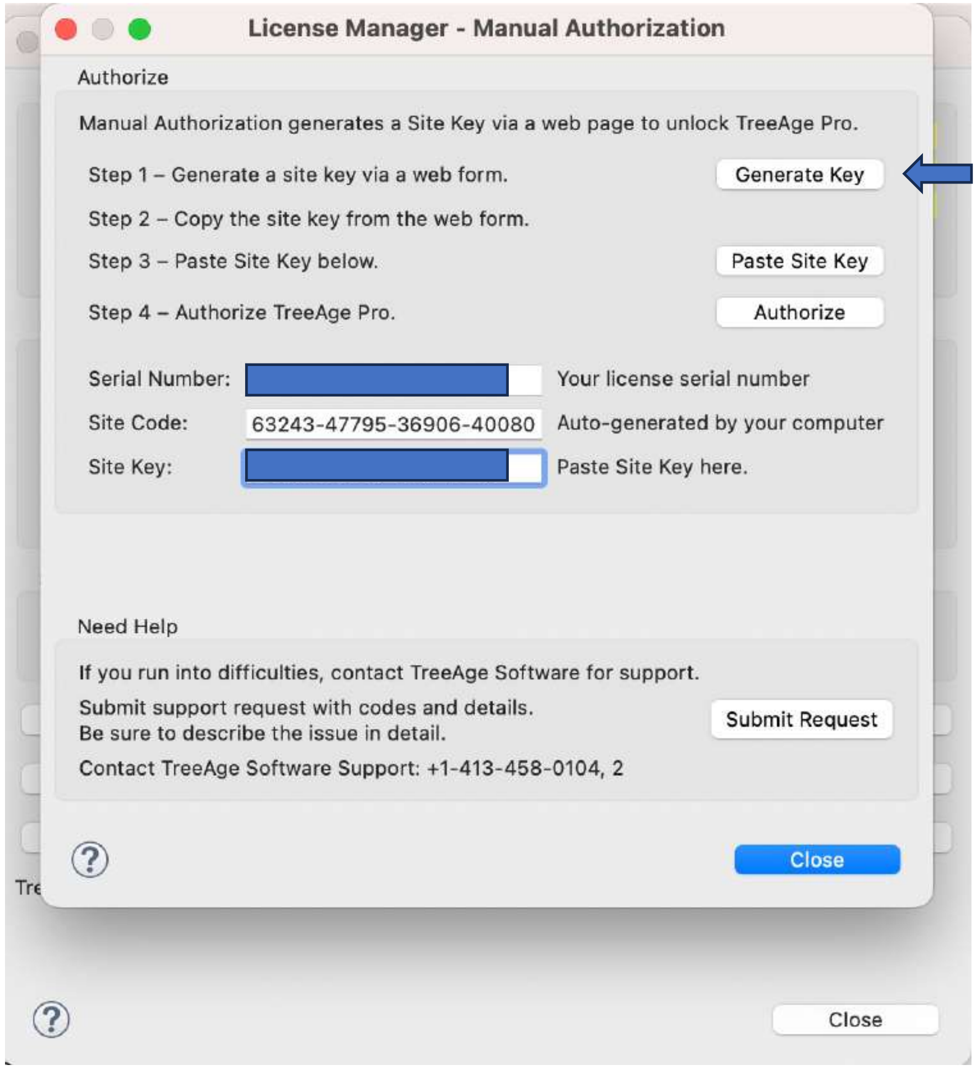


TreeAge 下載

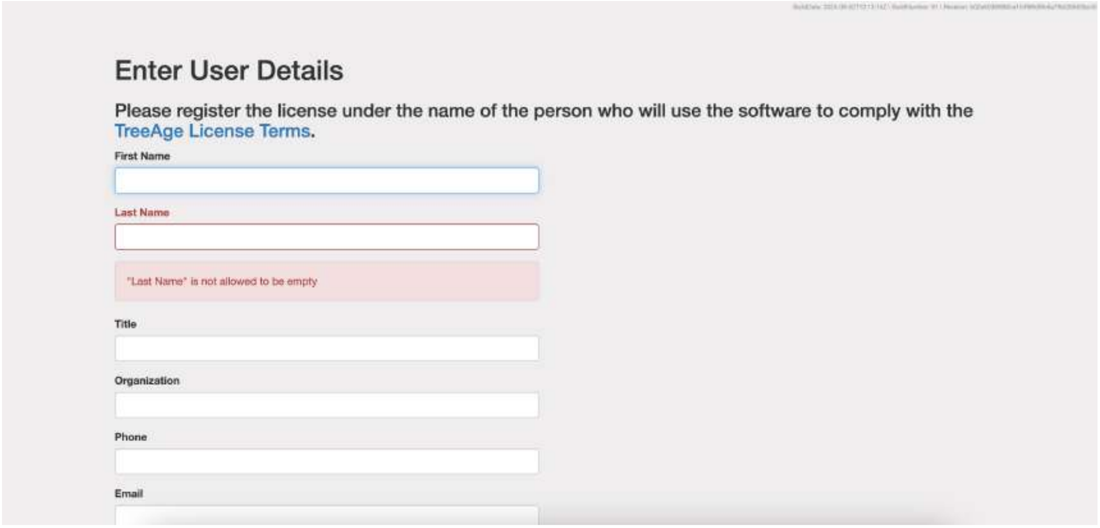
6.填寫黃色網底必填欄位之資料後
按OK(Save)



TreeAge 下載

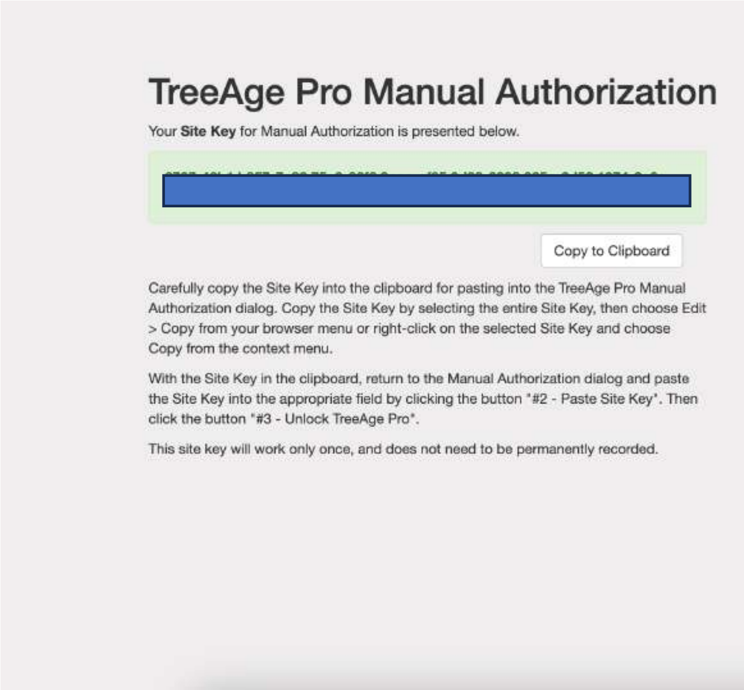


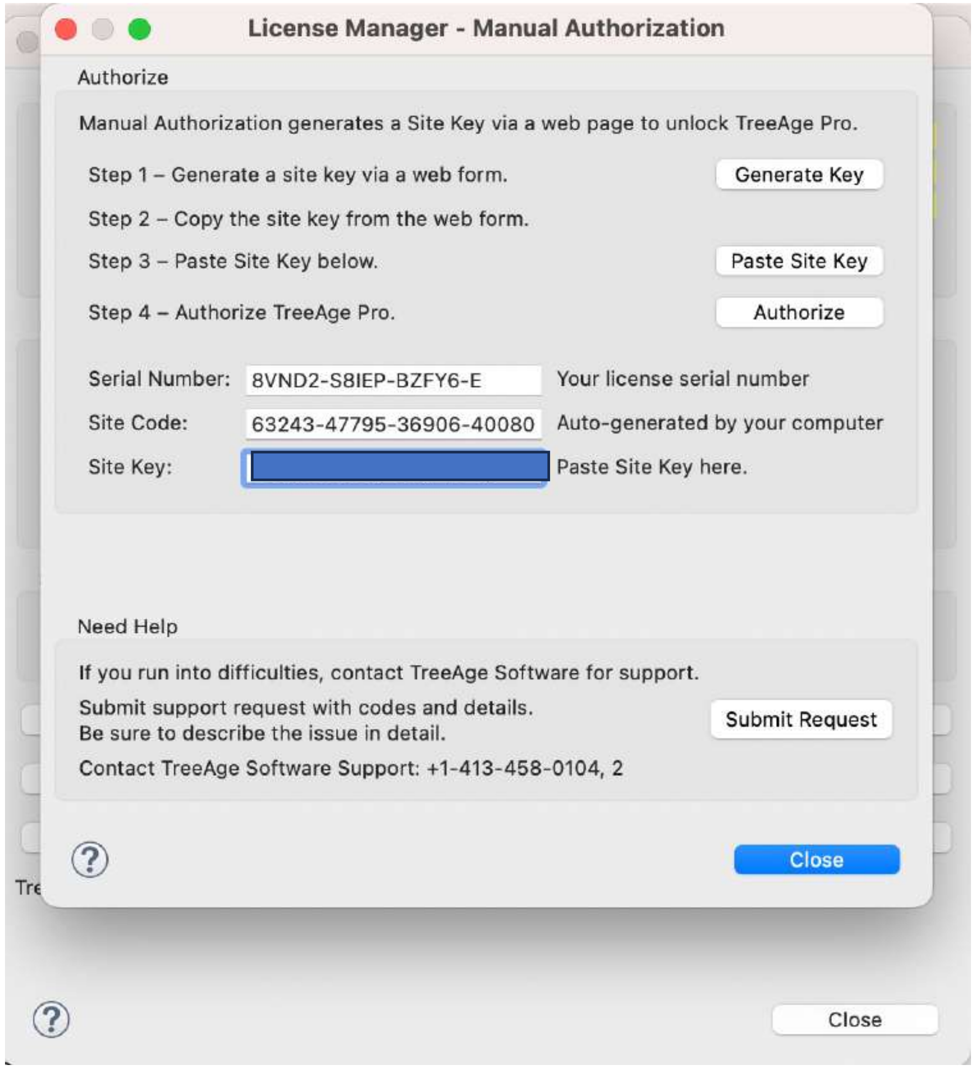
7.Generate Key ,跳到下面網站把資料填完



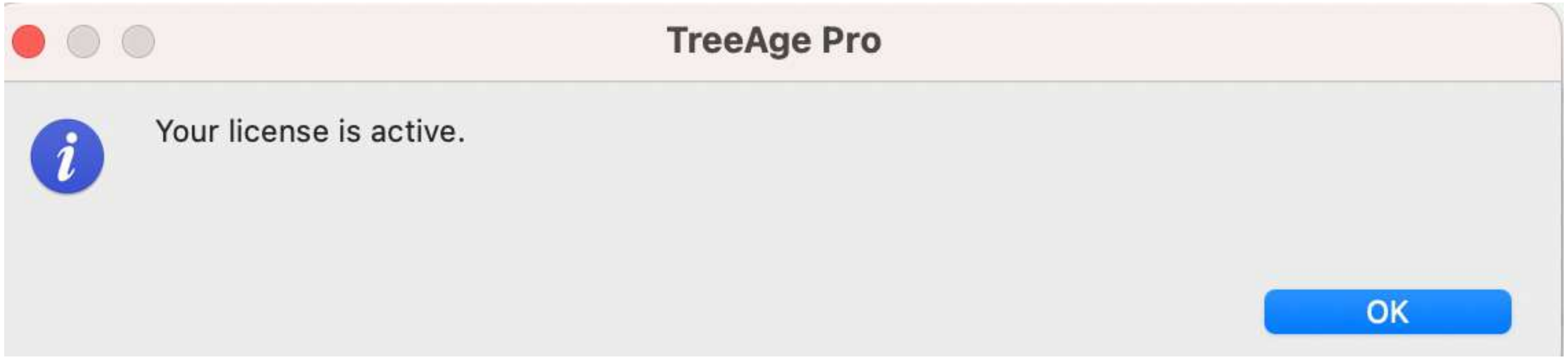
TreeAge 下載

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

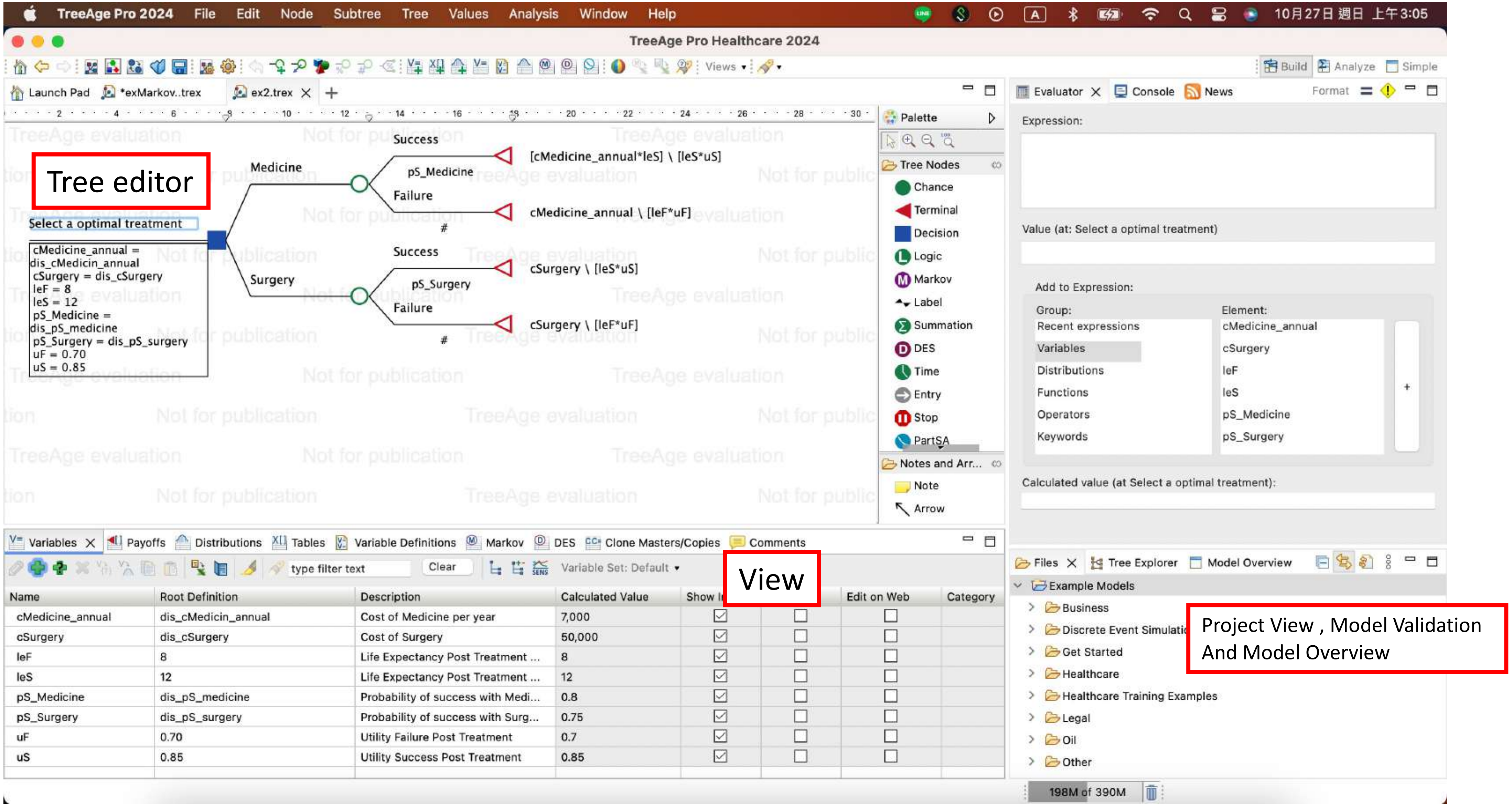




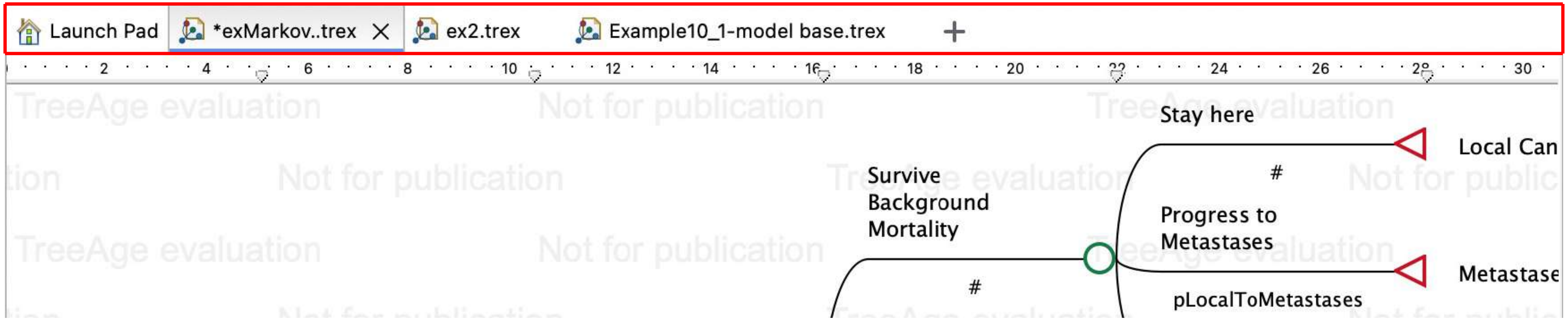
TreeAge 下載



Workbench


TreeAge Pro 2024 File Edit Node Subtree Tree Values Analysis Window Help
TreeAge Pro Healthcare 2024
Launch Pad
*exMarkov..trex
ex2.trex
Tree editor
Select a optimal treatment
Medicine
Surgery
Success
Failure
pS_Medicine
pS_Surgery
[cMedicine_annual*leS] \ [leS*uS]
cMedicine_annual \ [leF*uF]
cSurgery \ [leS*uS]
cSurgery \ [leF*uF]
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
Palette
Tree Nodes
Chance
Terminal
Decision
Logic
Markov
Label
Summation
DES
Time
Entry
Stop
PartSA
Notes and Arr...
Note
Arrow
Evaluator
Console
News
Expression:
Value (at: Select a optimal treatment)
Add to Expression:
Group:
Recent expressions
Variables
Distributions
Functions
Operators
Keywords
Element:
cMedicine_annual
cSurgery
leF
leS
pS_Medicine
pS_Surgery
Calculated value (at Select a optimal treatment):
Variables
Payoffs
Distributions
Tables
Variable Definitions
Markov
DES
Clone Masters/Copies
Comments
View
Name
Root Definition
Description
Calculated Value
Edit on Web
Category
cMedicine_annual dis_cMedicin_annual Cost of Medicine per year 7,000
cSurgery dis_cSurgery Cost of Surgery 50,000
leF 8 Life Expectancy Post Treatment ... 8
leS 12 Life Expectancy Post Treatment ... 12
pS_Medicine dis_pS_medicine Probability of success with Medi... 0.8
pS_Surgery dis_pS_surgery Probability of success with Surg... 0.75
uF 0.70 Utility Failure Post Treatment 0.7
uS 0.85 Utility Success Post Treatment 0.85
Files
Tree Explorer
Model Overview
Example Models
Business
Get Started
Healthcare
Healthcare Training Examples
Legal
Oil
Other
Project View , Model Validation
And Model Overview
198M of 390M

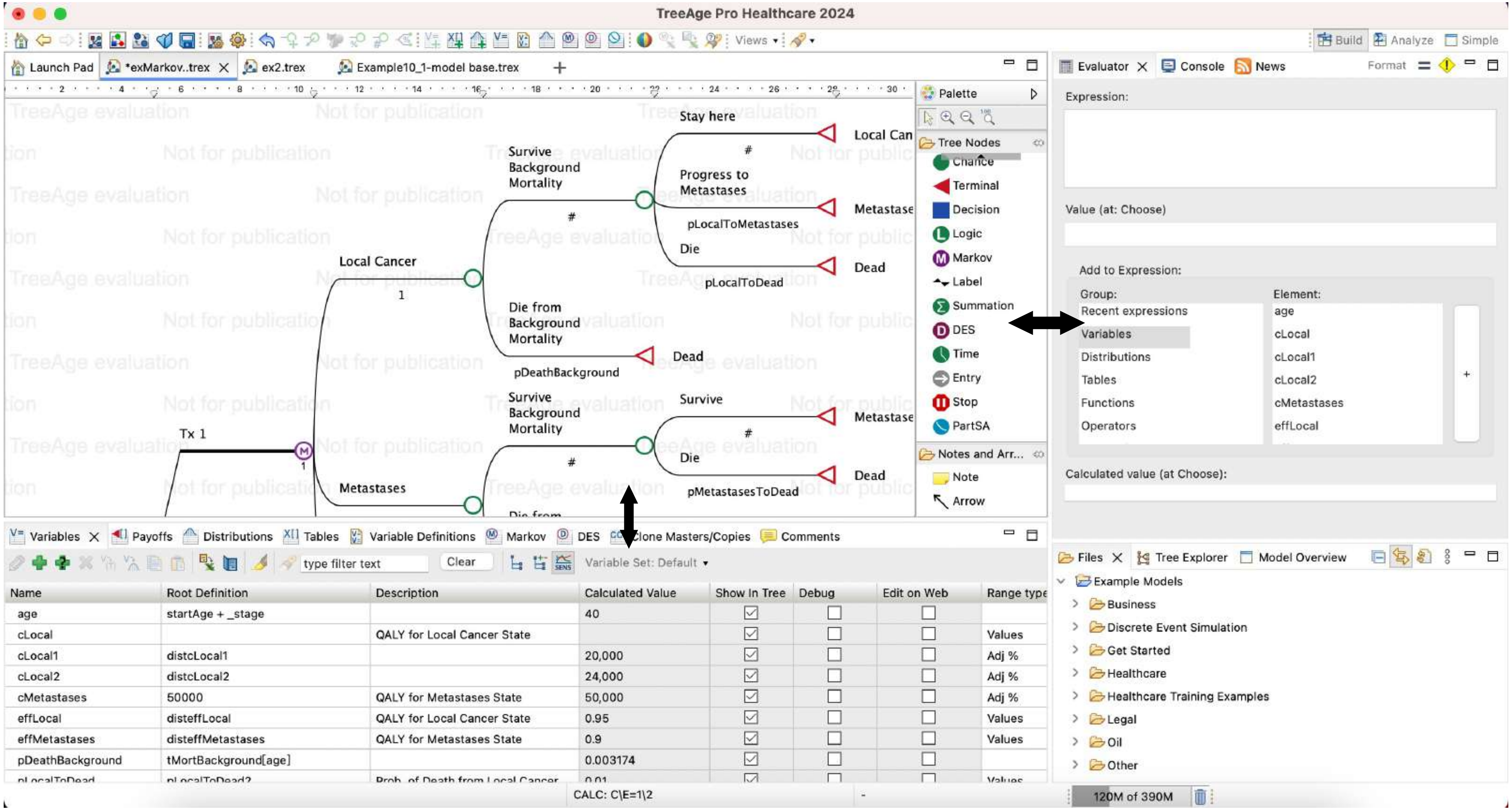
Workbench-Tree Diagram Editor



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.

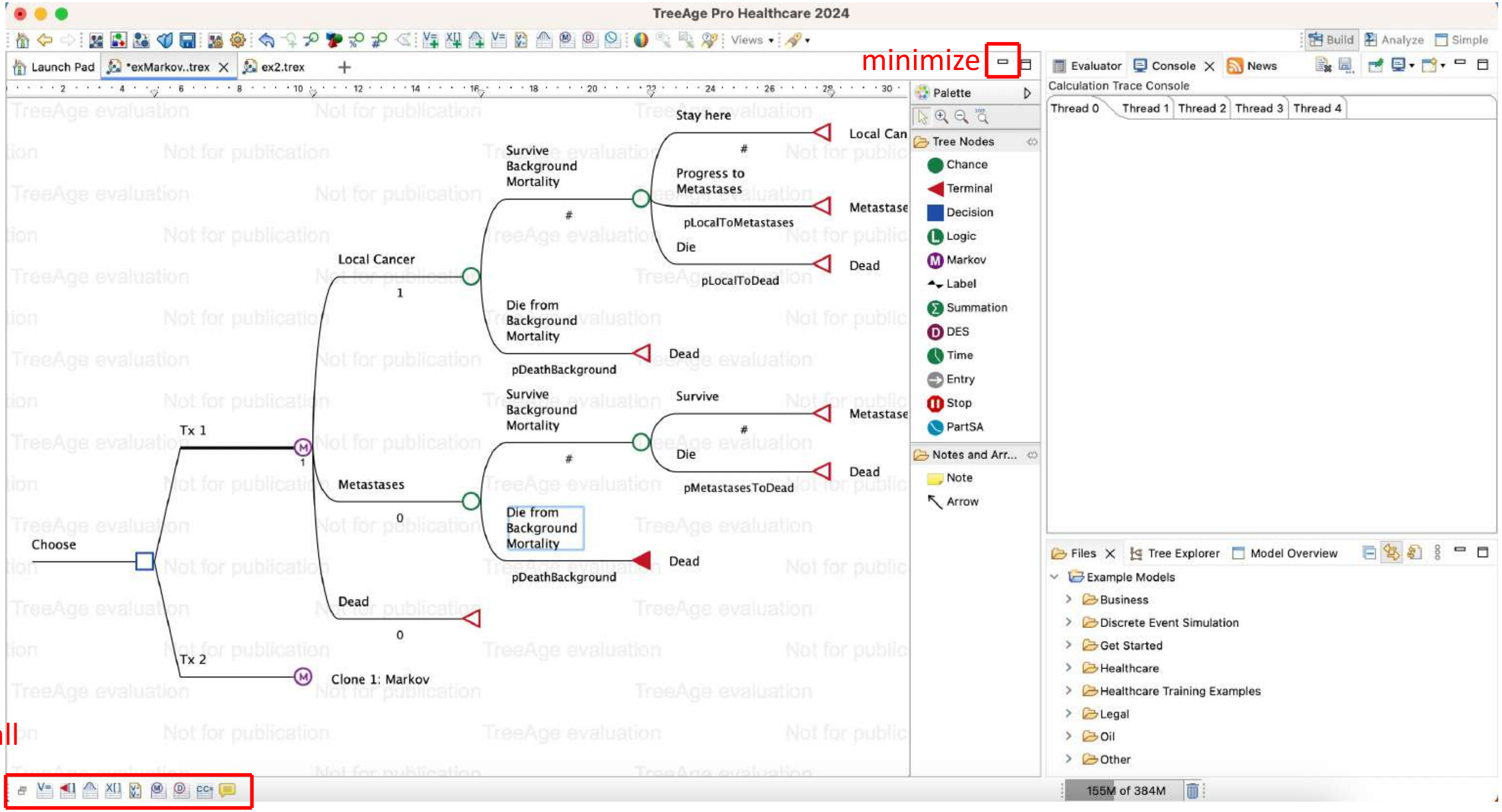
Workbench

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



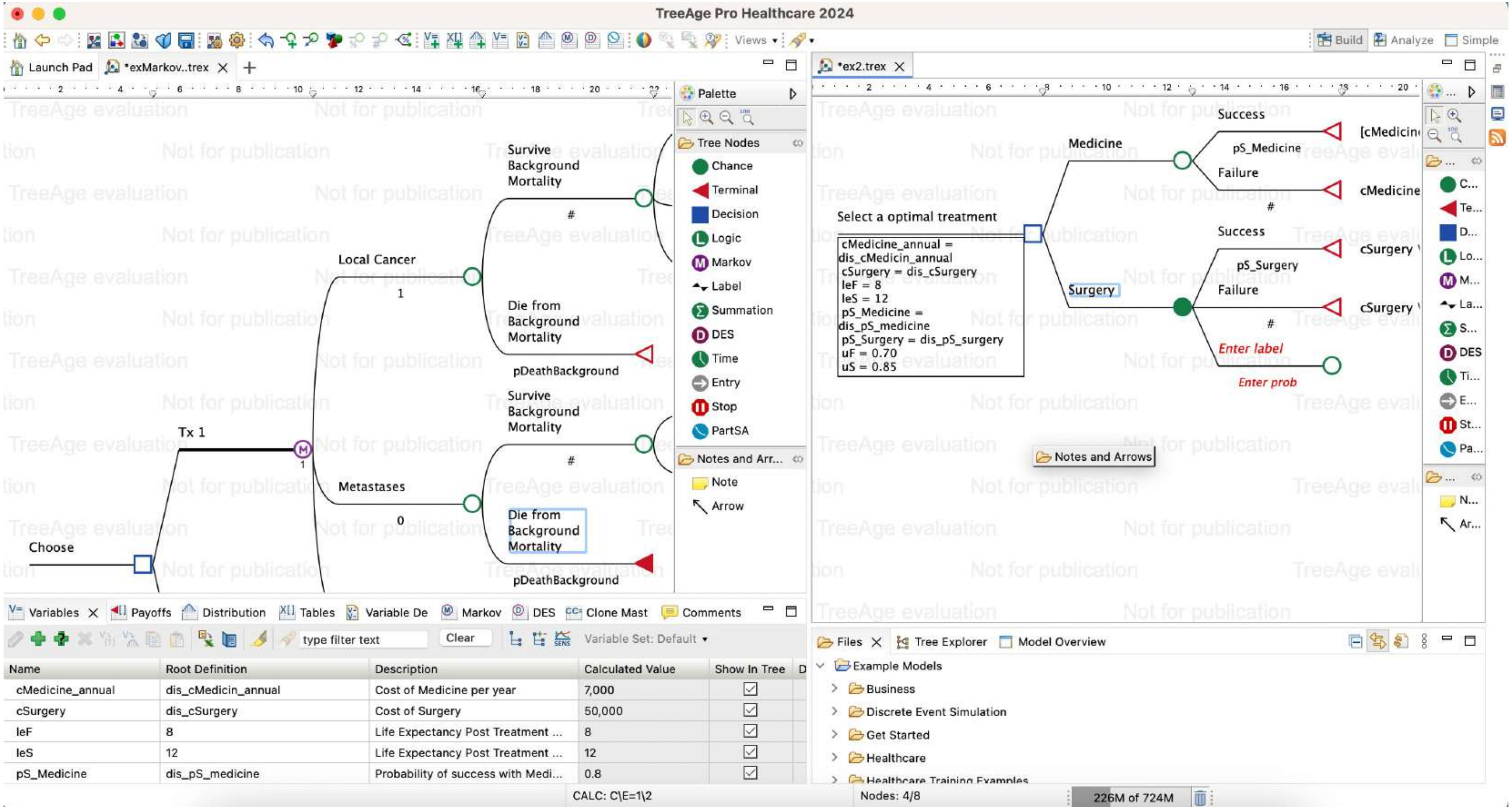
Workbench

minimize



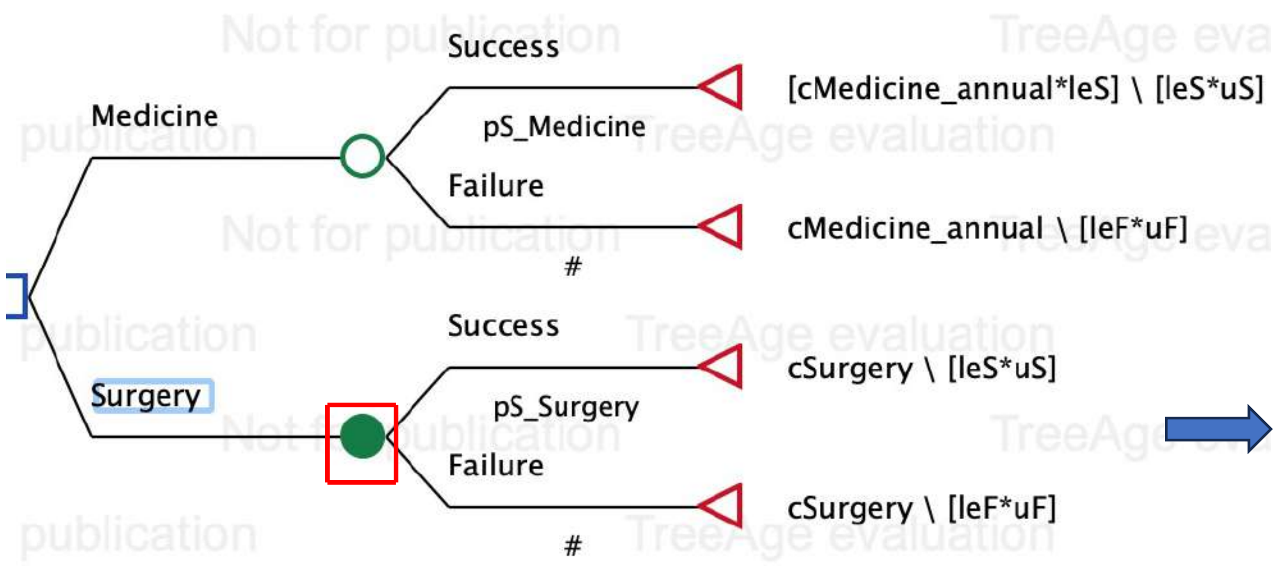
Restore one or all

Workbench

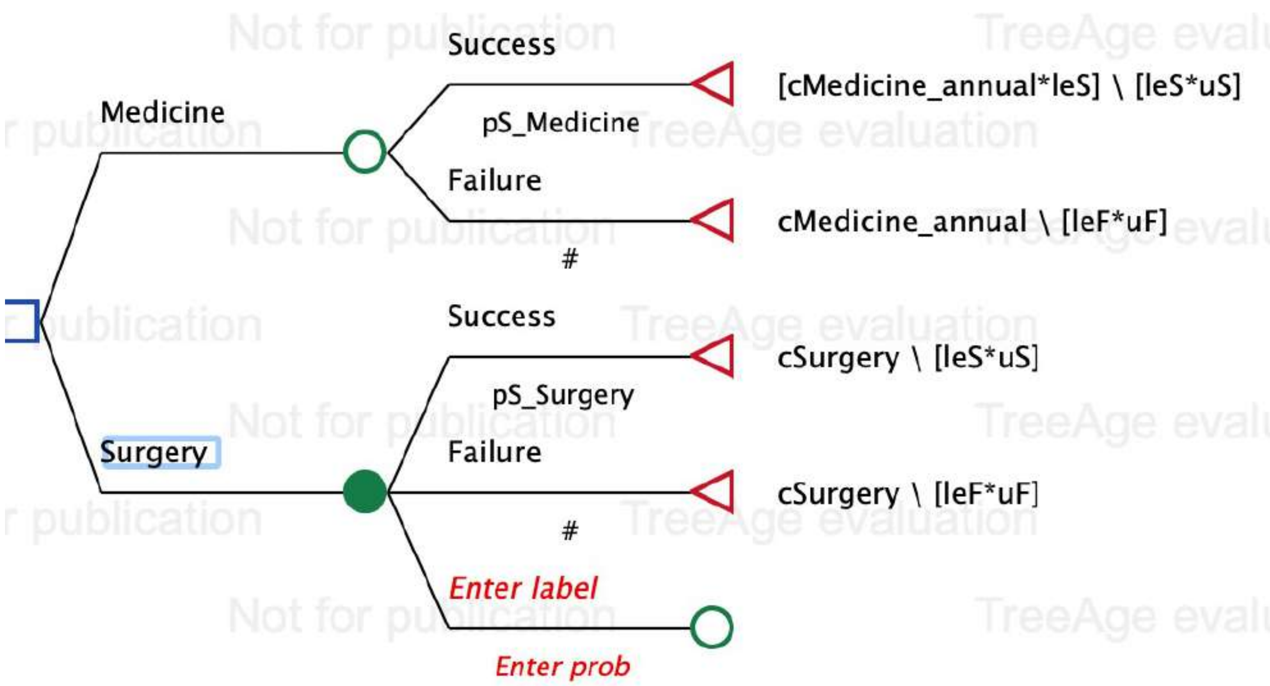


TreeAge Pro Healthcare 2024
Launch Pad
*exMarkov..trex
*ex2.trex
Palette
Tree Nodes
Chance
Terminal
Decision
Logic
Markov
Label
Summation
DES
Time
Entry
Stop
PartSA
Notes and Arr...
Note
Arrow
Survive Background Mortality
Local Cancer
Die from Background Mortality
pDeathBackground
Metastases
Tx 1
Choose
Select a optimal treatment
Medicine
Surgery
Success
Failure
pS_Medicine
pS_Surgery
Enter label
Enter prob
Notes and Arrows
Variables
Payoffs
Distribution
Tables
Markov
DES
Comments
type filter text
Clear
Variable Set: Default
Name
Root Definition
Description
Calculated Value
Show In Tree
cMedicine_annual
dis_cMedicin_annual
Cost of Medicine per year
7,000
cSurgery
dis_cSurgery
Cost of Surgery
50,000
Files
Tree Explorer
Model Overview
Example Models
Business
Discrete Event Simulation
Get Started
Healthcare
CALC: C\E=1\2
Nodes: 4/8
226M of 724M

Workbench



點兩下新增



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

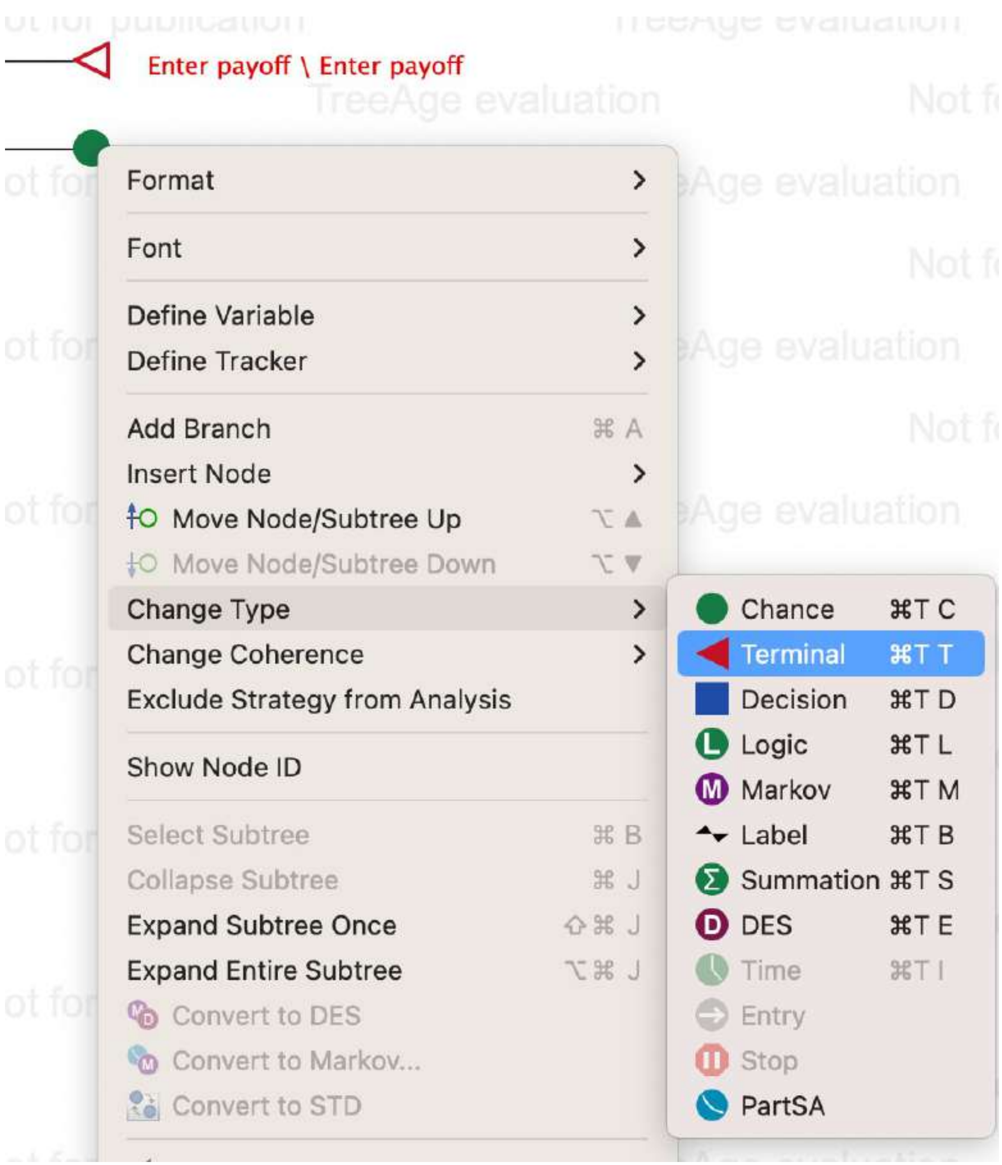
- non-Markov: End point for a scenario within the model
-Markov: End point for a cycle

Markov

- Indicates the start of Markov model

Change Node Types

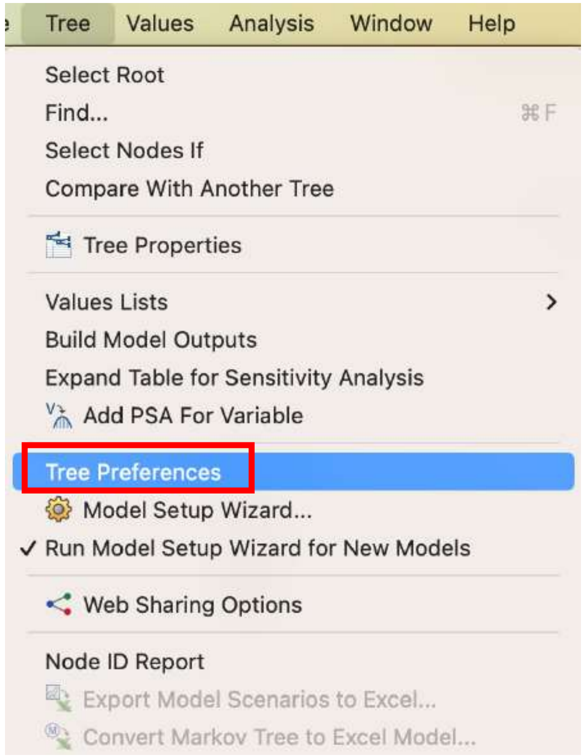
按住Node/右鍵/Change Type

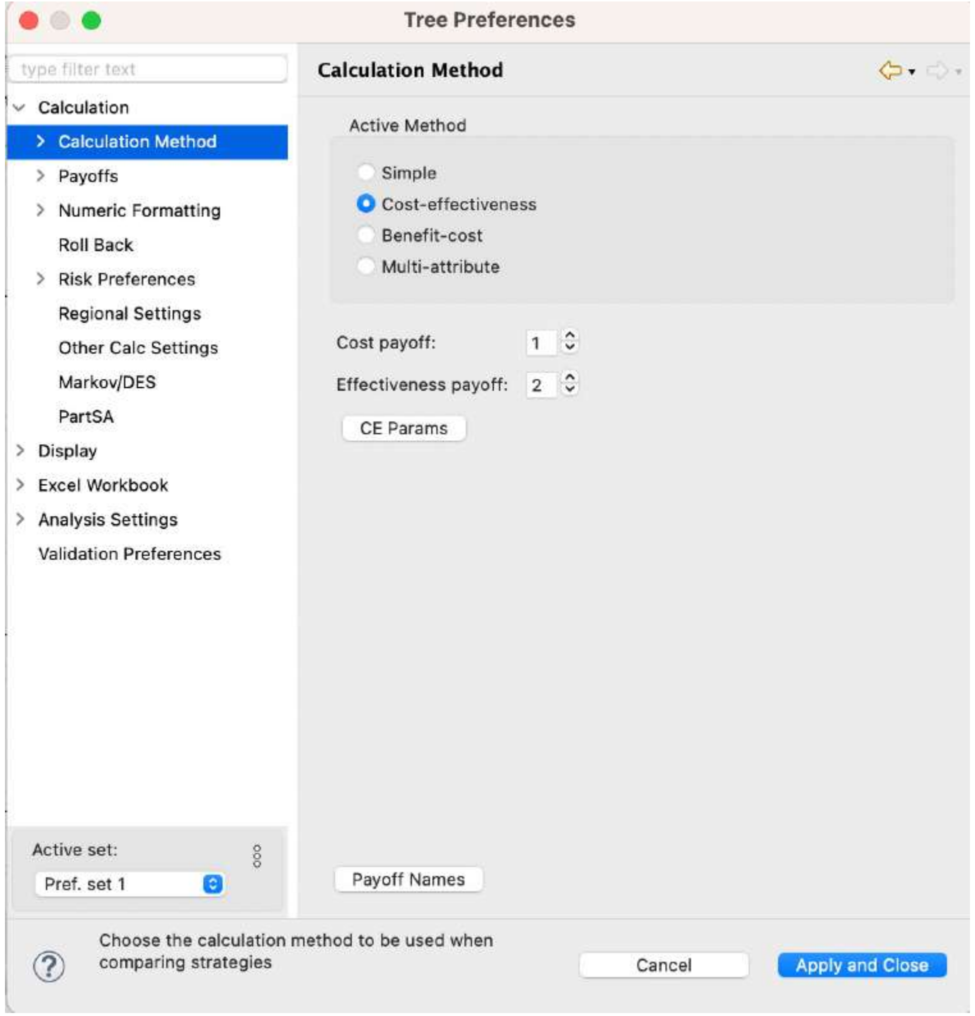


Tree Preferences

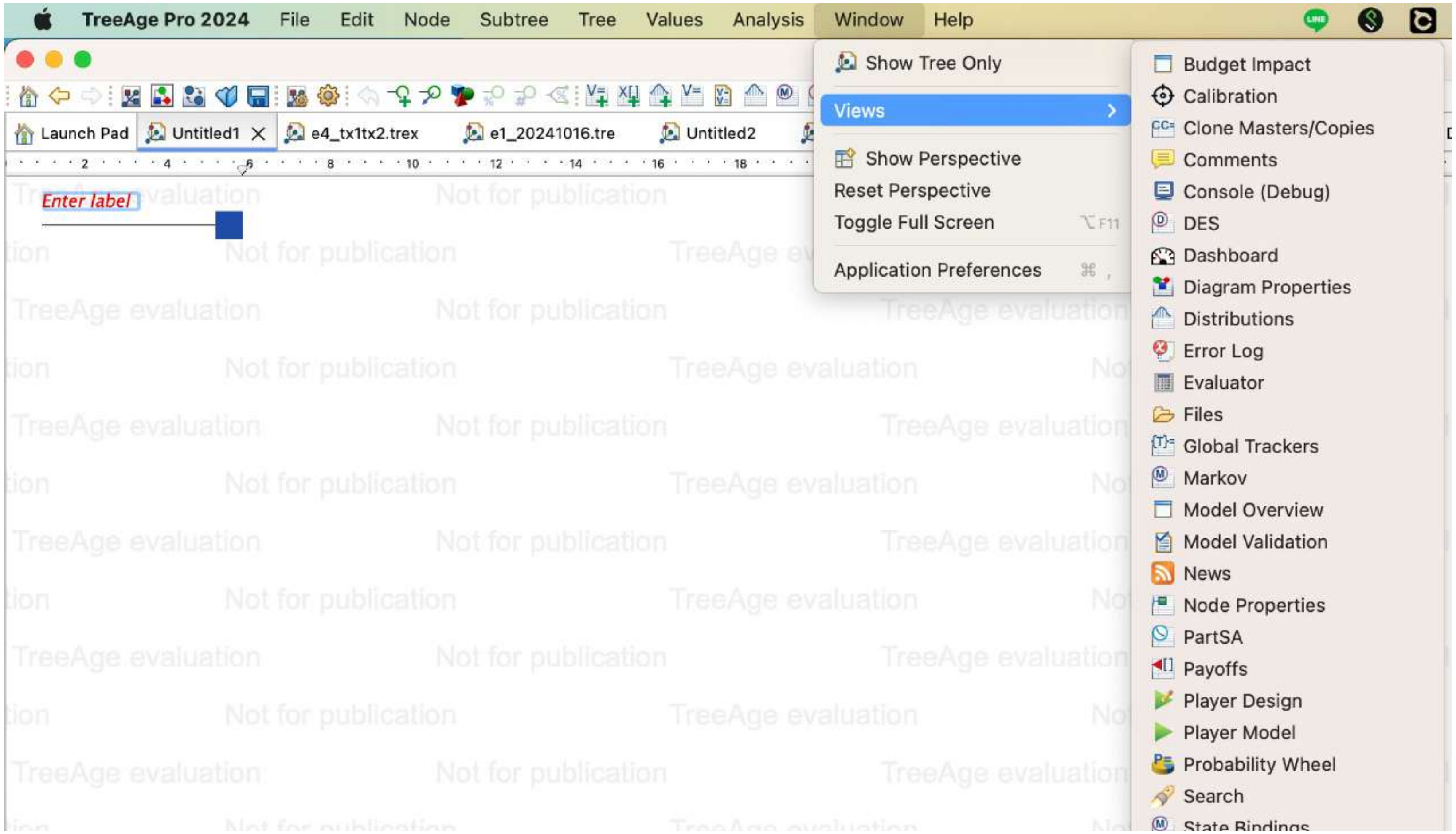
- To compare strategies on the basis of cost-effectiveness

- Calculation Method: Cost-effectiveness
- Two active payoffs (cost and effectiveness)
- Willingness-to-Pay (WTP)





Views


TreeAge Pro 2024
File
Edit
Node
Subtree
Tree
Values
Analysis
Window
Help
Launch Pad
Untitled1
e4_tx1tx2.trex
e1_20241016.tre
Untitled2
Enter label
TreeAge evaluation
Not for publication
Show Tree Only
Views
Show Perspective
Reset Perspective
Toggle Full Screen
Application Preferences
Budget Impact
Calibration
Clone Masters/Copies
Comments
Console (Debug)
DES
Dashboard
Diagram Properties
Distributions
Error Log
Evaluator
Files
Global Trackers
Markov
Model Overview
Model Validation
News
Node Properties
PartSA
Payoffs
Player Design
Player Model
Probability Wheel
Search
State Bindings

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

Variables | Payoffs | Distributions | Tables | Variable Definitions | Markov | DES | Clone Masters/Copies | Co

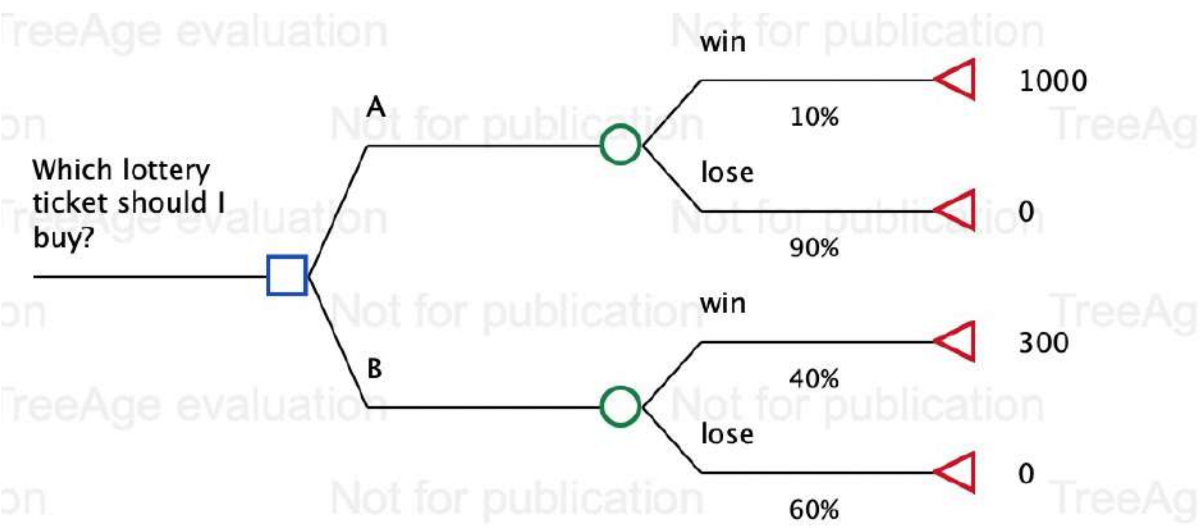
type filter text | Clear | Variable Set: Default

Name	Root Definition	Description	Calculated Value	Show In Tree
age	startAge + _stage		17.5	☑
cLocal	cLocal2	QALY for Local Cancer State	24,333.33333333...	☑
cLocal1	distcLocal1		20,000	☑
cLocal2	distcLocal2		24,333.33333333...	☑
cMetastases	50000	QALY for Metastases State	50,000	☑
effLocal	disteffLocal	QALY for Local Cancer State	0.96	☑
effMetastases	disteffMetastases	QALY for Metastases State	0.88	☑

❑ 單元六：Decision Tree in TreeAge

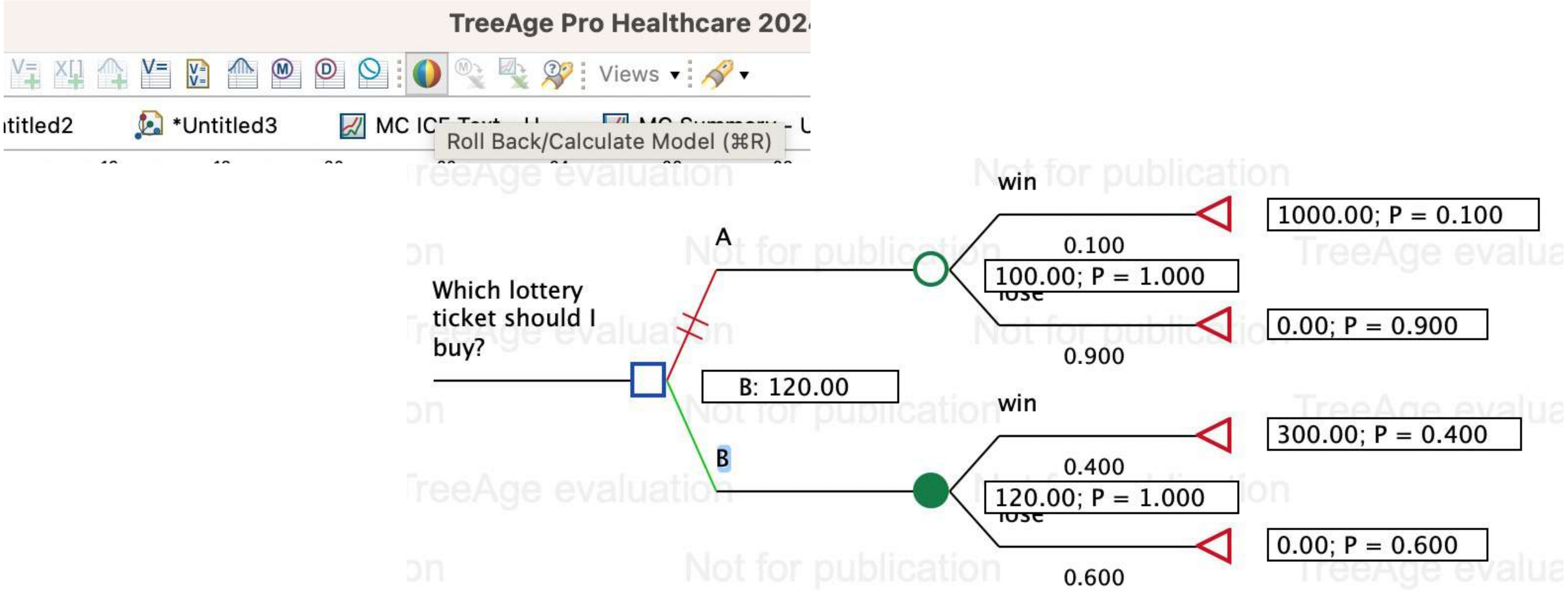
Example 1: A decision about playing a lottery

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.



