Aspects of Decision Making in Cost-effectiveness Modelling

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(with thanks to Gianluca Baio, Chris Jackson, Nicky J. Welton, Mark Strong, Anna Heath)

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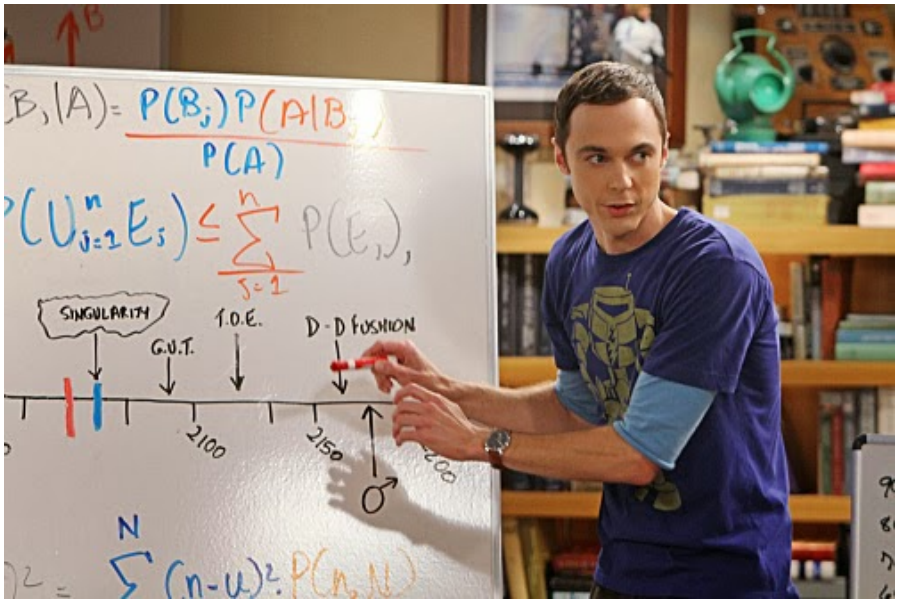
Preliminaries

University College London

- UCL was rated 2nd in the UK for research power in the Research Excellence Framework 2021
- UCL is ranked 8th in the 2022 QS World University Rankings
- The Department of Statistical Science has played a major role in the development of the subject ever since its foundation in 1911 as the Department of Applied Statistics

Objectives

Lectures



- Introduction to *Health economics modelling*
  - Decision trees
  - Markov models
- Introduction to sensitivity analyses
  - Deterministic
    - ★ One-way & multi-way
    - ★ Scenario
  - Probabilistic

Objectives

Computer practicals

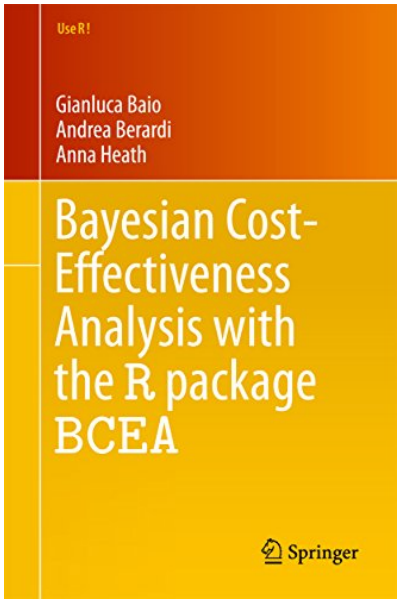
- Emphasis on practical examples
  - Decision tree and Markov models
  - using R programming language

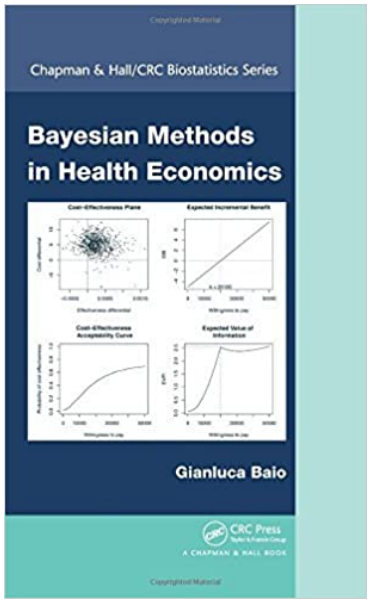
Timetable

- 0:00-1:00 Health Economics modelling lecture
- 1:00 - 1:45 Decision tree and Markov model practical
- BREAK
- 1:50 - 2:20 Sensitivity analysis
- 2:20-3:00 Sensitivity analysis practical

More Bayesian Health Economics...

Books





- This course is only a small part of an *annual week-long summer school*
  - usually in Florence, Italy
- Several books available
- Edition two of BCEA book in the pipeline and a Health Economic in R book close to being finished!