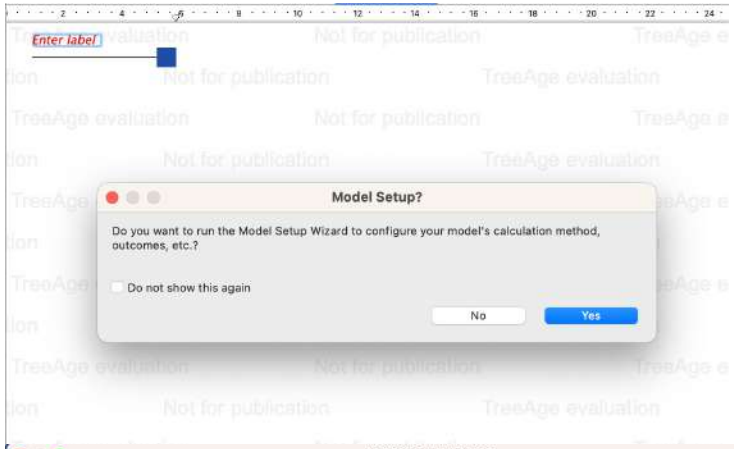
Example 2:Select a optimal treatment

- 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

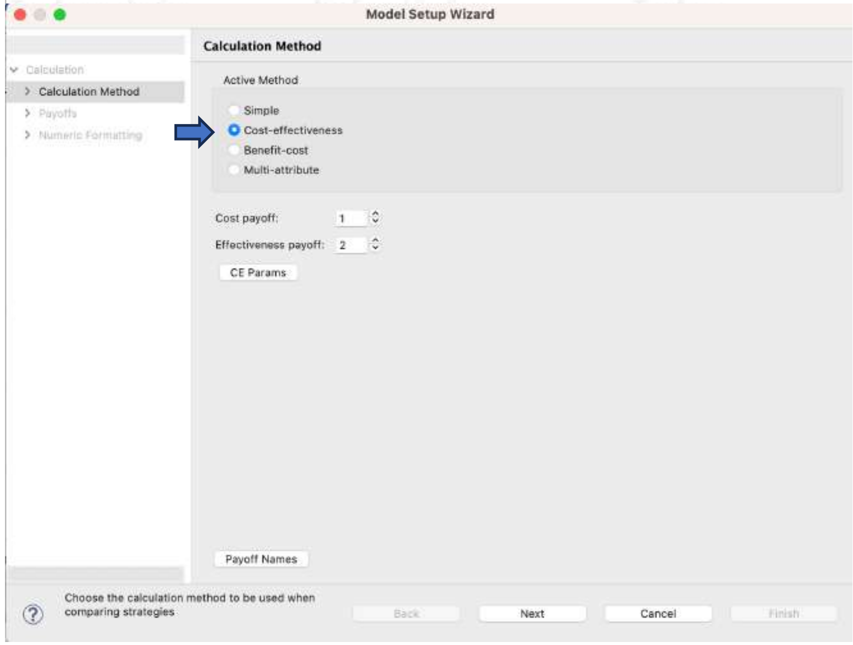
Question	Answer for this example
What is the underlying problem?	Patients with disease X have historically only had one treatment option. A new treatment has become available. We want to identify the most cost-effective treatment for patients with disease X.
What are our strategies/options?	1. Medicine (new treatment) 2. Surgery (standard of care)
How do we measure the outcomes associated with these strategies?	Cost is measured in NT$ Effectiveness is measured in QALYs

Example 2-Model Setup

1.



2.



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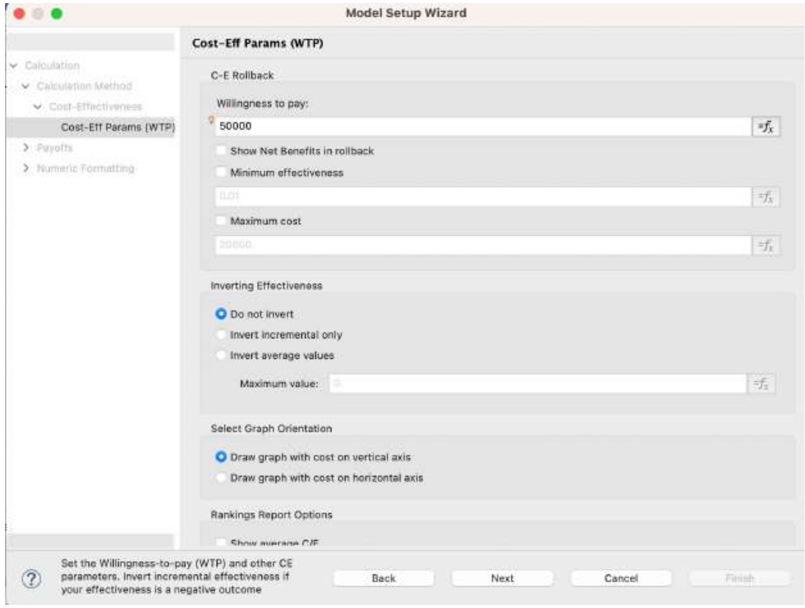

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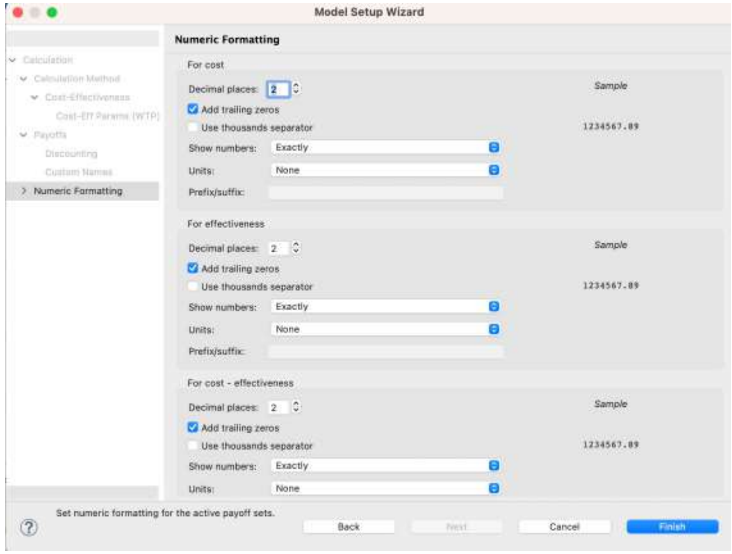
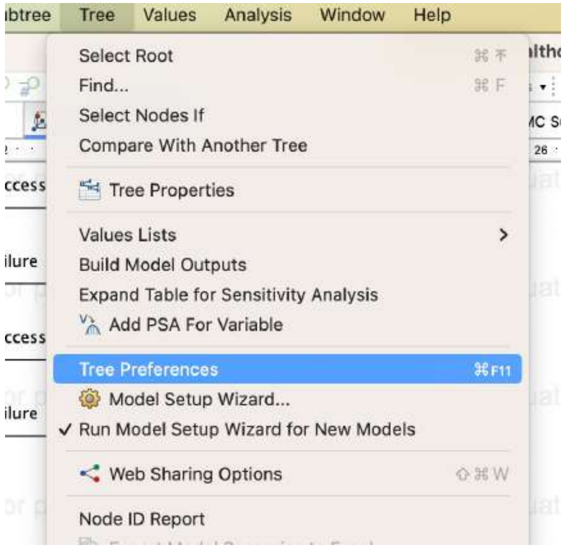
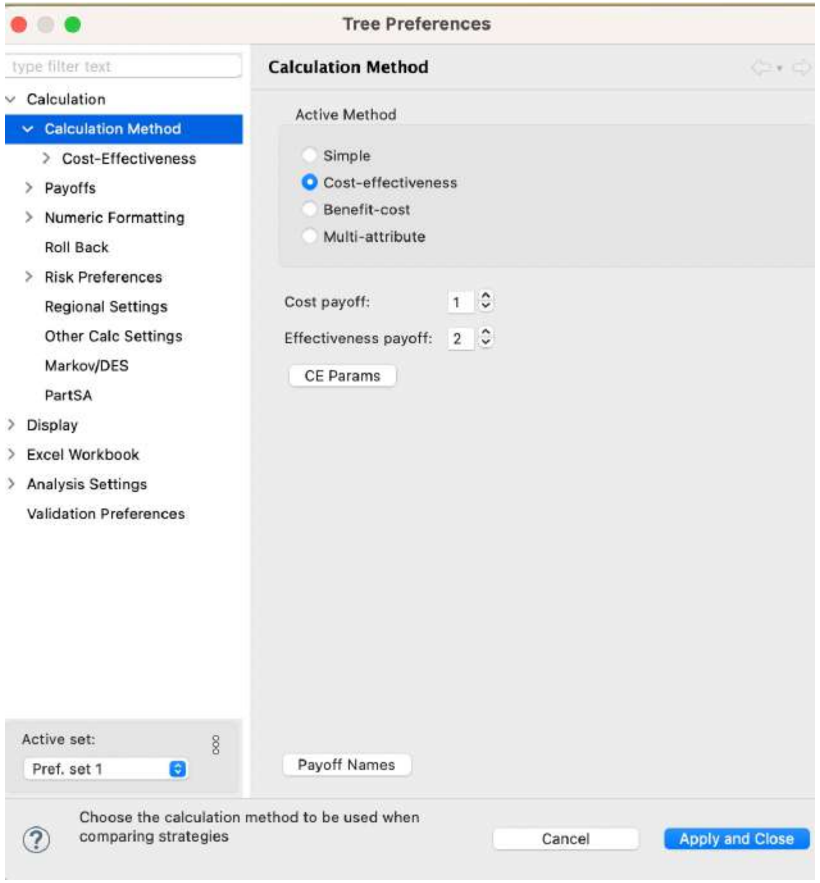
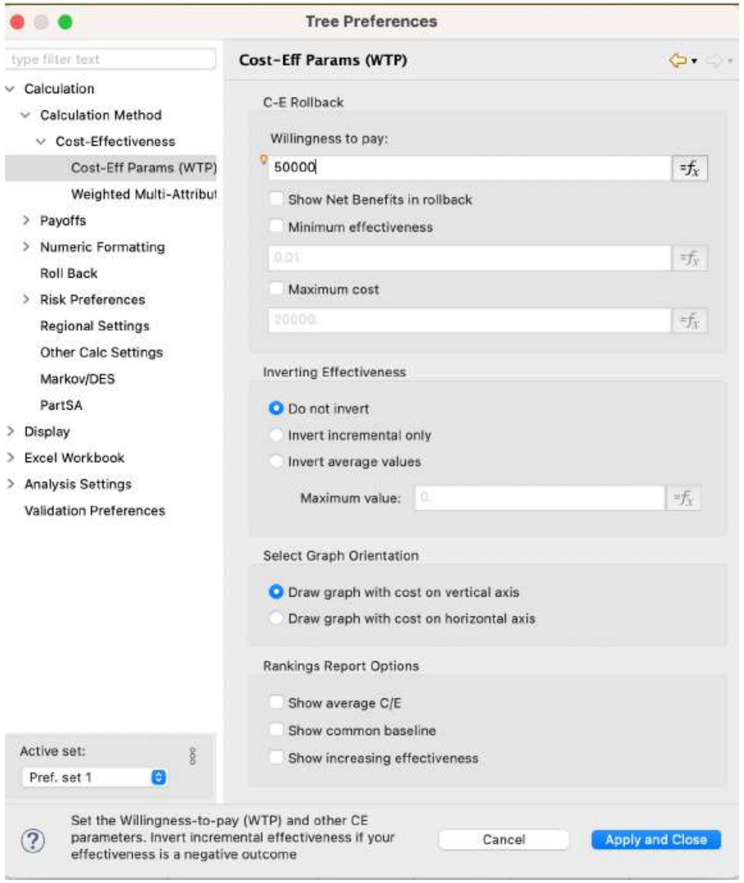


Example 2-Model Setup

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



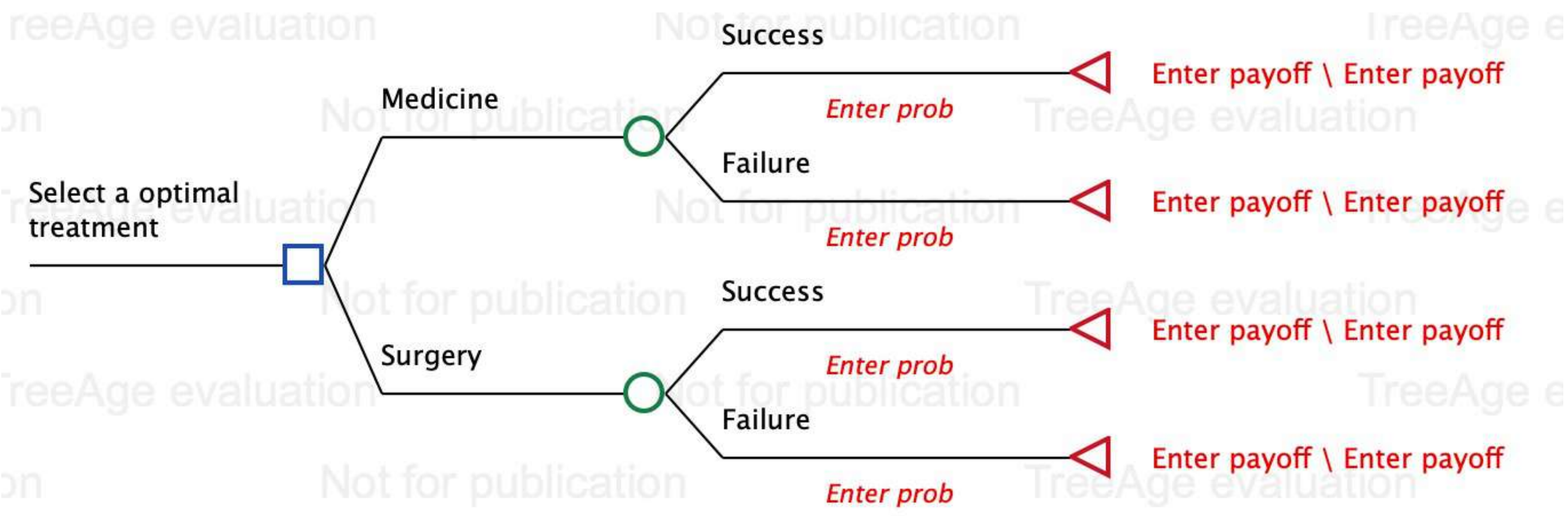




Example 2-Model Setup

- Develop the model

- define patient pathways for each strategy



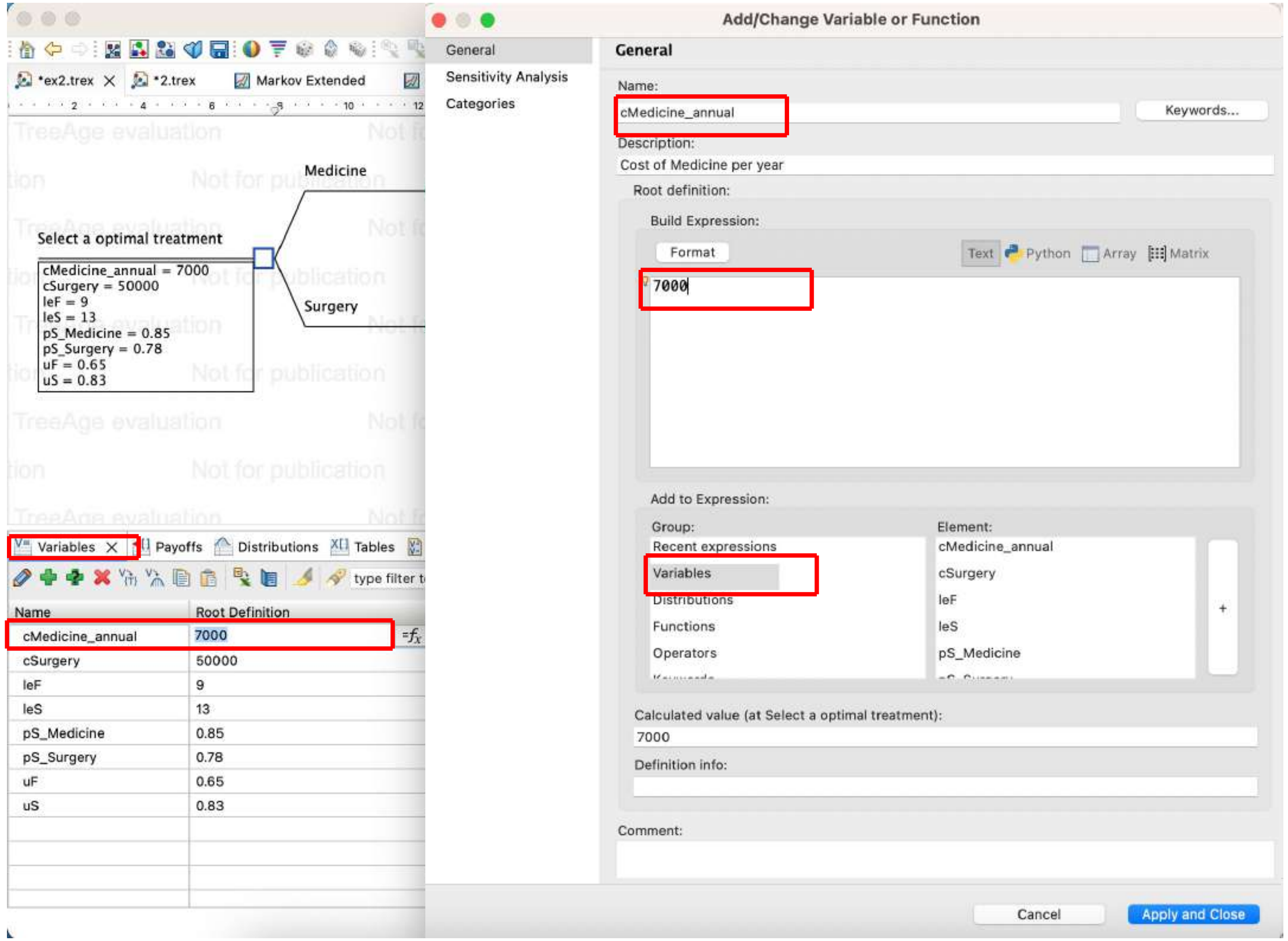
Example 2-Parameter definition and estimation

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.

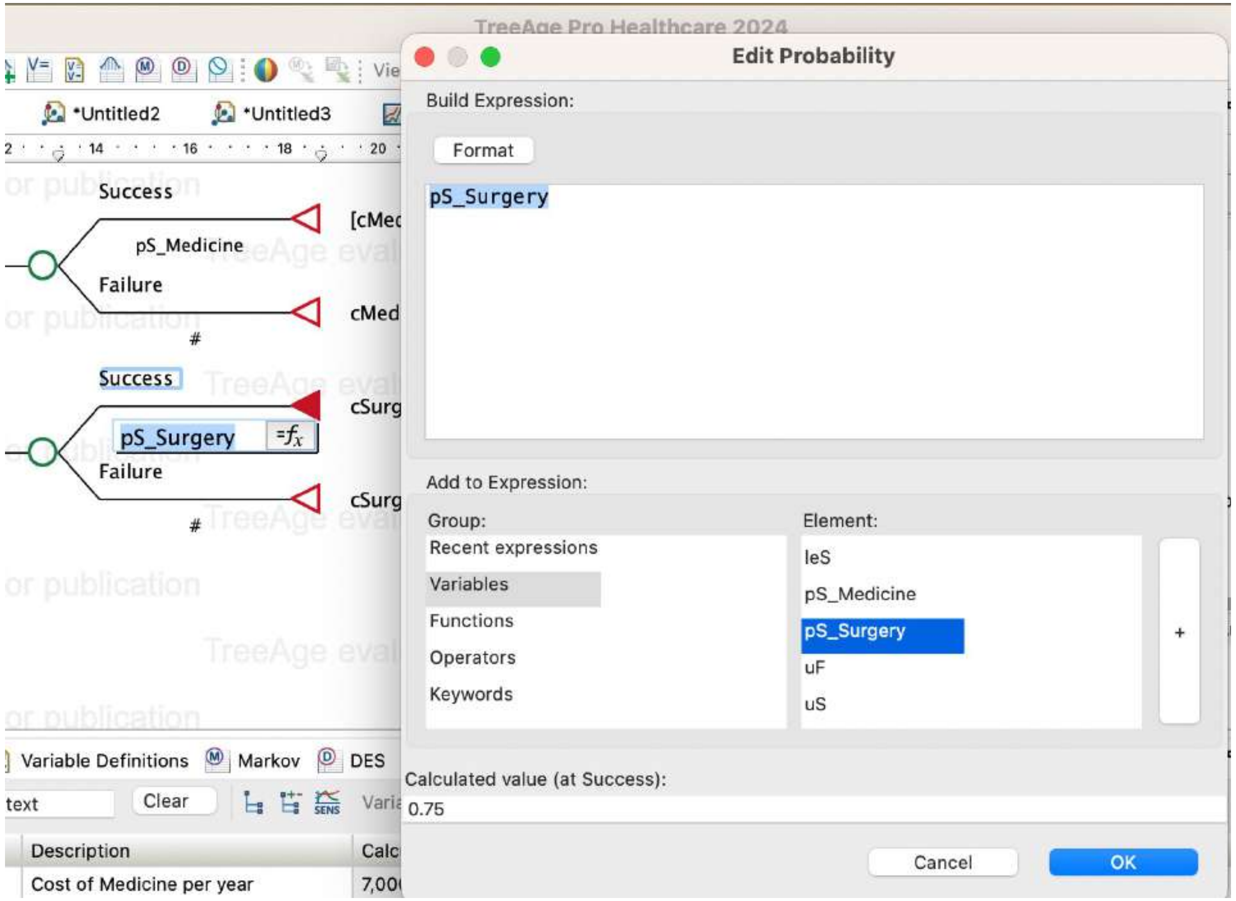
Example 2-Add variables at the root node

- 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 "#"

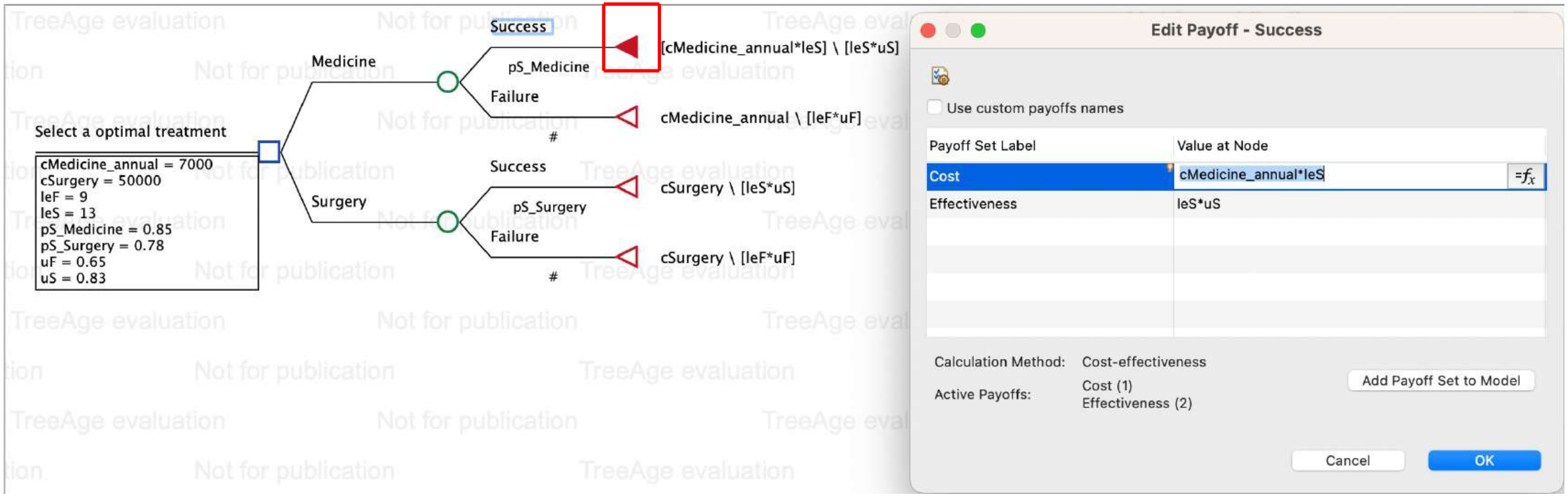


Example 2- Define outcome measures

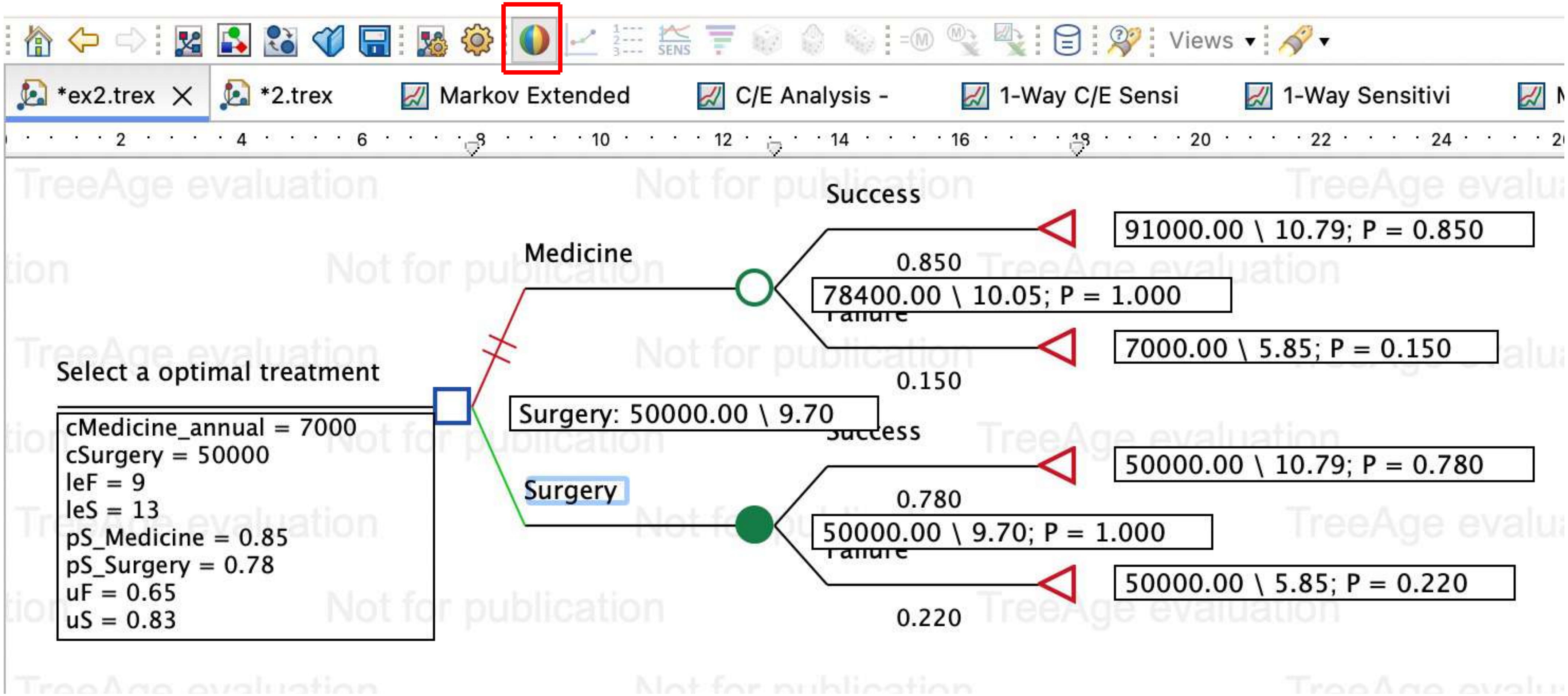
Treatment	Consequence	Costs*	Effectiveness (QALYs)
Medicine	success	cMedicine_ annual*leS =7,000*13	leS*uS =13*0.83
	failure	cMedicine_annual =7,000	leF*uF =9*0.65
Surgery	success	cSurgery=50,000	leS*uS =13*0.83
	failure	cSurgery=50,000	leF*uF =9*0.65

* 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.

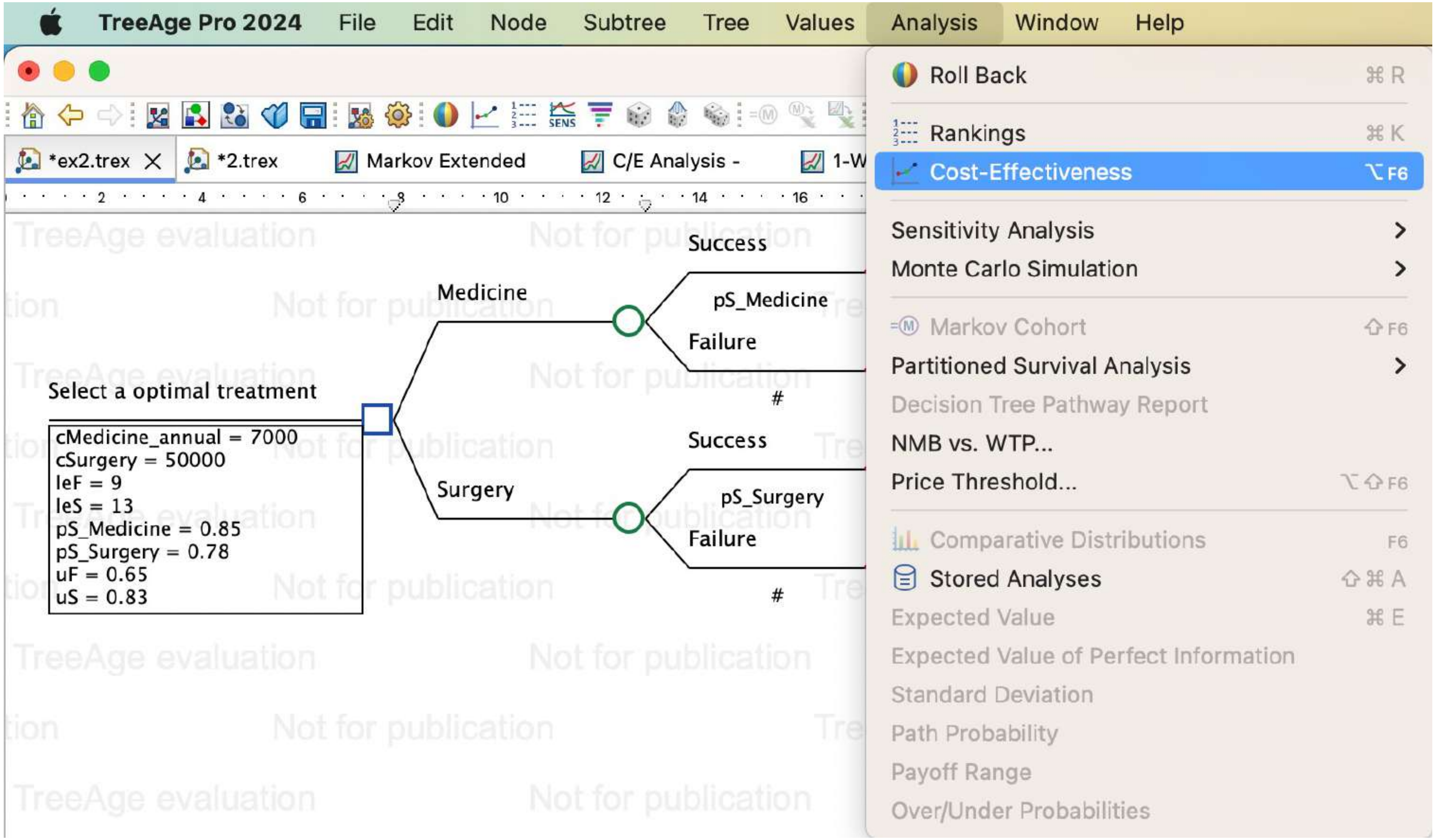
Example 2- Add outcome measures



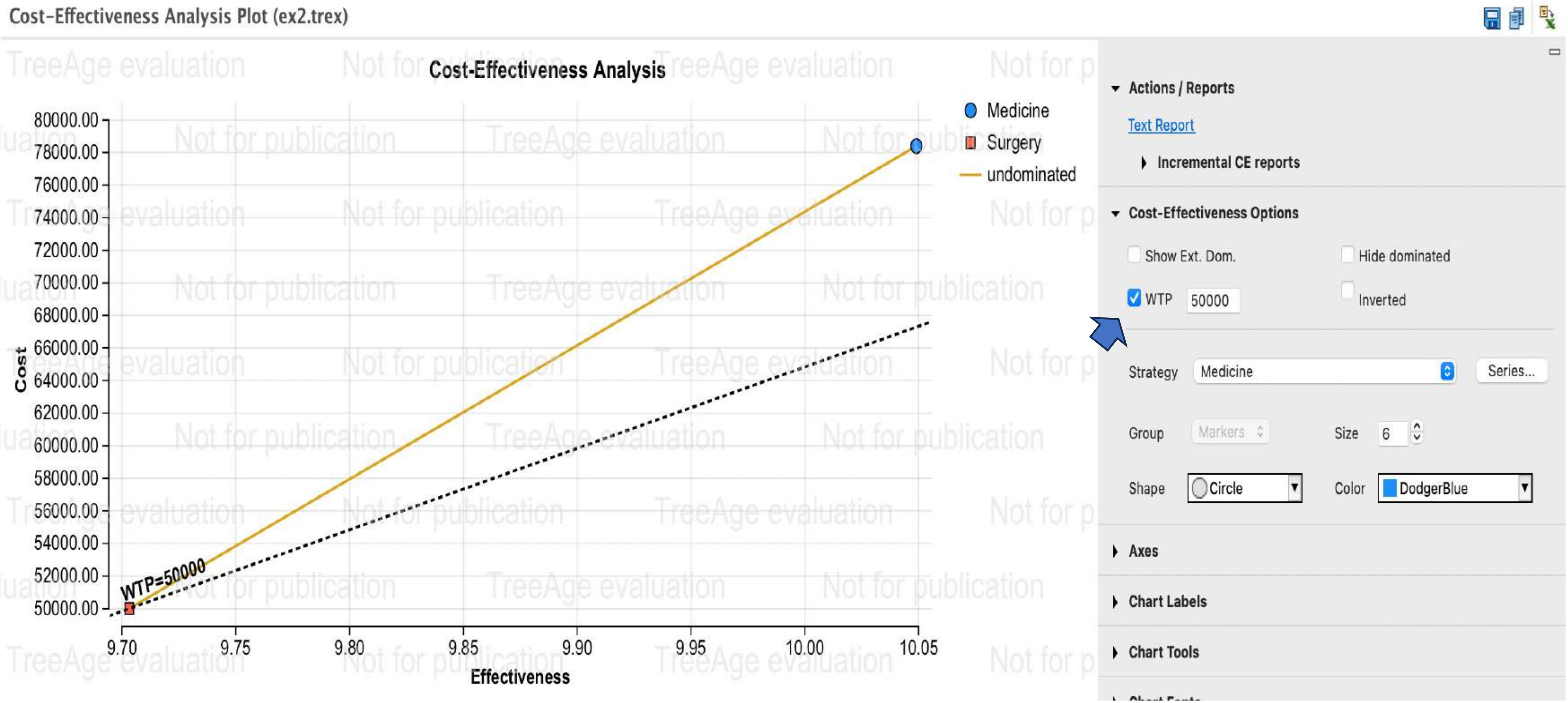
Example 2- Analyze the tree (run Roll Back)



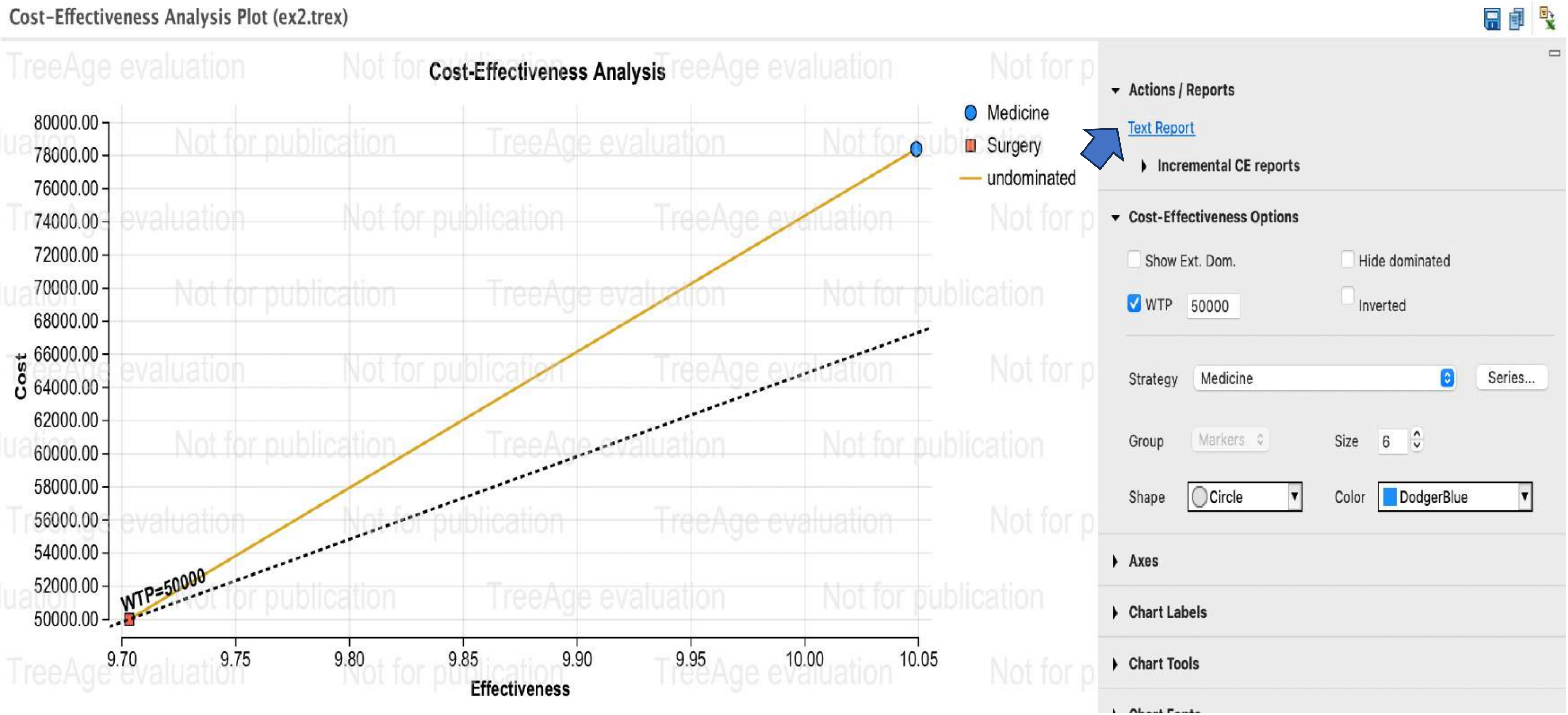
Example 2- Analyze the tree (run Cost-Effectiveness)



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

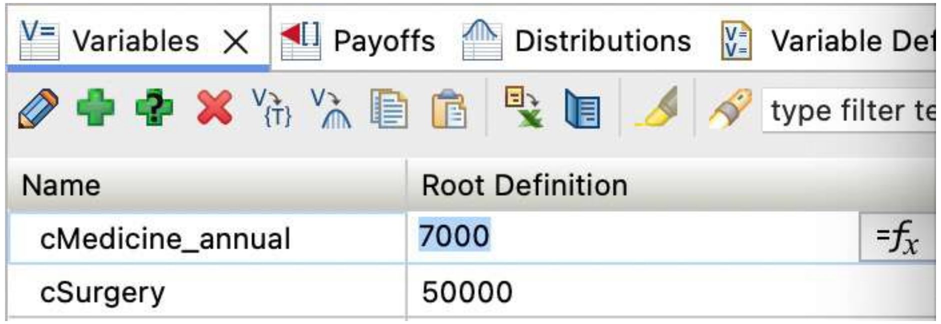
- Net Monetary Benefits (NMB) = Effectiveness * WTP - Cost
- Net Health Benefits (NHB) = Effectiveness - Cost / WTP

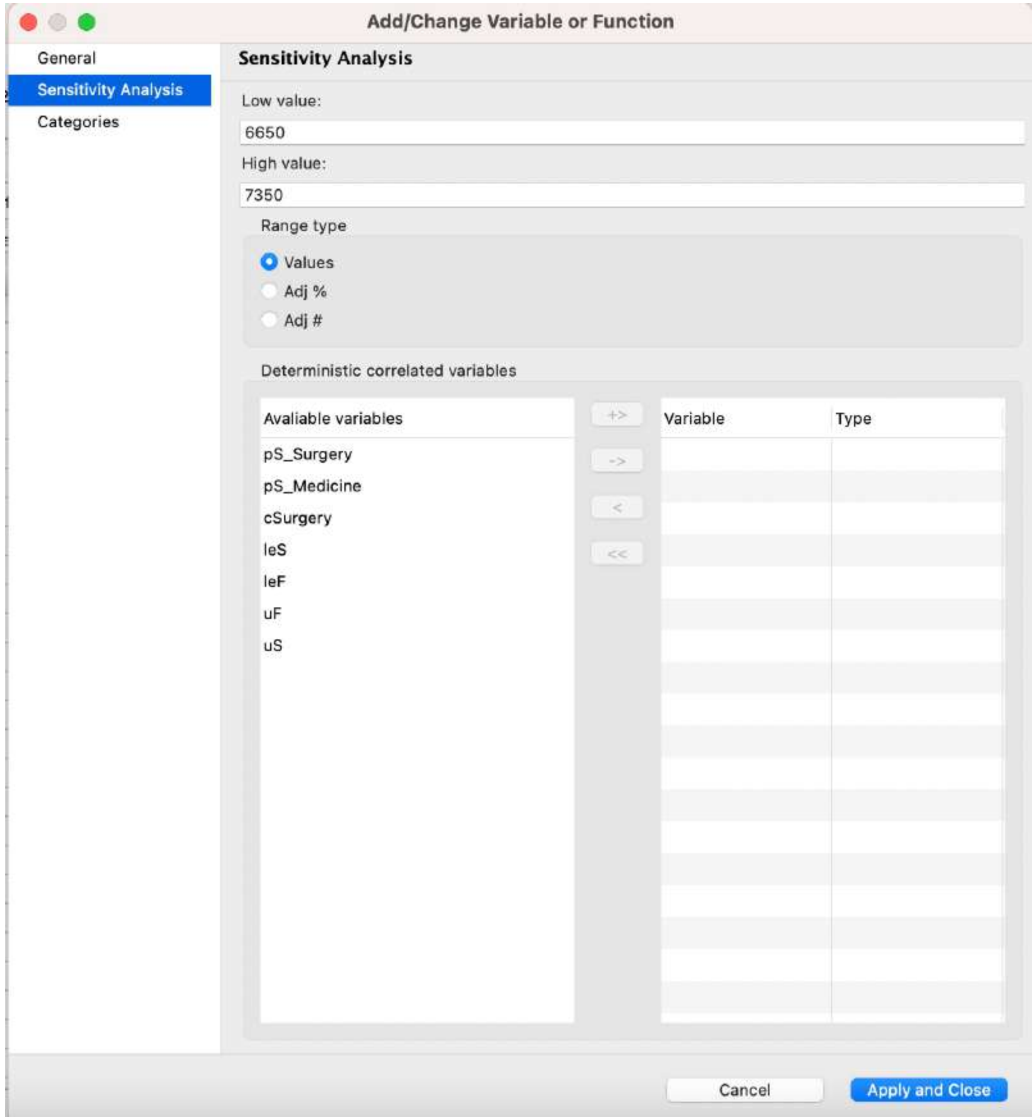
What if the willingness to pay threshold is 100,000/QALY?

❑ 單元七：
Sensitivity Analysis

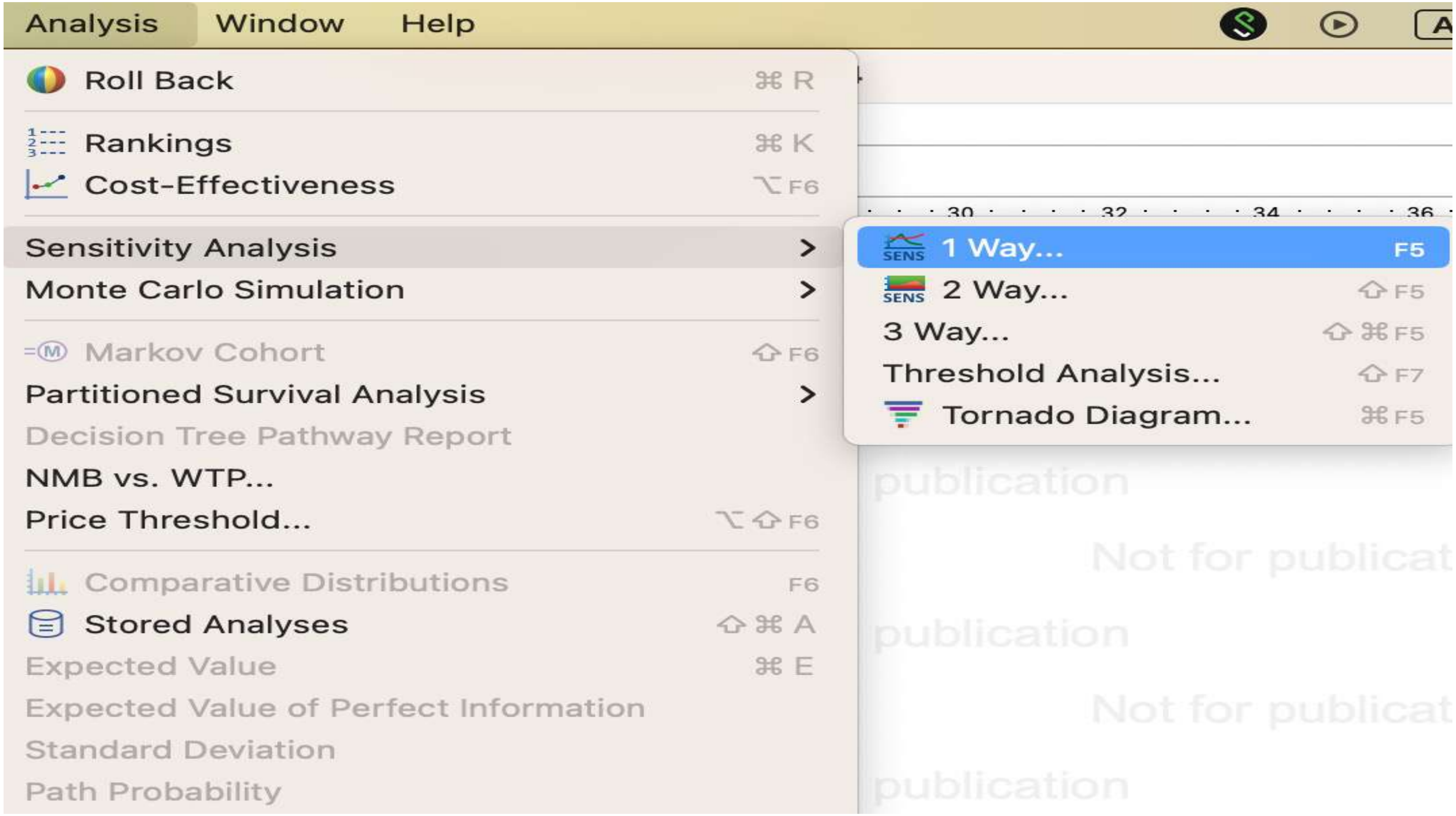
Example 2-One-way Sensitive Analysis

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)

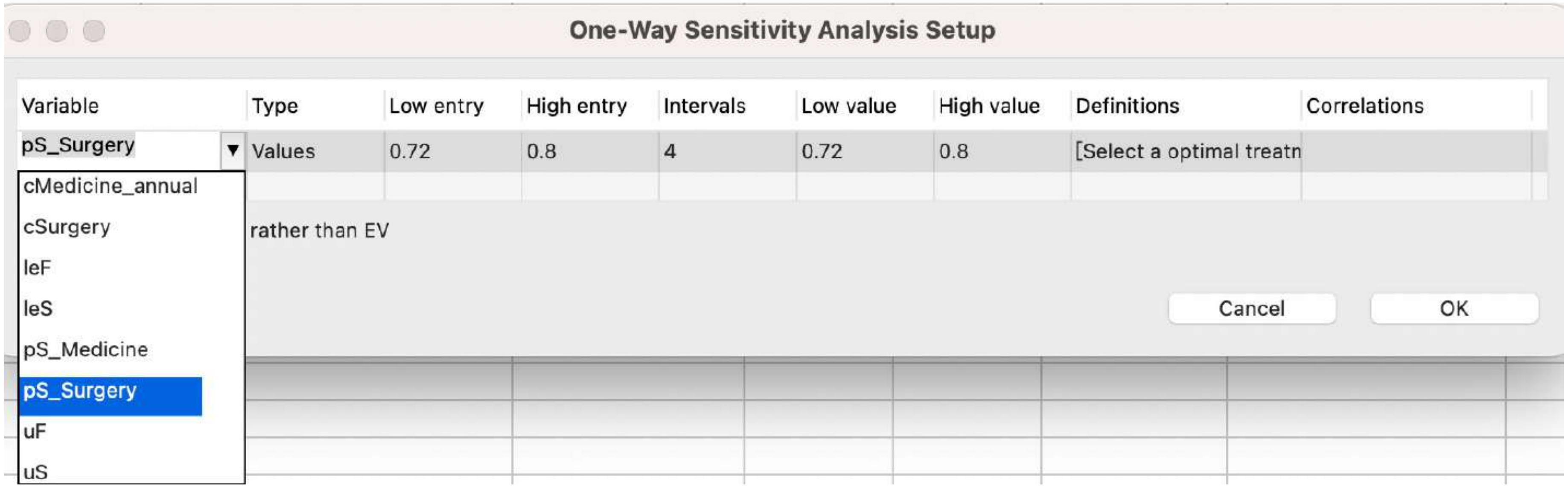


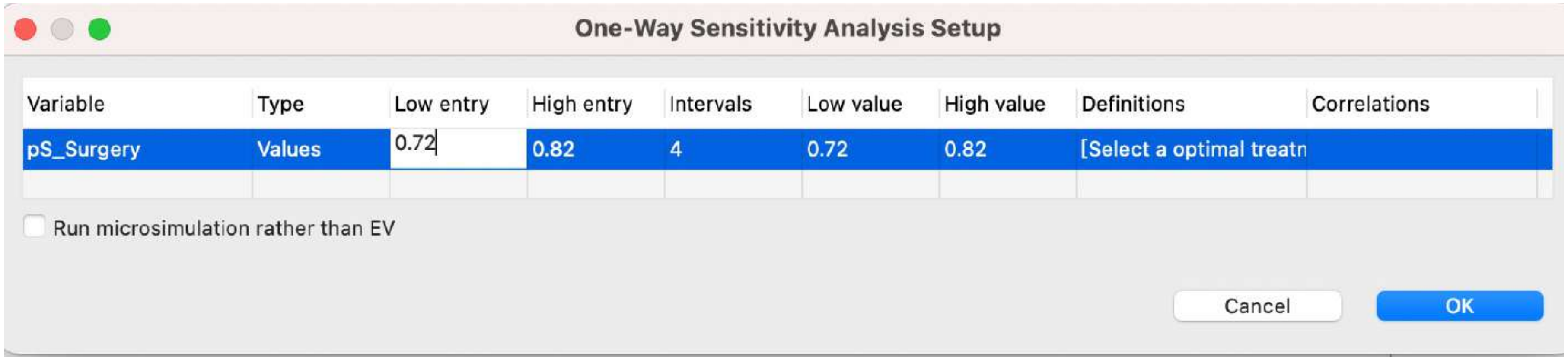


Example 2-One-way Sensitive Analysis

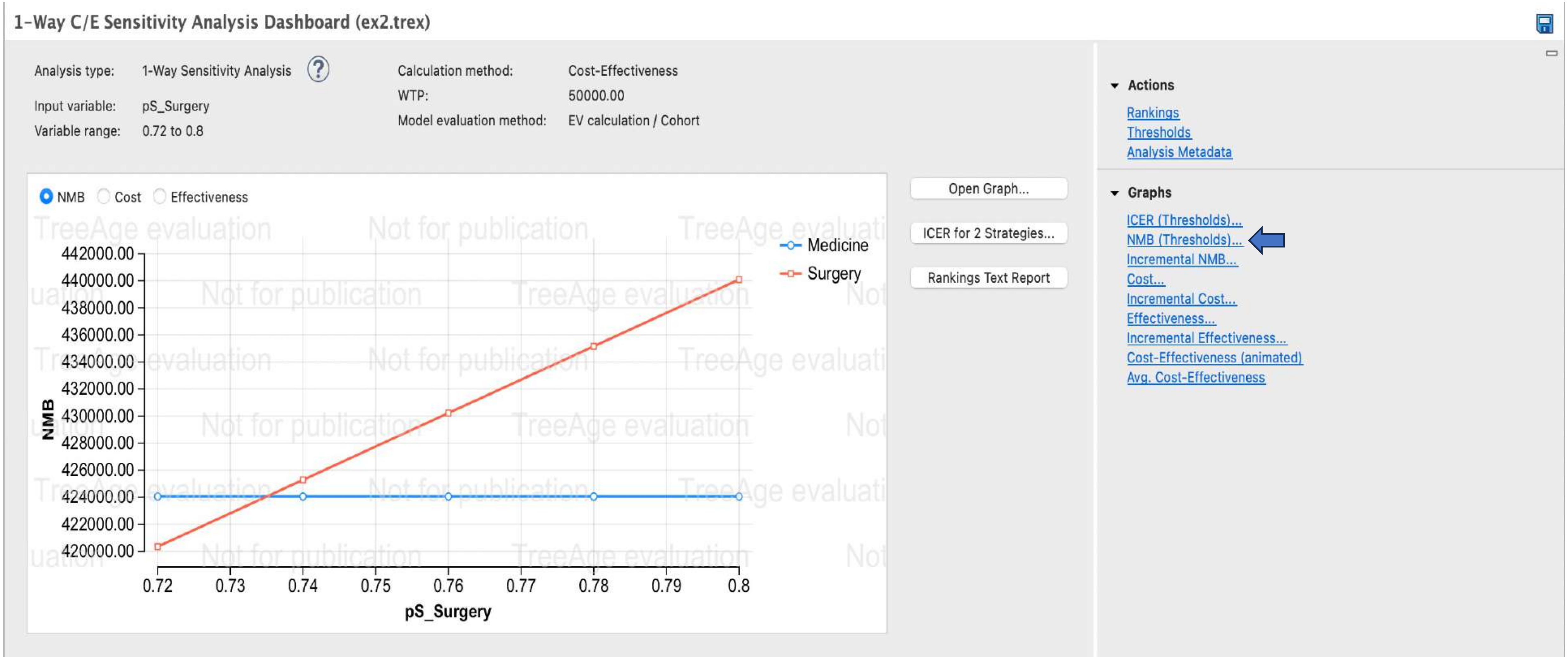


Example 2-One-way Sensitive Analysis

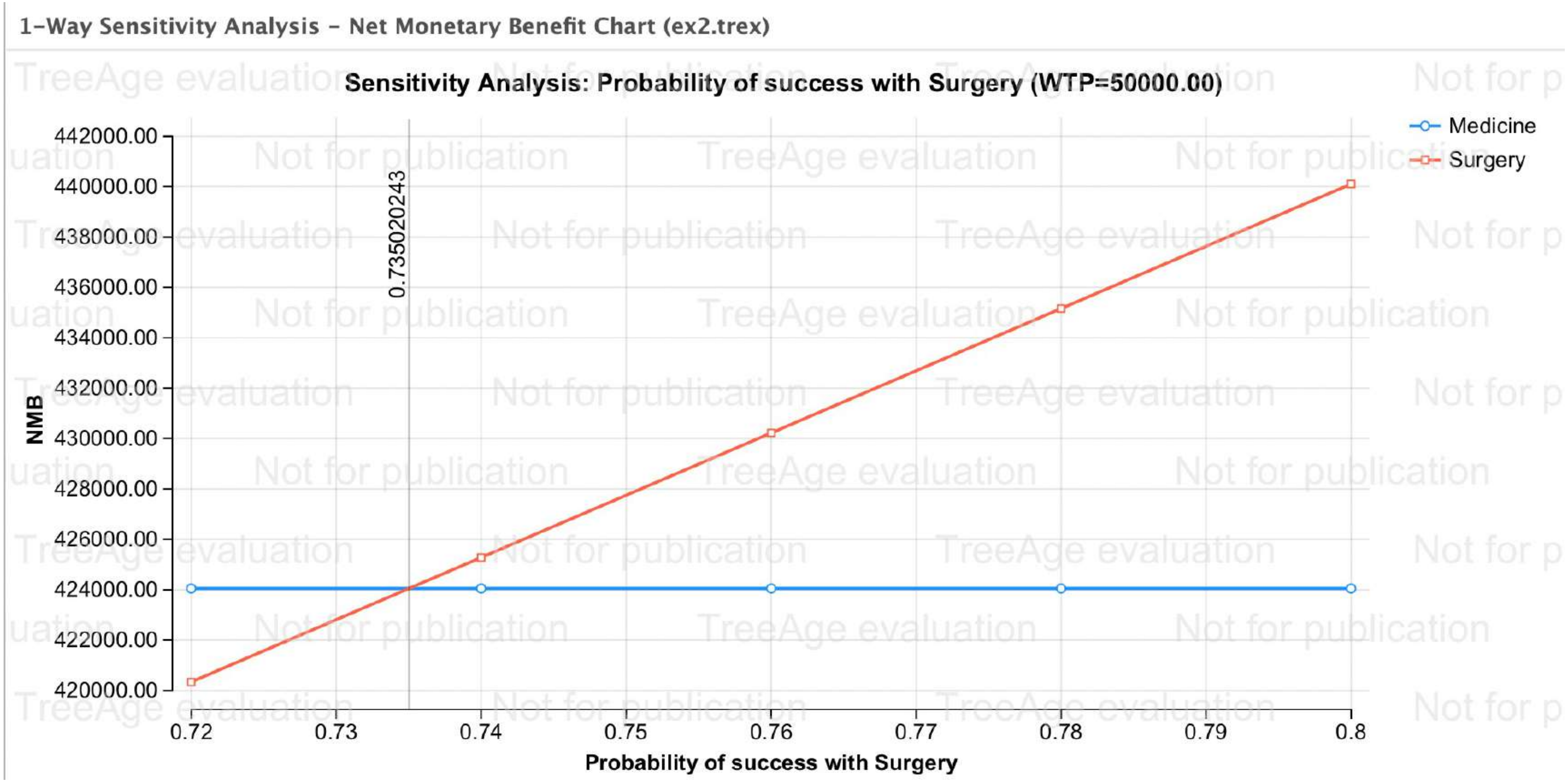




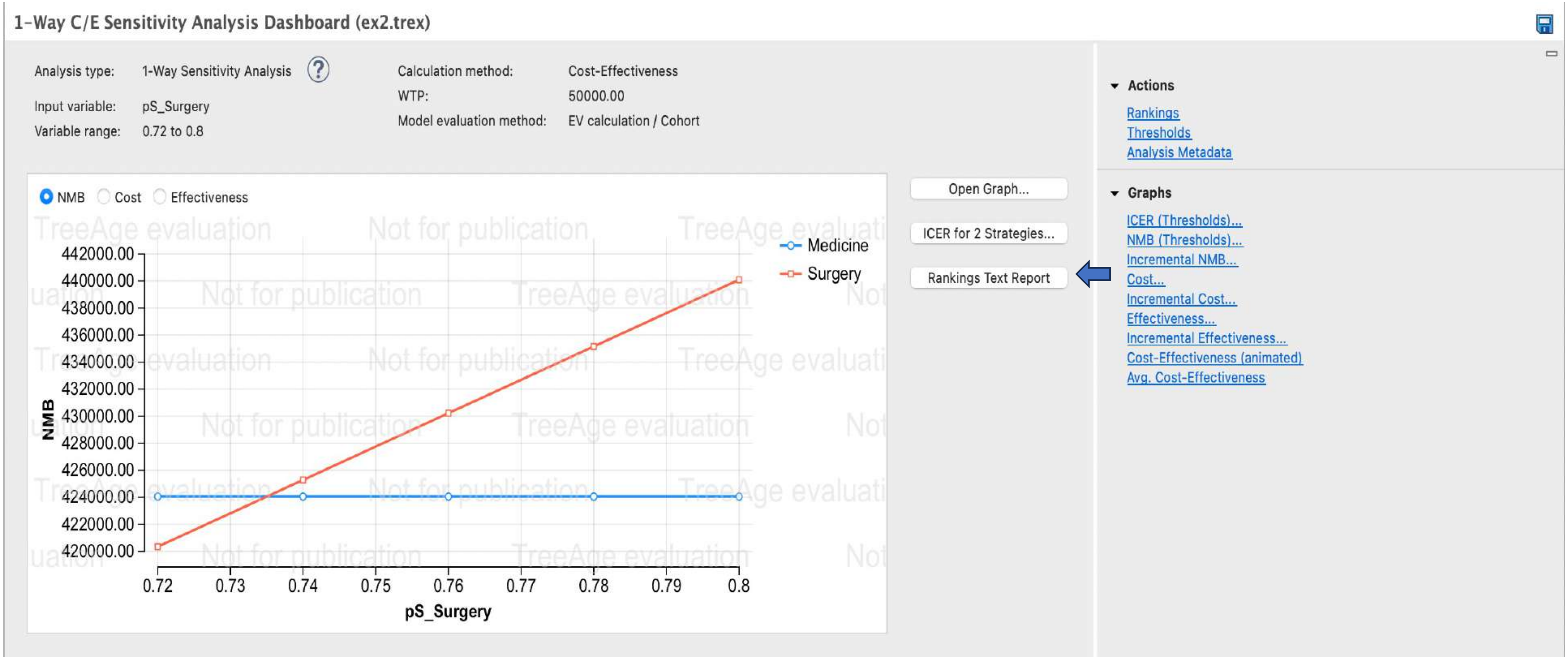
Example 2-Net Monetary Benefits Chart



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



Example 2-Net Monetary Benefits Chart



Example 2-One-way Sensitive Analysis

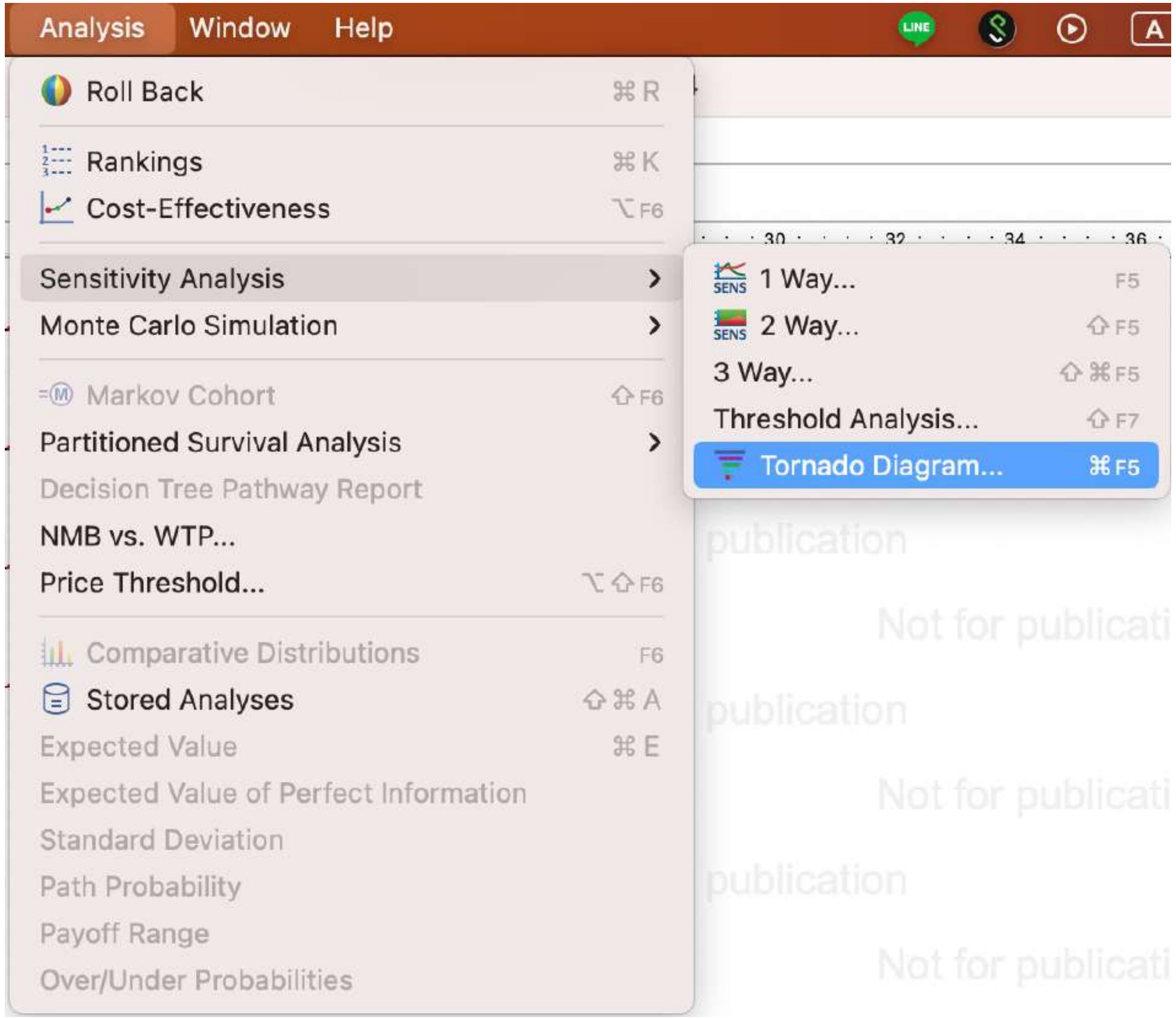
Medicine is the optimal strategy

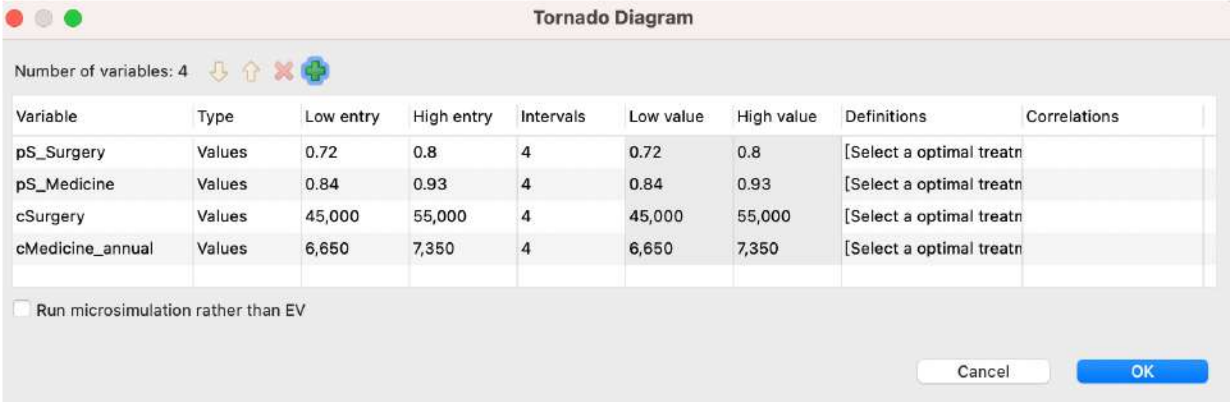
Surgery is the optimal strategy

1-Way Sensitivity Analysis – C/E Text Report (ex2.trex)

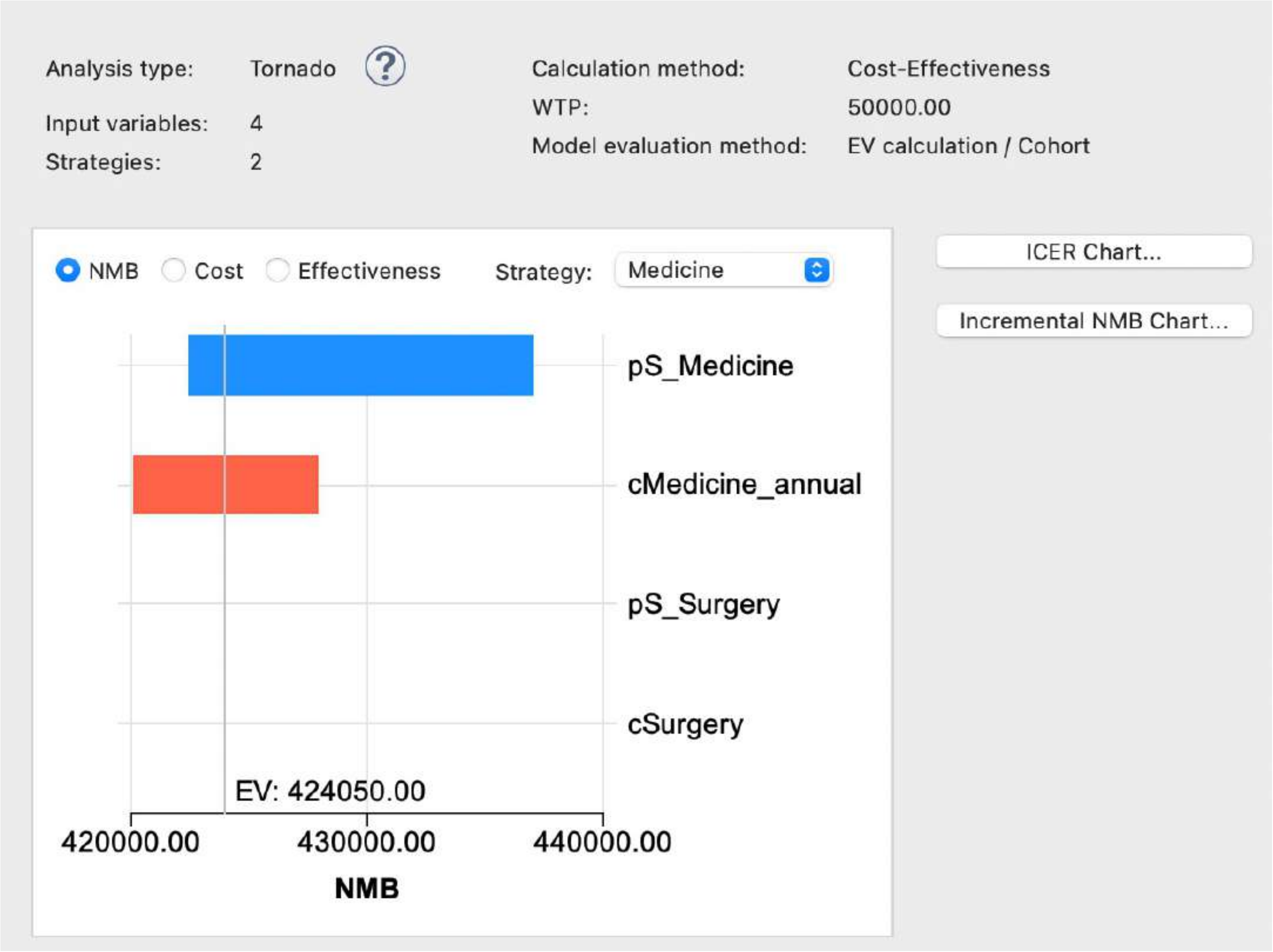
pS_Surgery	Strategy	Cost	Incr. Cost	Effectiveness	Incr. Effectiveness	ICER	NMB	C/E	Dominance
0.72									
0.72	Surgery	50000.00	0.00	9.41	0.00	0.00	420340.00	5315.30	
0.72	Medicine	78400.00	28400.00	10.05	0.64	44222.98	424050.00	7801.77	
0.74									
0.74	Surgery	50000.00	0.00	9.51	0.00	0.00	425280.00	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



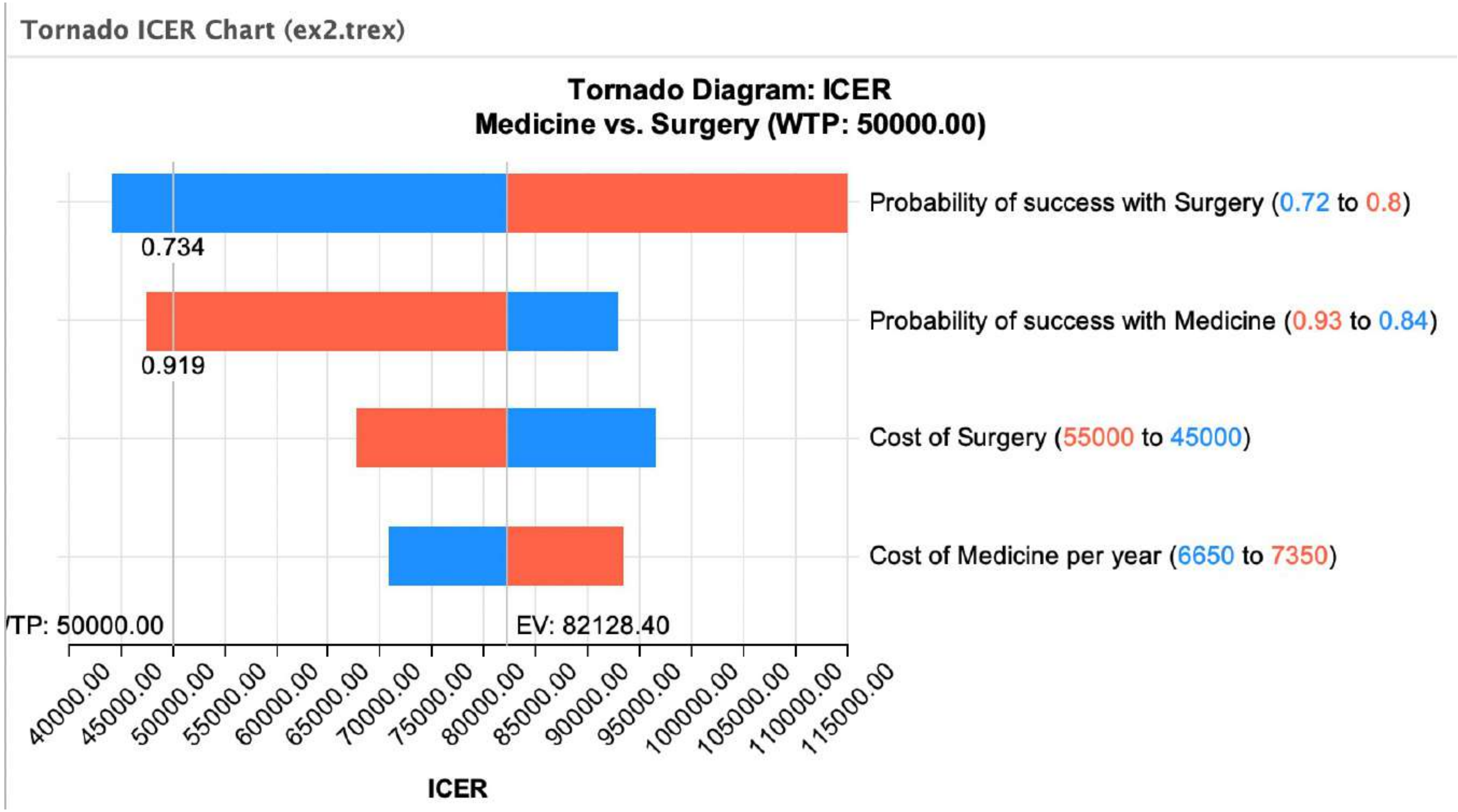


Example 2-Tornado Diagrams



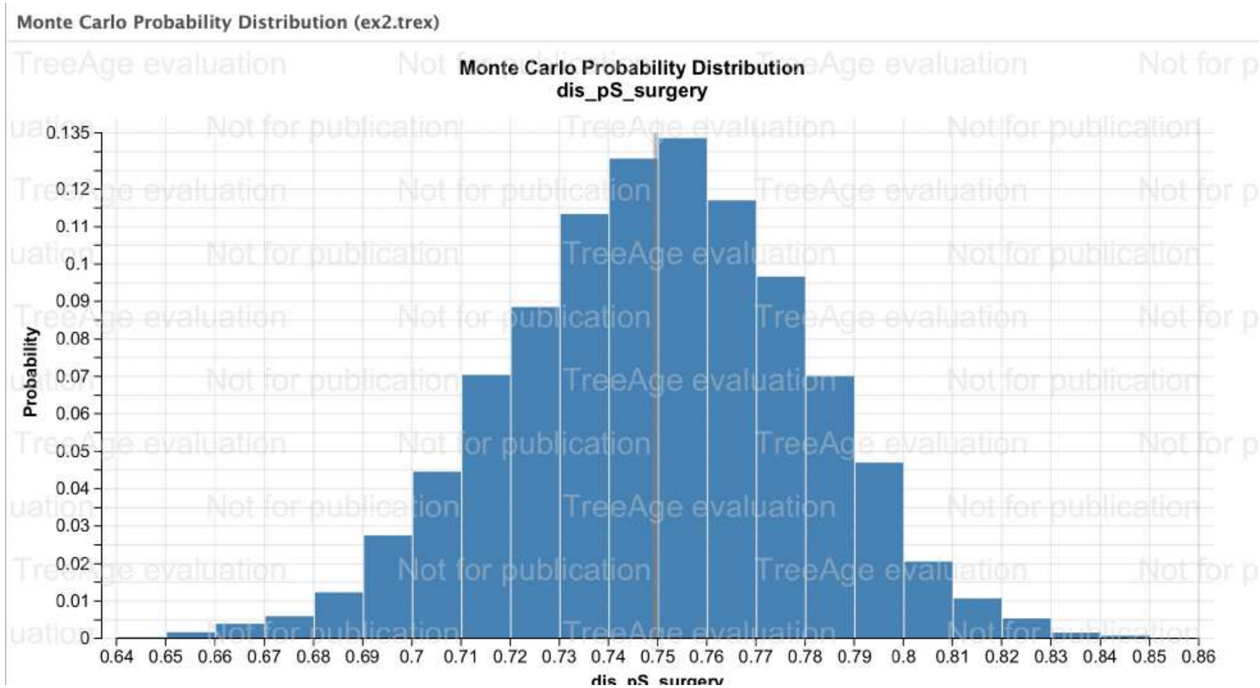
Example 2-Tornado Diagrams

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.

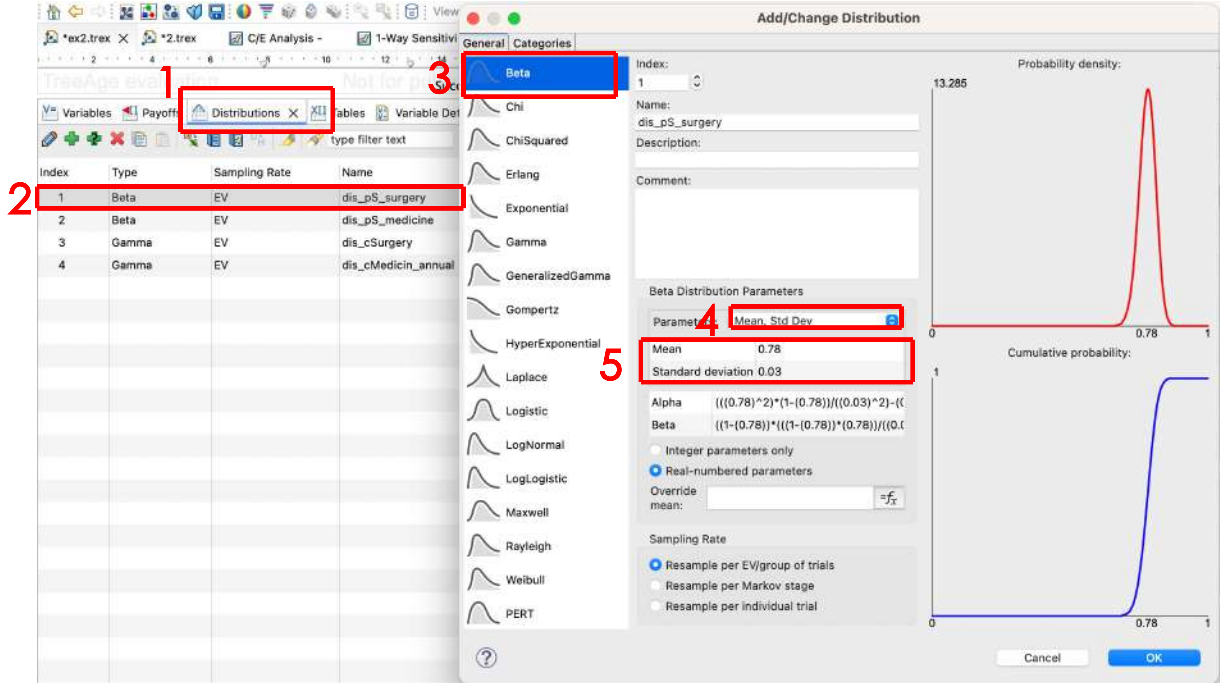
Example 2- Probabilistic Sensitivity Analysis(PSA)

- 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

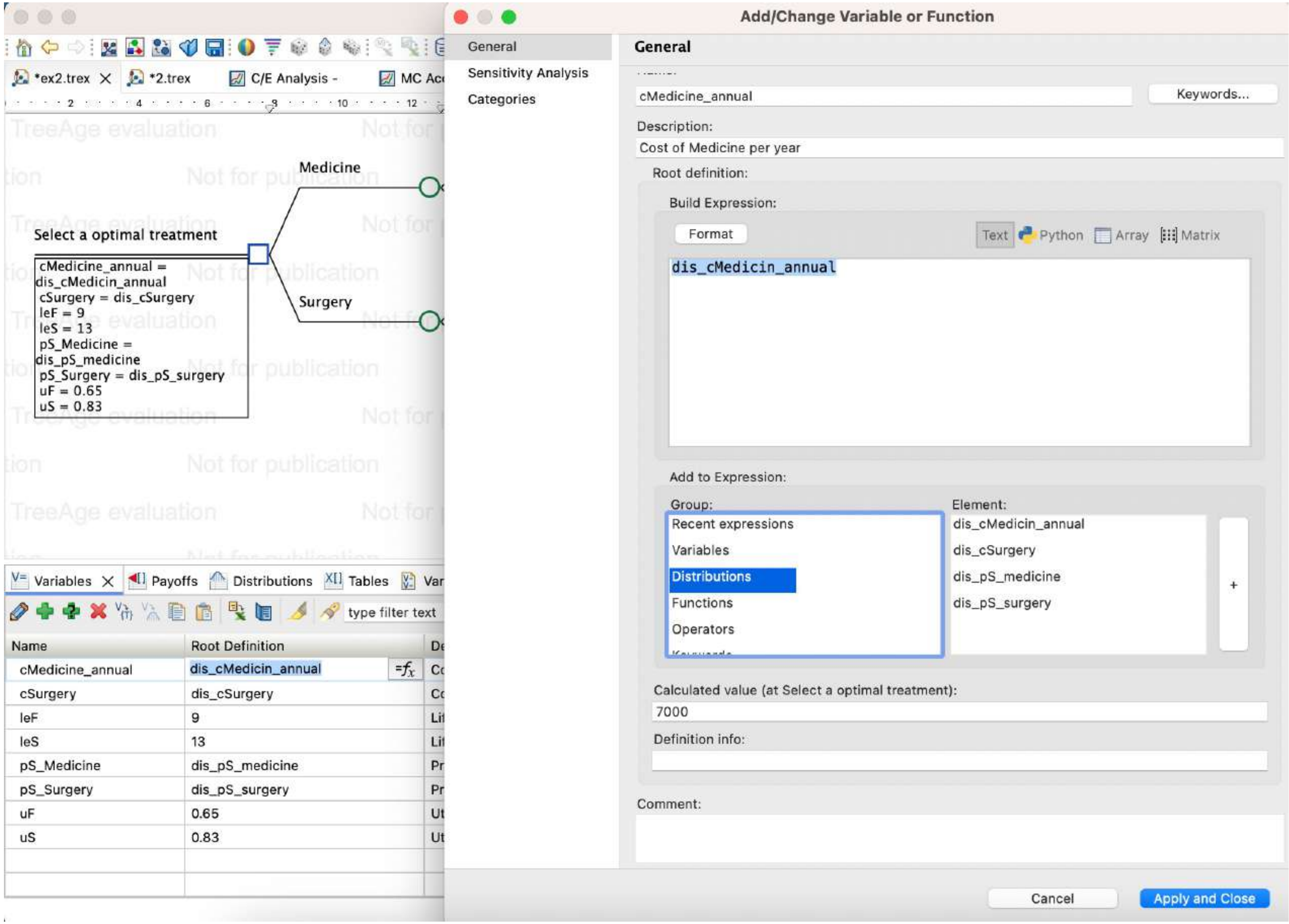
Distribution	interval	parameter
Beta distribution	[0,1]	• Transition probabilities • utility
Gamma distribution	[0,+∞]	• Cost • disutility
log-normal distribution		• Cost • Treatment effects • disutility

Example 2-PSA- Set up distributions for 4 parameters

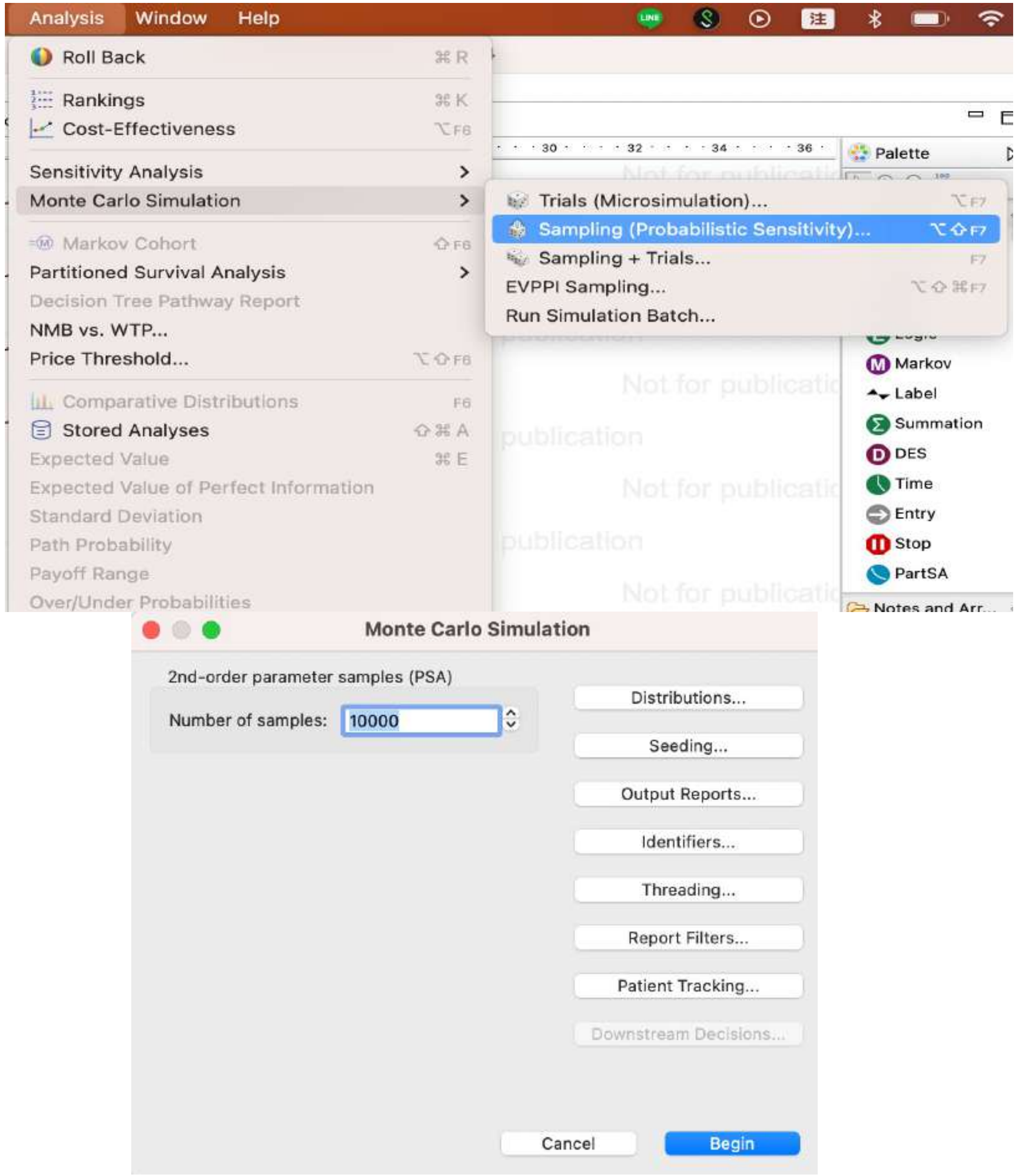
Variable	New name	Type	Mean	SD
pS_surgery	dis_pS_surgery	Beta	0.78	0.03
pS_medicine	dis_pS_medicine	Beta	0.85	0.02
cSurgery	dis_cSurgery	Gamma	50,000	3,000
cMedicine_annual	dis_cMedicine_annual	Gamma	7,000	600

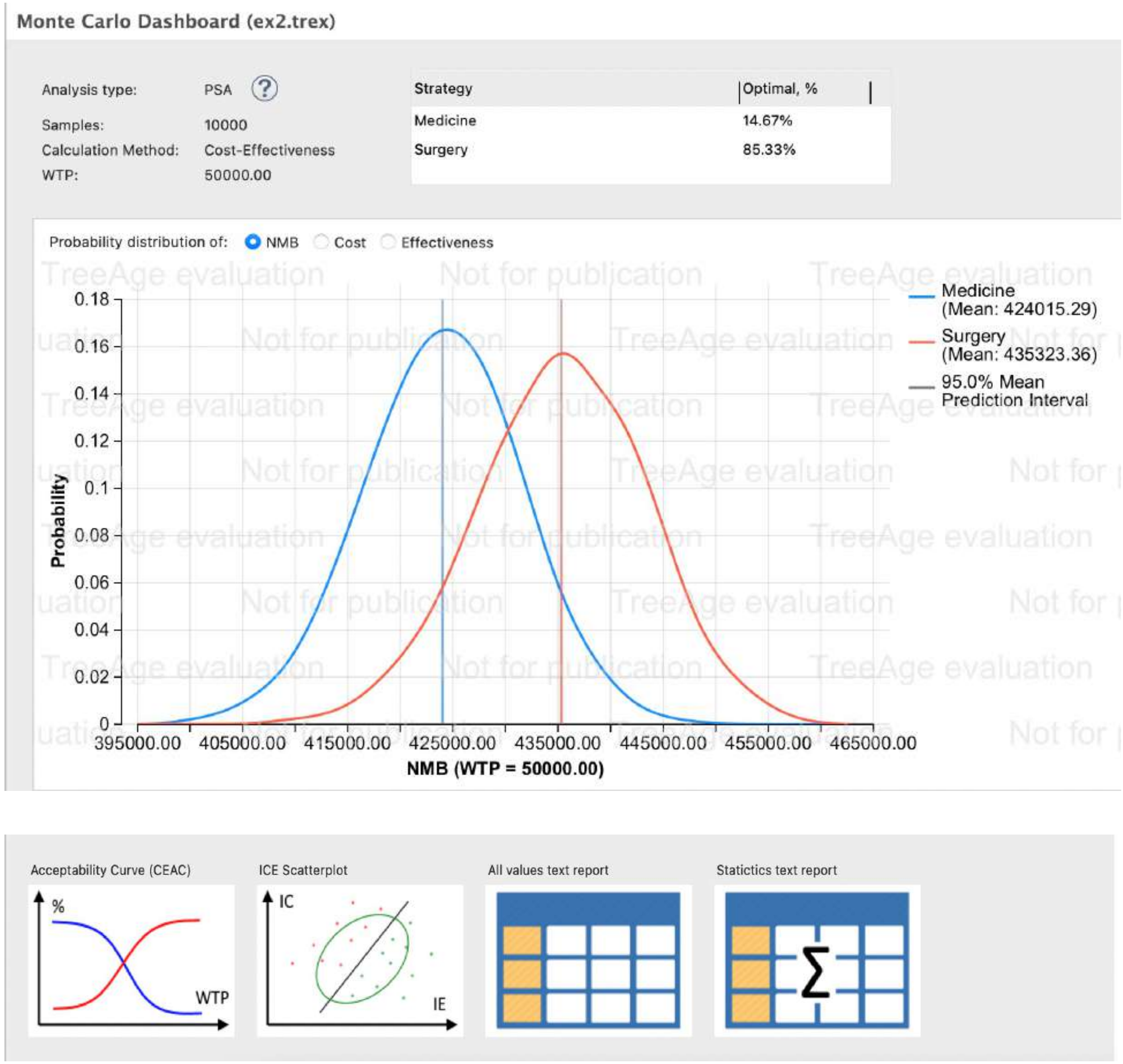


Example 2-PSA- Set up distributions for 4 parameters

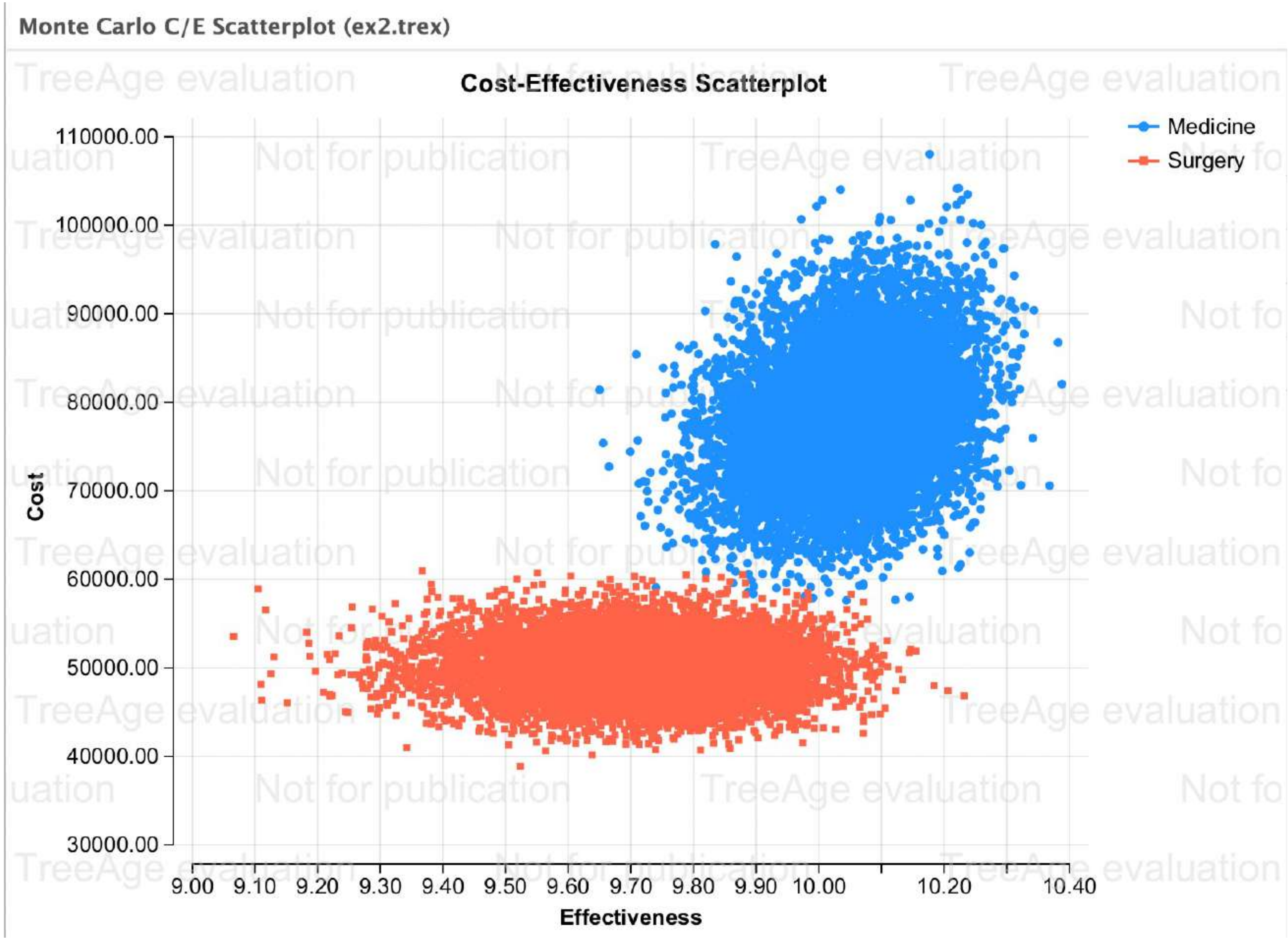


Example 2-Monte Carlo Simulation

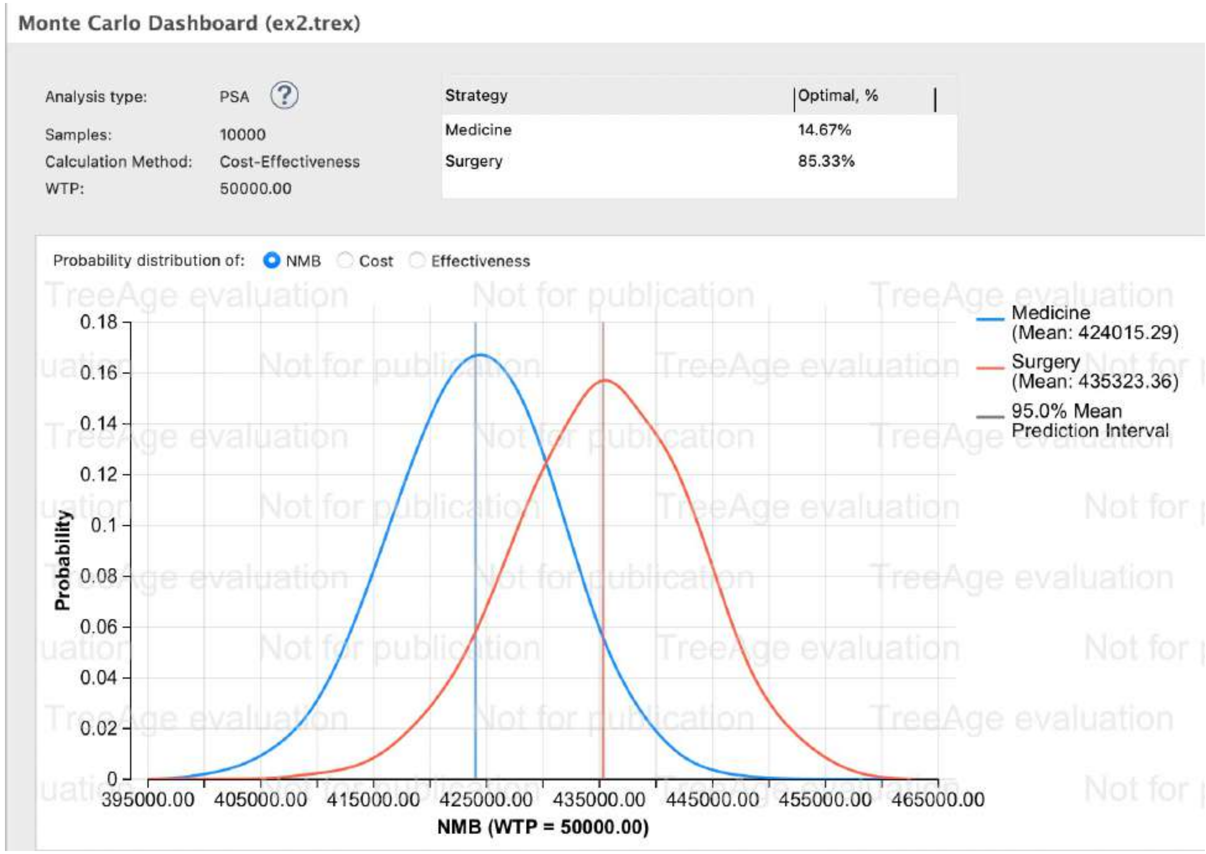


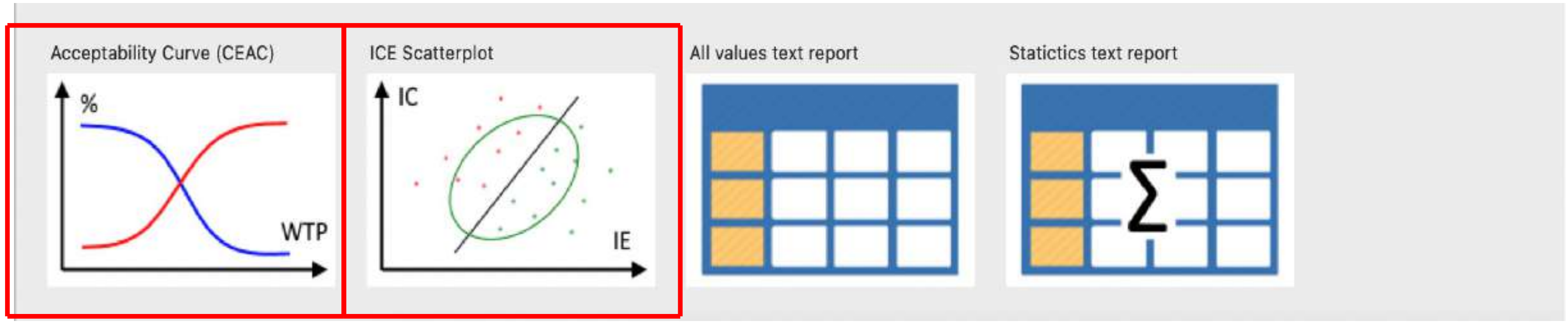


Example 2-Monte Carlo Simulation

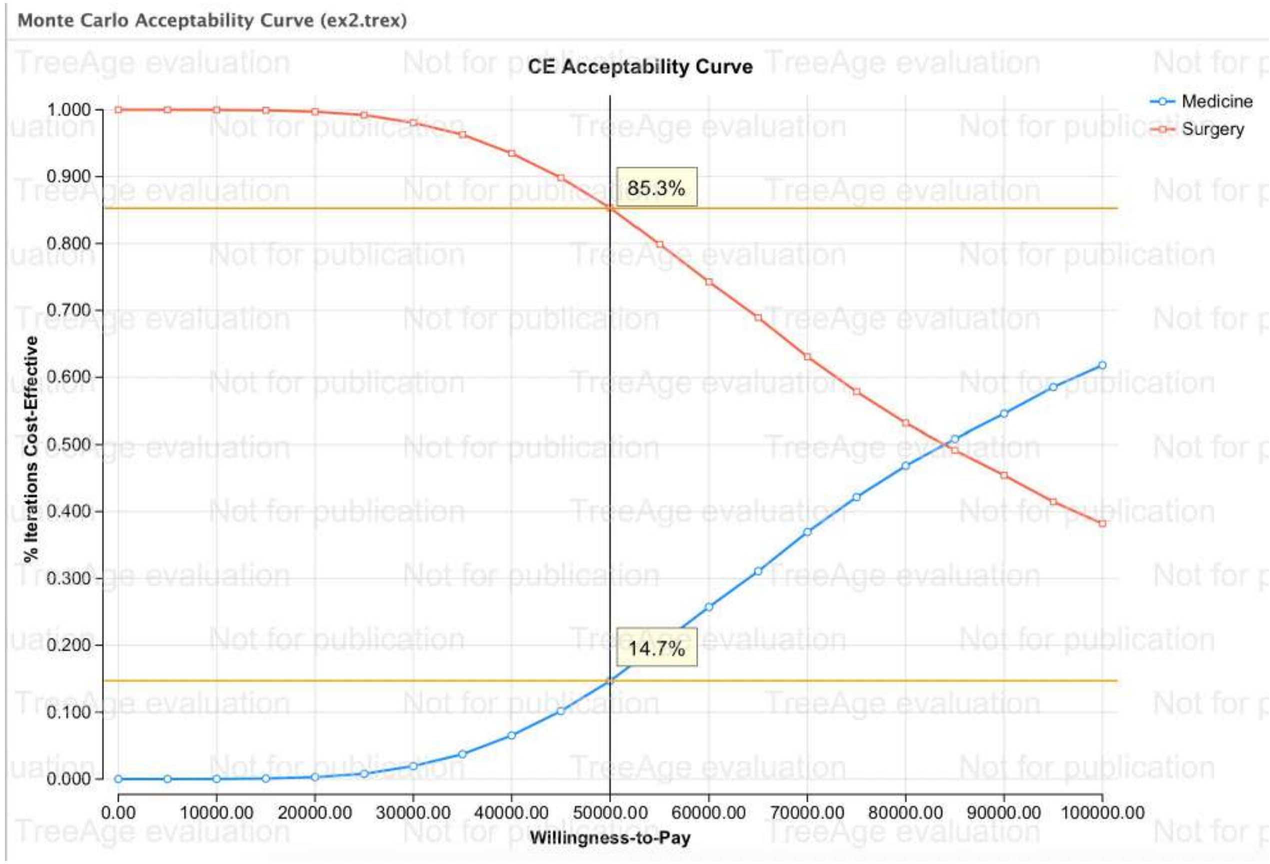


Example 2-Monte Carlo Simulation





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

- [x] Show Mean Line
- [x] Show Prediction Interval

Confidence level (%): 95.0

Data Reports

Dashboard Graph
Statistics
All Data
Export All Data to Excel/CSV
Text Report
Identifying Variables