Lecture 2

Uncertainty analysis

Handling uncertainty in economic evaluations

- Population uncertainty: Sub-group analysis
- Parameter uncertainty: Sensitivity analysis
- Structural uncertainty: Sensitivity analysis
- Collect more data
- Sensitivity analysis (SA)
- Deterministic sensitivity analysis
  - One-way SA
  - Two-way SA
  - Scenario analysis (best or worst case, what if..)
- Probabilistic sensitivity analysis (PSA)
  - Monte Carlo simulation
- Cost-effectiveness acceptability curves (CEAC)

How robust are health economic evaluations

- Do limitations in either the quality or availability of evidence affect the recommended decision?
- If the decision is not altered despite 'reasonable' variations in key assumptions/parameters, then the analysis can be considered to be 'robust'
- Two types of uncertainty:
  - Structural (is the model design correct?)
  - Parameter (are the values correct?)
- In economic evaluation, some form of sensitivity analysis is frequently carried out in order to allow for uncertainty
- This uncertainty may be present in the evaluation for several reasons:
  - Data are unavailable and assumptions are necessary
  - Available but inaccurate
- In this type of analysis the values recorded for important parameters are varied, usually one at a time, in order to determine whether the results are sensitive to the assumptions made

Uncertainty in economic evaluations

- Structural: scenario analysis
- Re-run the analysis with alternate assumptions and model structures
- Parameter: sensitivity analysis (SA)
- Re-run the analysis with different parameter values
- Type of sensitivity analysis:
  - One-way SA
  - Multi-way SA
  - Extreme values SA
  - Probabilistic SA

Types of sensitivity analysis

- Simple sensitivity analysis entails varying one or more of the components of an evaluation to see how it affects the results
- Probabilistic sensitivity analysis assigns ranges and distribution to variables and computer programs are used to select values at random from each range and to record the results
- By using these different methods of sensitivity analysis it is possible to show whether the results of a particular study over a range of assumptions or hinge on the accuracy of particular assumptions

Uncertainty in economic evaluations

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References

Bayesian Methods in Health Economics, chapter 1.
Baio et al (2017). *Bayesian Cost-Effectiveness Analysis with the* R *package* BCEA

Uncertainty in economic evaluations

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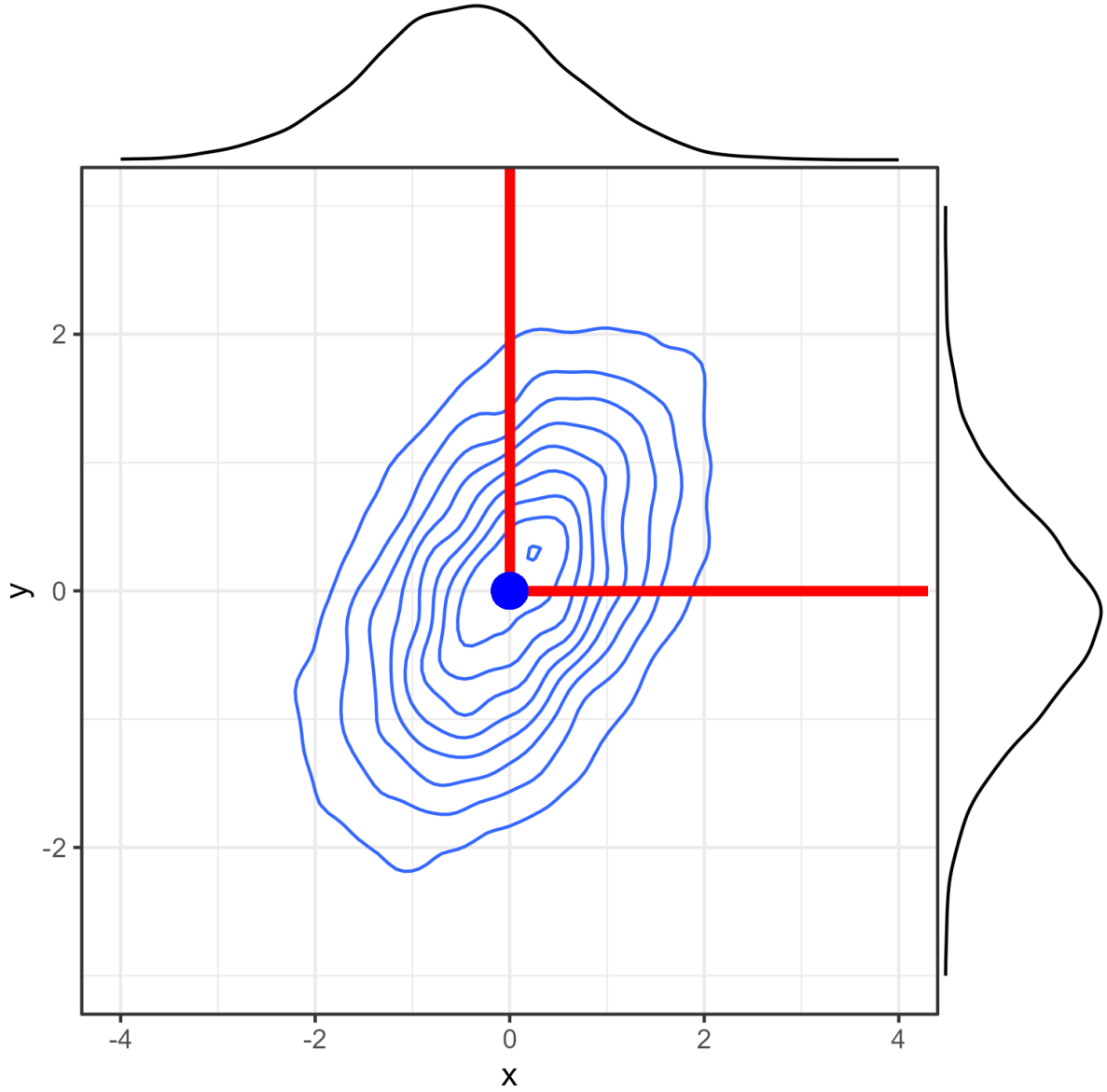
A two input example