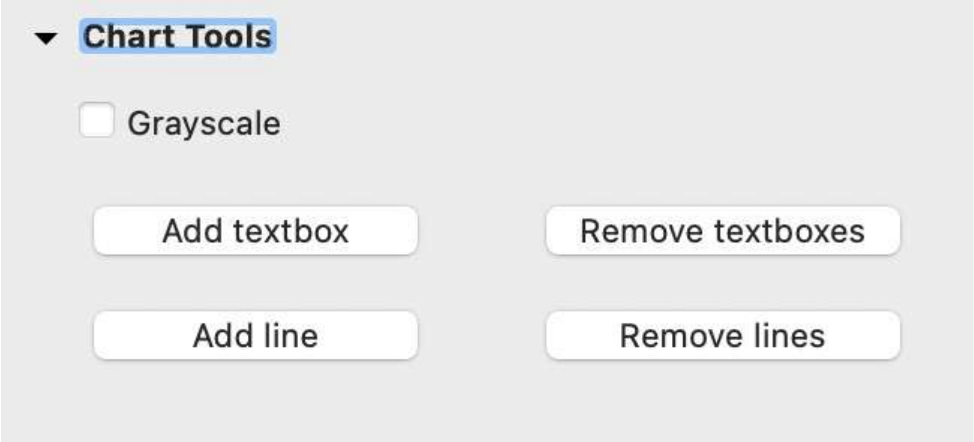
CE Outputs

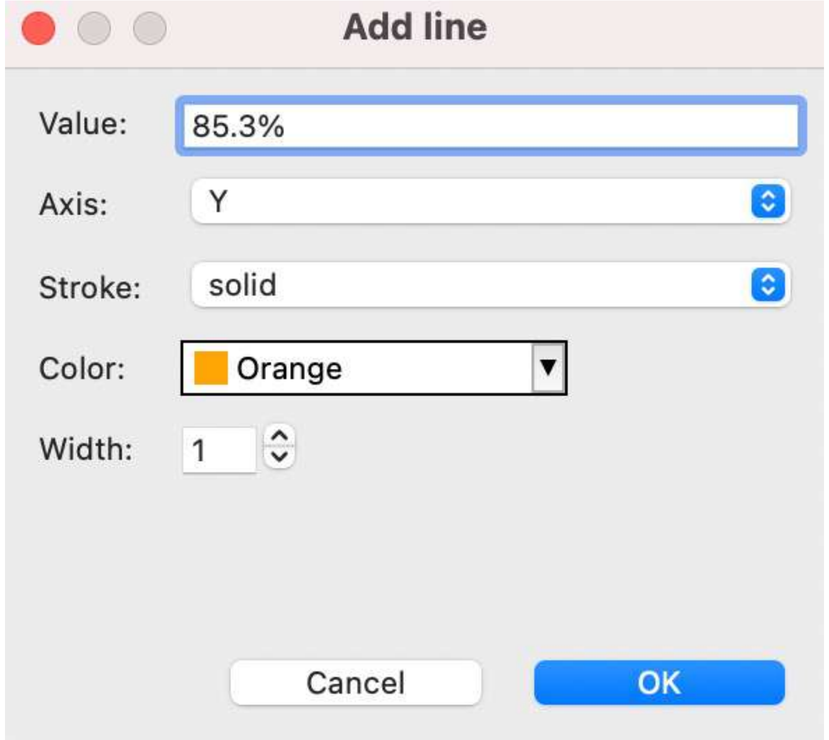
CE Graph
CE Rankings
NMB vs. WTP...
INMB vs. WTP...

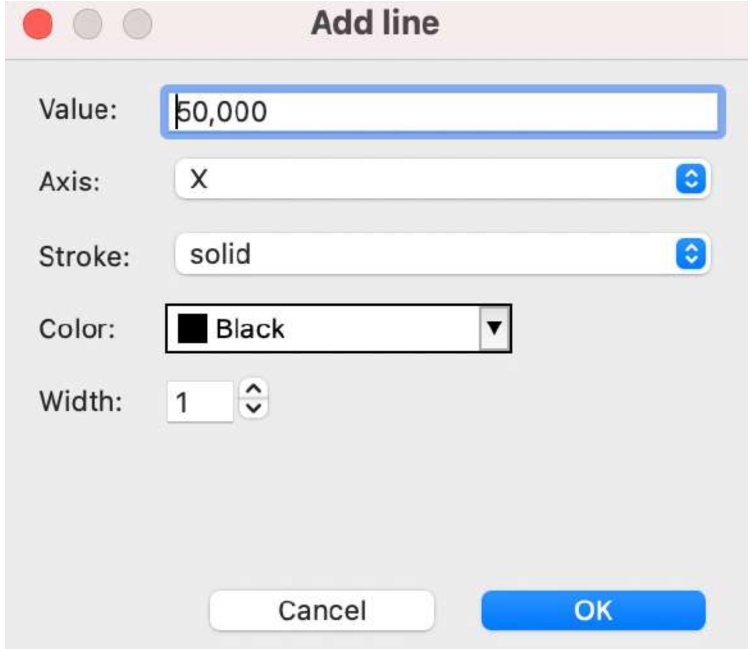
PSA Outputs

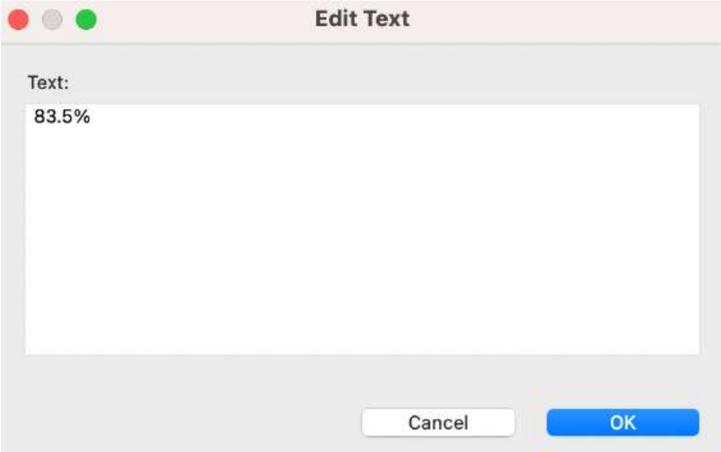
Acceptability Curve...
CE Scatter Plot
ICE Scatterplot...
ICER Histogram...
Acceptability at WTP...
EVPI\EVPPI Summary Report...
EVPI\EVPPI vs. WTP...

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



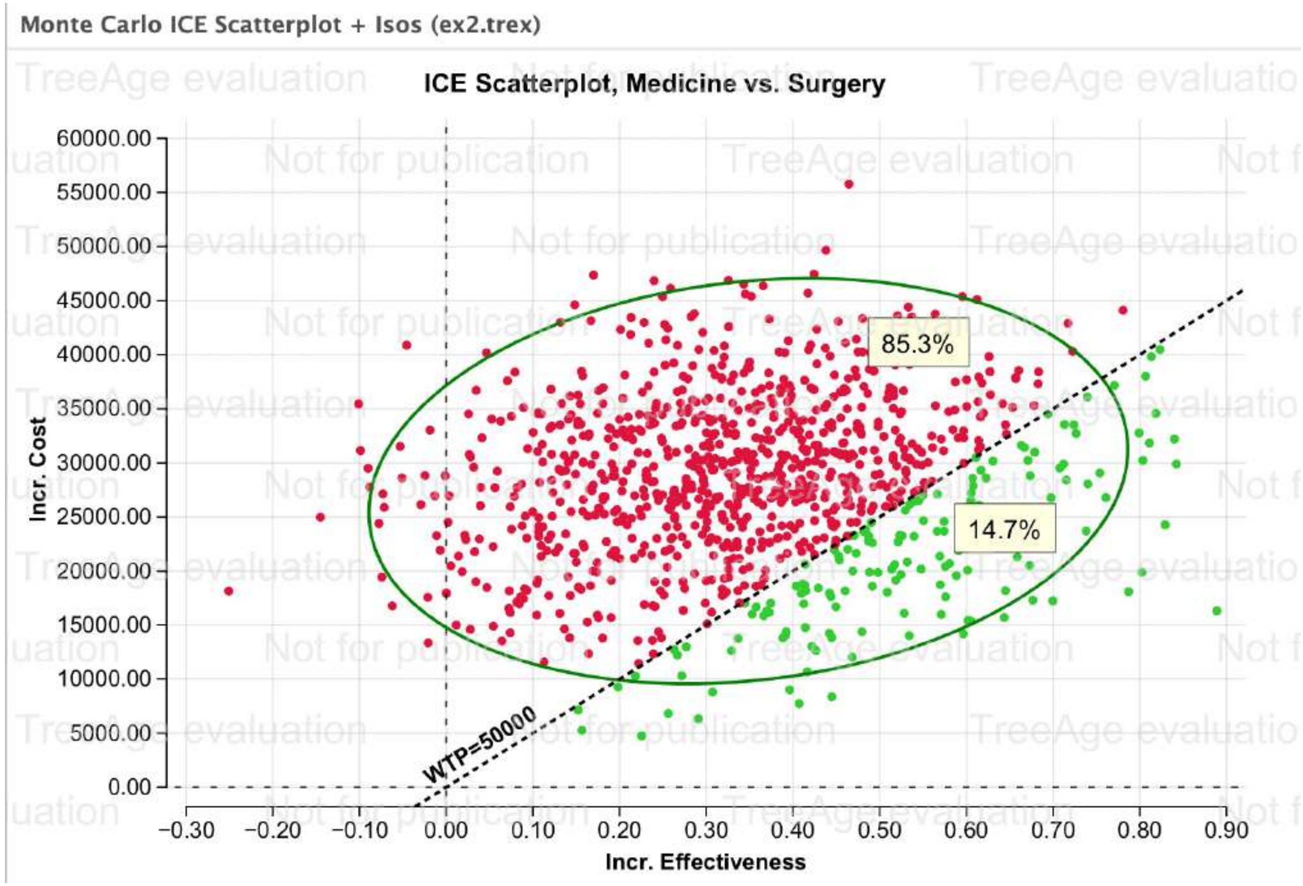




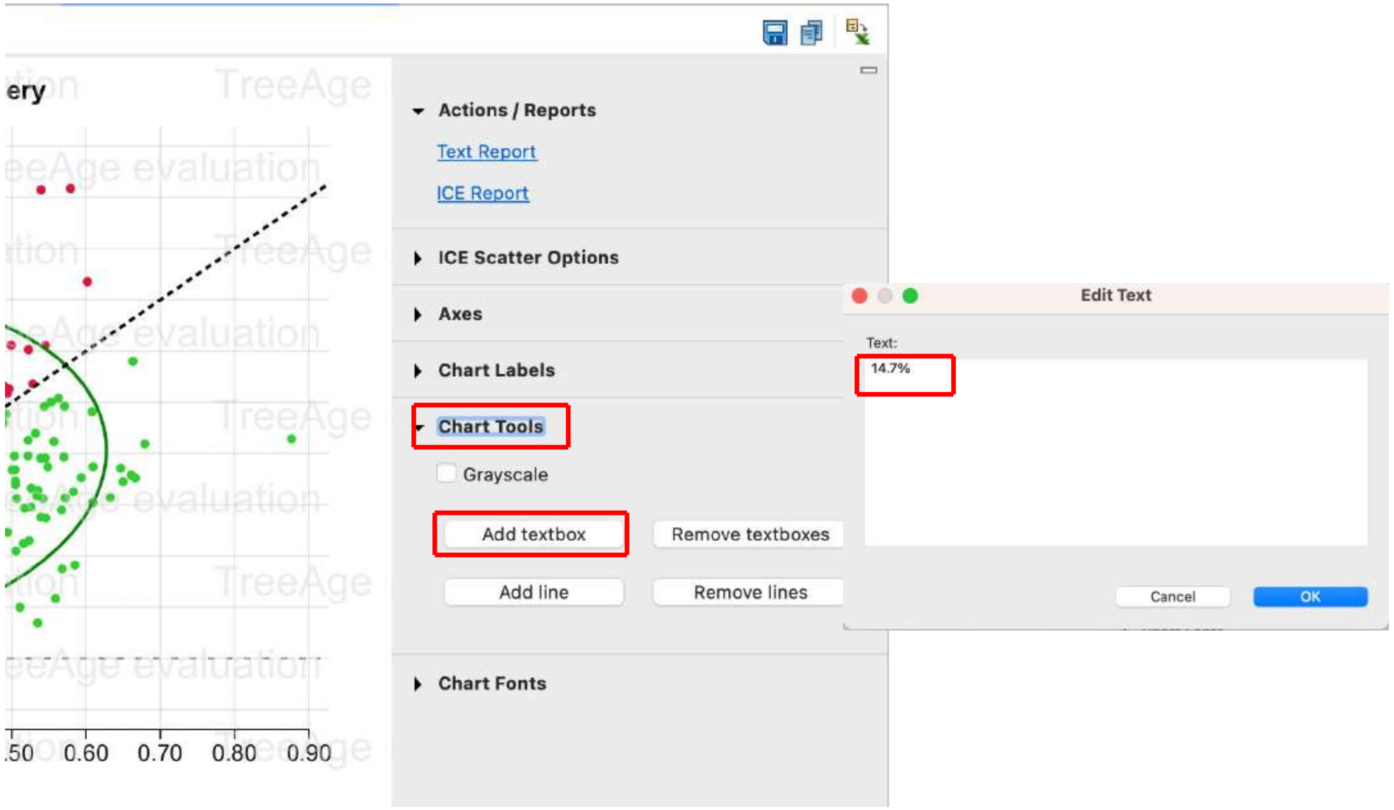


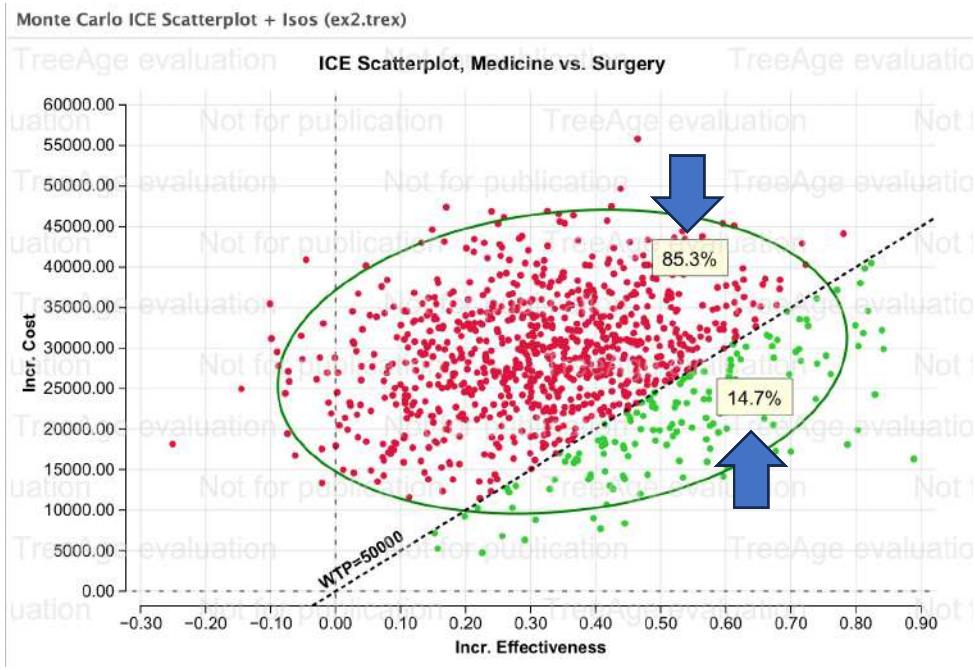
Example 2-Monte Carlo Simulation- ICE Scatterplot : Medicine vs Surgery

-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.



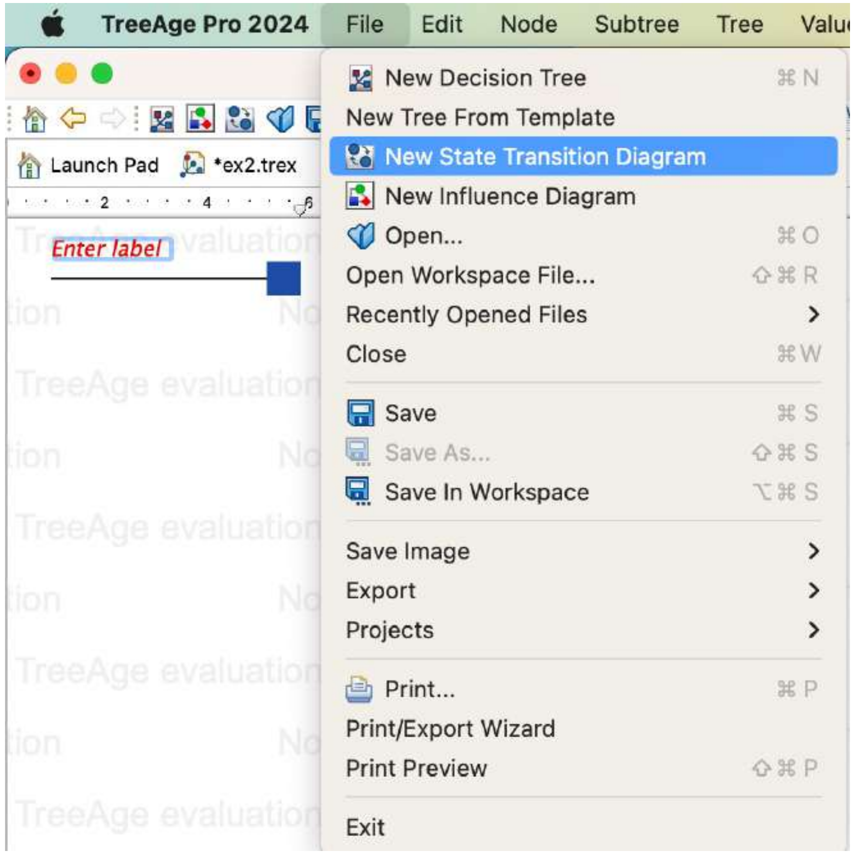
Example 2-Monte Carlo Simulation- ICE Scatterplot : Medicine vs Surgery

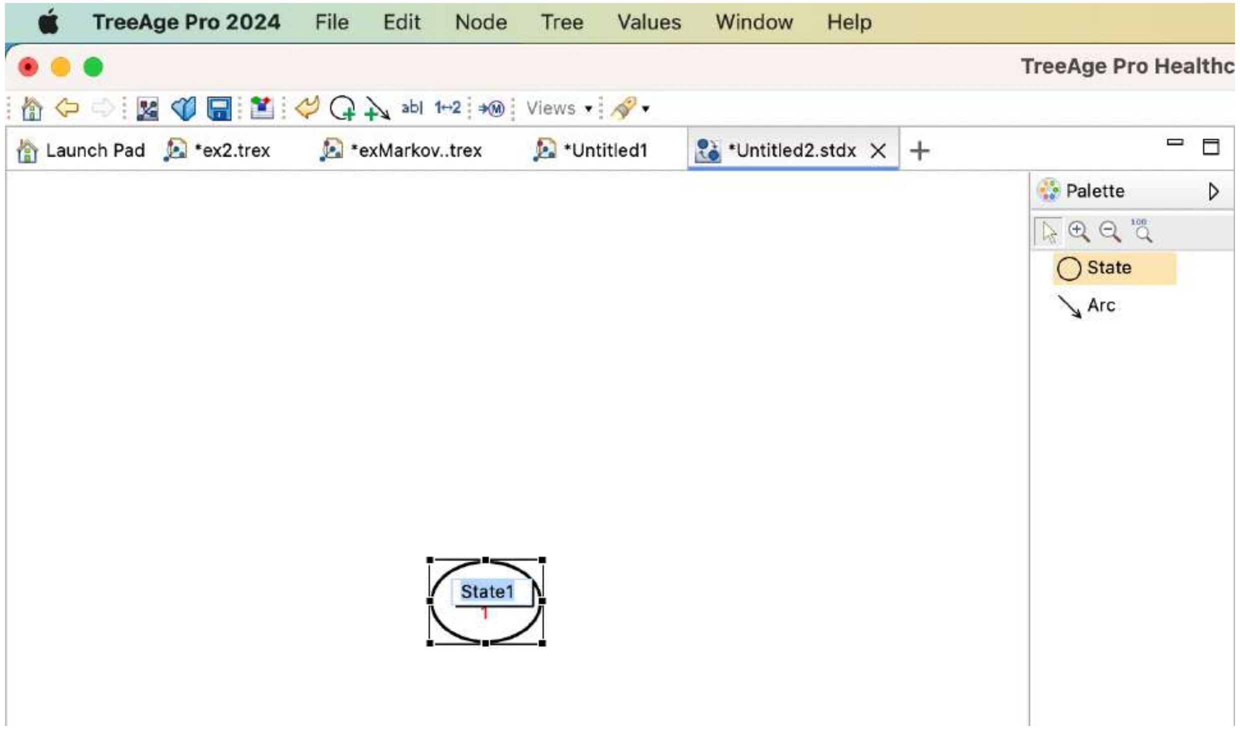




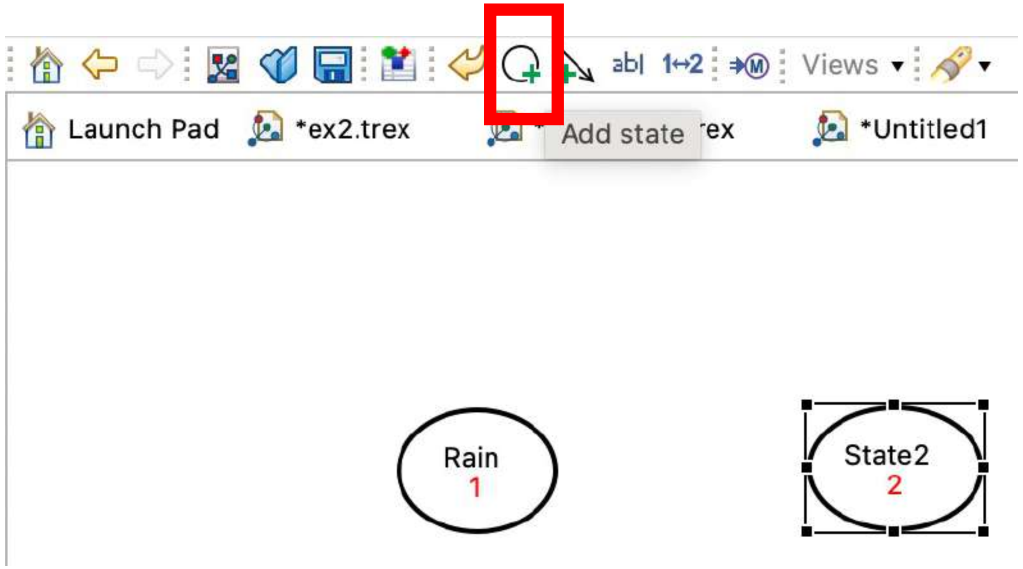
❑ 單元八：
Markov Model in TreeAge

Example 3-Markov Model





Example 3-Markov Model



點兩下改Label

Or點這裡改Label

Example 3-Markov Model

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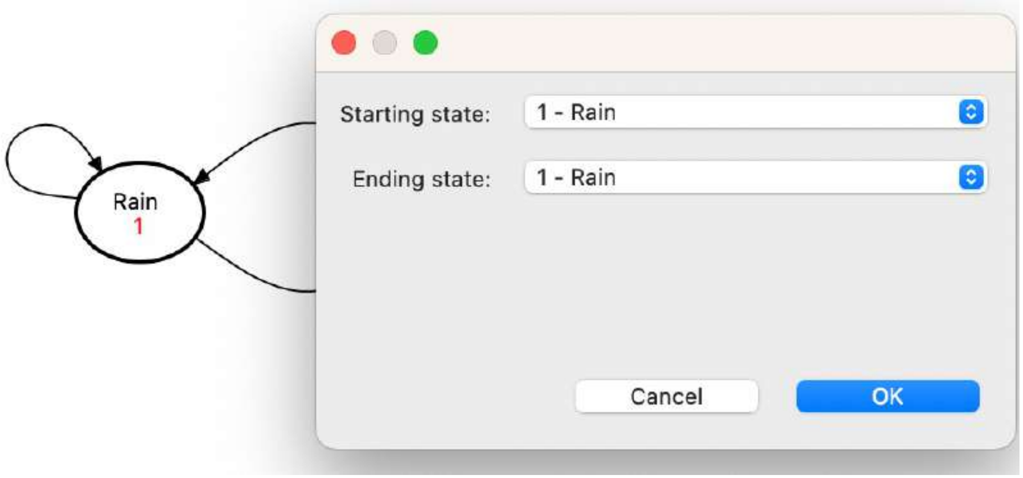

Example 3-Markov Model

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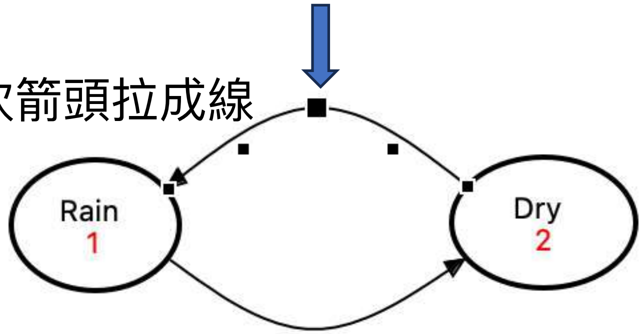

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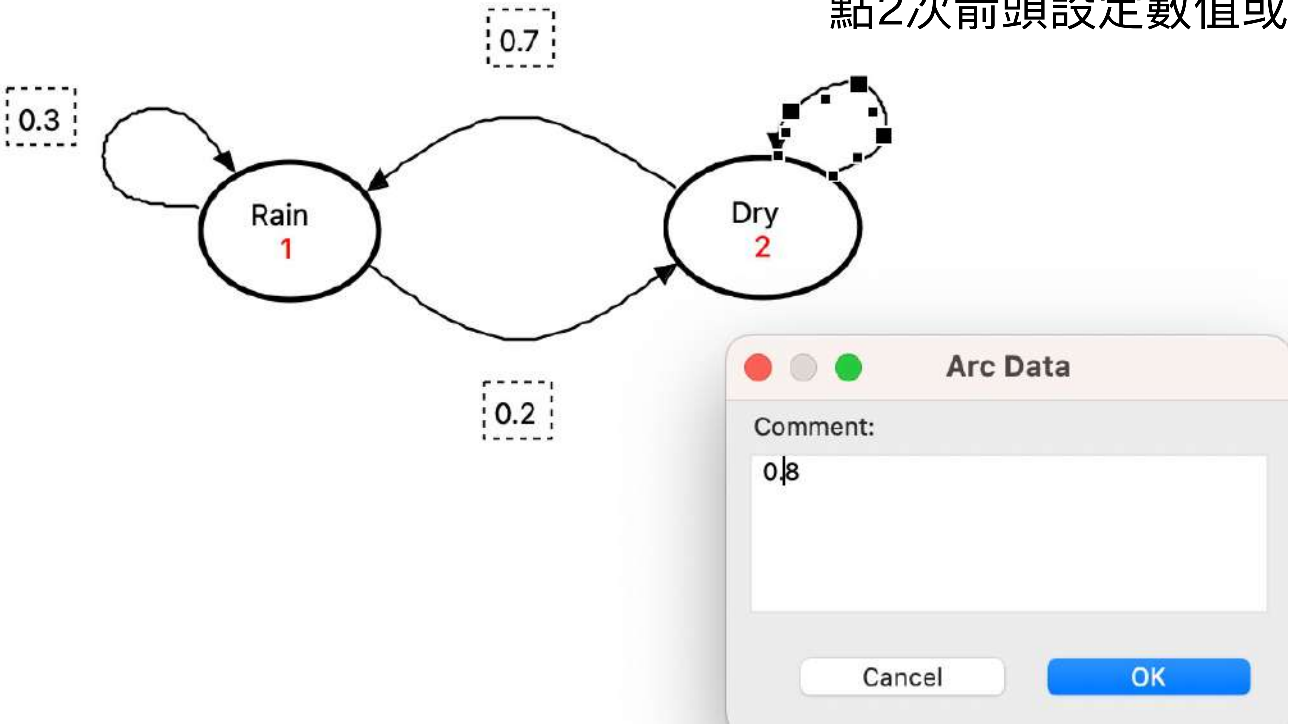
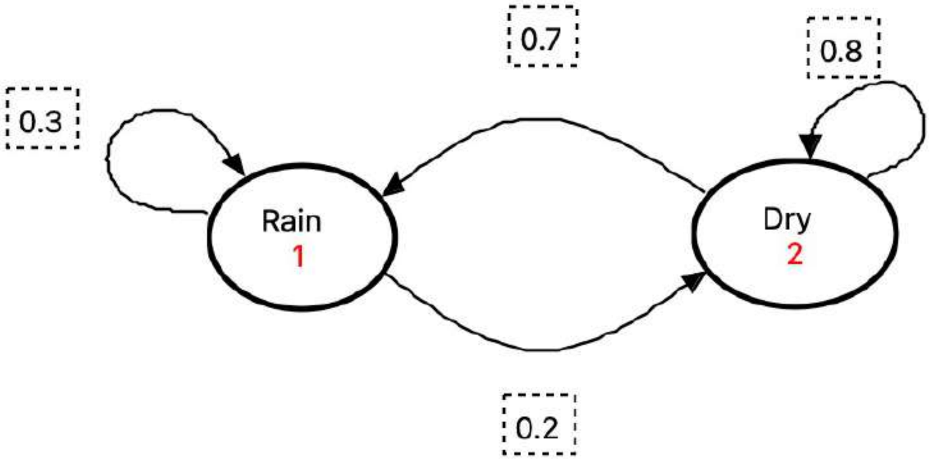


Example 3-Markov Model

- 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 ,

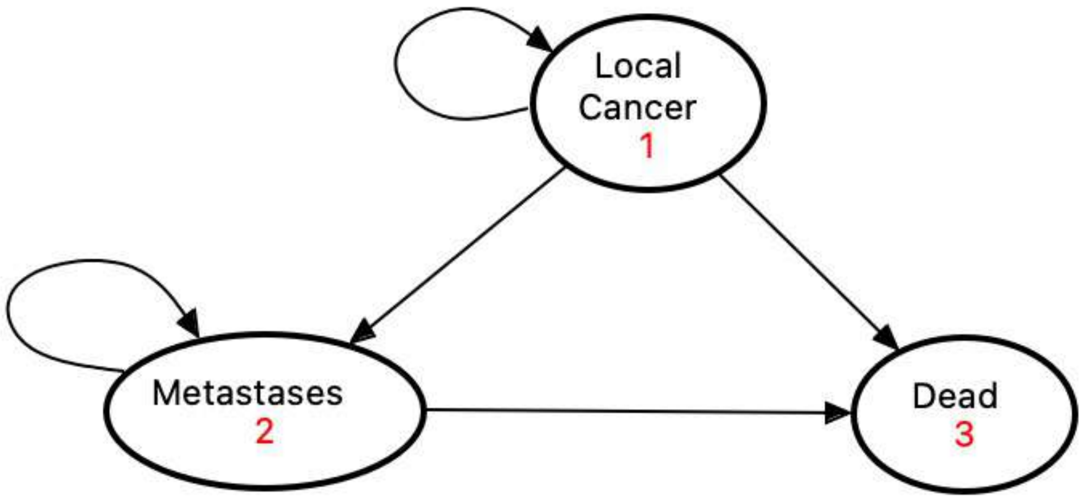
  each transition has a probability (transition probabilities /rates)
- **Cycle**: transition happen over a period of time
- **Cost & effectiveness** : each state can have a cost and /or effectiveness

  associated to it (called rewards in Markov model, payoffs in decision model)

Example 3-Markov Model

Developing the Markov model

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



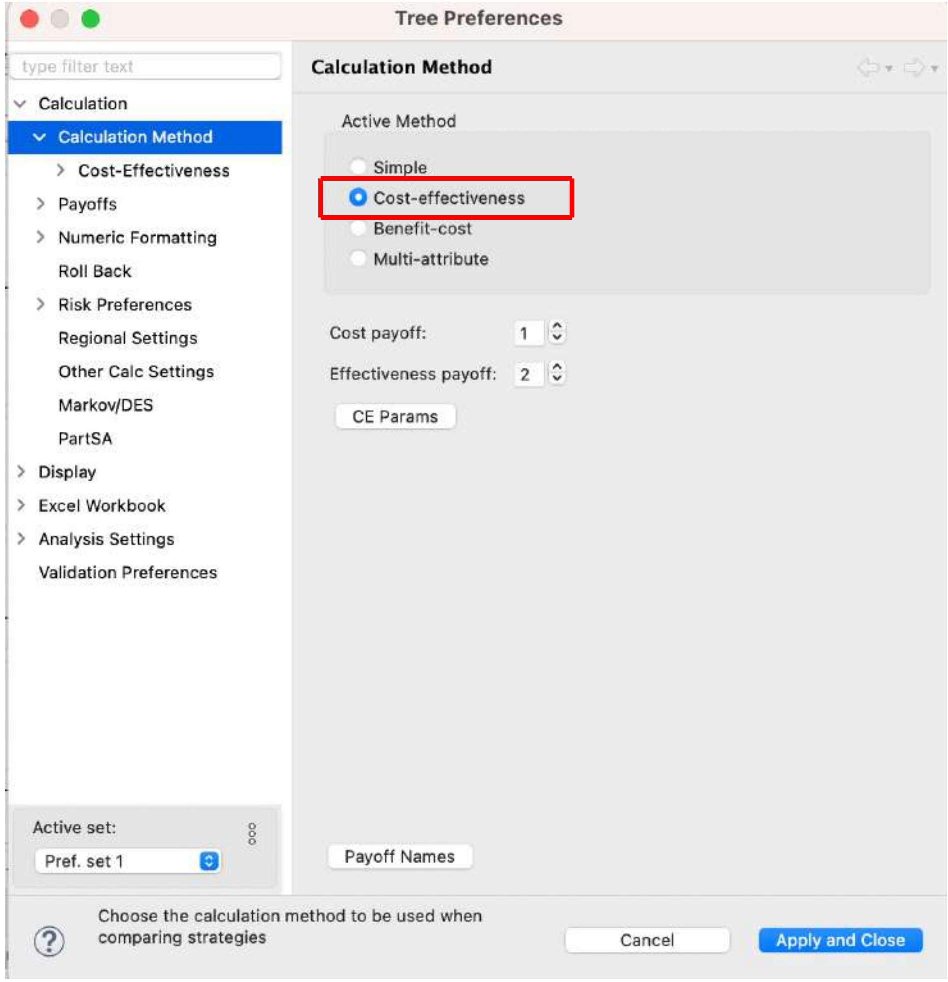
- **Cycle**

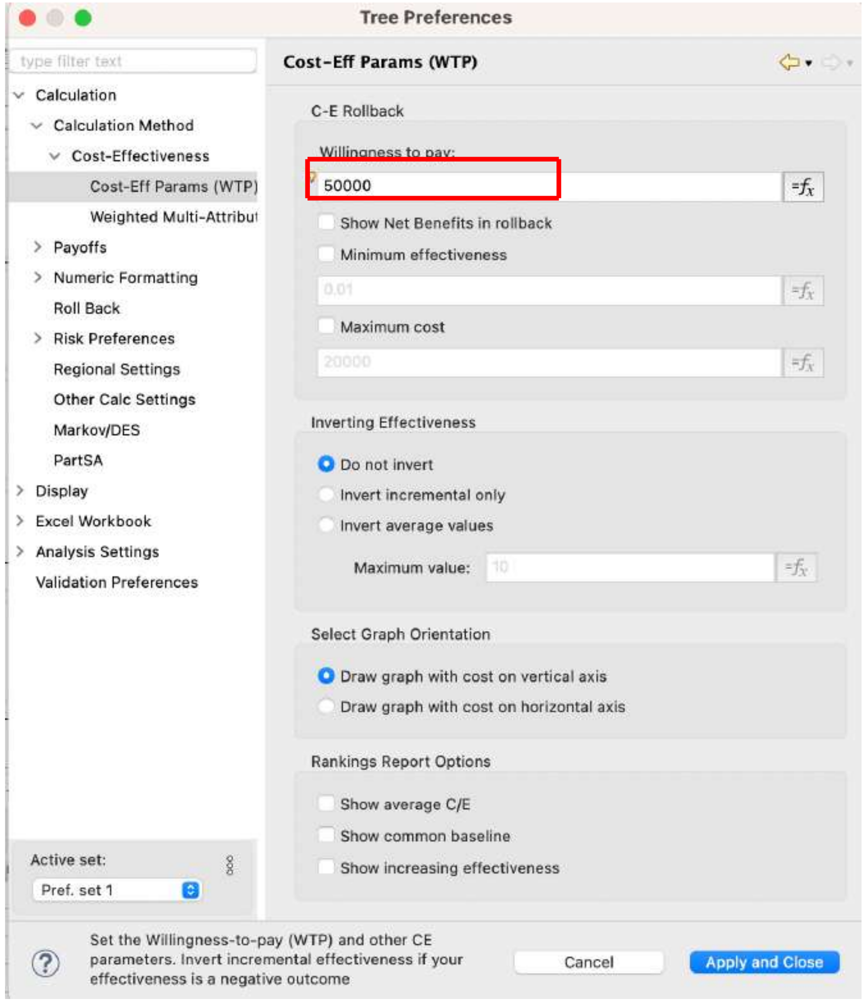
  Length of each cycle: 1year

  Total cycles : 20 years (time horizon)

Example 3-Markov Model-Set calculation Method as "Cost-effectiveness

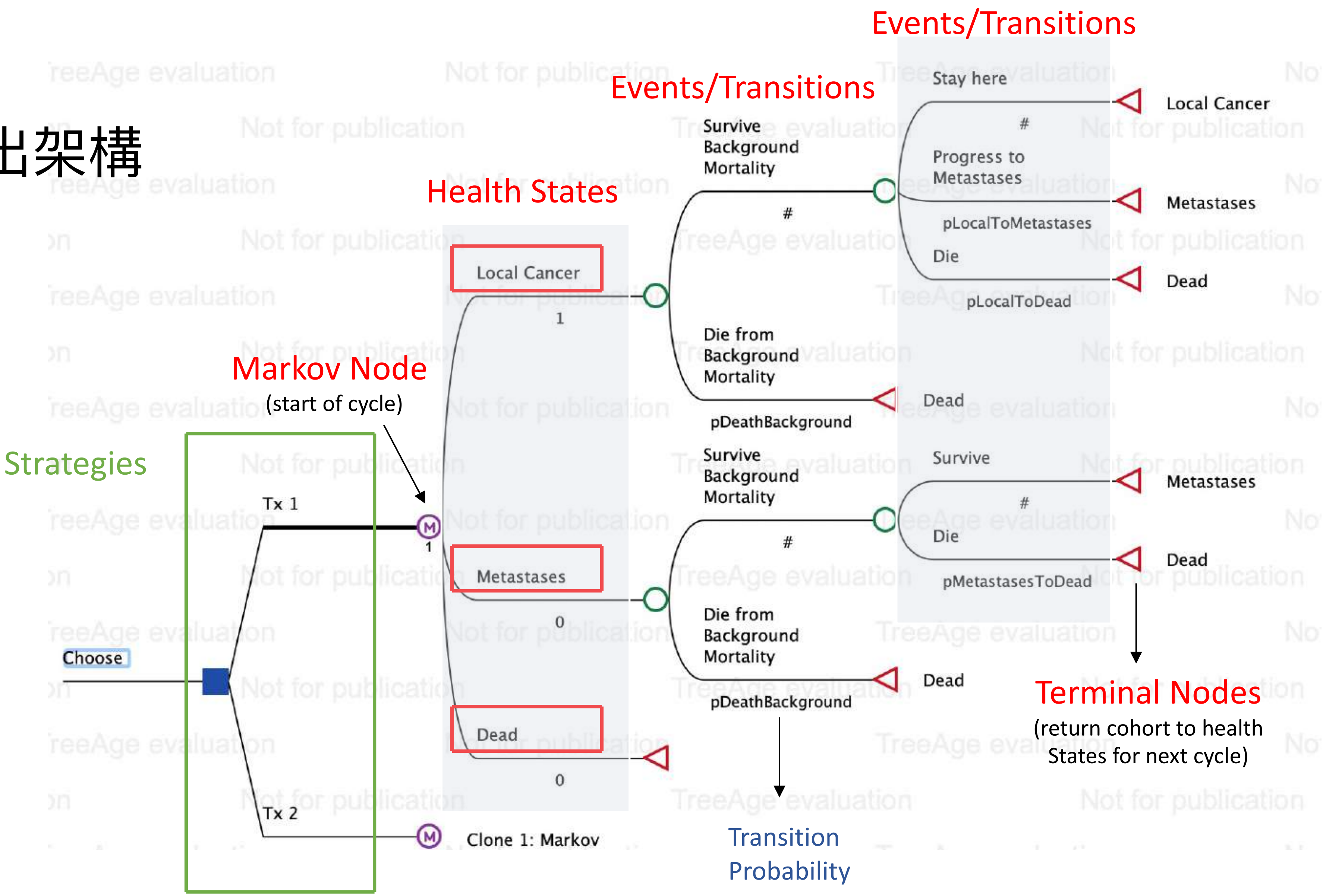
Tree\Tree Preferences\Calculation Method





Example 3-Markov Model Structure

先畫出架構



Example 3-Markov Model Structure

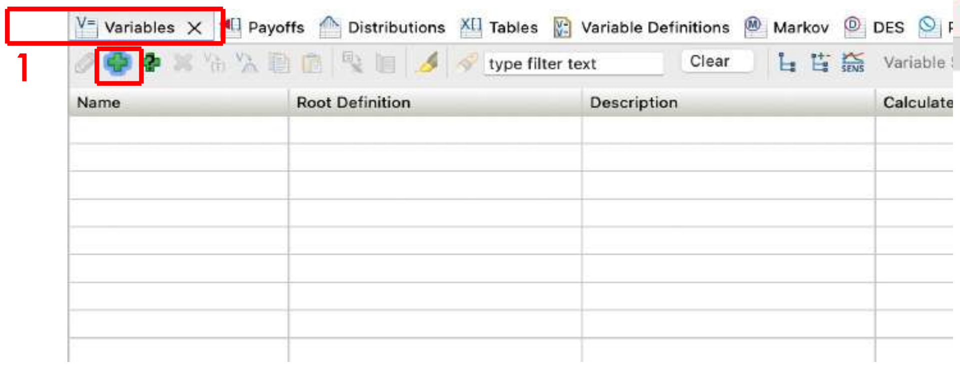
Parameter	Variable name	Value
age in each cycle	Age	startAge+_stage
cost for local cancer stage	cLocal	
	TX1:cLocal1	20,000
	TX2:cLocal2	23,000
cost for metastases stage	cMetastases	50,000
QALY for local cancer state	effLocal	0.96
QALY for metastases state	effMetastases	0.88
probability of death from 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

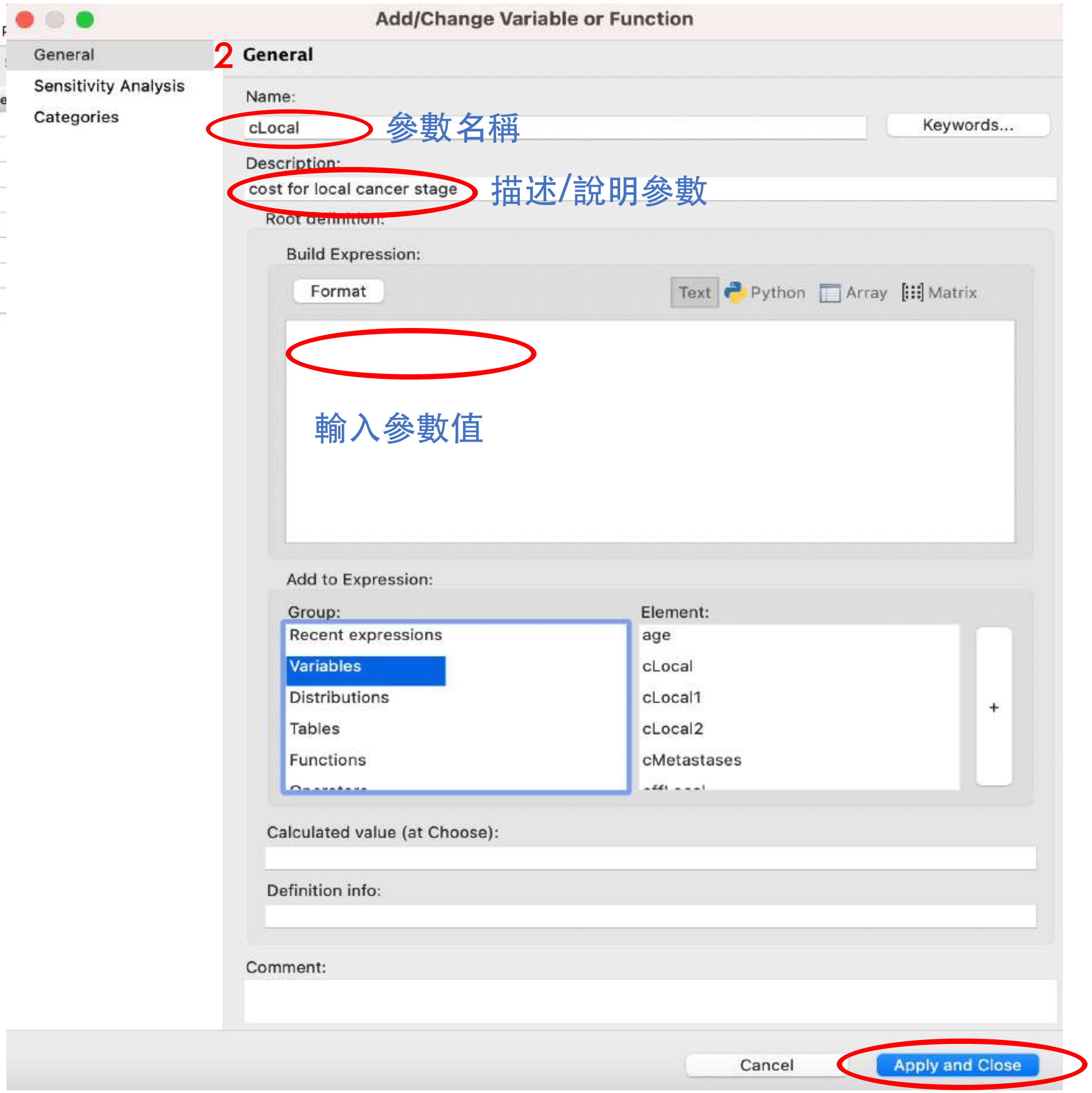
cost

effectiveness

Transition probabilities

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





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 SENS 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

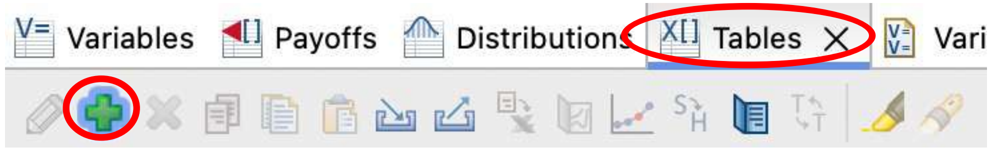
Example 3- Time-dependence variables

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

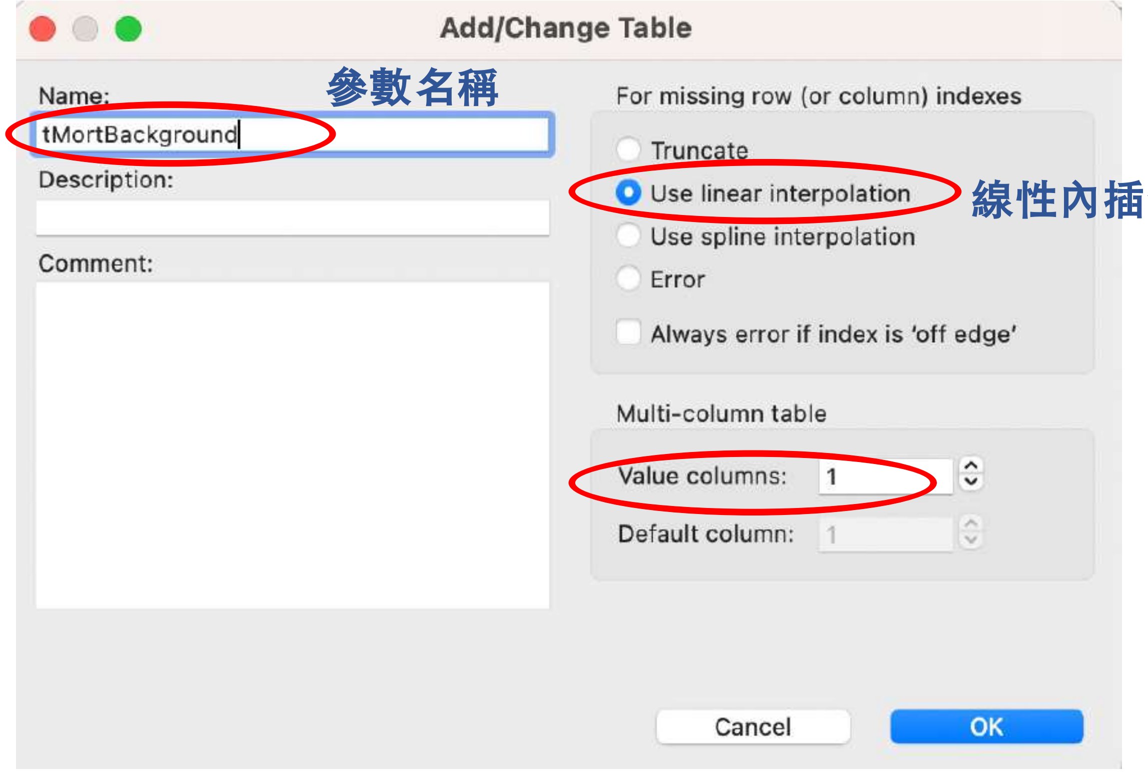
Example 3-Markov Model Structure- create a Table for Background Mortality

1



2

參數名稱



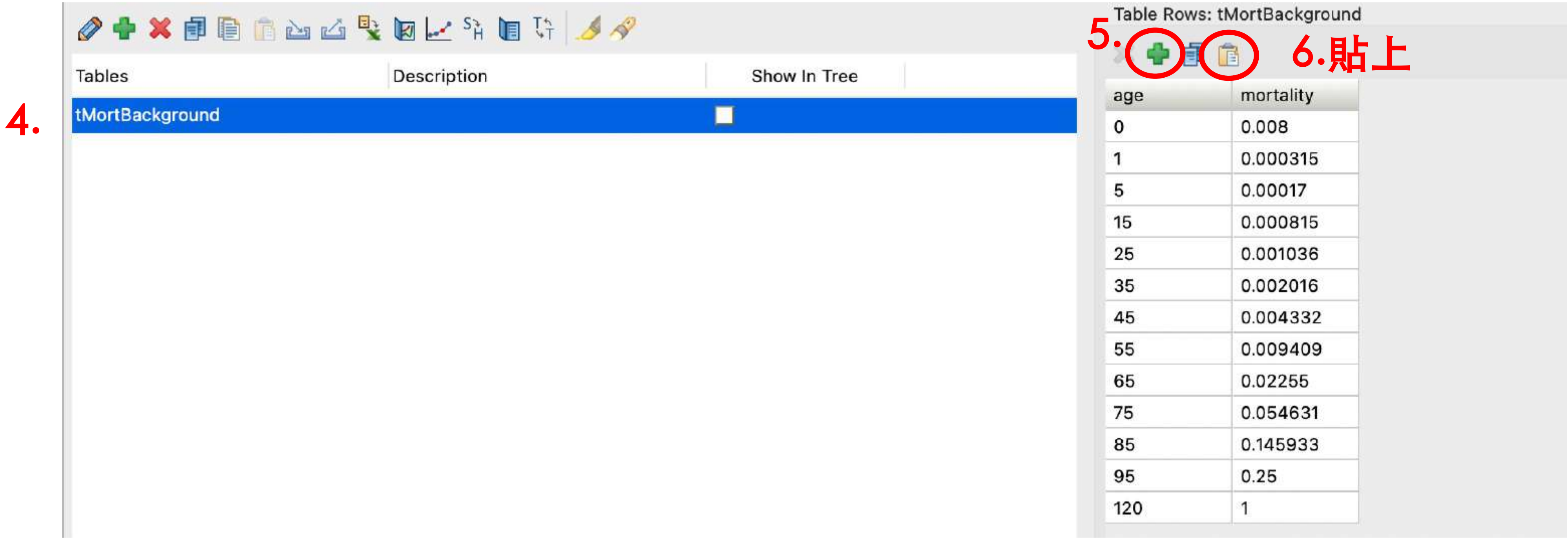
線性內插法

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

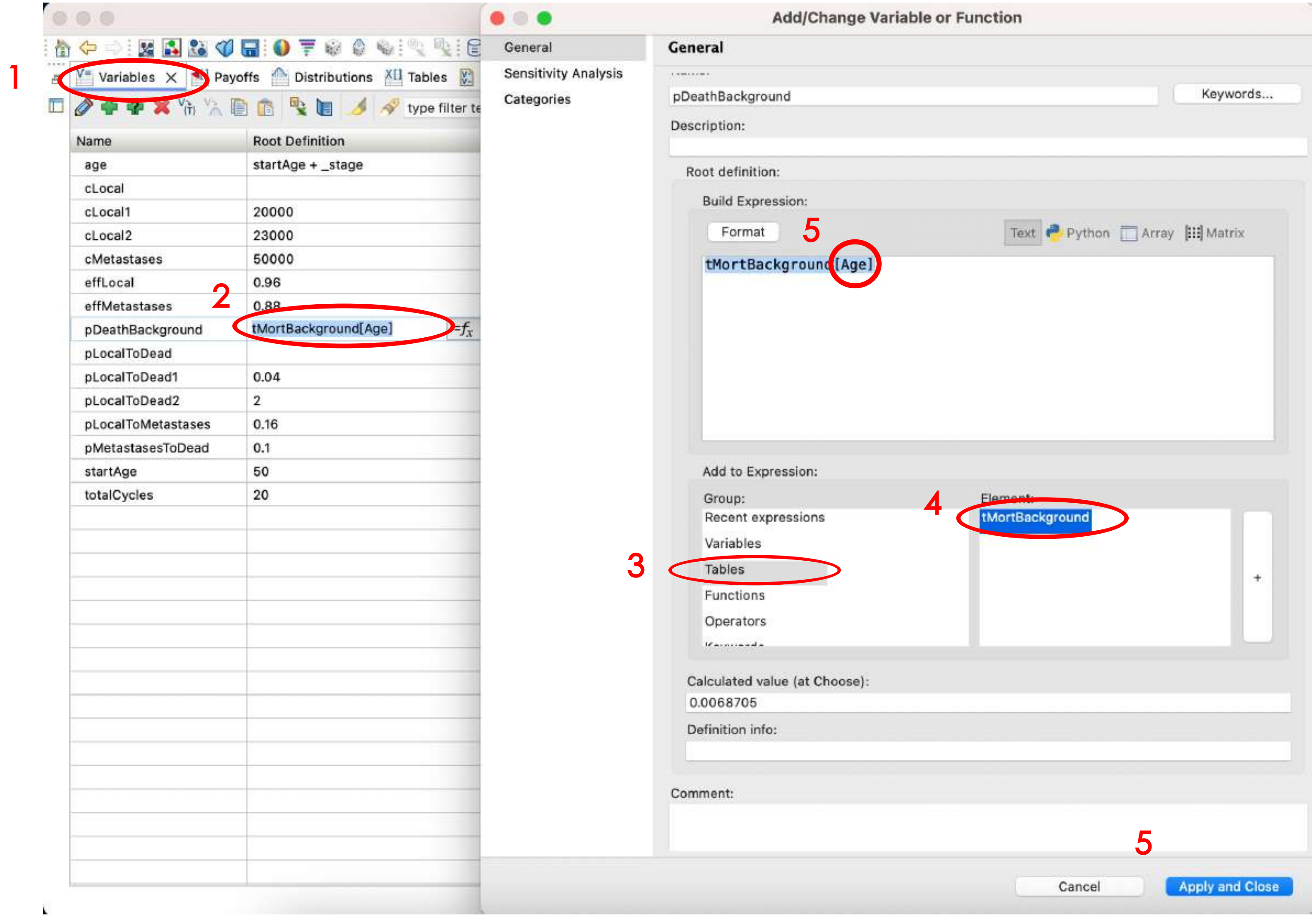


age	mortality
0	0.008
1	0.000315
5	0.00017
15	0.000815
25	0.001036
35	0.002016
45	0.004332
55	0.009409
65	0.02255
75	0.054631
85	0.145933
95	0.25
120	1

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

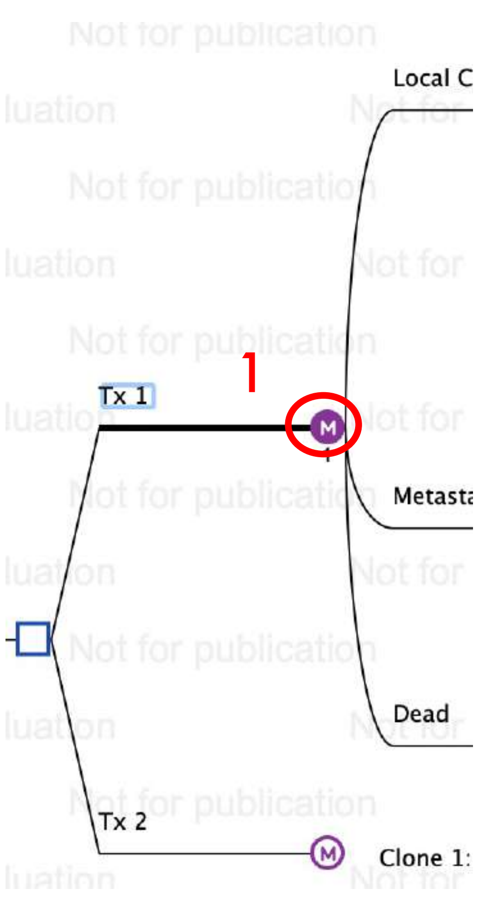
-startAge=50

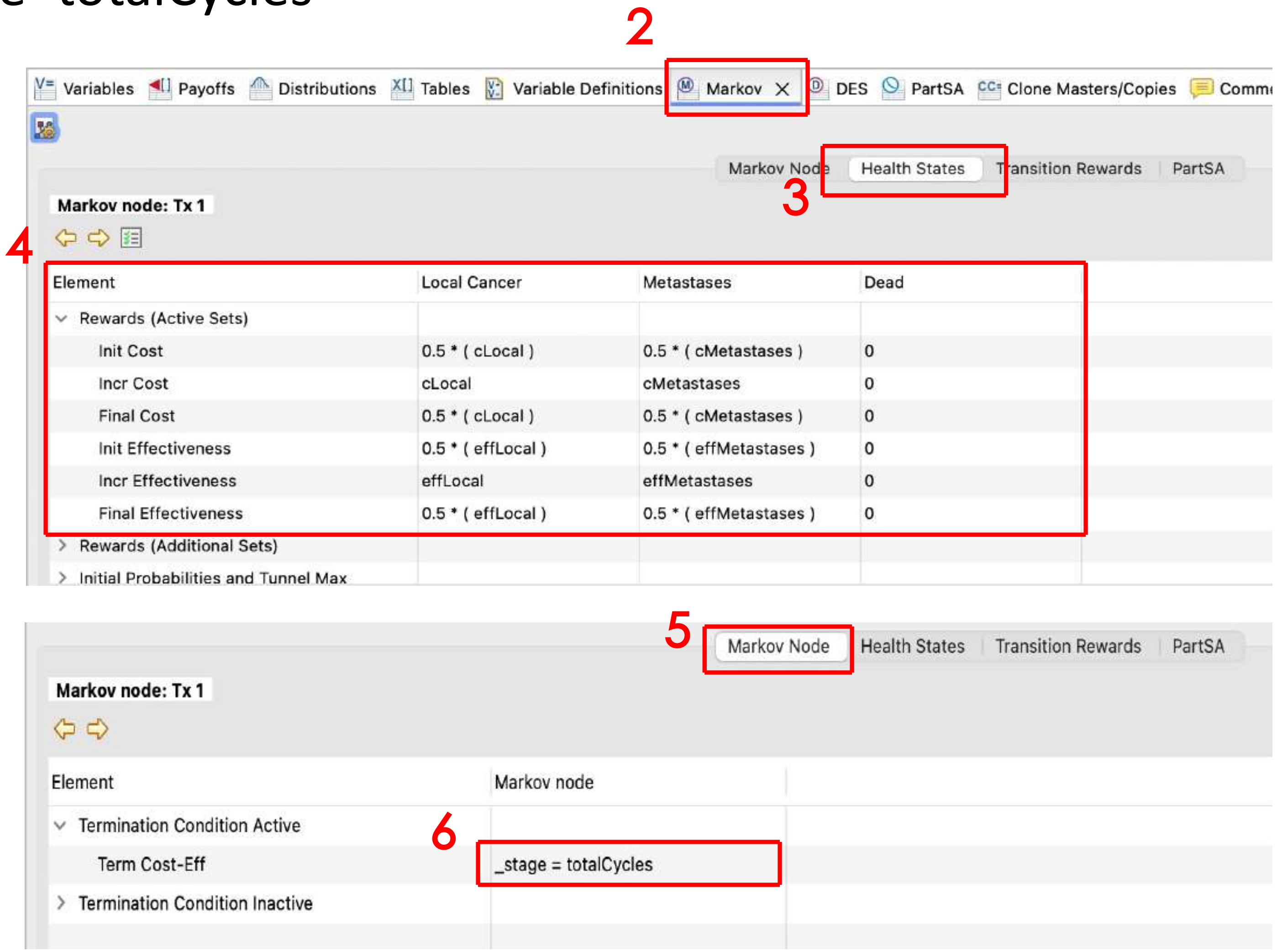
-age= startAge+_stage



Example 3-Markov Model Structure

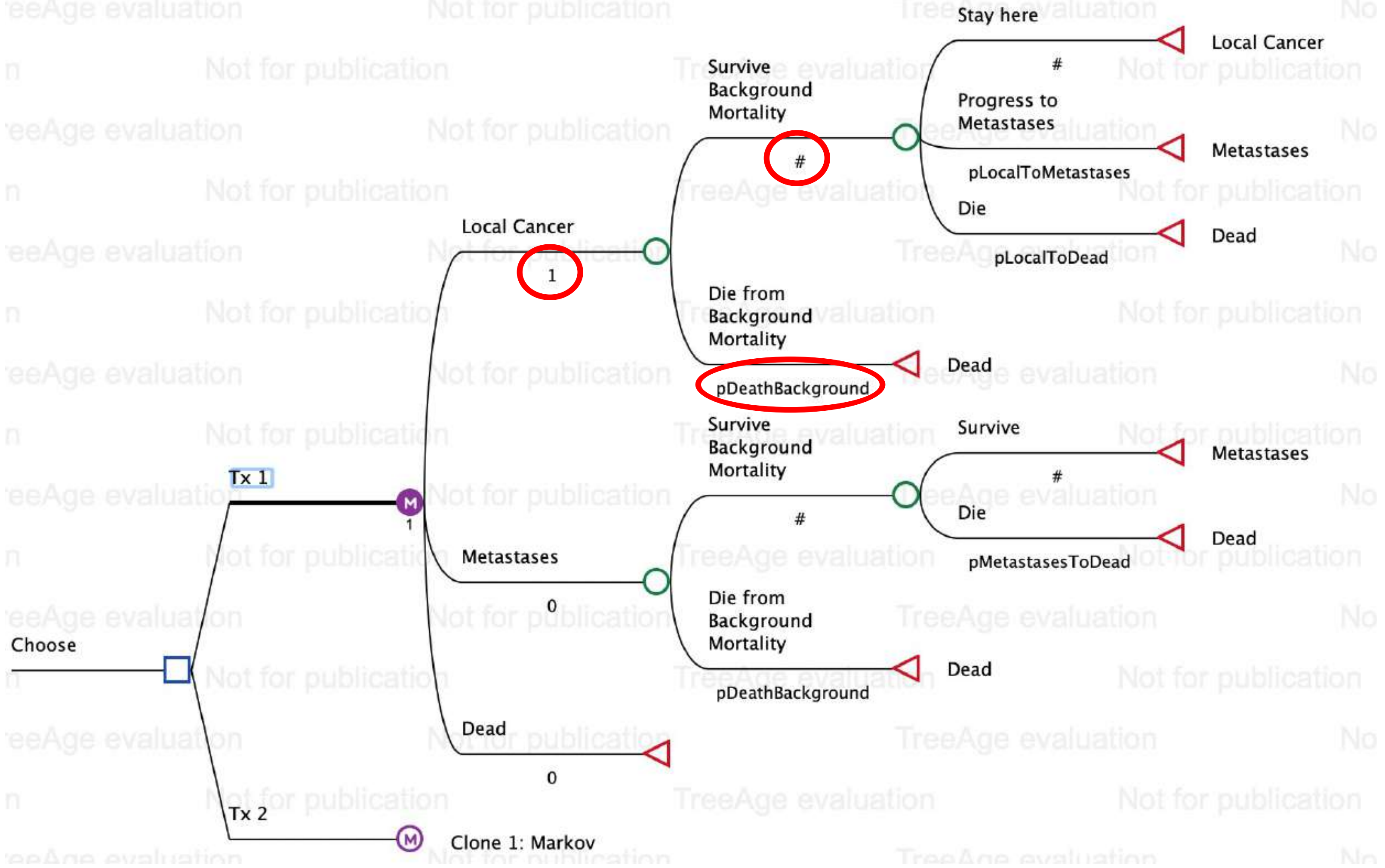
- The half-cycle correction (0.5*outcome) can improve the accuracy of the results.
- Set termination:_stage=totalCycles



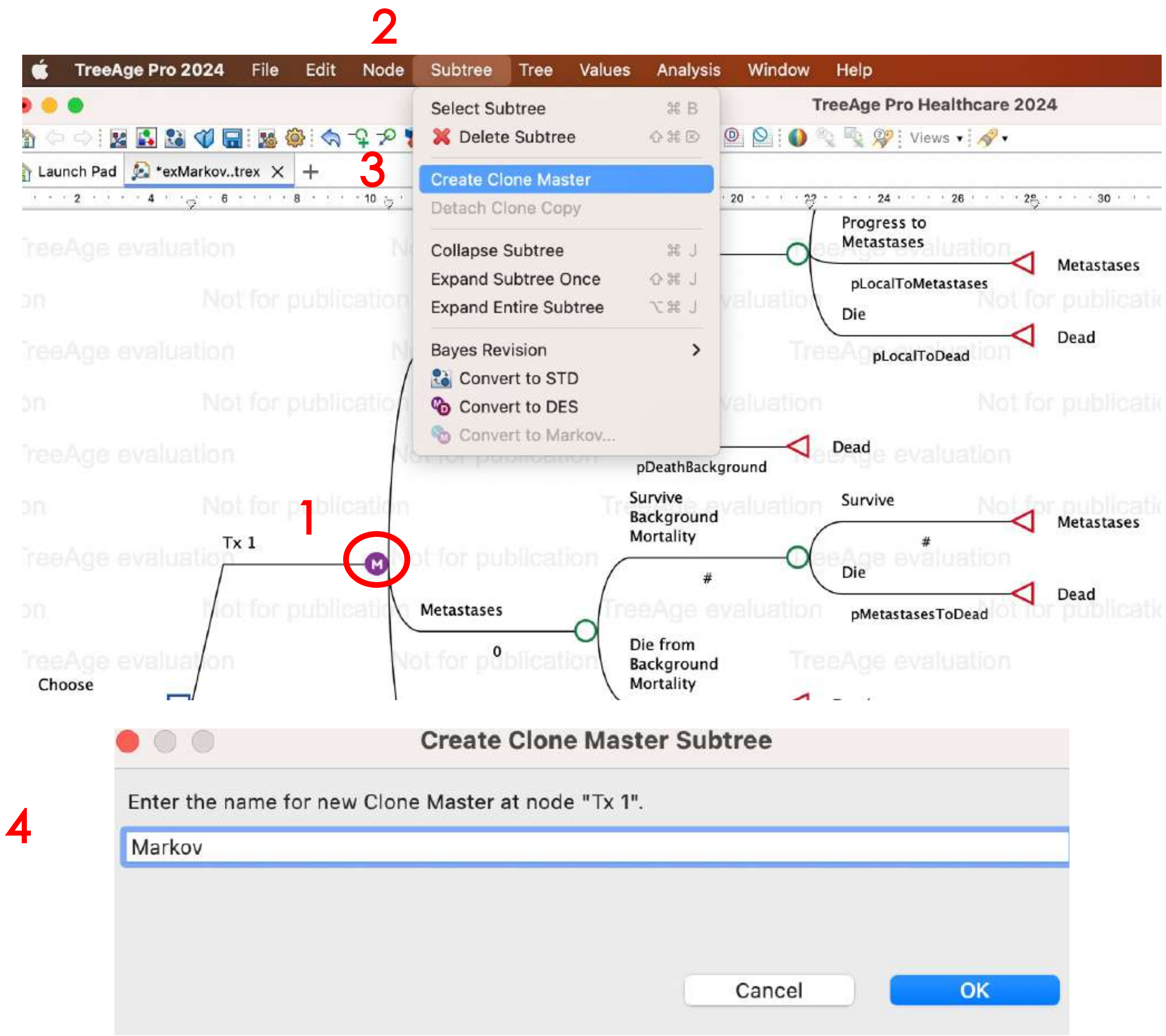


Example 3-Markov Model Structure

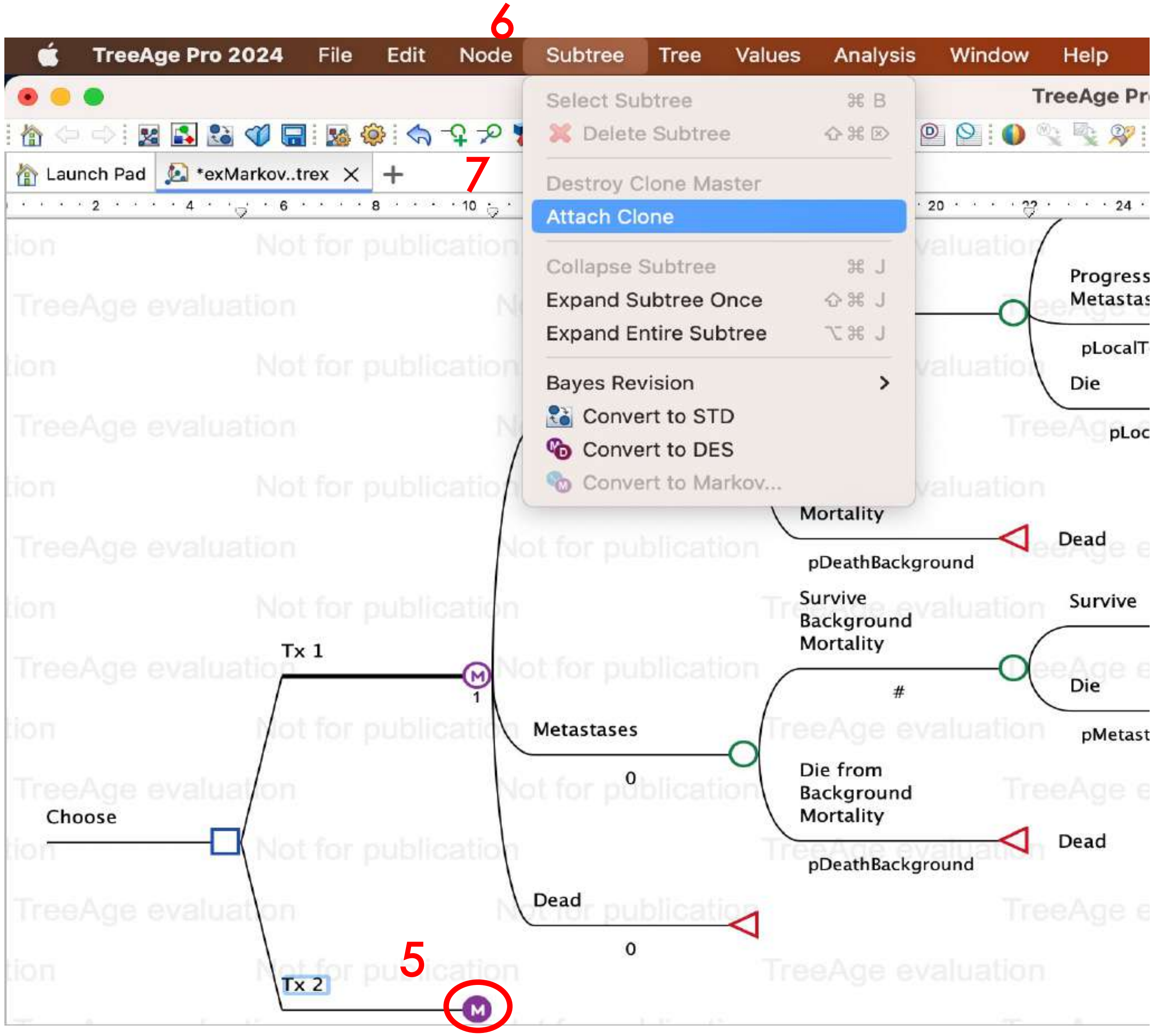
- Add **initial probabilities** and **transition probabilities**

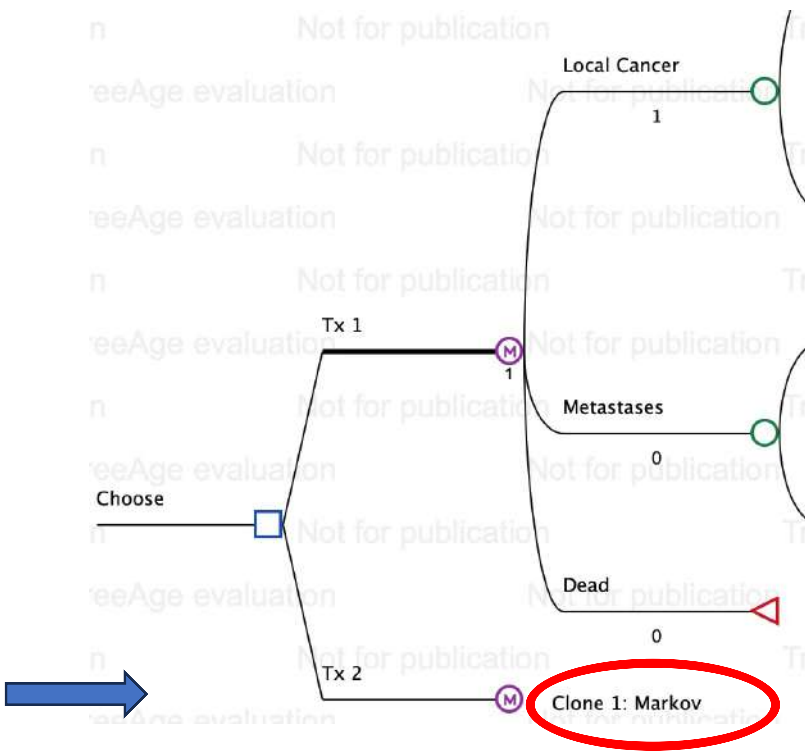


Example 3-Markov Model Structure-Create clone master



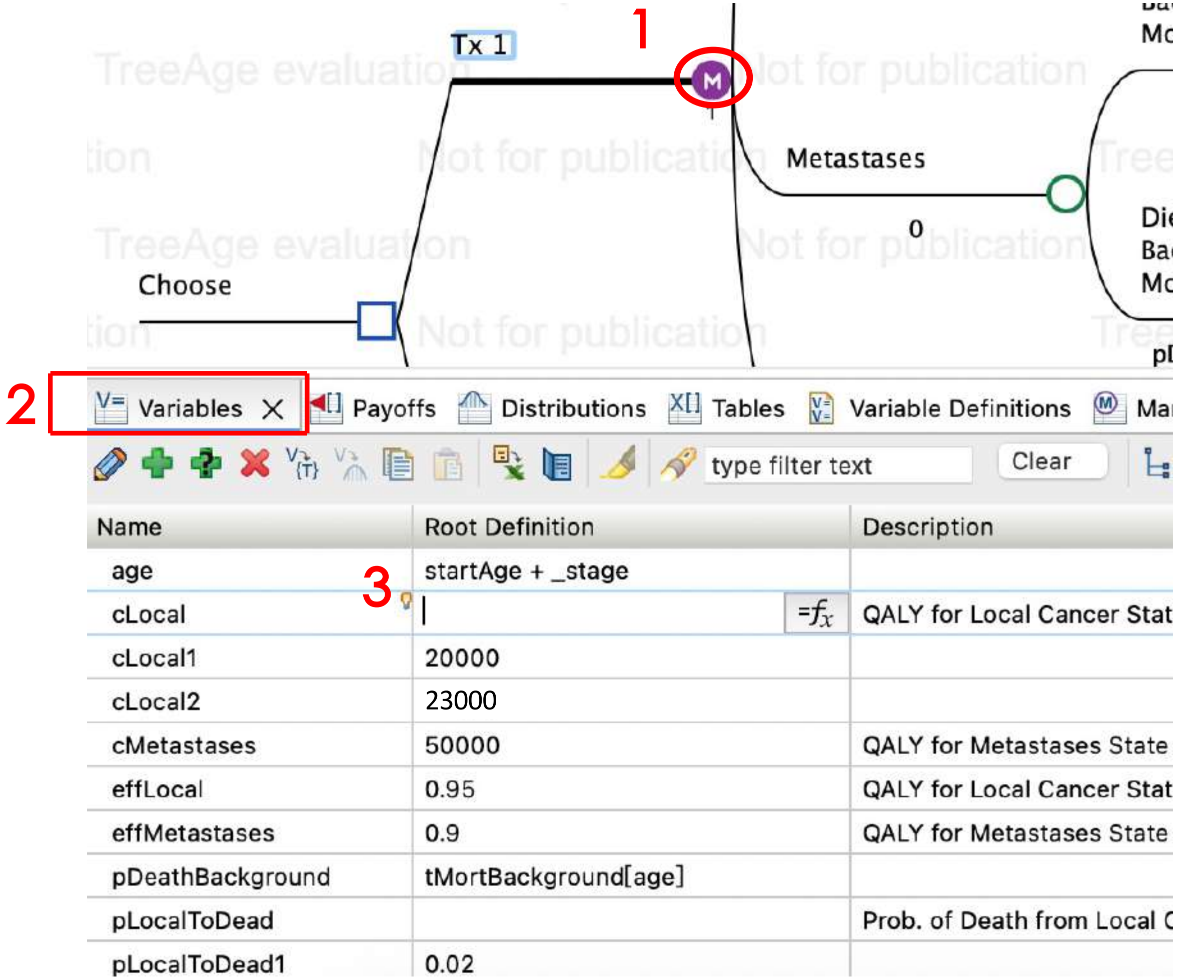
Example 3-Markov Model Structure-Attach clone to the Markove node of Tx2

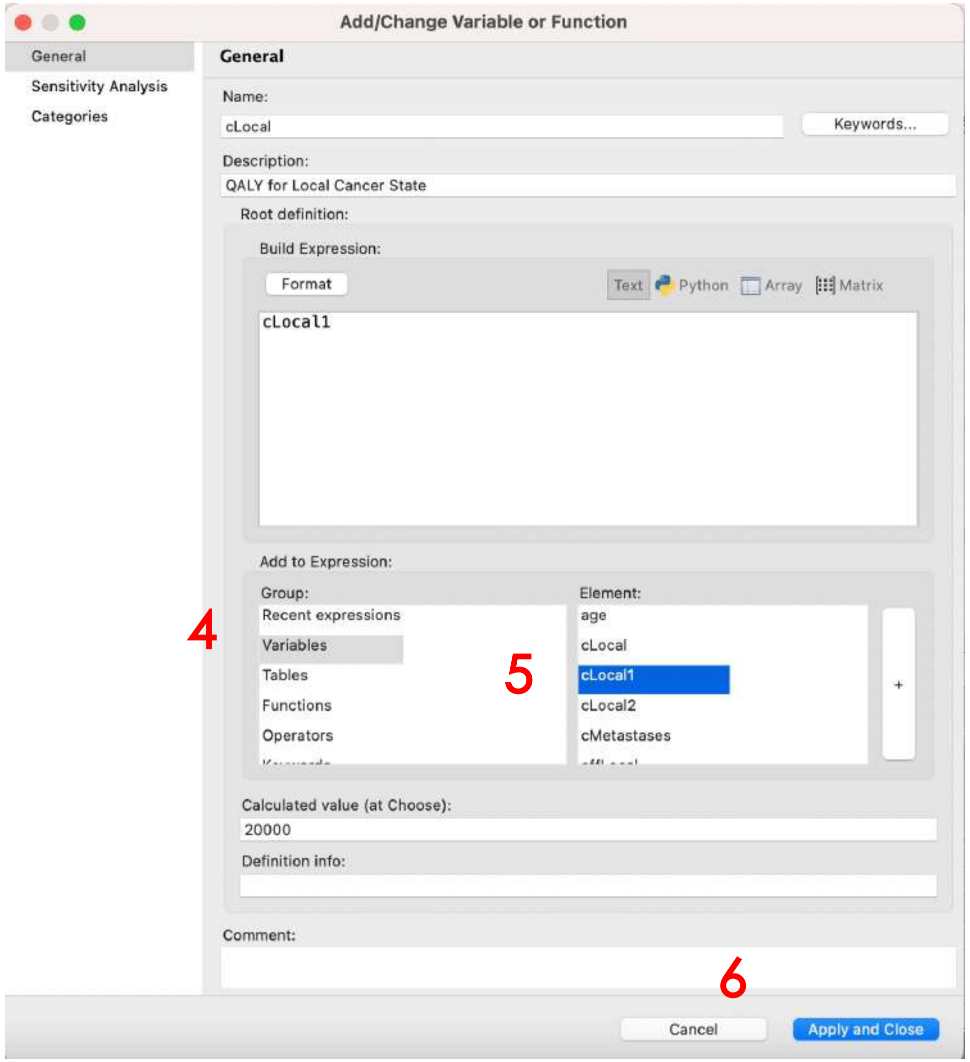




Example 3-Markov Model Structure-Define variables

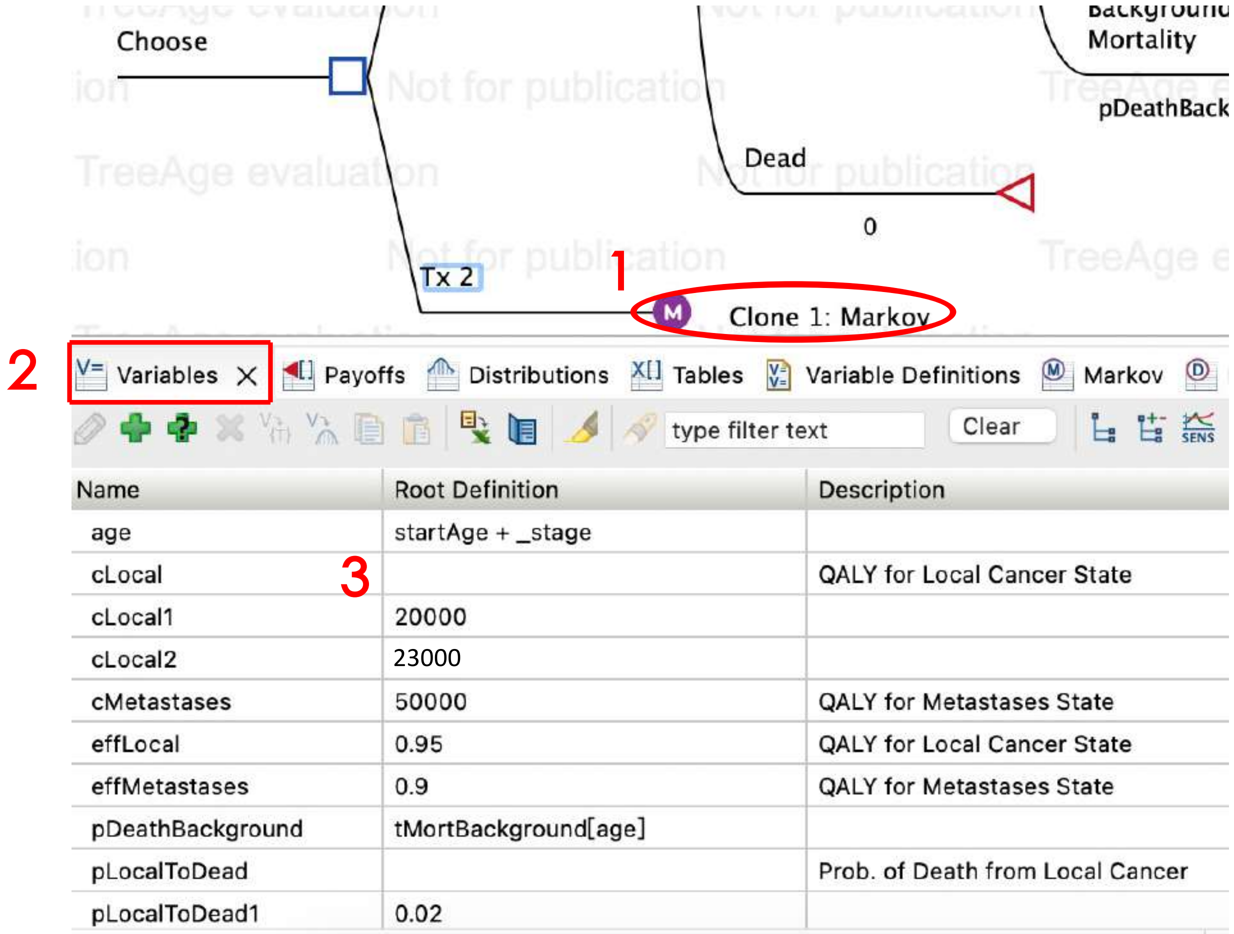
-Tx1: **cLoocal**= cLoocal1, **pLocalToDead**=pLocalToDead1

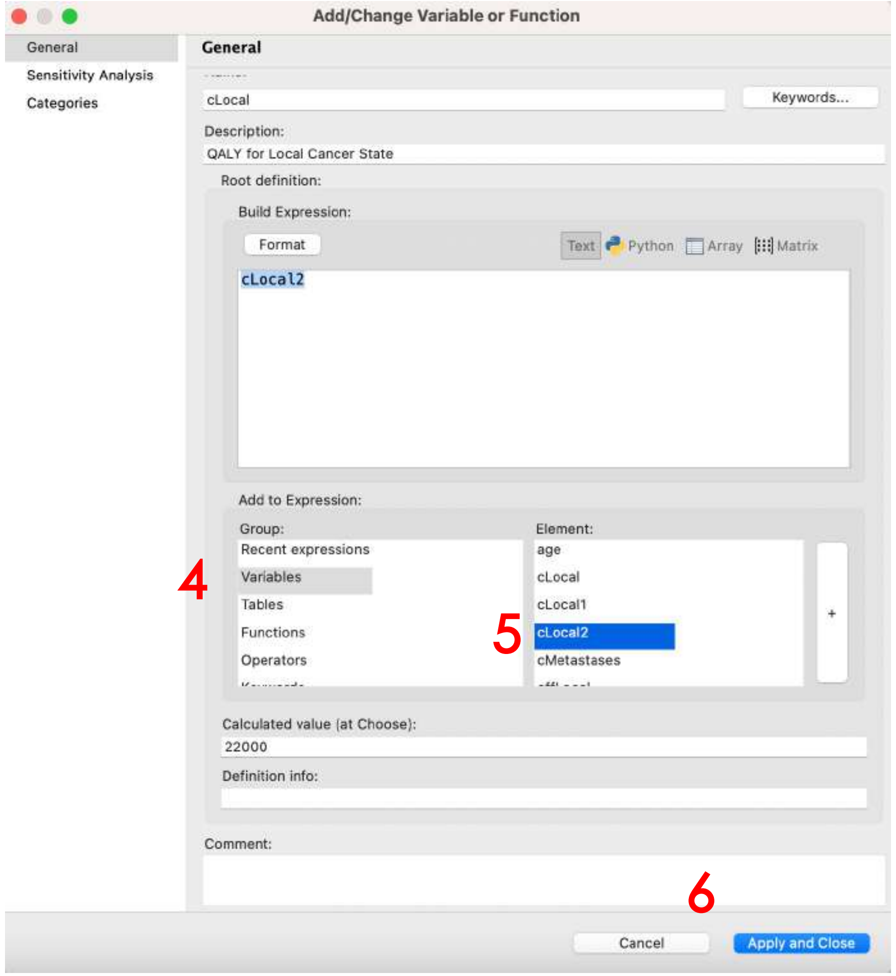




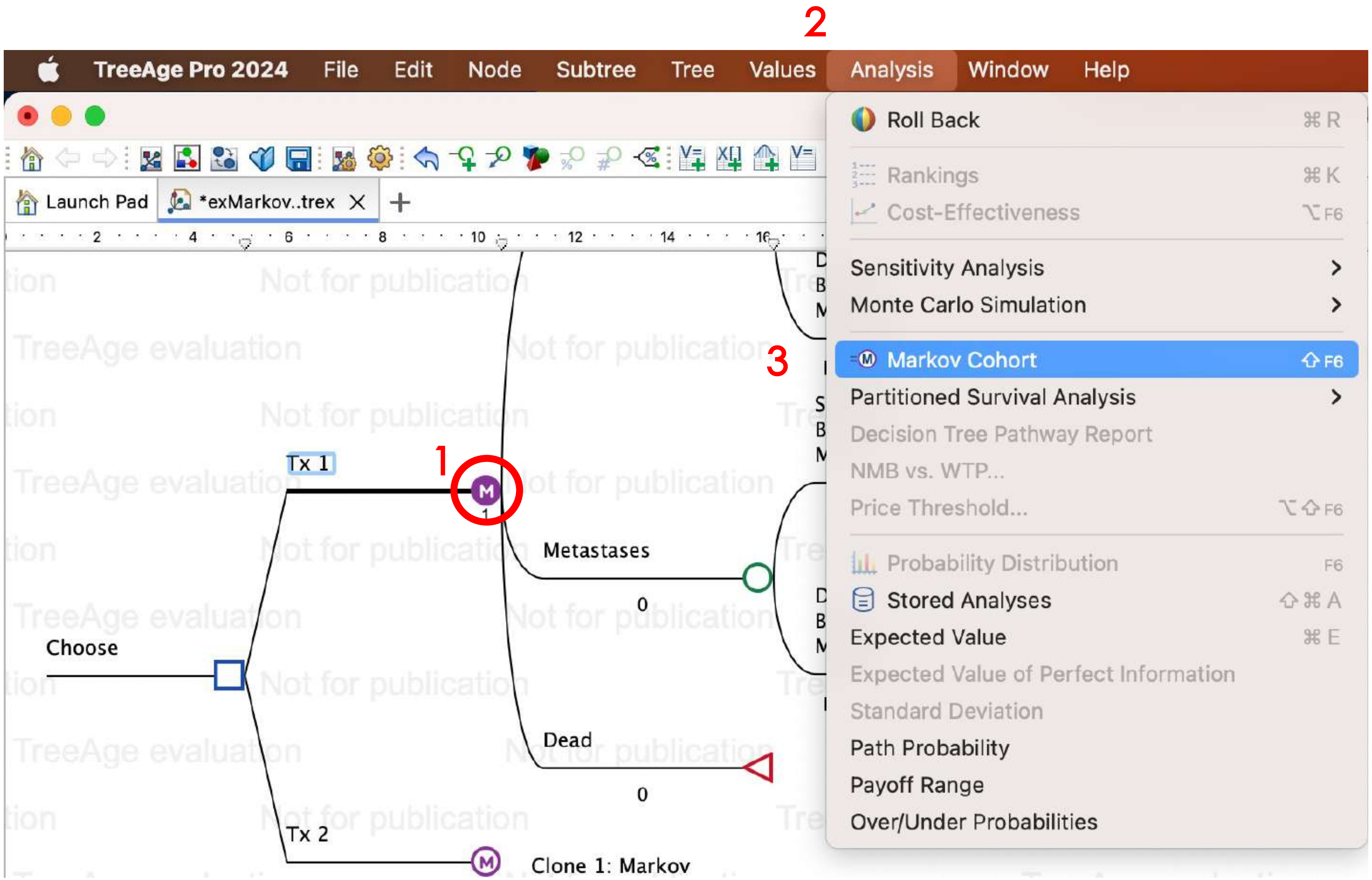
Example 3-Markov Model Structure-Define variables