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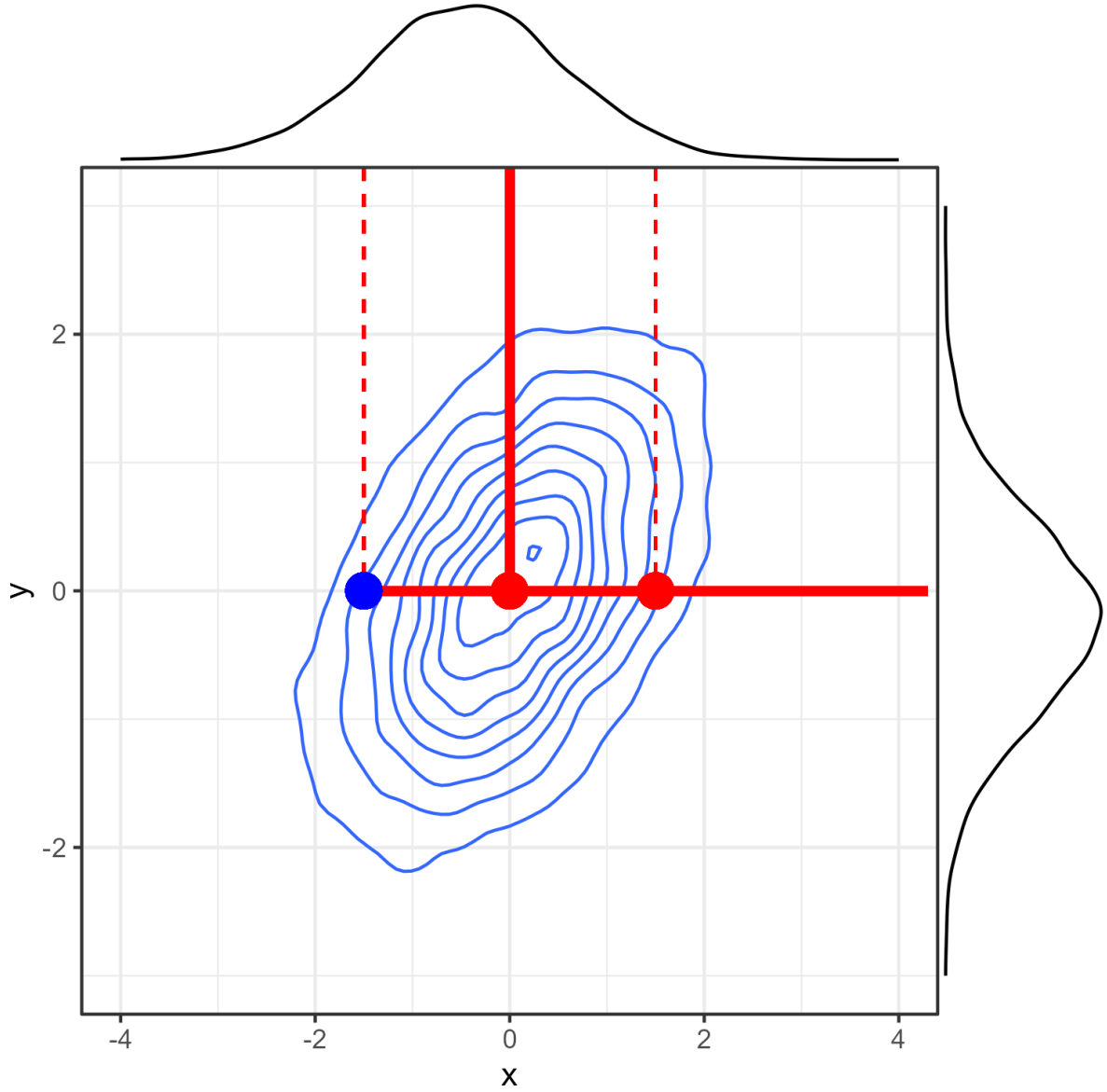