-Tx2: **cLoocal**= cLoocal2, **pLocalToDead**=pLocalToDead2

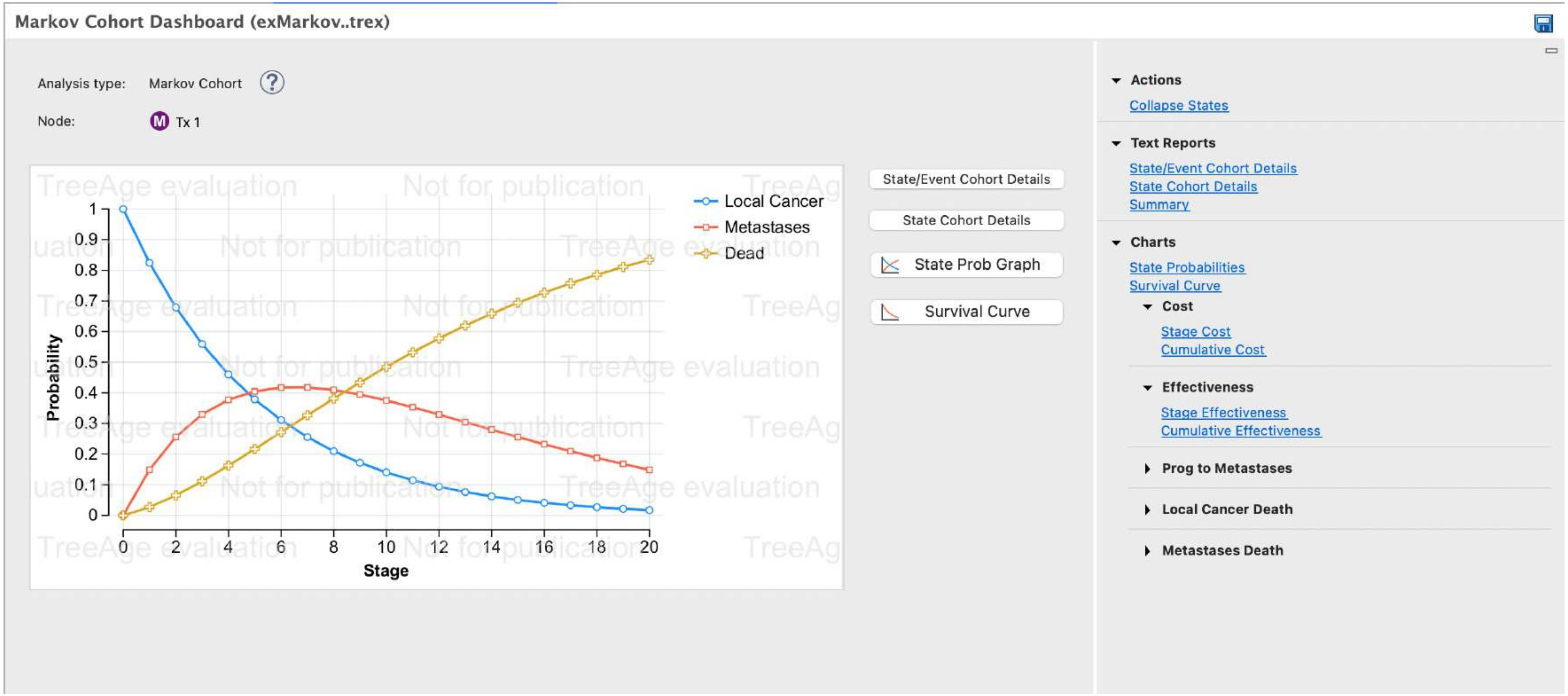




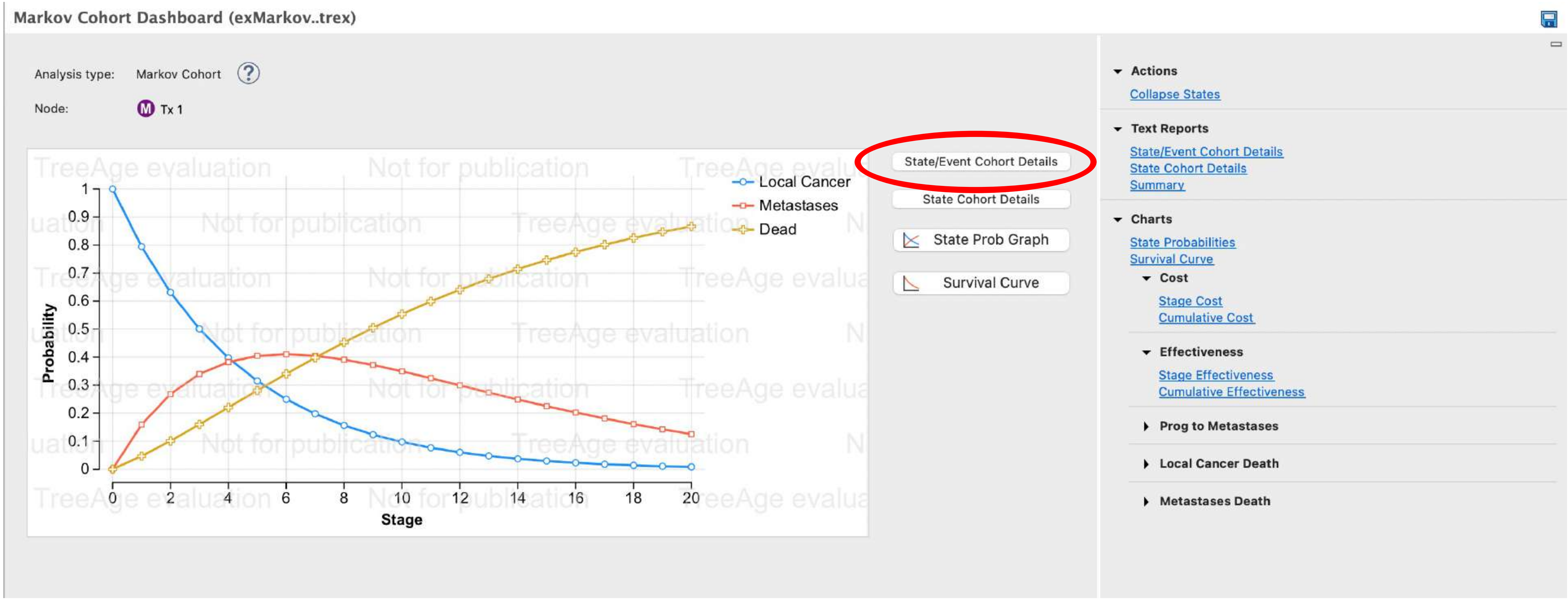
Example 3-Markov Model Structure-Check the model



Example 3-Markov Model Structure-Check the model



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



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

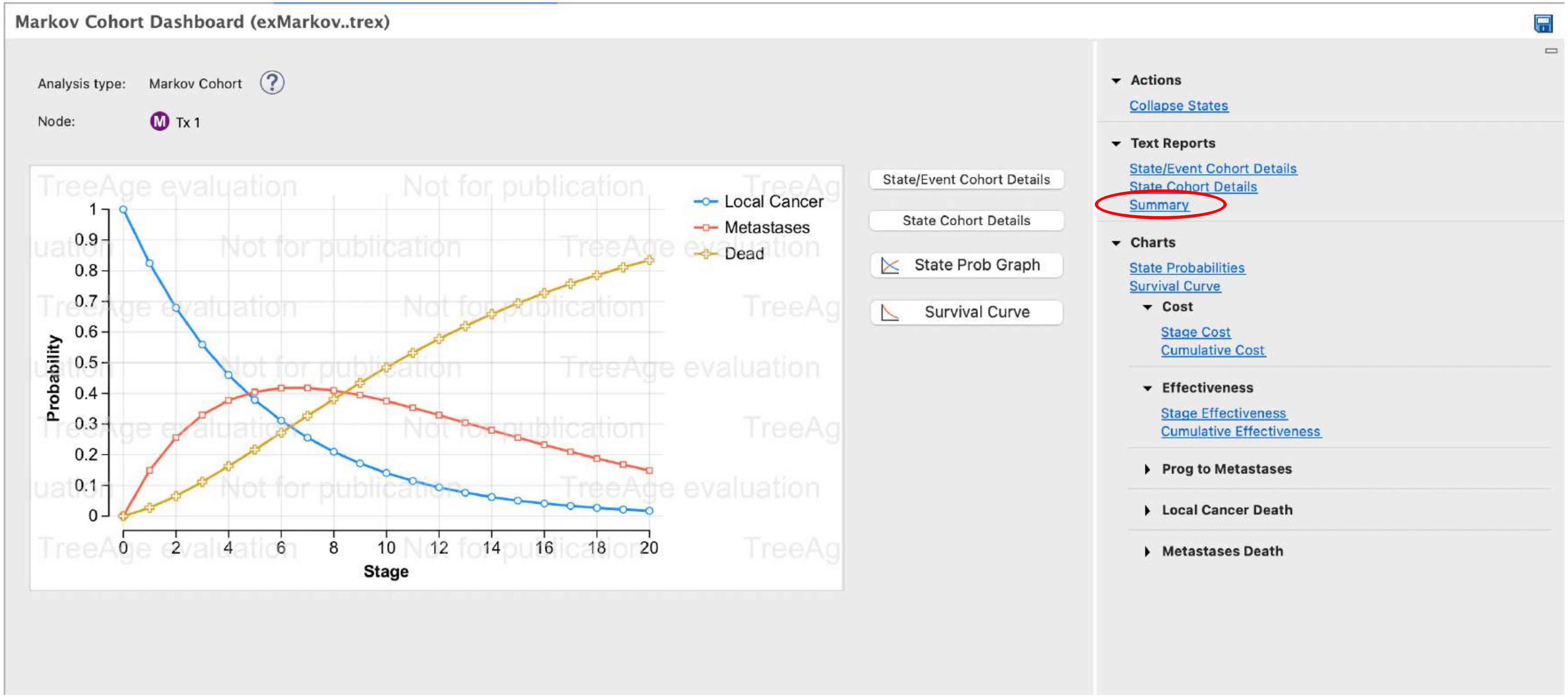
50yr background mortality=0.007

Half correction

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

State/Transition	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 Dea Entry
Summary	0			10,000	10,000		0.48	0.48		0.159	0.159		0.040	0.040	
Local Cancer	0	1.000	10,000	10,000		0.48	0.48		0.000	0.000		0.000	0.000		0.000
Metastases	0	0.000	25,000	0		0.44	0.00		0.000	0.000		0.000	0.000		0.000
Dead	0	0.000	0	0		0.00	0.00		0.000	0.000		0.000	0.000		0.000
Summary	1			23,835	33,835		0.90	1.38		0.126	0.285		0.032	0.071	
Local Cancer	1	0.795	20,000	15,890		0.96	0.76		0.000	0.000		0.000	0.000		0.000
Metastases	1	0.159	50,000	7,945		0.88	0.14		0.000	0.000		0.000	0.000		0.000
Dead	1	0.047	0	0		0.00	0.00		0.000	0.000		0.000	0.000		0.000
Summary	2			26,025	59,860		0.84	2.22		0.100	0.385		0.025	0.096	
Local Cancer	2	0.631	20,000	12,618		0.96	0.61		0.000	0.000		0.000	0.000		0.000
Metastases	2	0.268	50,000	13,407		0.88	0.24		0.000	0.000		0.000	0.000		0.000
Dead	2	0.101	0	0		0.00	0.00		0.000	0.000		0.000	0.000		0.000
Summary	3			26,994	86,854		0.78	3.00		0.079	0.465		0.020	0.116	
Local Cancer	3	0.501	20,000	10,015		0.96	0.48		0.000	0.000		0.000	0.000		0.000
Metastases	3	0.340	50,000	16,979		0.88	0.30		0.000	0.000		0.000	0.000		0.000
Dead	3	0.160	0	0		0.00	0.00		0.000	0.000		0.000	0.000		0.000
Summary	4			27,070	113,923		0.72	3.72		0.063	0.528		0.016	0.132	
Local Cancer	4	0.397	20,000	7,945		0.96	0.38		0.000	0.000		0.000	0.000		0.000
Metastases	4	0.382	50,000	19,125		0.88	0.34		0.000	0.000		0.000	0.000		0.000
Dead	4	0.220	0	0		0.00	0.00		0.000	0.000		0.000	0.000		0.000
Summary	5			26,508	140,431		0.66	4.38		0.050	0.578		0.012	0.144	
Local Cancer	5	0.315	20,000	6,299		0.96	0.30		0.000	0.000		0.000	0.000		0.000
Metastases	5	0.404	50,000	20,209		0.88	0.36		0.000	0.000		0.000	0.000		0.000
Dead	5	0.281	0	0		0.00	0.00		0.000	0.000		0.000	0.000		0.000
Summary	6			25,505	165,936		0.60	4.98		0.040	0.617		0.010	0.154	
Local Cancer	6	0.250	20,000	4,992		0.96	0.24		0.000	0.000		0.000	0.000		0.000
Metastases	6	0.410	50,000	20,513		0.88	0.36		0.000	0.000		0.000	0.000		0.000
Dead	6	0.340	0	0		0.00	0.00		0.000	0.000		0.000	0.000		0.000

Example 3-Markov Model Structure-Summary

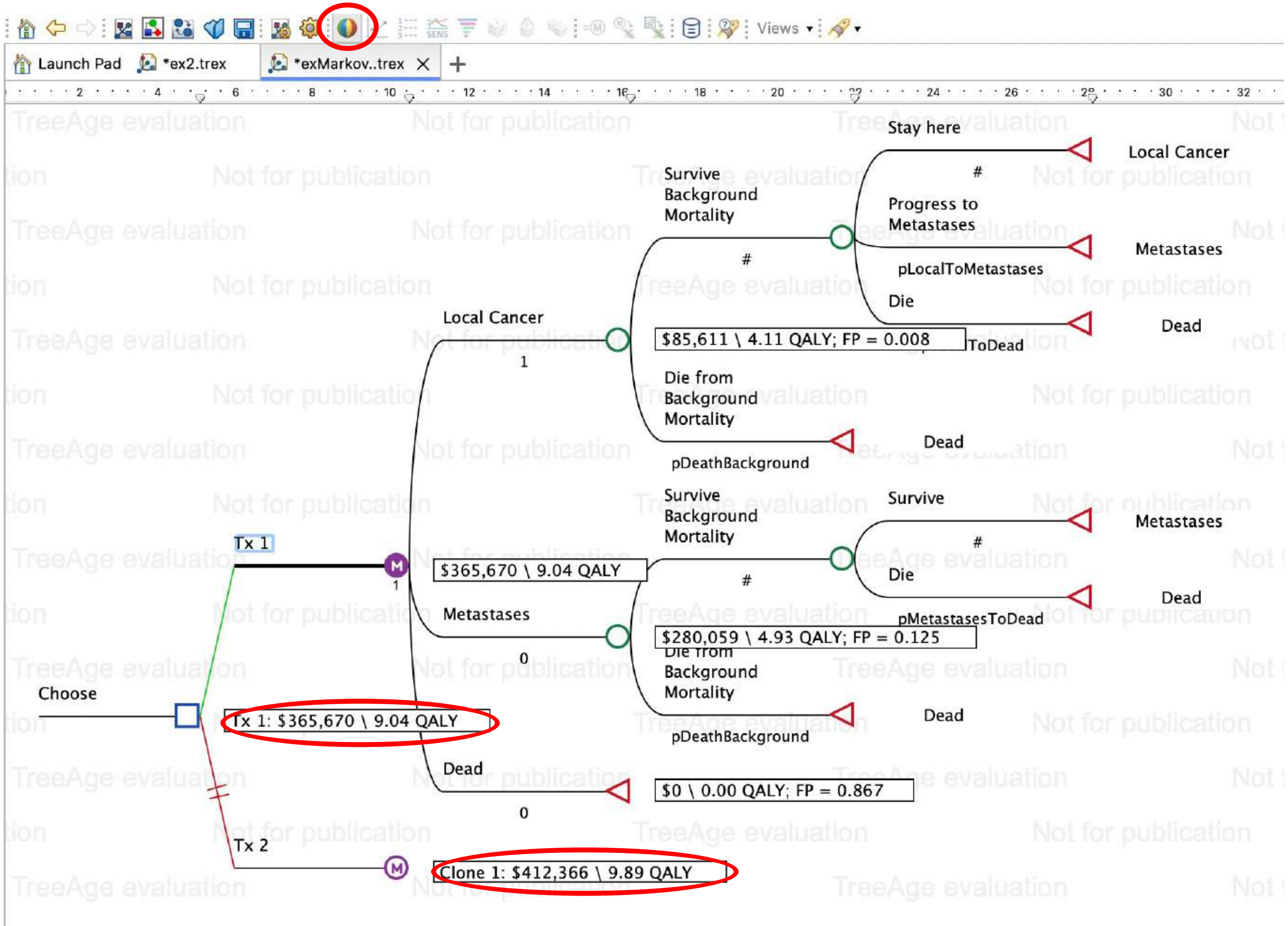


Example 3-Markov Model Structure-Summary

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

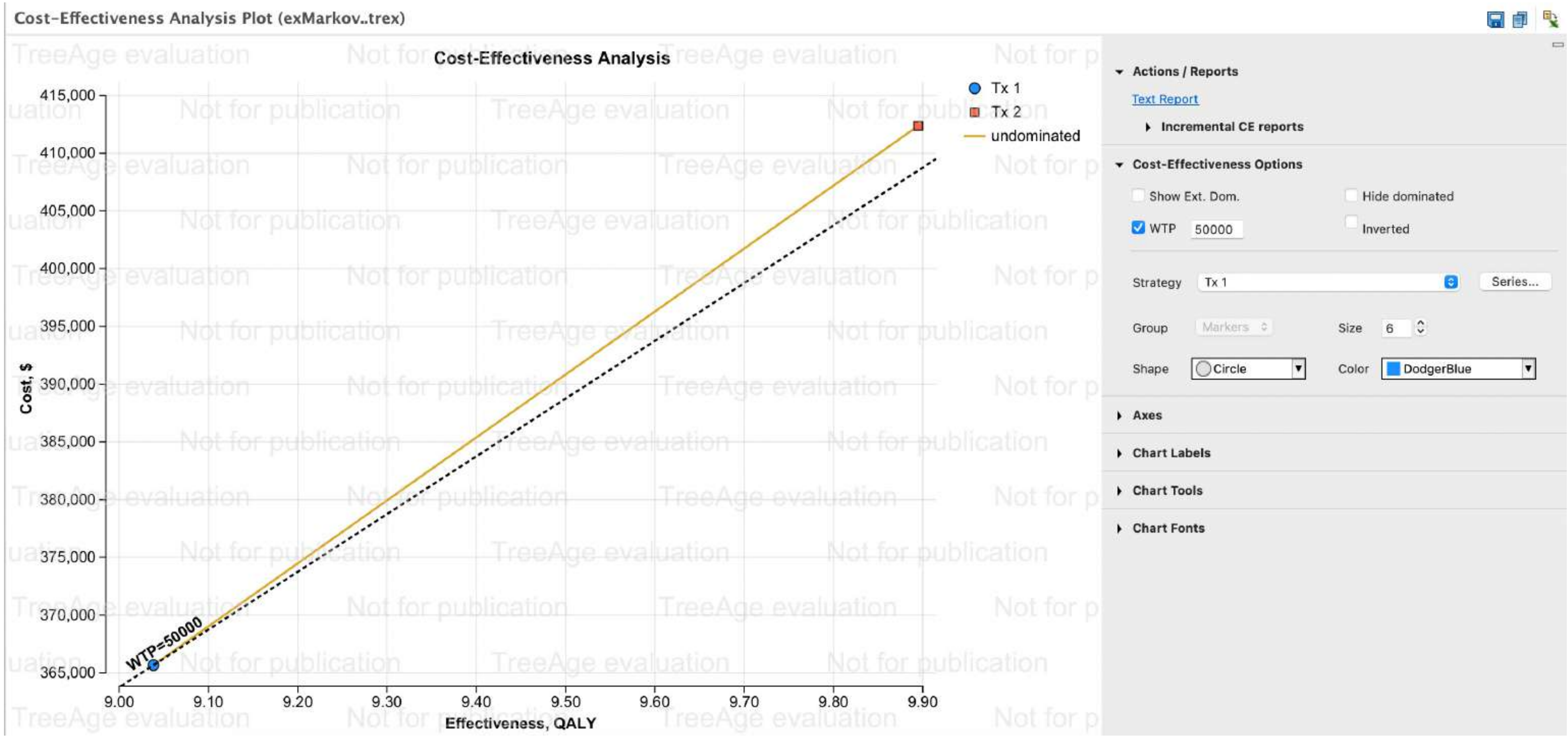
(Tx1: 9.04*50,000-365,670)

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

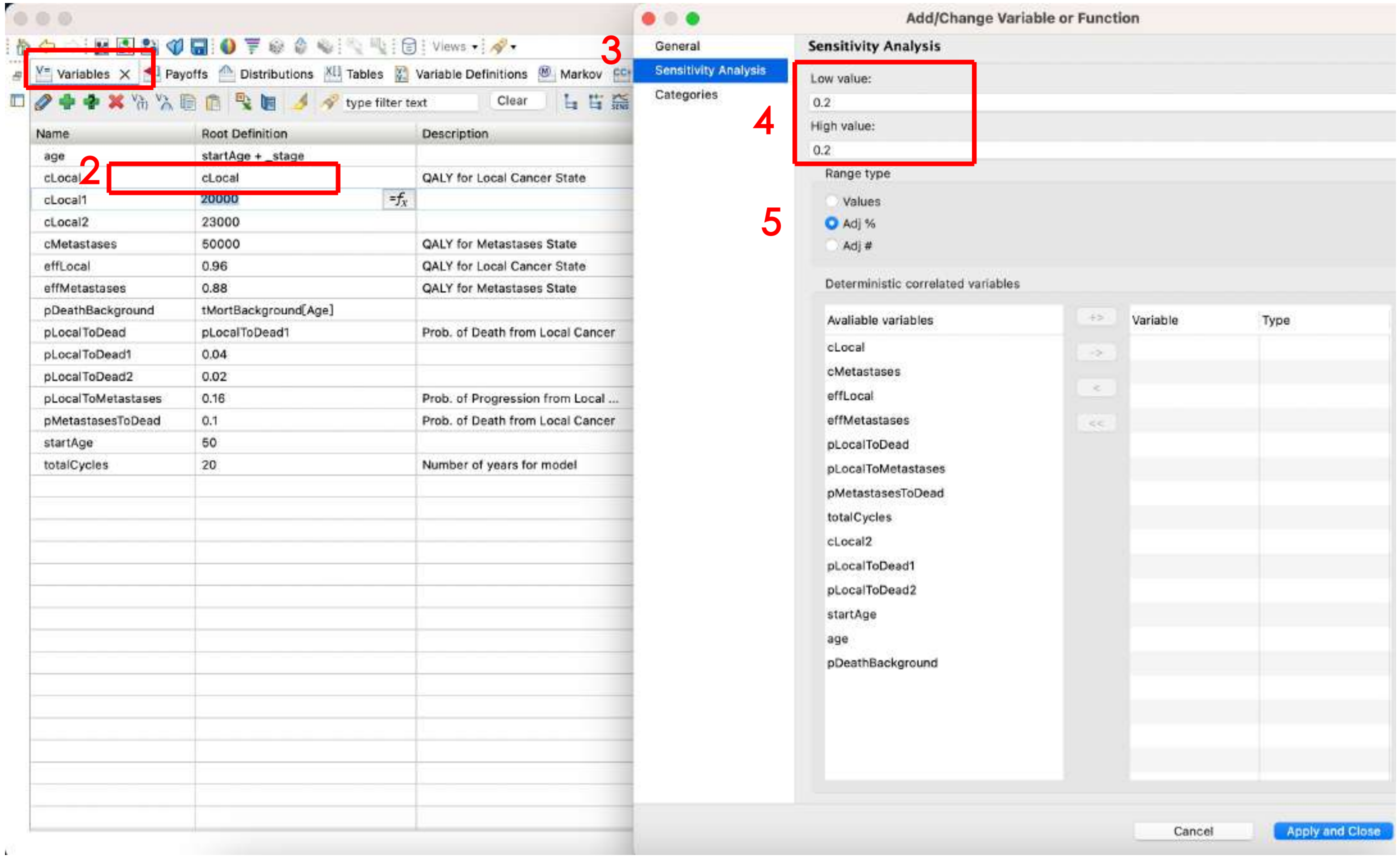


Example 3-Markov Model Structure-One way Sensitive analysis

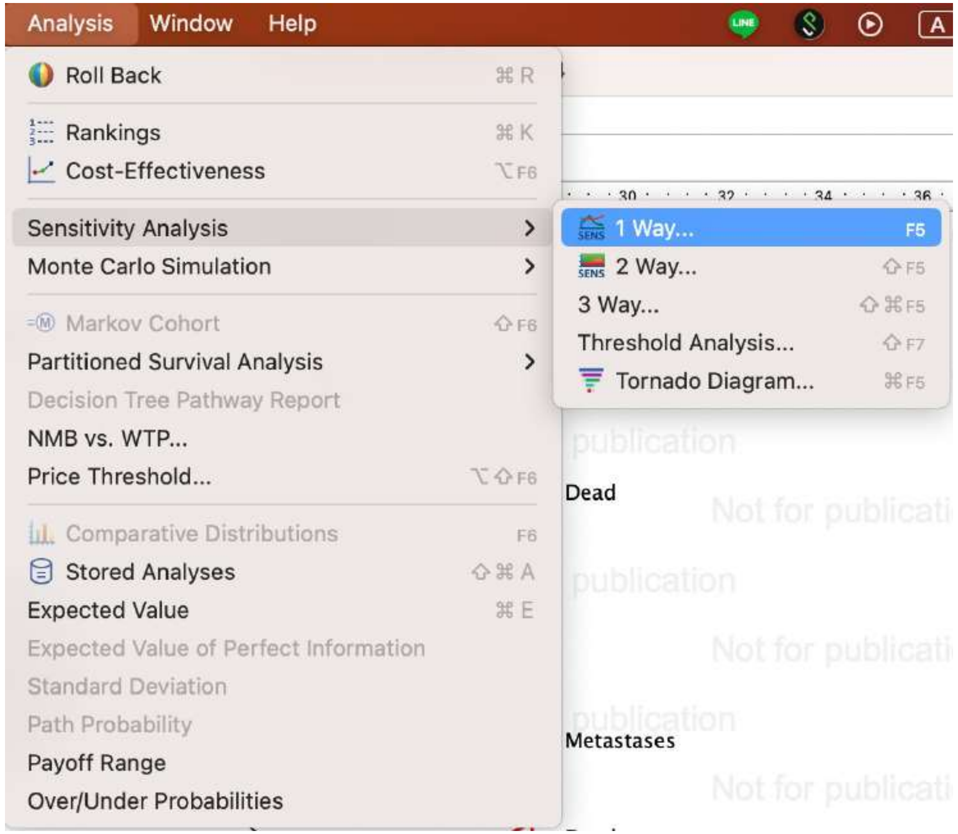
- One way Sensitive analysis

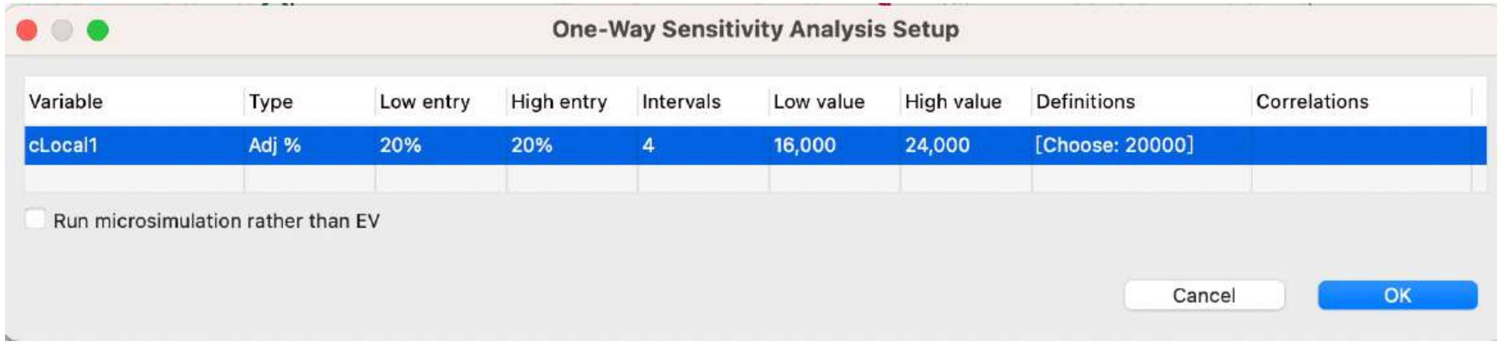
  Define low/ high value

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

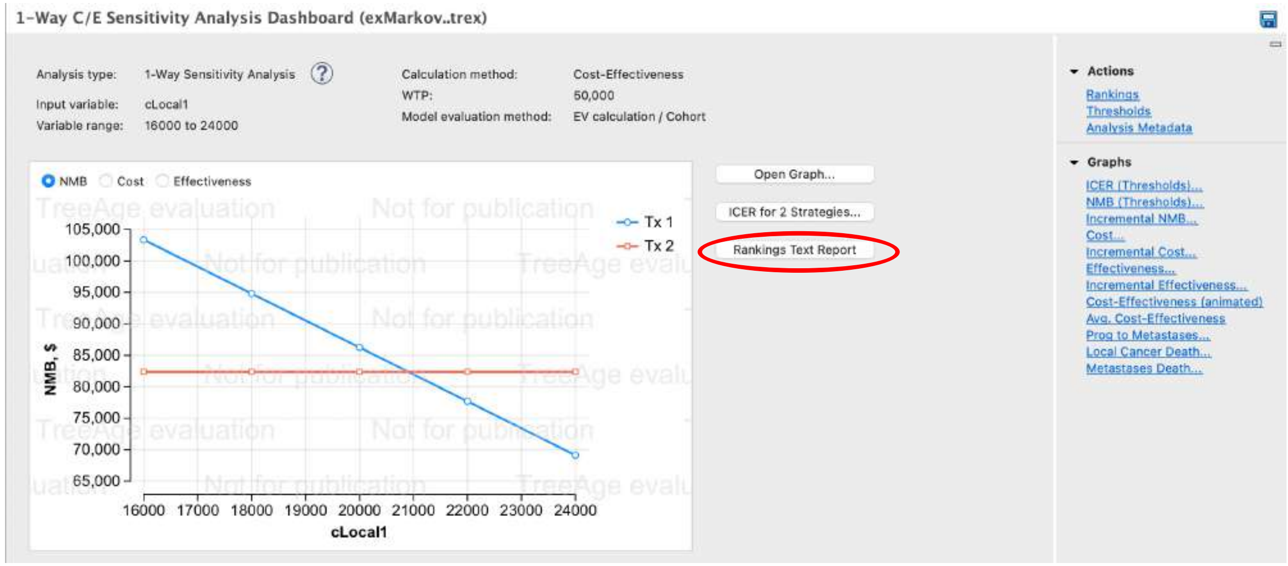


Example 3-Markov Model Structure-One way Sensitive analysis





Example 3-Markov Model Structure-One way Sensitive analysis



WTP=50,000

Tx1 is the optimal strategy

Tx2 is the optimal strategy

1-Way Sensitivity Analysis – C/E Text Report (exMarkov..trex)

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 Diagram

Number of variables: 15

Variable	Type	Low entry	High entry	Intervals	Low value	High value	Definitions	Correlations
cLocal	Values	0	0	4	0	0	[Choose: cLocal], [Tx 1:	
cMetastases	Adj %	20%	20%	4	40,000	60,000	[Choose: 50000]	
effLocal	Values	0	0.96	4	0	0.96	[Choose: 0.96]	
effMetastases	Values	0	0.88	4	0	0.88	[Choose: 0.88]	
pLocalToDead	Values	0	0.04	4	0	0.04	[Choose: pLocalToDeac	
pLocalToMetastases	Values	0	0.16	4	0	0.16	[Choose: 0.16]	
pMetastasesToDead	Values	0	0.1	4	0	0.1	[Choose: 0.1]	
totalCycles	Values	0	20	4	0	20	[Choose: 20]	
cLocal1	Adj %	20%	20%	4	16,000	24,000	[Choose: 20000]	
cLocal2	Adj %	20%	20%	4	18,400	27,600	[Choose: 23000]	
pLocalToDead1	Values	0	0.04	4	0	0.04	[Choose: 0.04]	
pLocalToDead2	Values	0	0.02	4	0	0.02	[Choose: 0.02]	
startAge	Values	0	50	4	0	50	[Choose: 50]	
age	Values	0	50	4	0	50	[Choose: startAge + _s	
pDeathBackground	Values	0	0.0068705	4	0	0.0068705	[Choose: tMortBackgro	

Run microsimulation rather than EV

cLocal: High value must be greater than low value.

Cancel OK

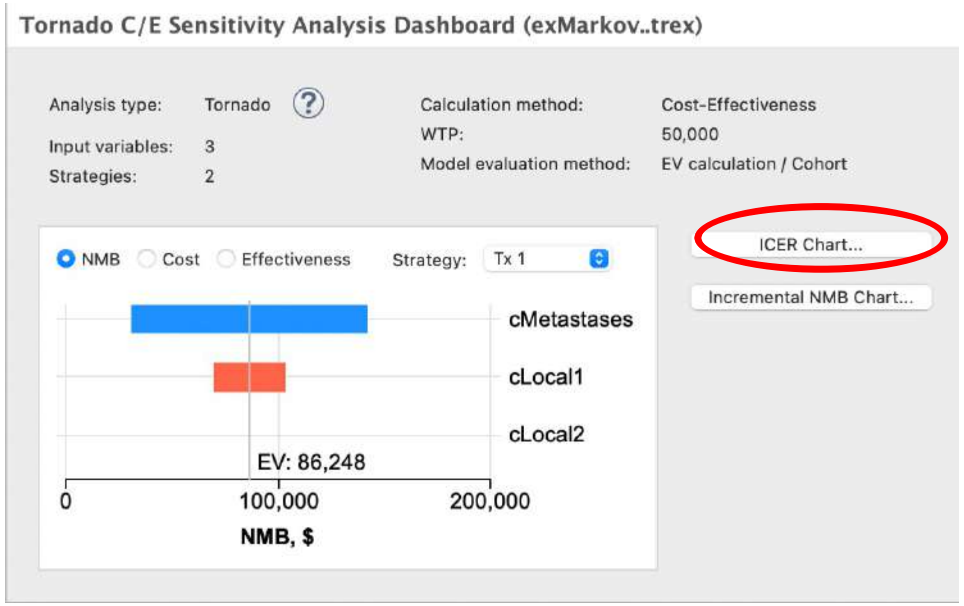
Tornado Diagram

Number of variables: 3

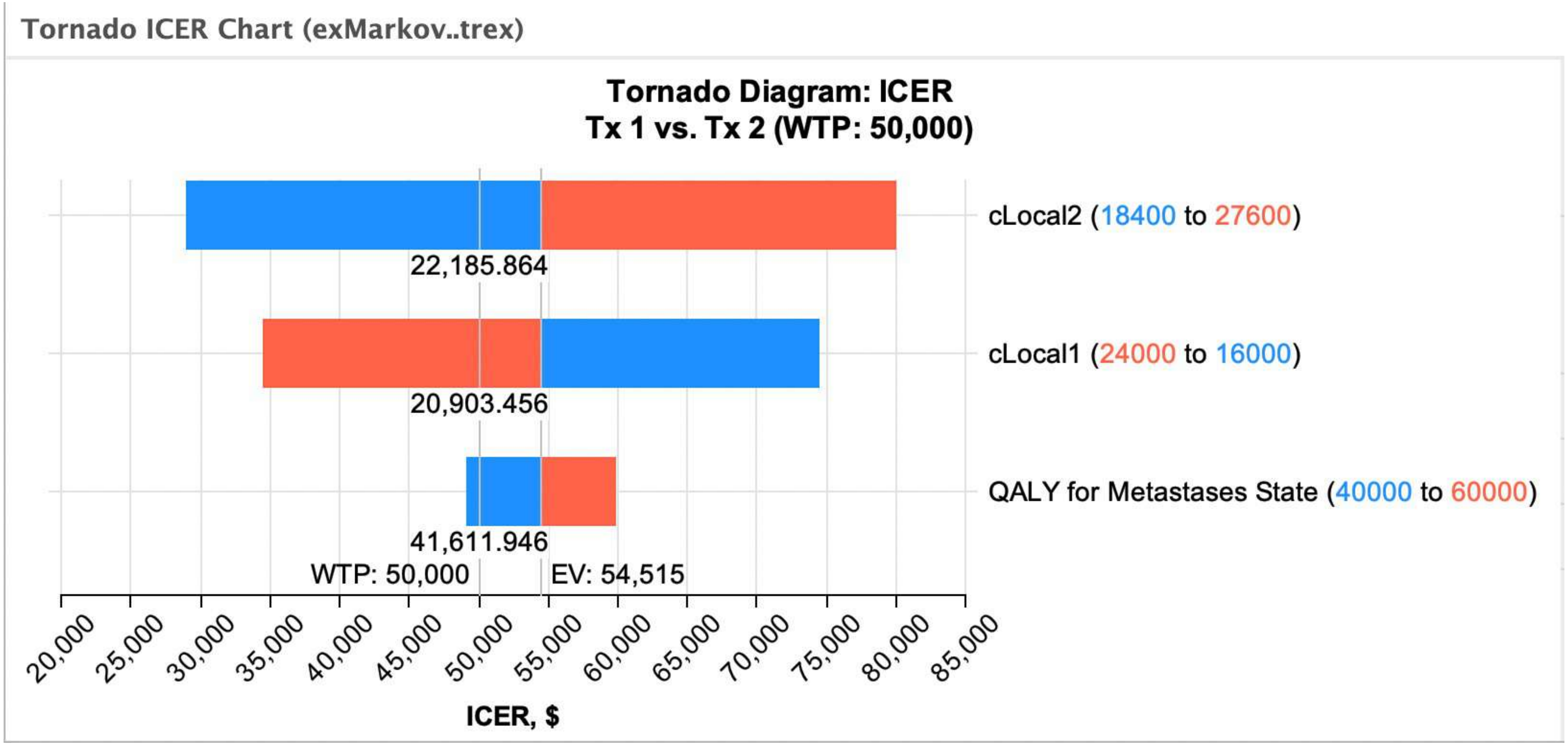
Variable	Type	Low entry	High entry	Intervals	Low value	High value	Definitions	Correlations
cLocal1	Adj %	20%	20%	4	16,000	24,000	[Choose: 20000]	
cLocal2	Adj %	20%	20%	4	18,400	27,600	[Choose: 23000]	
cMetastases	Adj %	20%	20%	4	40,000	60,000	[Choose: 50000]	

Run microsimulation rather than EV

Cancel OK

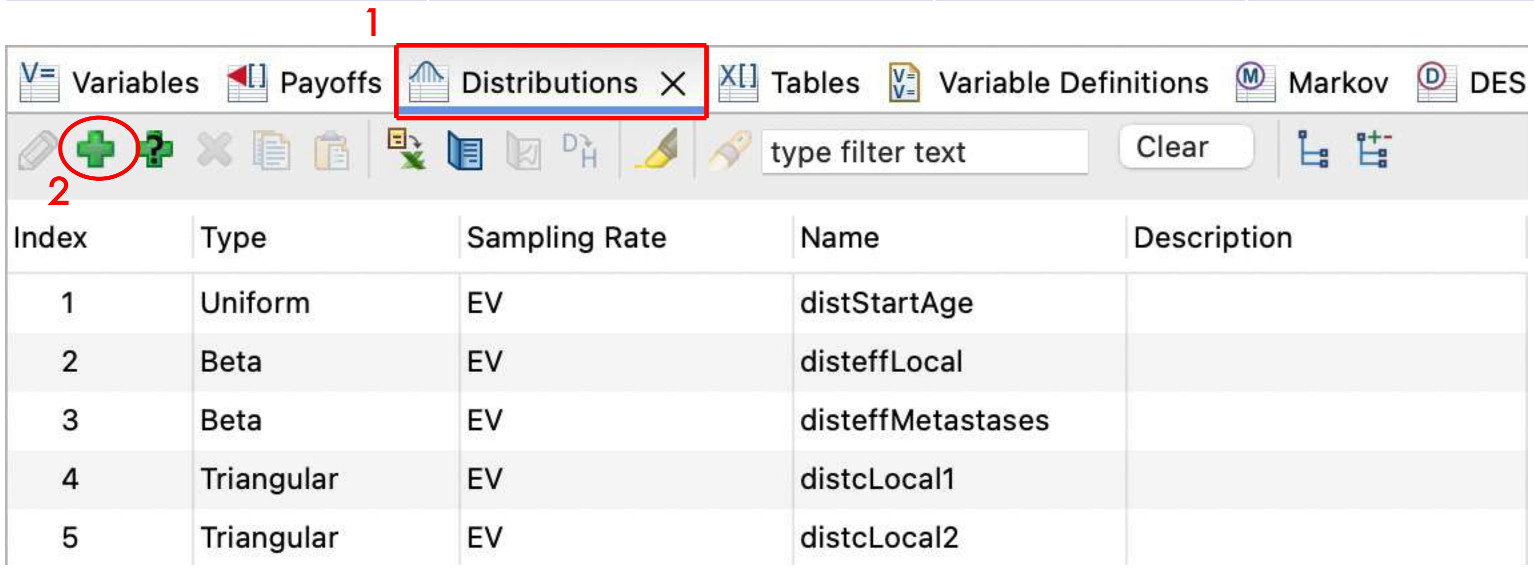


Example 3-Markov Model Structure-Tornado Diagrams



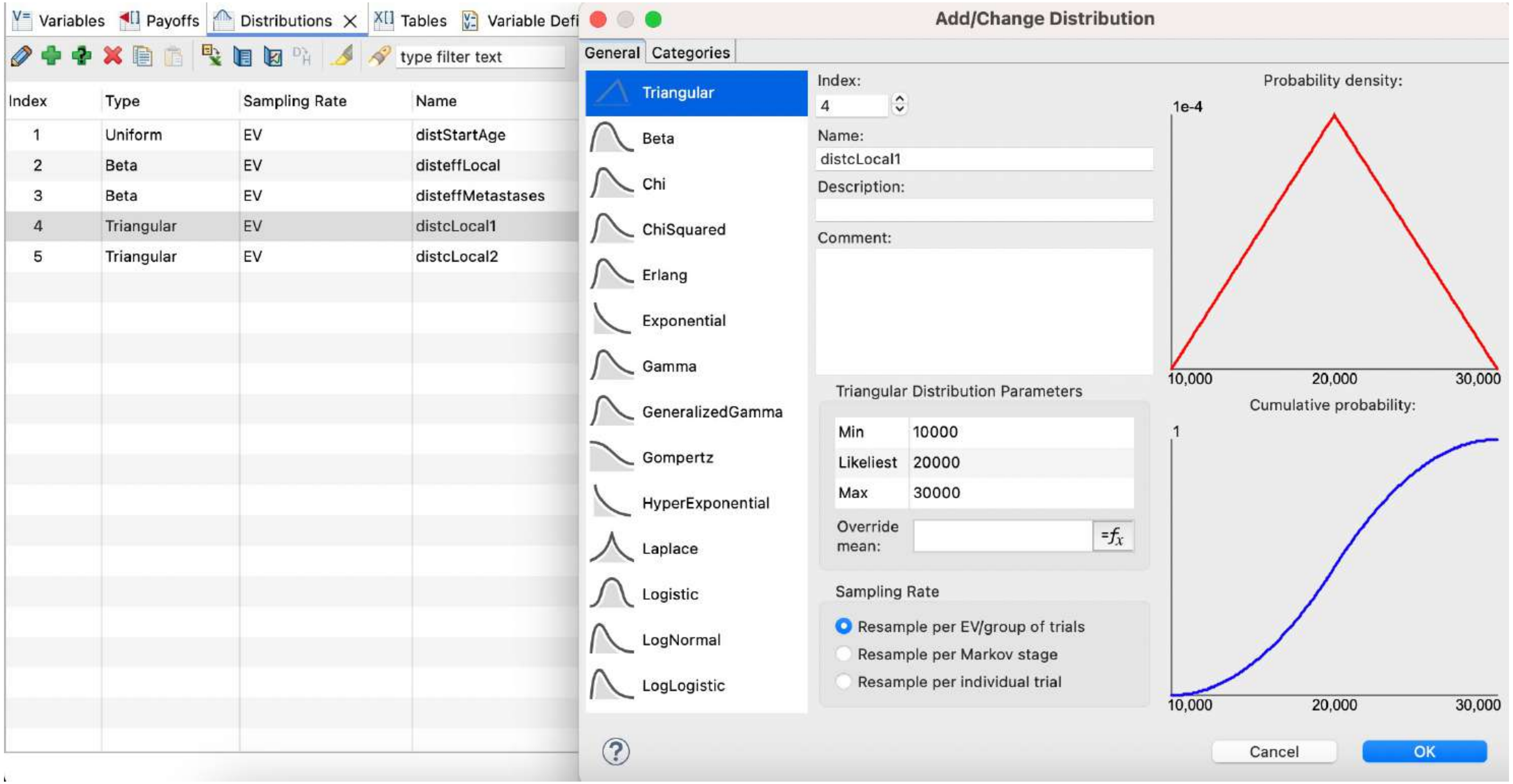
Example 3-PSA-Set up distribution for 5 variables

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



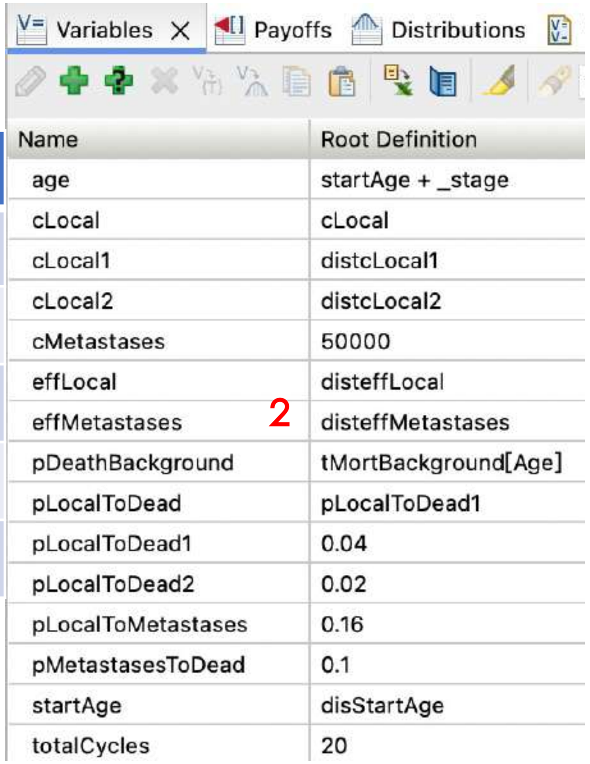
Index	Type	Sampling Rate	Name	Description
1	Uniform	EV	distStartAge	
2	Beta	EV	disteffLocal	
3	Beta	EV	disteffMetastases	
4	Triangular	EV	distcLocal1	
5	Triangular	EV	distcLocal2	

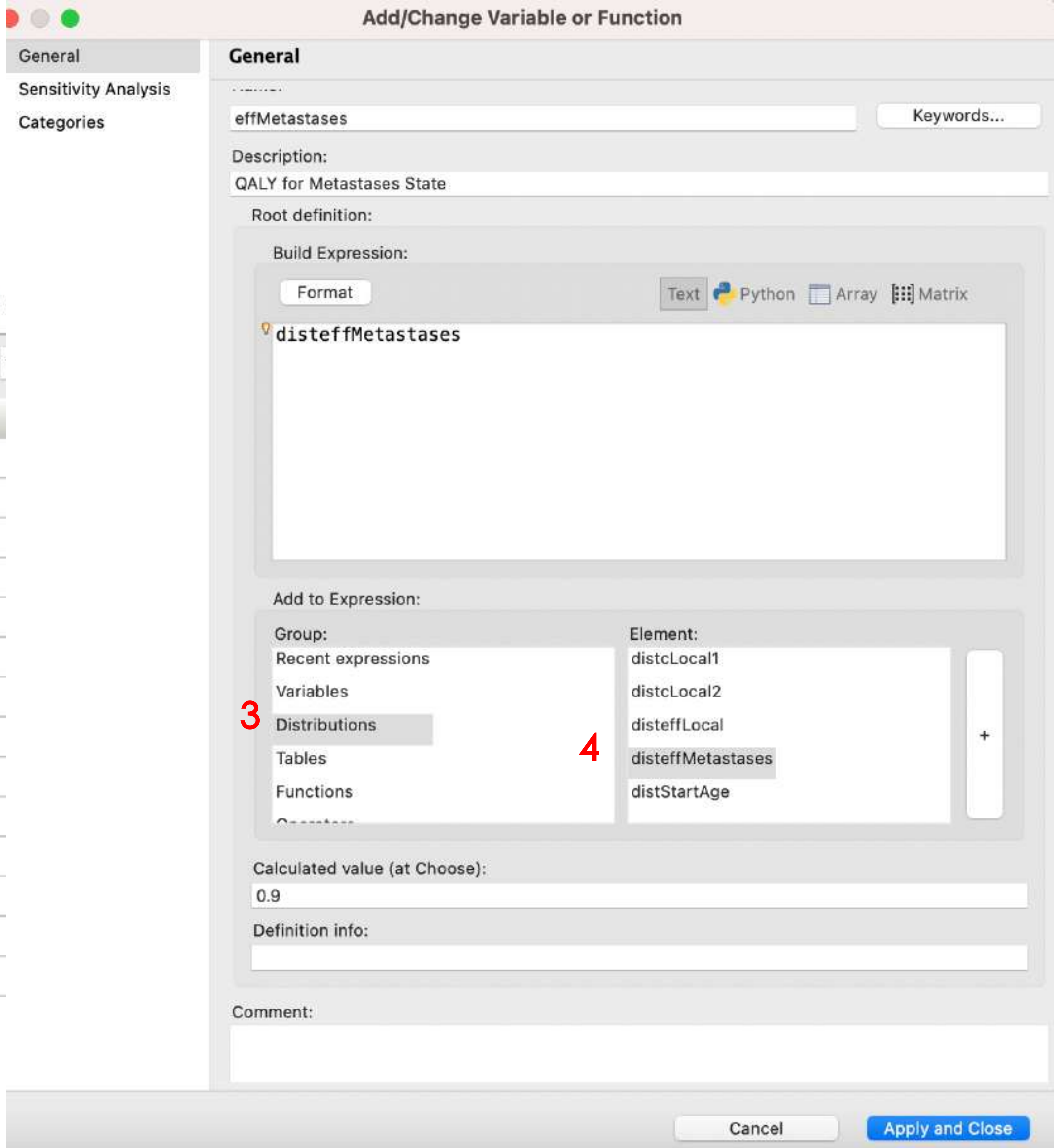
Example 3-PSA-Set up distribution for 5 variables



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

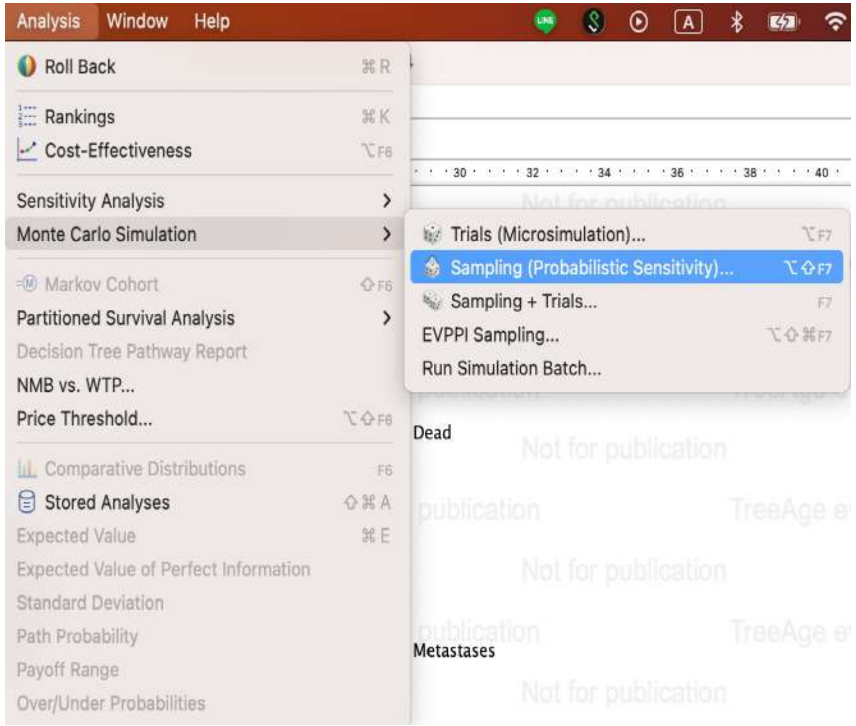
Variable	New name
StartAge	distStartAge
effLocal	disteffLocal
effMetastases	disteffMetastases
cLocal1	distcLocal1
cLocal2	distcLocal2

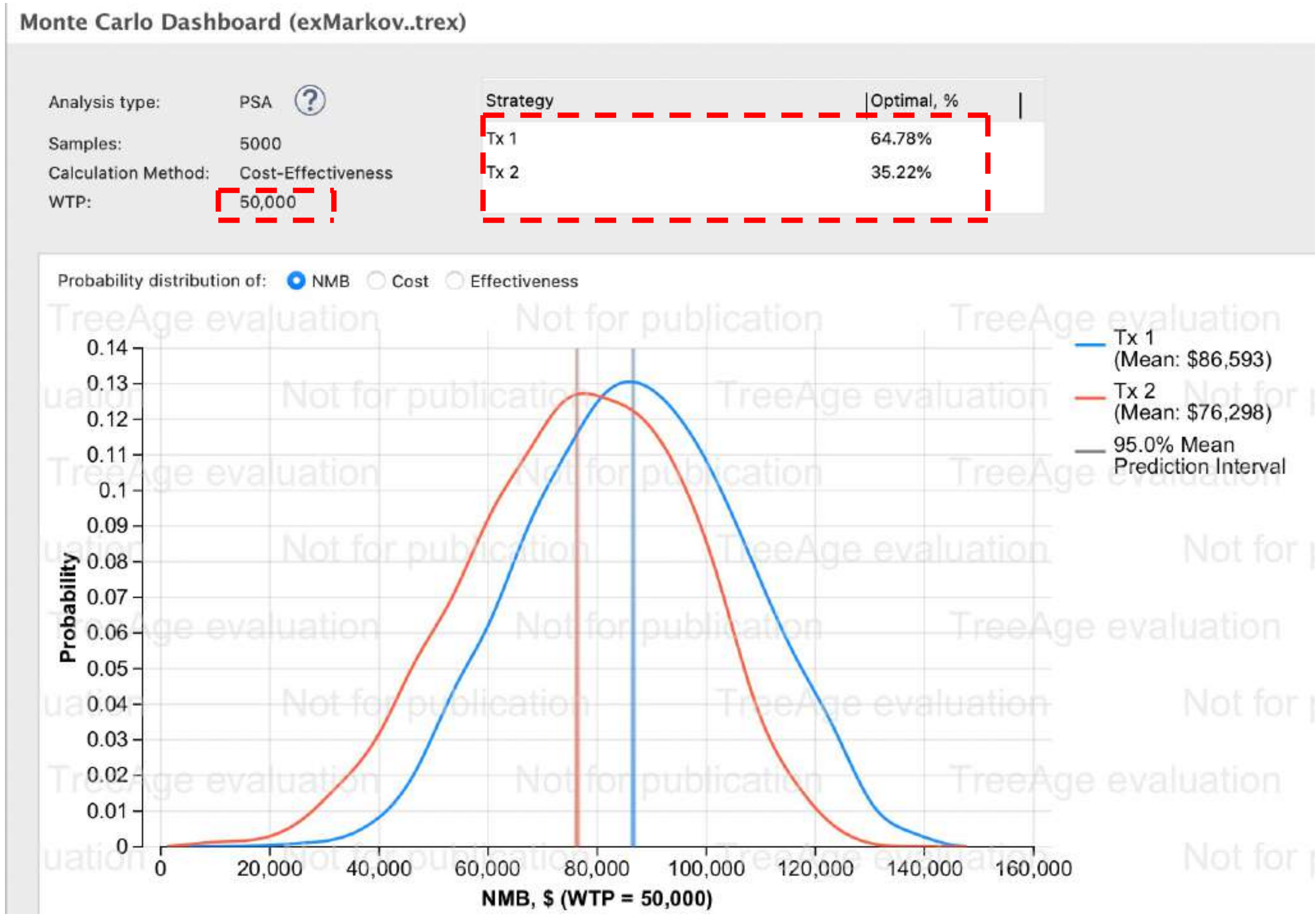




Example 3-PSA-Monte Carlo Dashboard

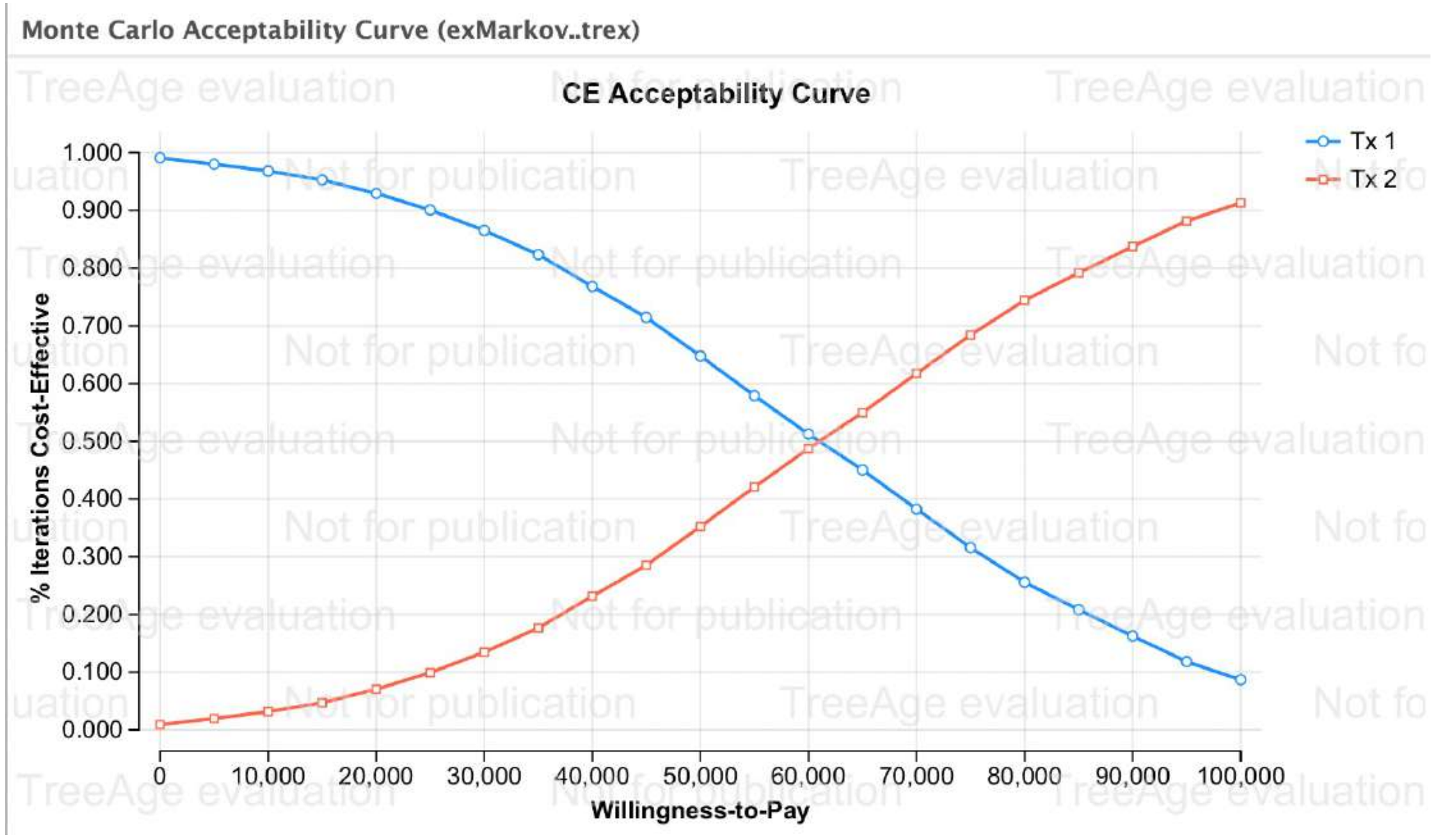
Analysis/Monte Carlo Simulation/ Sampling/sample:5000





Example 3-PSA-Monte Carlo Acceptability Curve

CEAC/Text Report

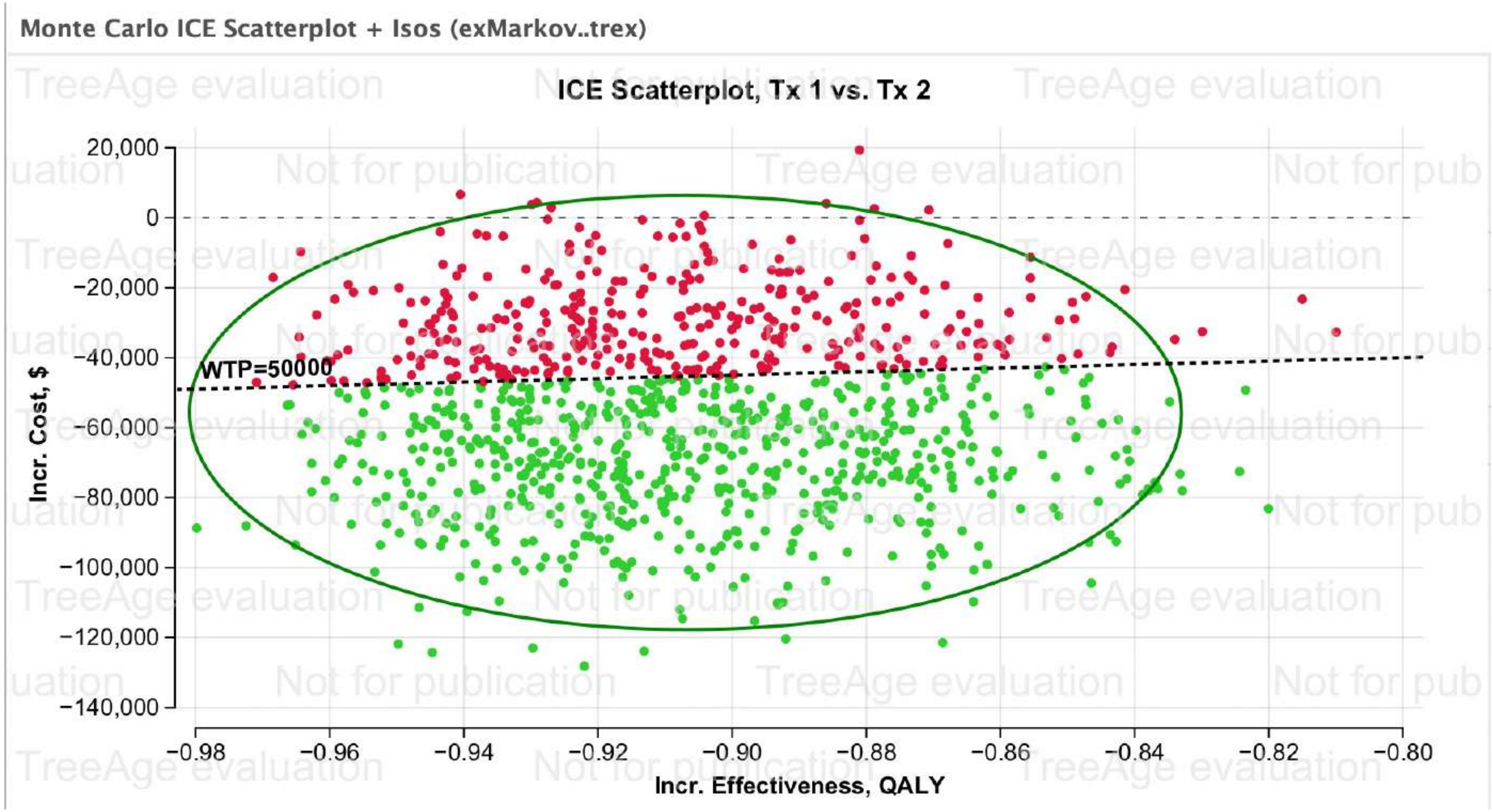


Monte Carlo Acceptability Text (e

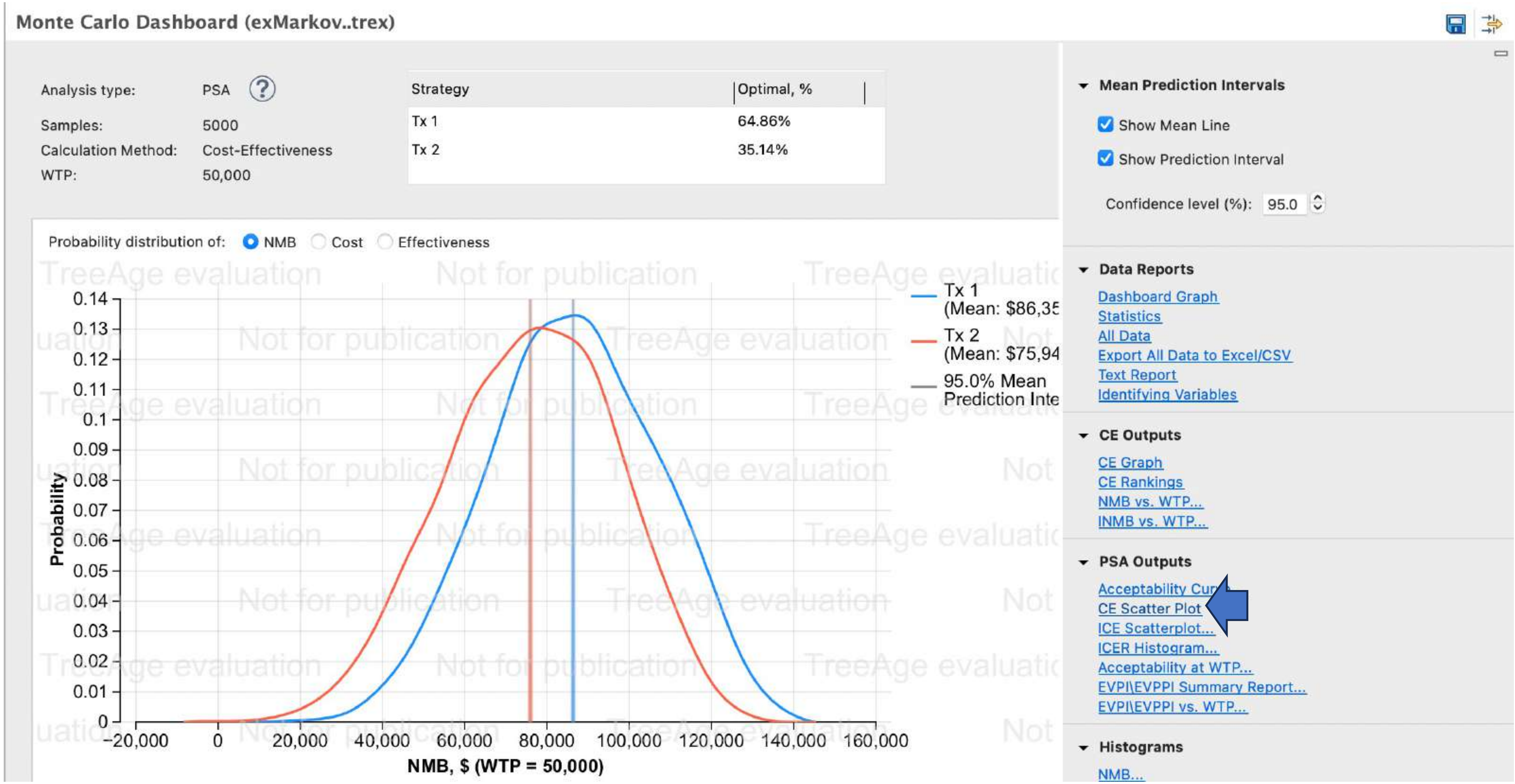
Willingness-to-Pay	Strategy	Acceptability
0	Tx 1	0.991
0	Tx 2	0.009
5,000	Tx 1	0.9802
5,000	Tx 2	0.0198
10,000	Tx 1	0.9684
10,000	Tx 2	0.0316
15,000	Tx 1	0.953
15,000	Tx 2	0.047
20,000	Tx 1	0.9296
20,000	Tx 2	0.0704
25,000	Tx 1	0.9008
25,000	Tx 2	0.0992
30,000	Tx 1	0.8654
30,000	Tx 2	0.1346
35,000	Tx 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

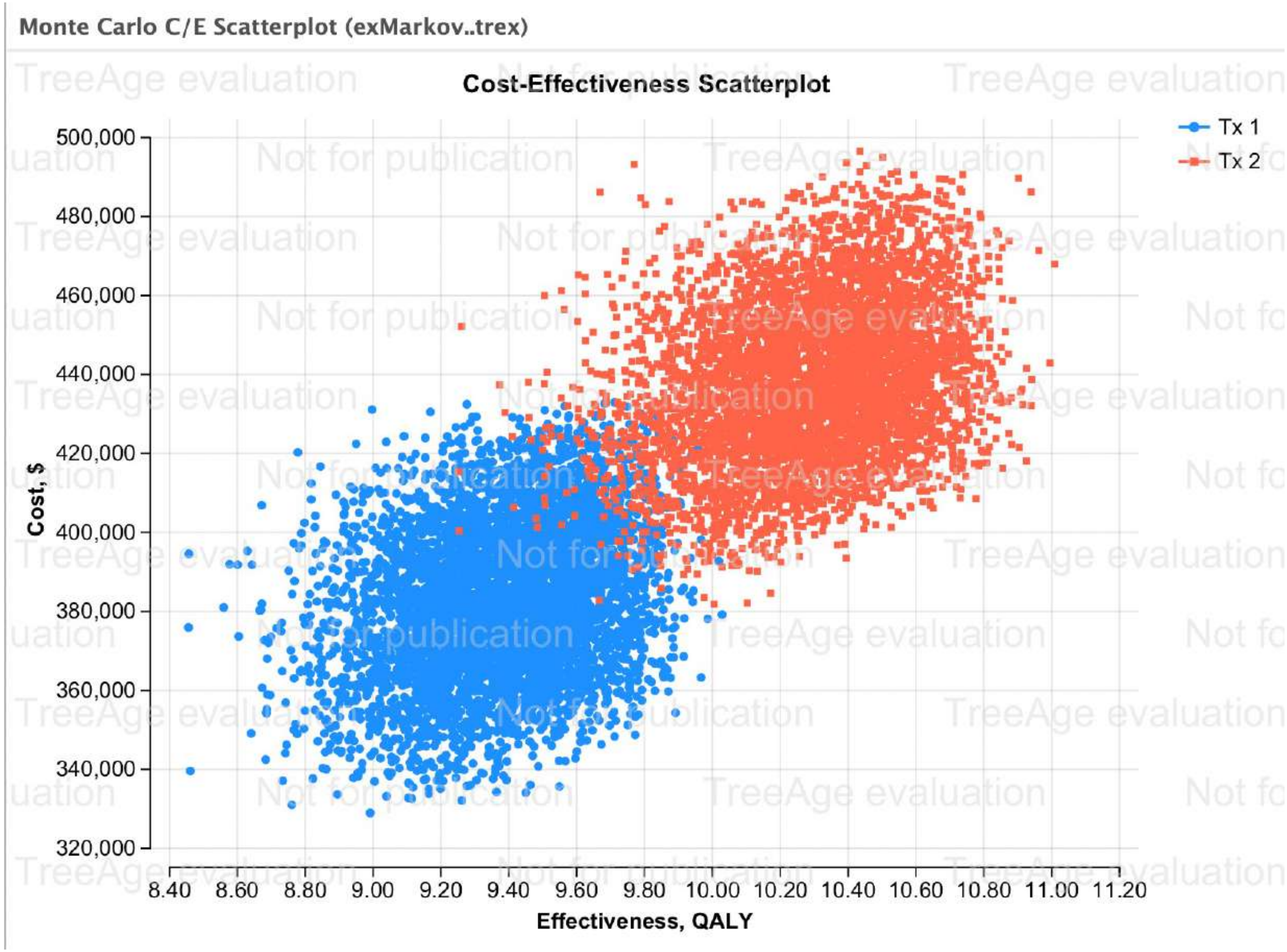
64.78% favored Tx1



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:

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

•**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.

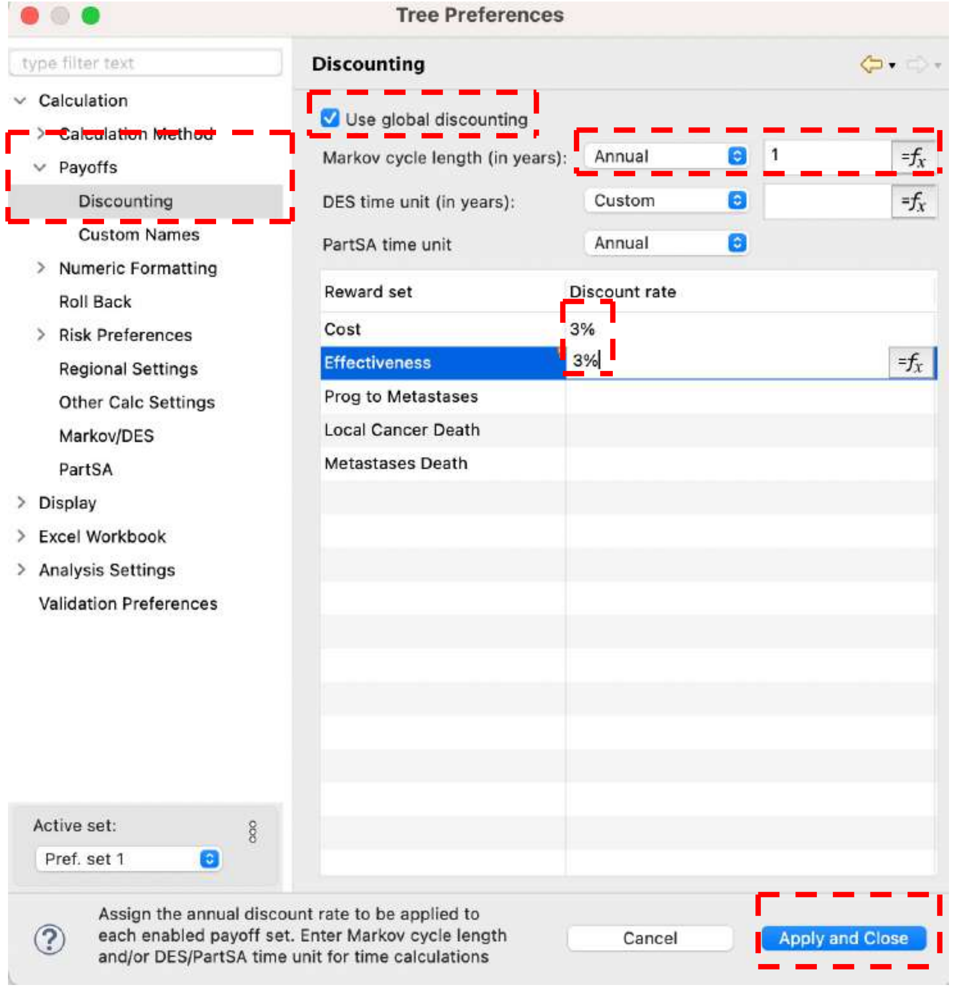
•**Cum Disc:** This is the cumulative value of the payoffs as the cycle (_stage) increases. If the payoff has been discounted it uses the discounted values.

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.

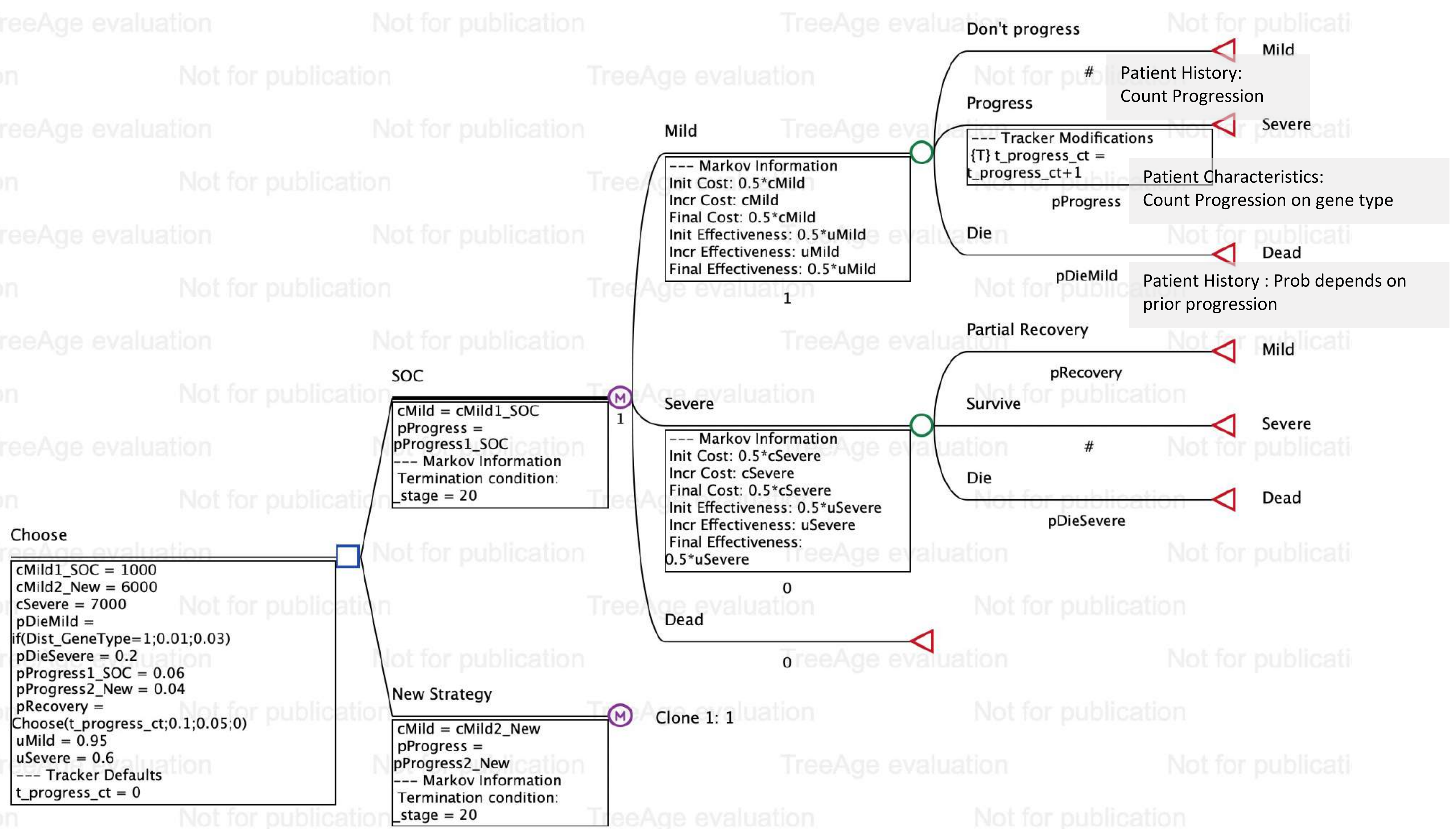
In the Health Care Tutorial Example, Markov Conversion Model Discounting .trex, global discounting is already setup on for the cost and effectiveness payoffs with a discount rate of 3% through the variable integrate. See below.

Tree/TreePreferences/Payoffs/Discounting



❑ 單元九:
TreeAge Microsimulation

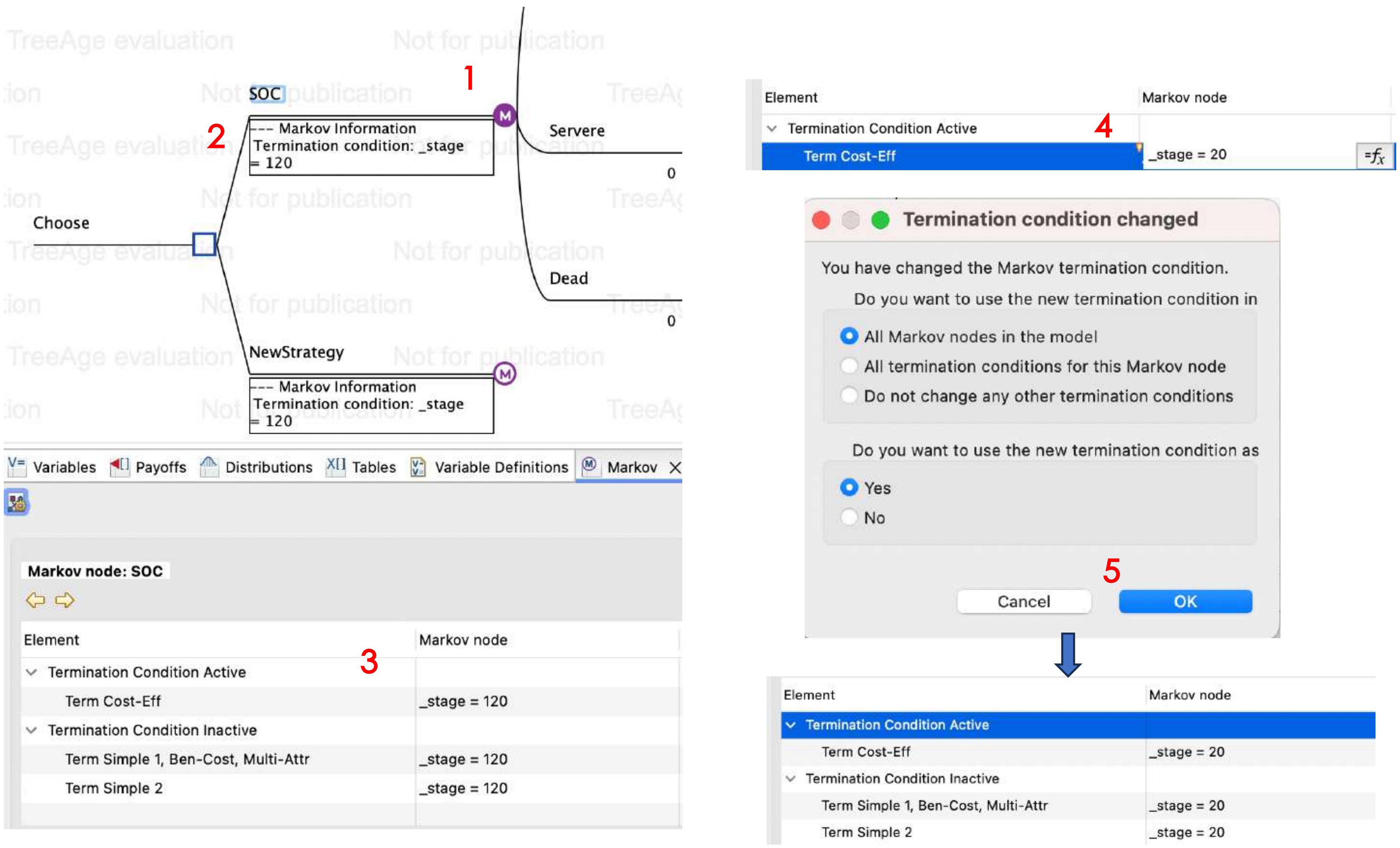
Example 4-Patient Level Simulation



Example 4-Patient Level Simulation

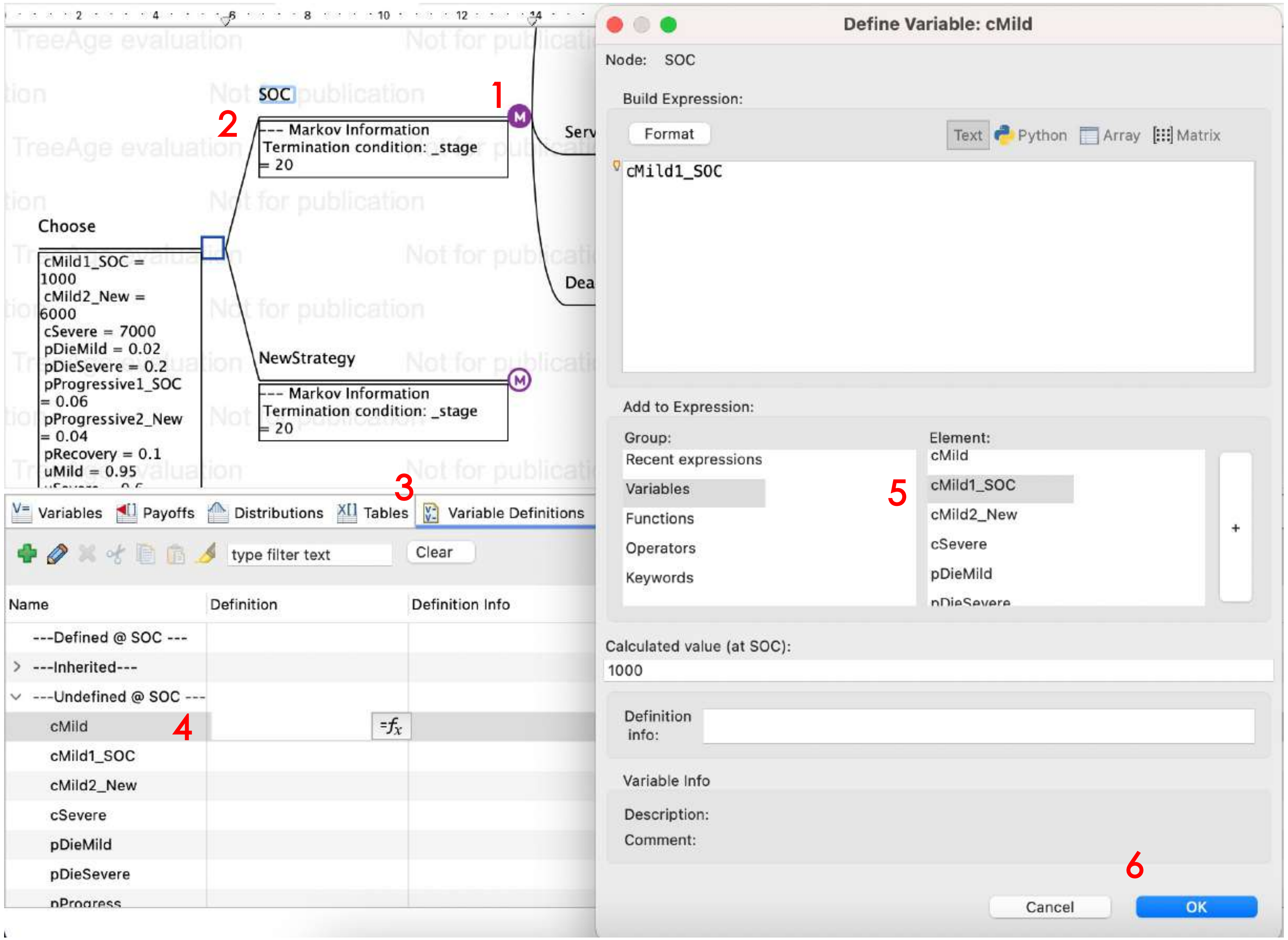
Variable name	Variable
cMild	
cMild1_SOC	1000
cMild2_New	6000
cSevere	7000
pDieMild	0.02
pDieSevere	0.2
pProgress	
pProgress1_SOC	0.06
pProgress2_New	0.04
pRecovery	0.1
uMild	0.95
pSevere	0.6

Example 4-Patient Level Simulation

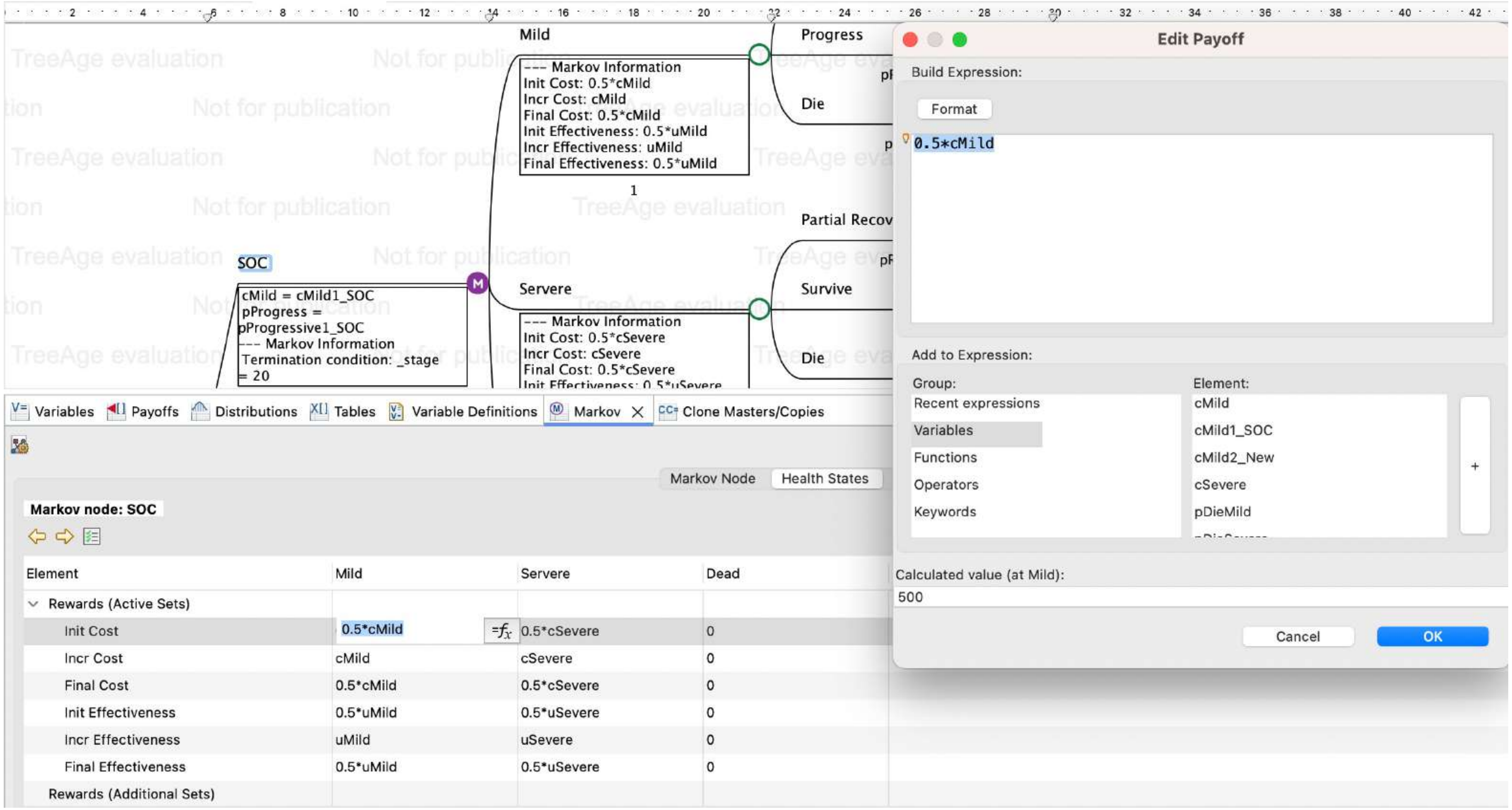


Example 4-Patient Level Simulation

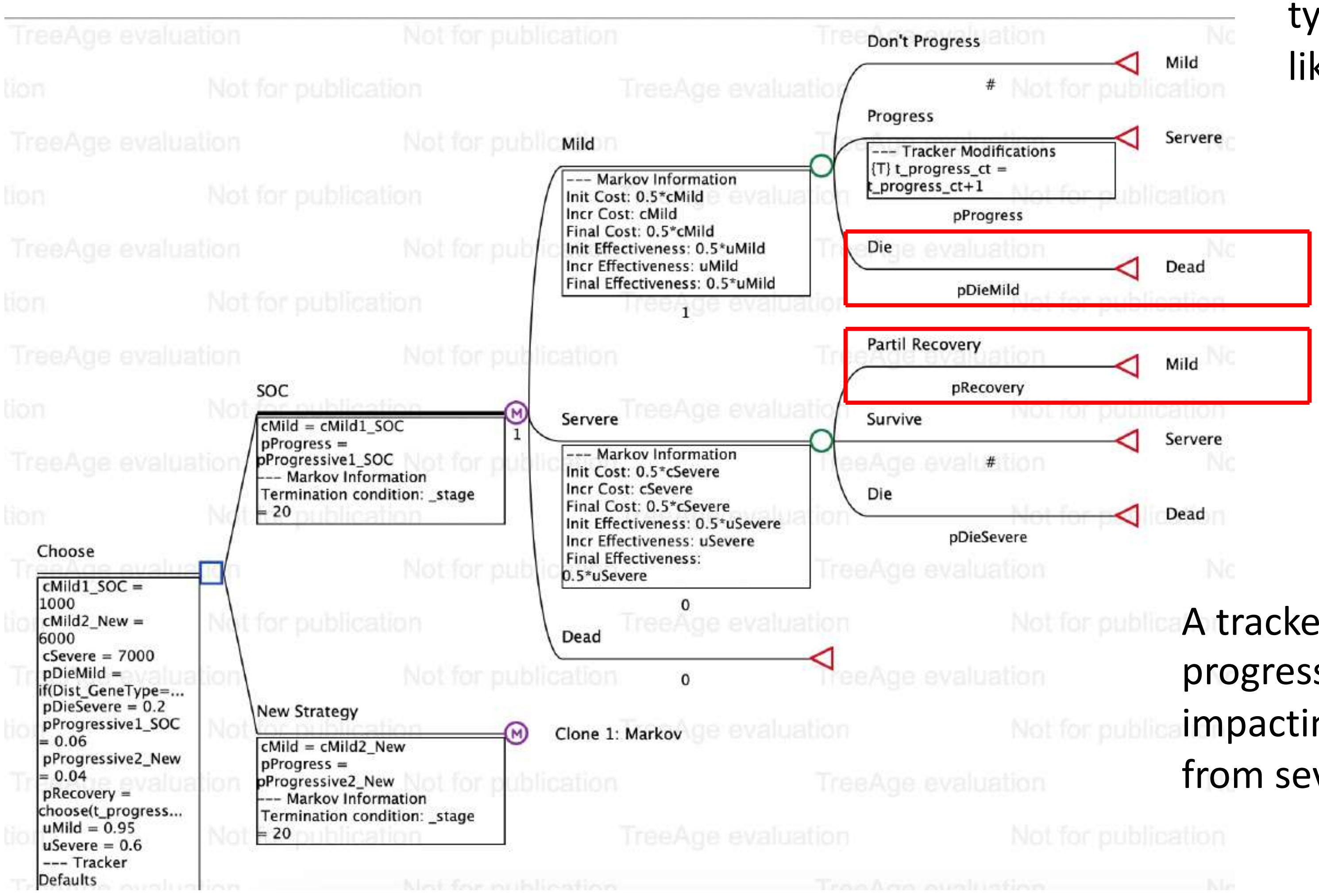
SOC	NewStrategy
cMild=cMild1_SOC	cMild=cMild1_New
pProgress=pProgress1_SOC	pProgress=pProgress2_New



Example 4-Patient Level Simulation



Example 4-Patient Level Simulation

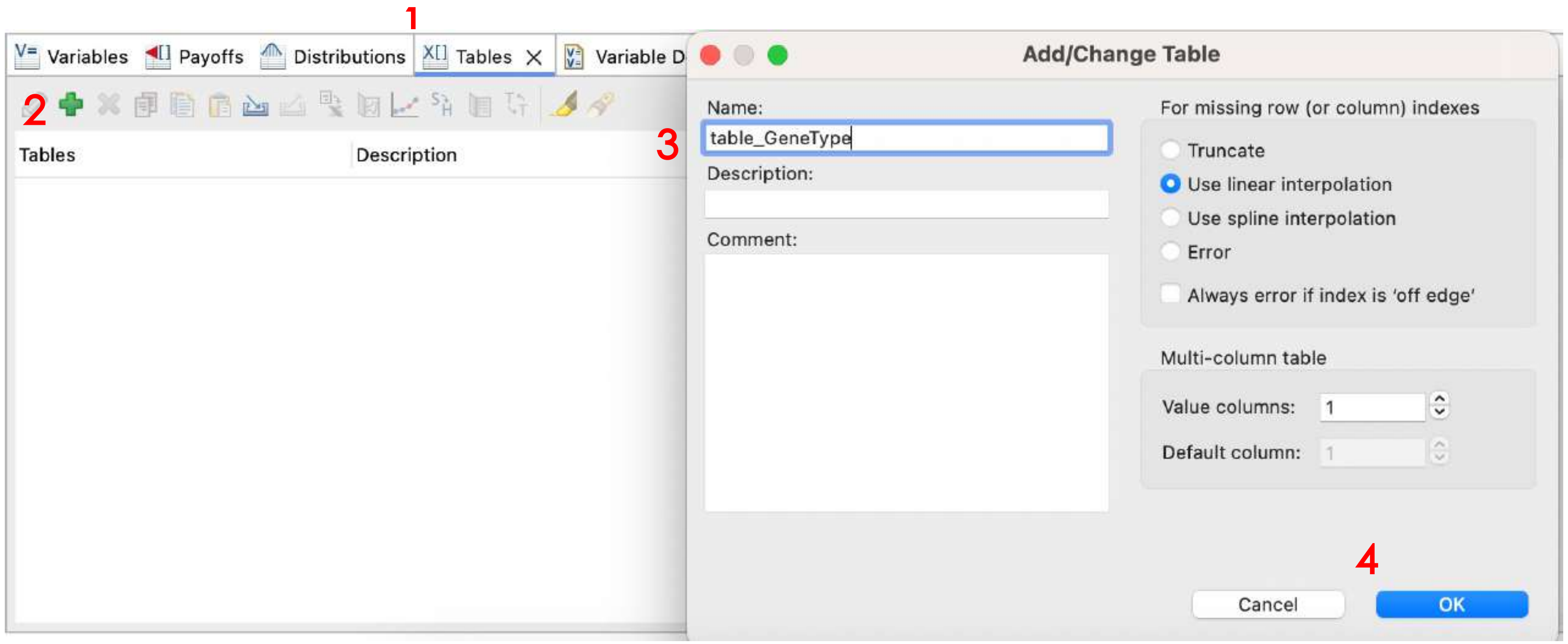


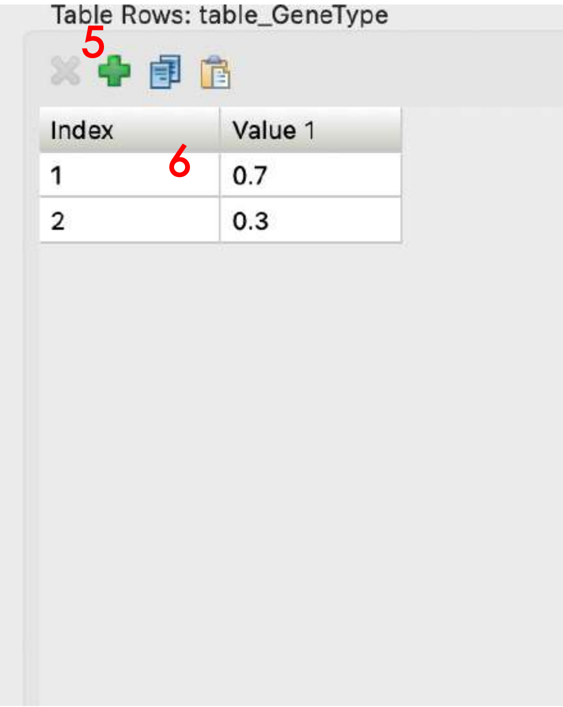
The model includes demographic data on gene types, affecting probabilities like death risk.

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

Example 4-Patient Level Simulation

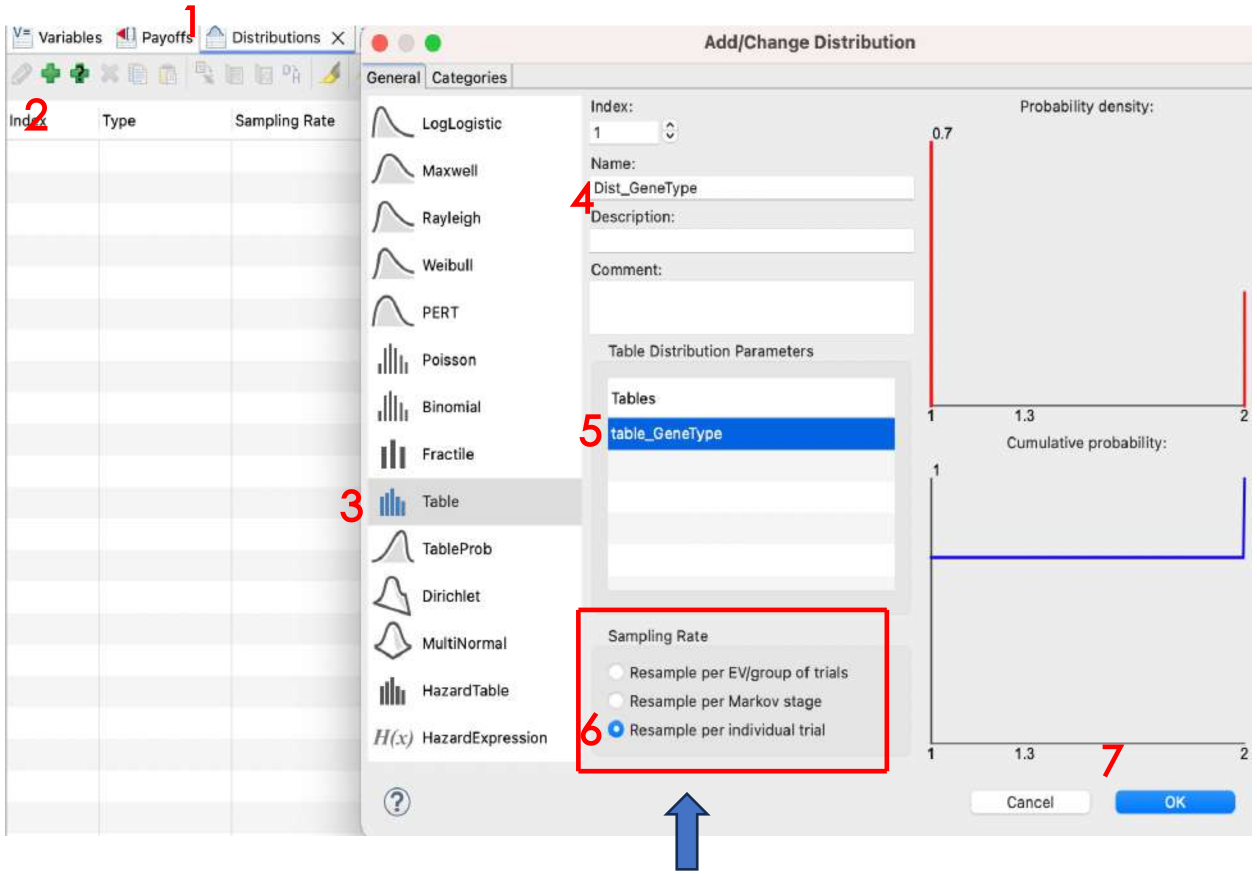
This is loaded in a table seventy percent of the population have gene type one and thirty percent of the population have gene type two the table gene type stores the demographic data in the model.





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。



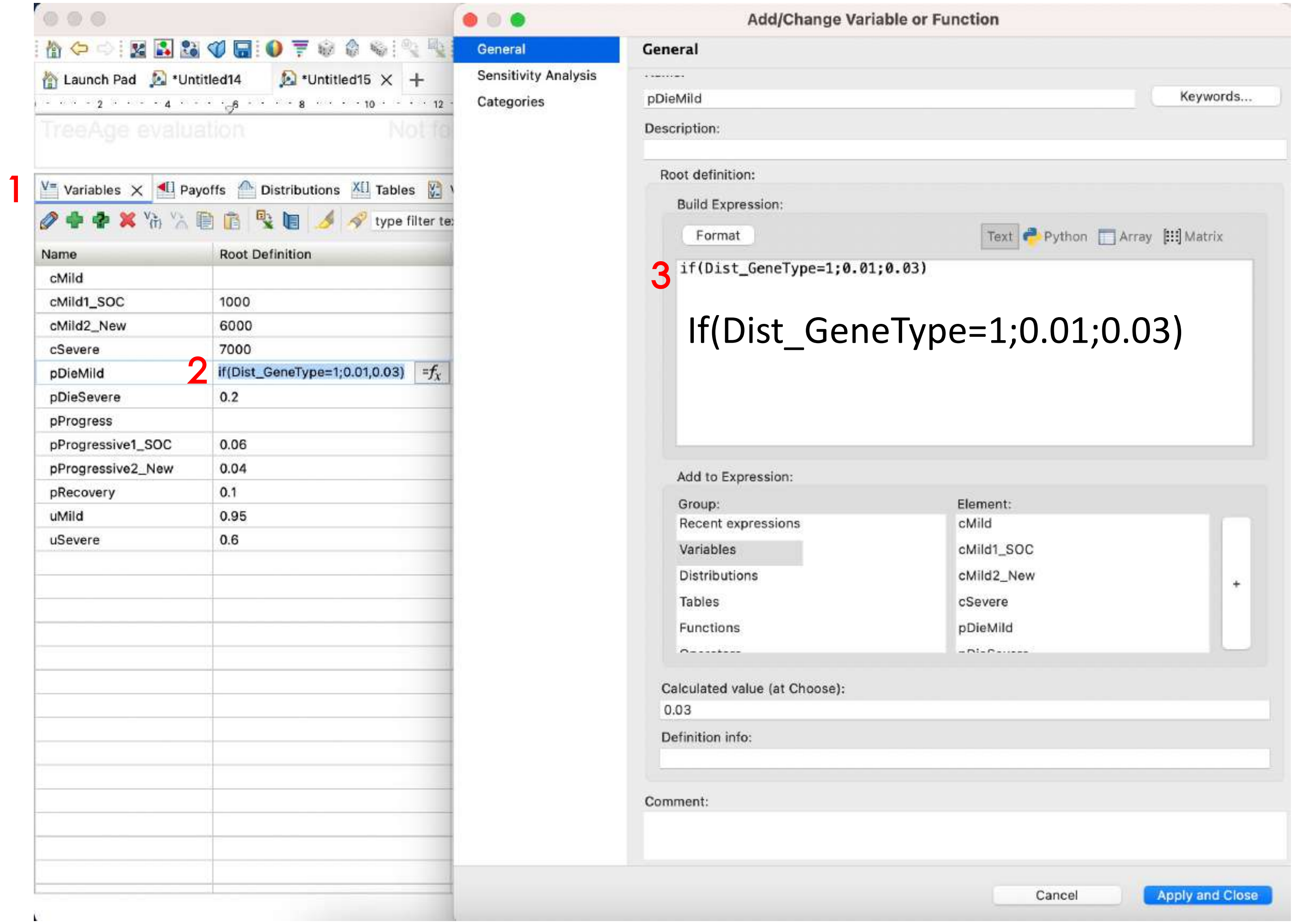
當模型運行時，將根據分佈為每位模擬患者分配一個基因類型。隨後，每當基因類型在模型中對患者產生影響時，就可以參照該分佈。

Example 4-Patient Level Simulation

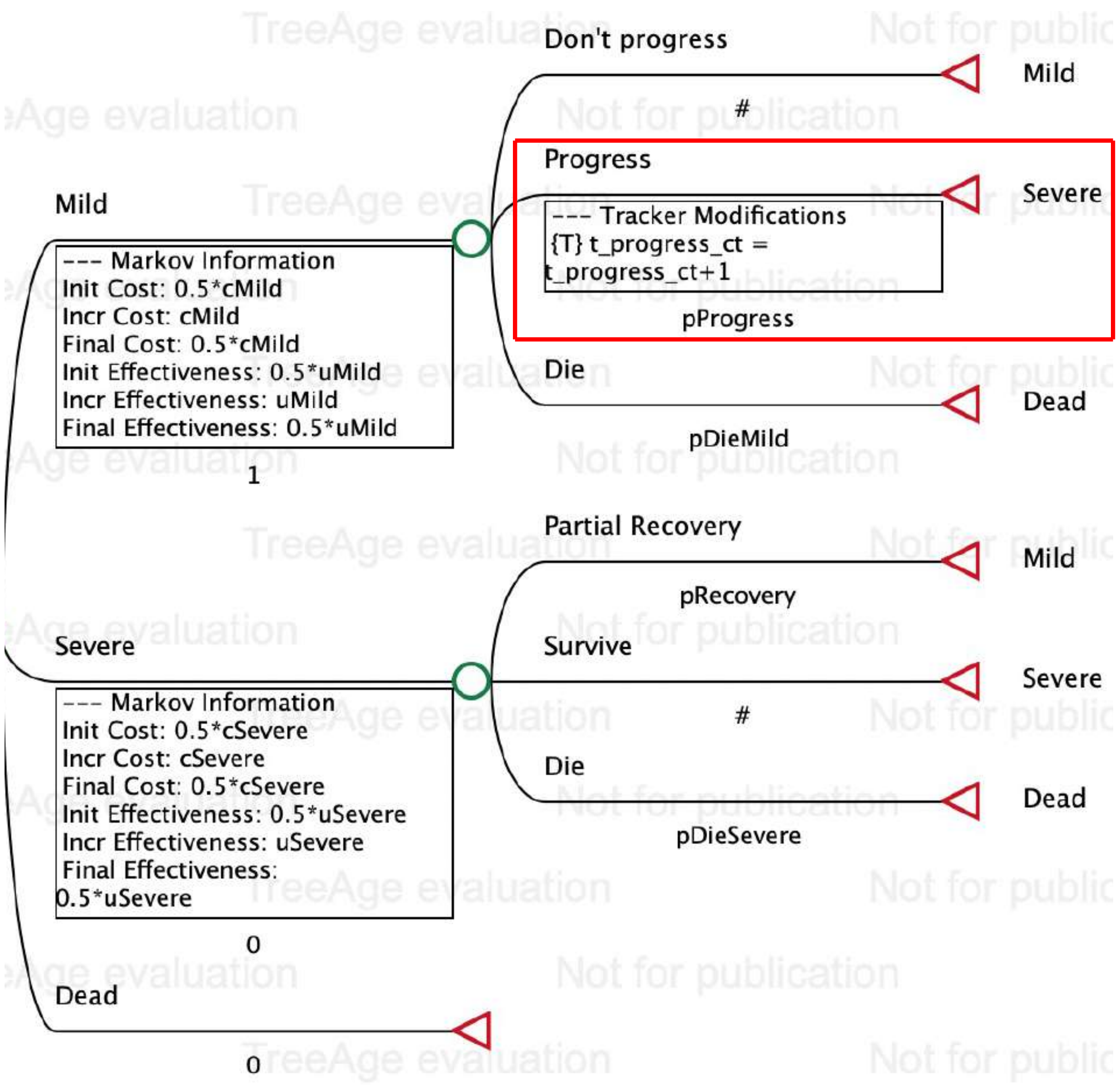
在模型中，如果要根據患者特徵（如基因類型）動態調整某個事件（如死亡）的機率，可以使用條件語句 if函數來改變機率。這樣可以根據不同的基因類型或特徵設定不同的機率數值。

GeneType=1,pDieMild=0.01

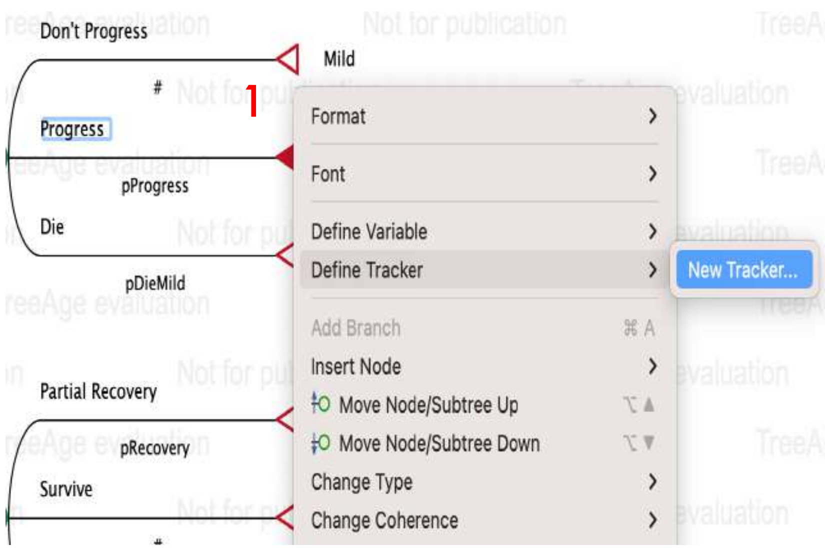
GeneType=2,pDieMild=0.03

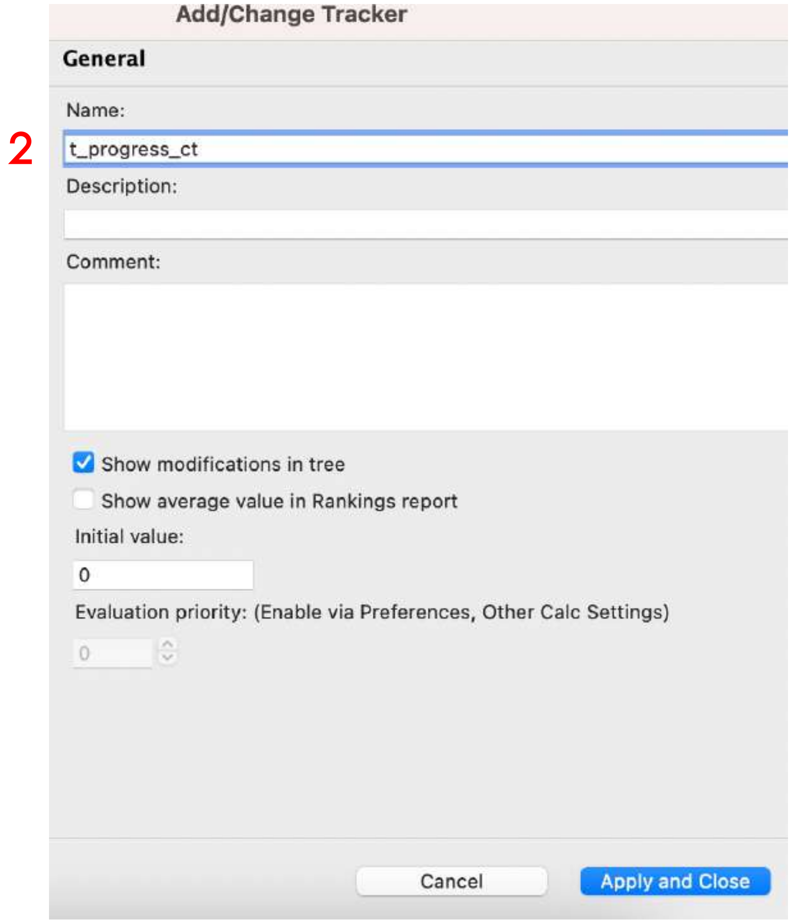


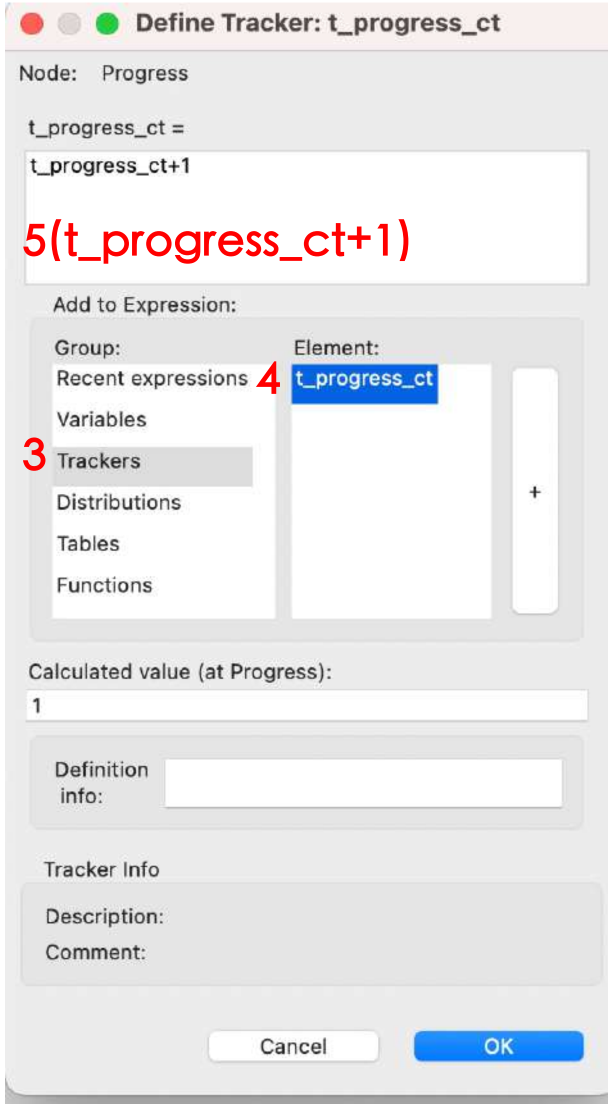
Example 4-Patient Level Simulation-The Tracker



Example 4-Patient Level Simulation-The Tracker

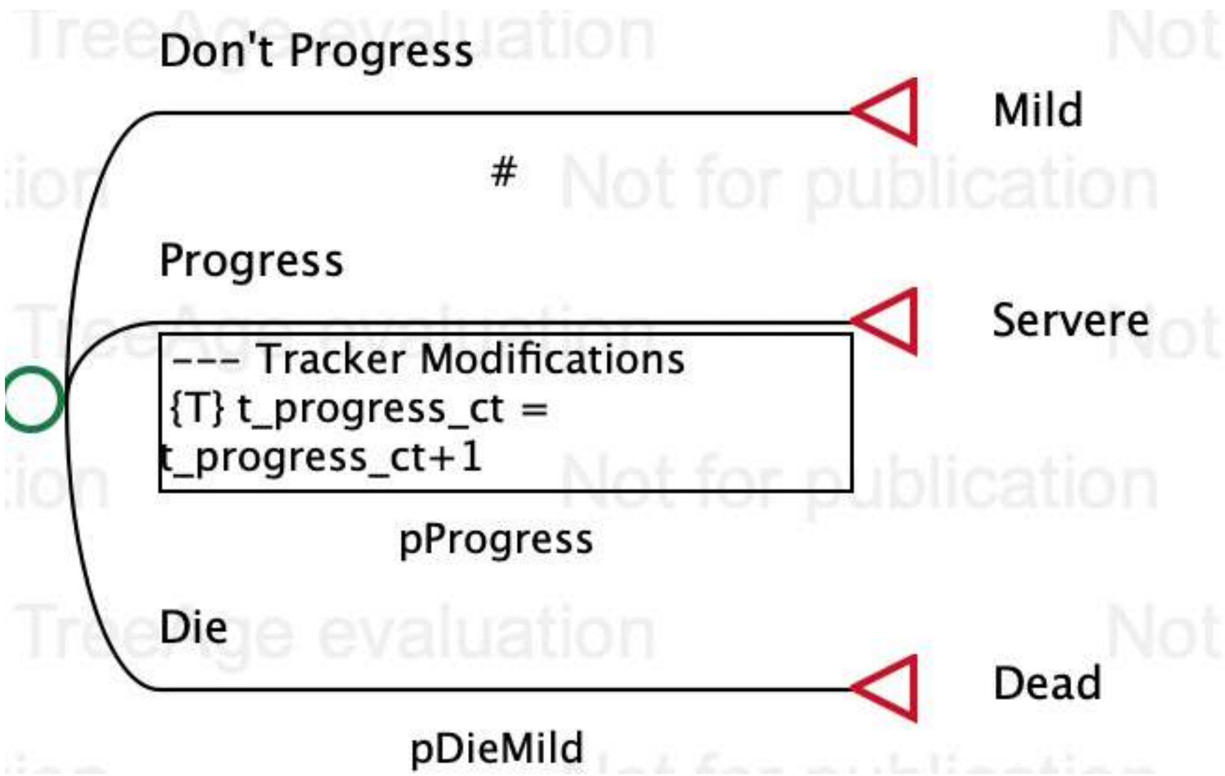






Example 4-Patient Level Simulation-The Tracker

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.

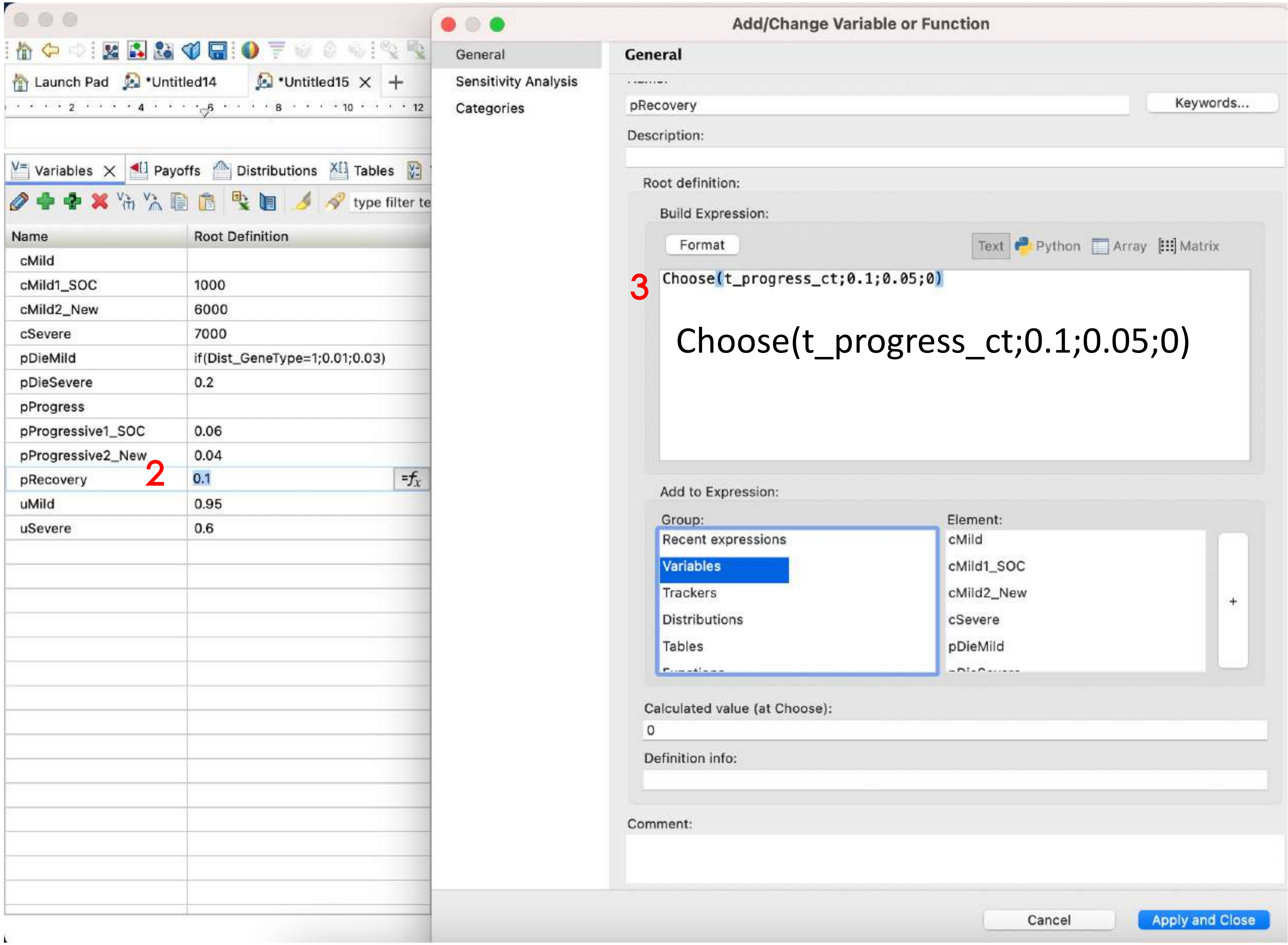


Example 4-Patient Level Simulation-The Tracker

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

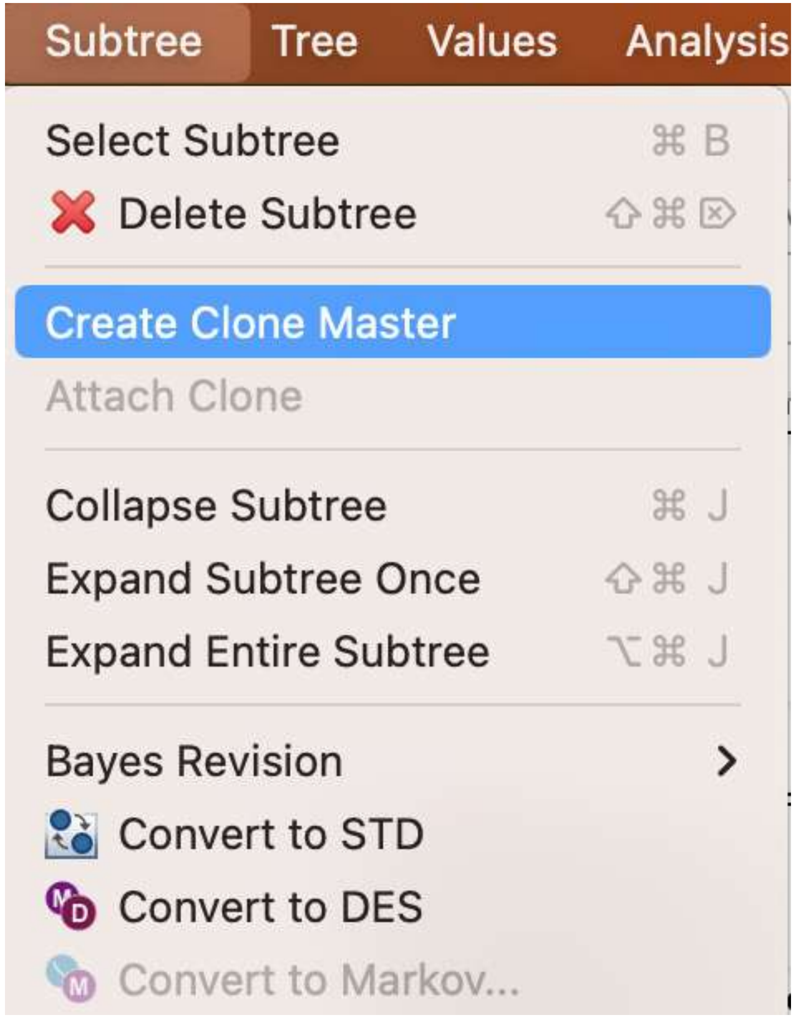
當追蹤器為1時，將返回值0.1；
當追蹤器為2時，將返回值0.05；
當追蹤器進展計數為3時，恢復率將為0，且不再可能恢復。

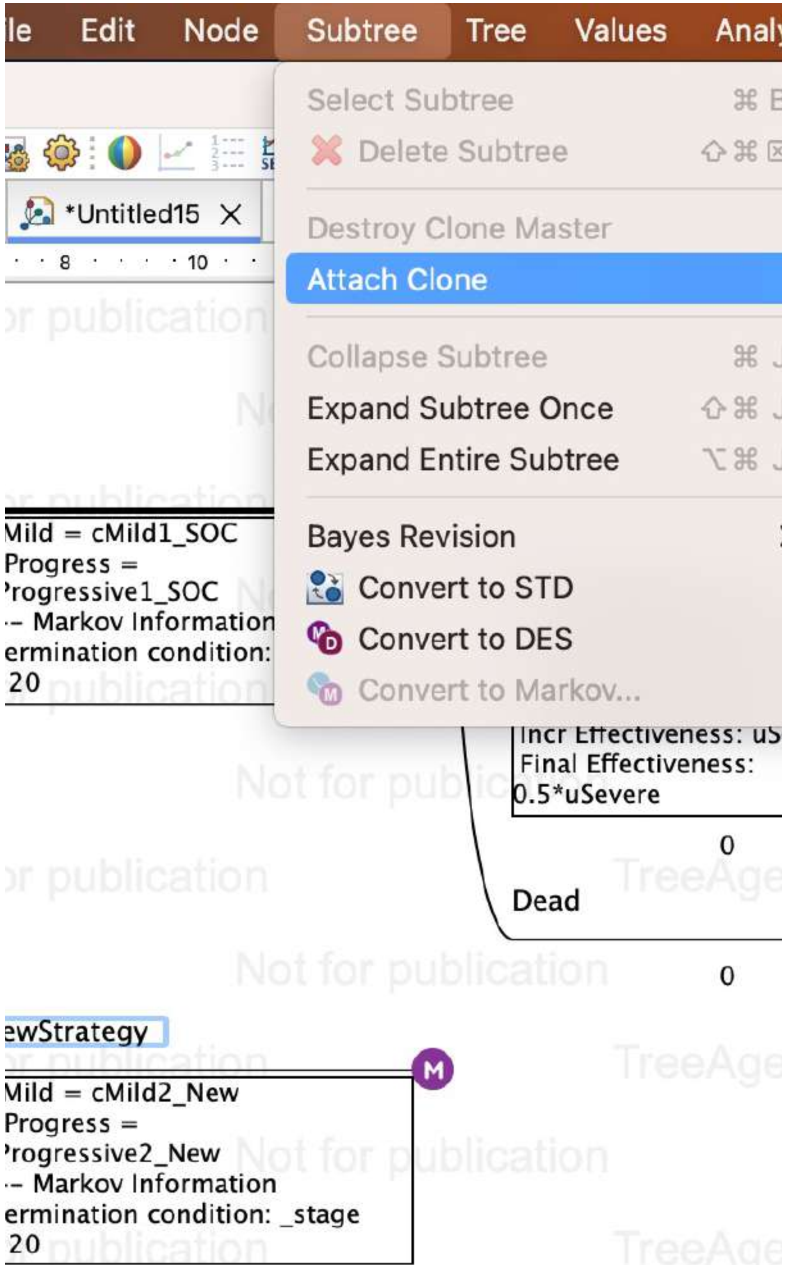
1



Example 4-Patient Level Simulation

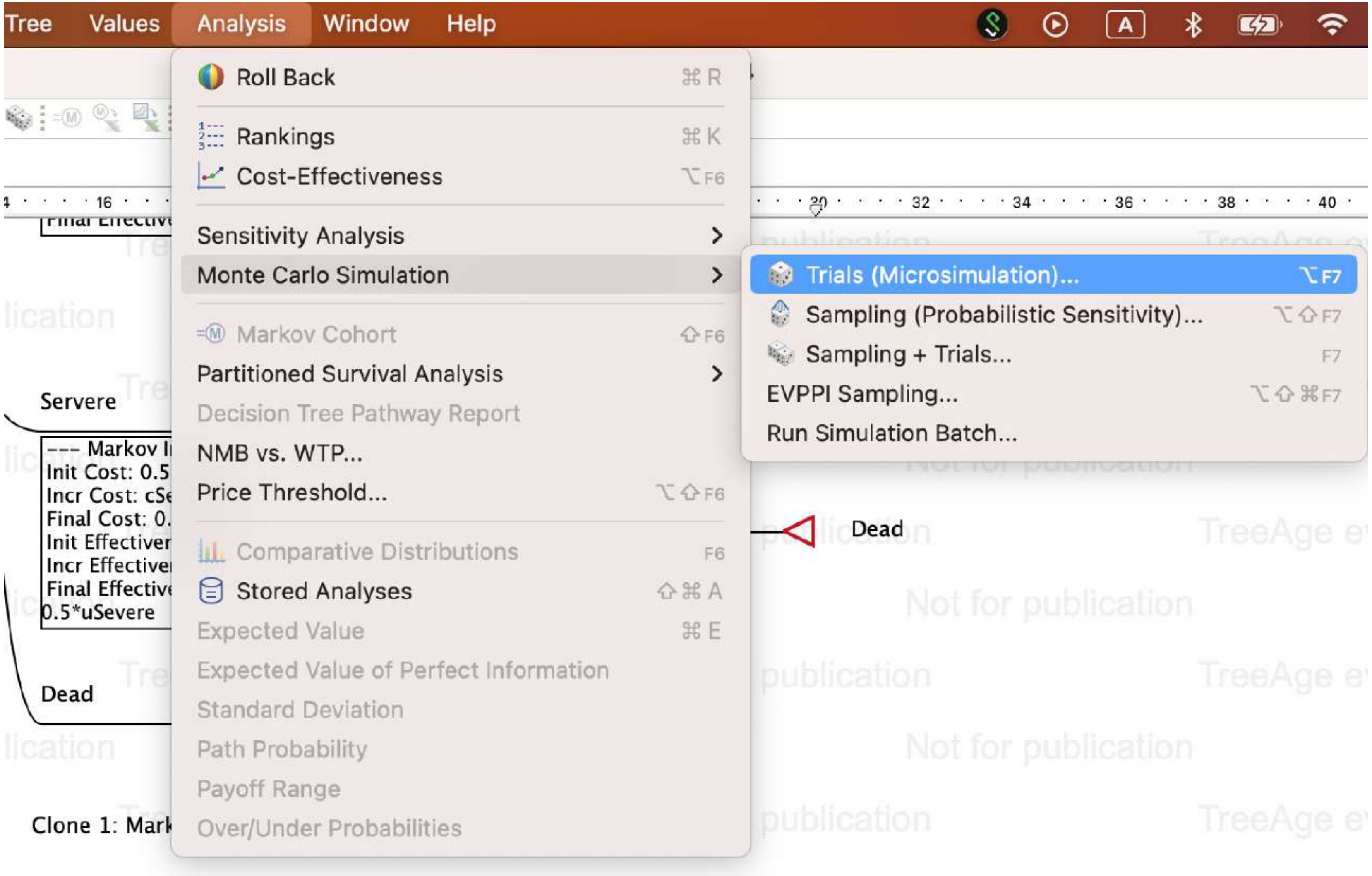
1.Clone SOC
2.Attach NewStrategy





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)

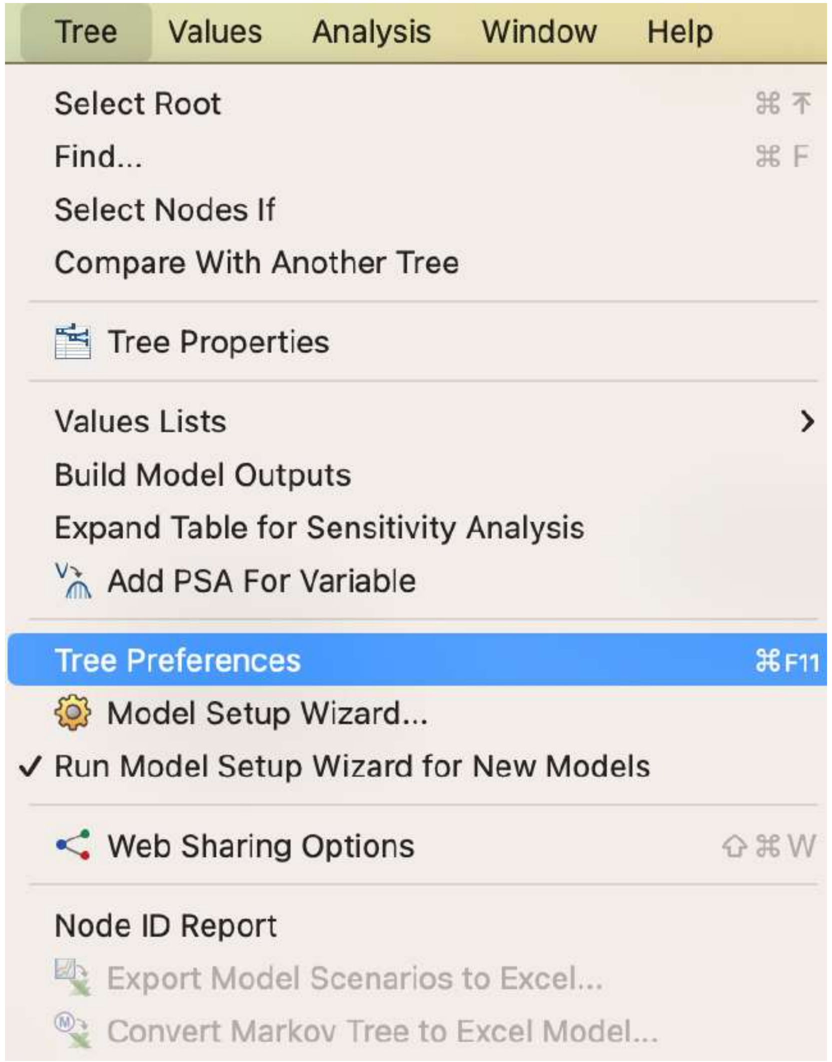
Attribute	Statistic	SOC	NewStrategy
Cost	Mean	26805.80	89637.45
Cost	Std Deviation	18408.36	39026.75
Cost	Minimum	500.00	3000.00
Cost	2.5%	1500.00	9000.00
Cost	10%	7500.00	27000.00
Cost	Median	20000.00	118000.00
Cost	90%	51500.00	122000.00
Cost	97.5%	77000.00	126500.00
Cost	Maximum	137000.00	137000.00
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

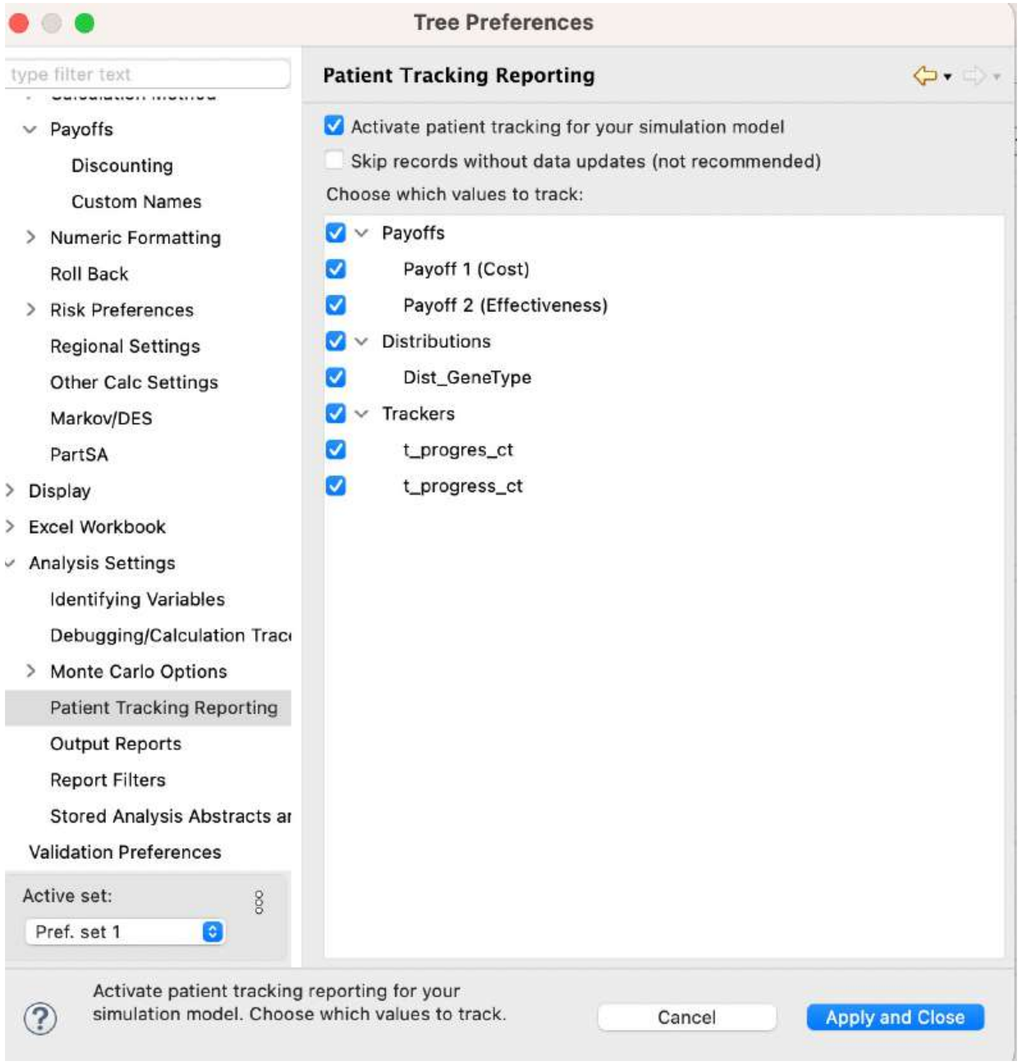
每位患者將經過模型並累積總成本和效果值，然後將每位患者的結果彙總為平均值，以提供每位患者的平均成本和效果。在微觀模擬模型中，我們仍然需要做出最佳決策。

Monte Carlo C/E Rankings Report (Untitled15)

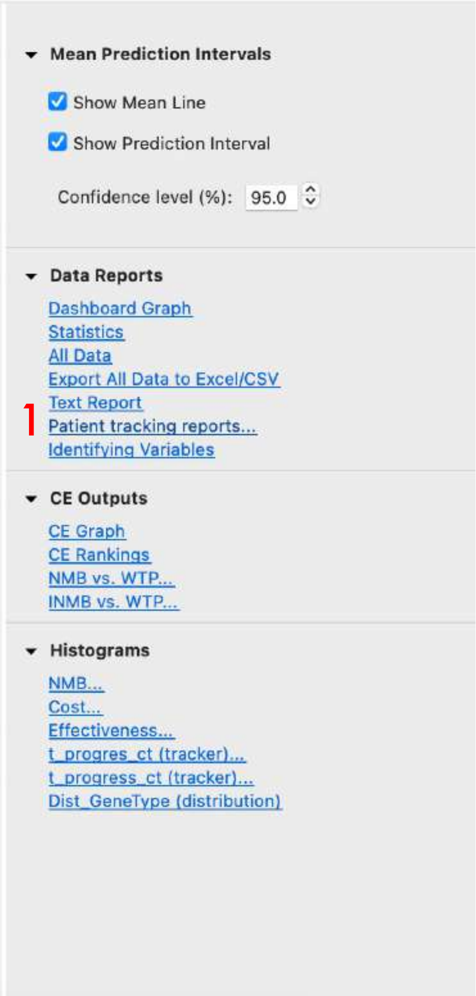
Category	Strategy	Cost	Incr. Cost	Effectiveness	Incr. Effectiveness	ICER (IC/IE)	NMB
All (no dominance)							
undominated	SOC	26805.80		12.21			-26805.80
undominated	NewStrategy	89637.45	62831.65	13.37	1.16	54061.17	-89637.45

Example 4-Patient Level Simulation

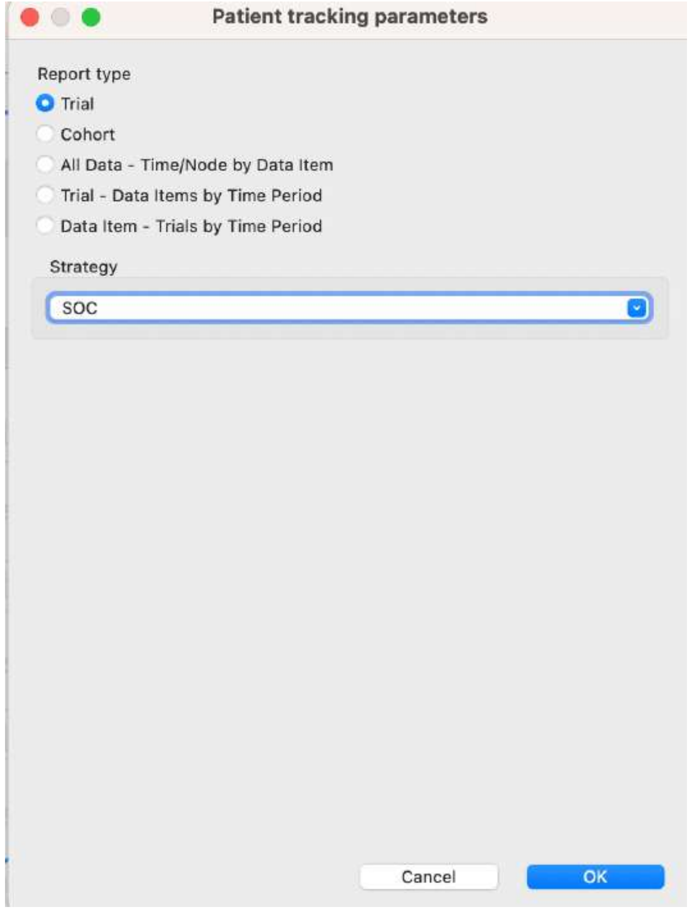


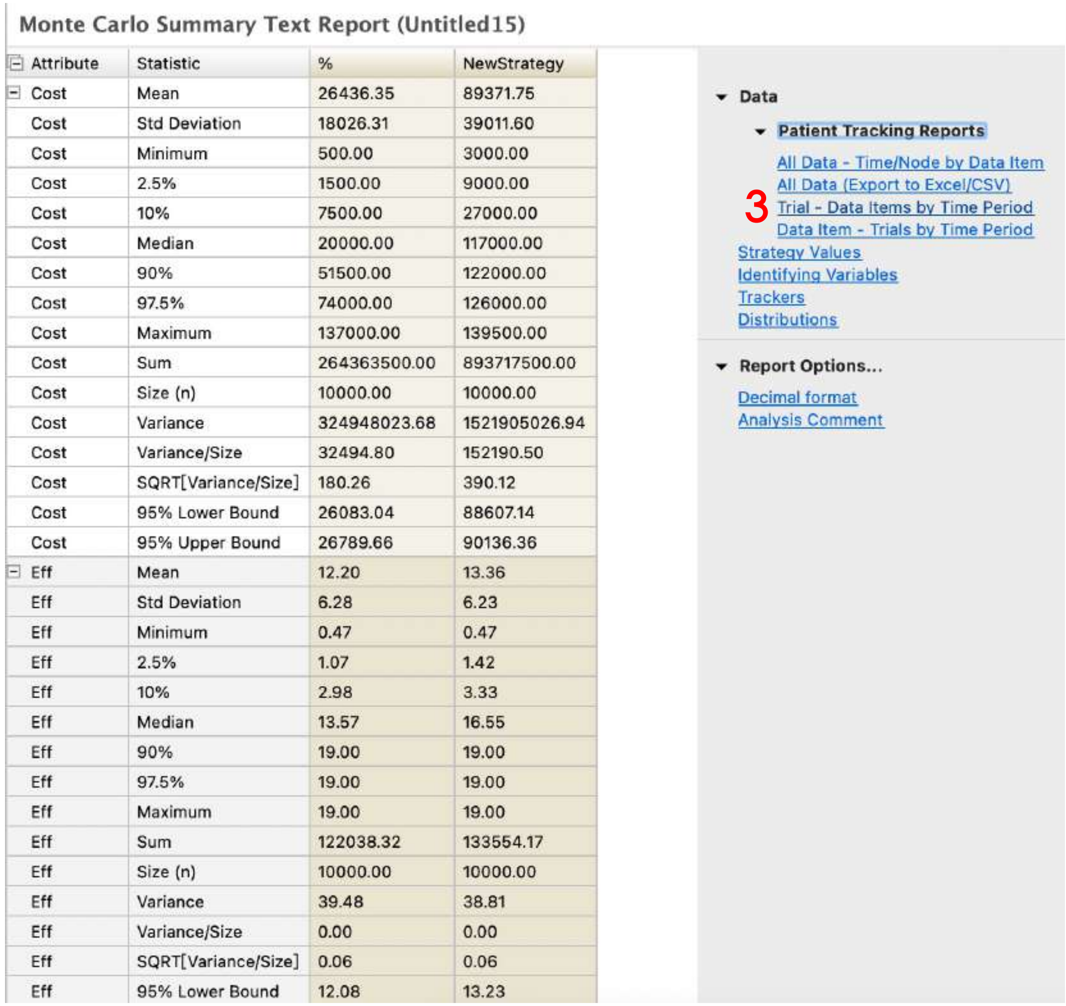


Example 4-Patient Level Simulation



2




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

Example 4-Patient Level Simulation

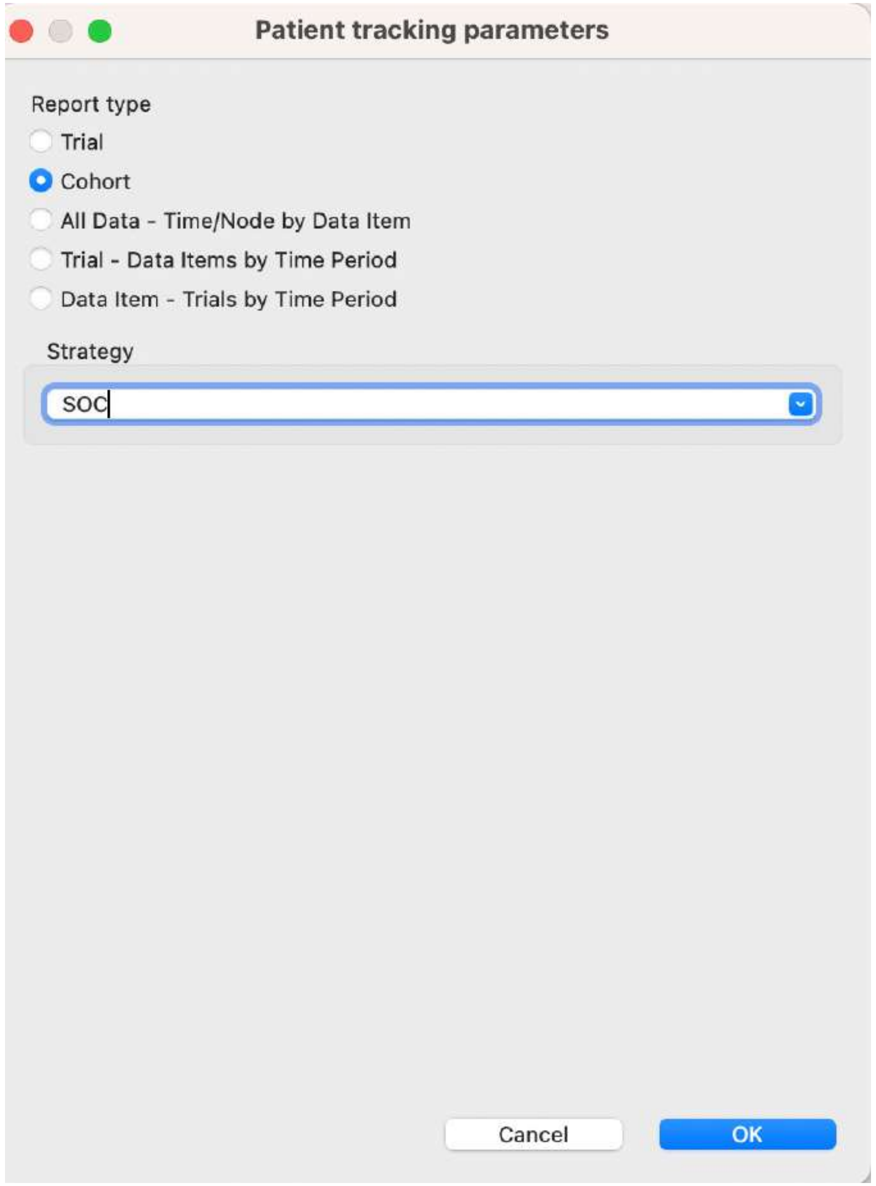
Individual trails unique paths through the model

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 Dist_GeneType	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

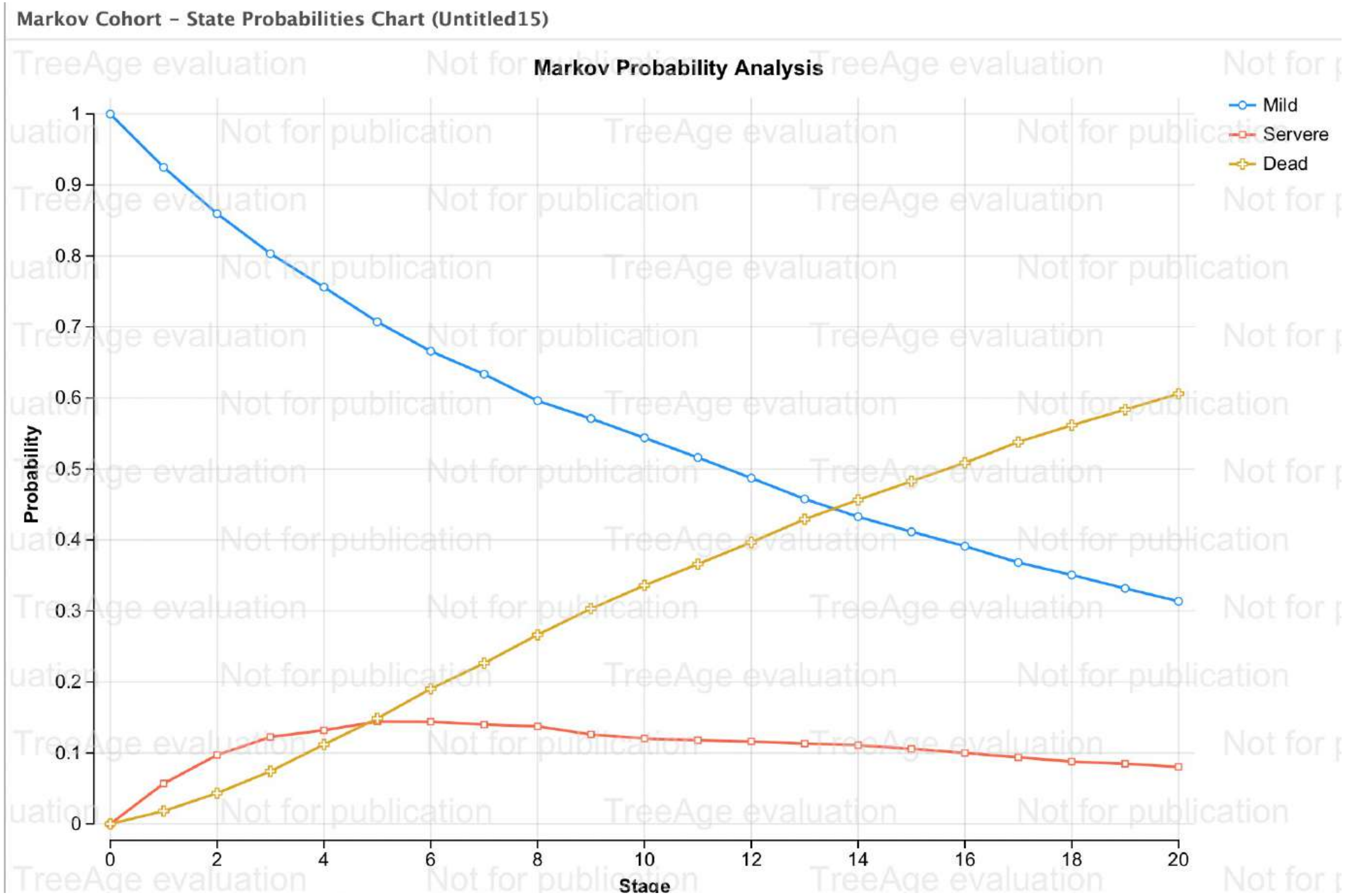


Cohort report for patient level simulation model

Monte Carlo Patient Tracking Cohort Report (Untitled15)

State/Transition	Stage	Cohort %	Cost	Cum Cost	Effectiveness	Cum Effectiveness	Tracker t_progres_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	0.140	980.70		0.08			

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！」

👏 為自己鼓掌吧，學習過程辛苦了！👏

Source: Shiba Says