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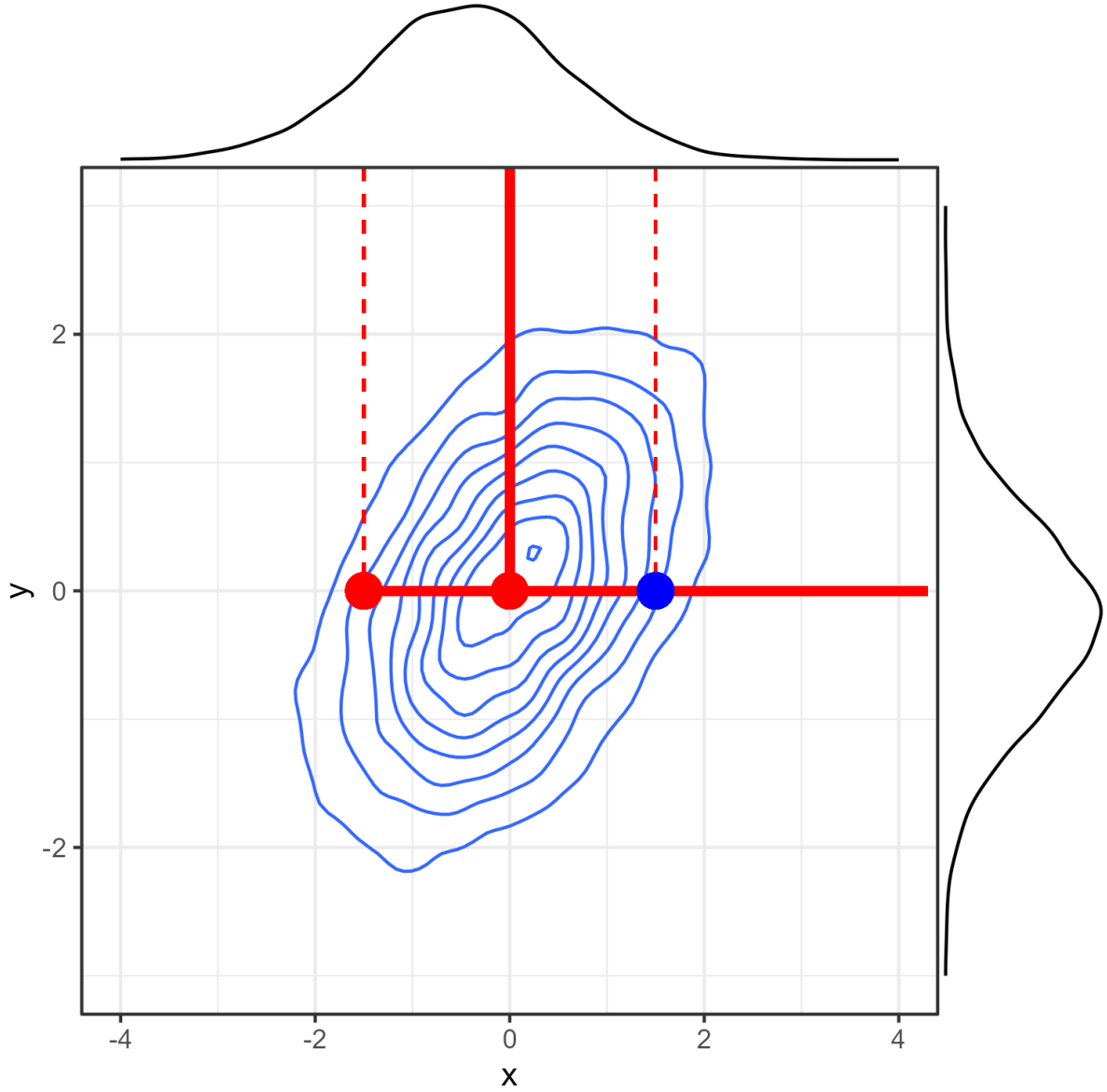

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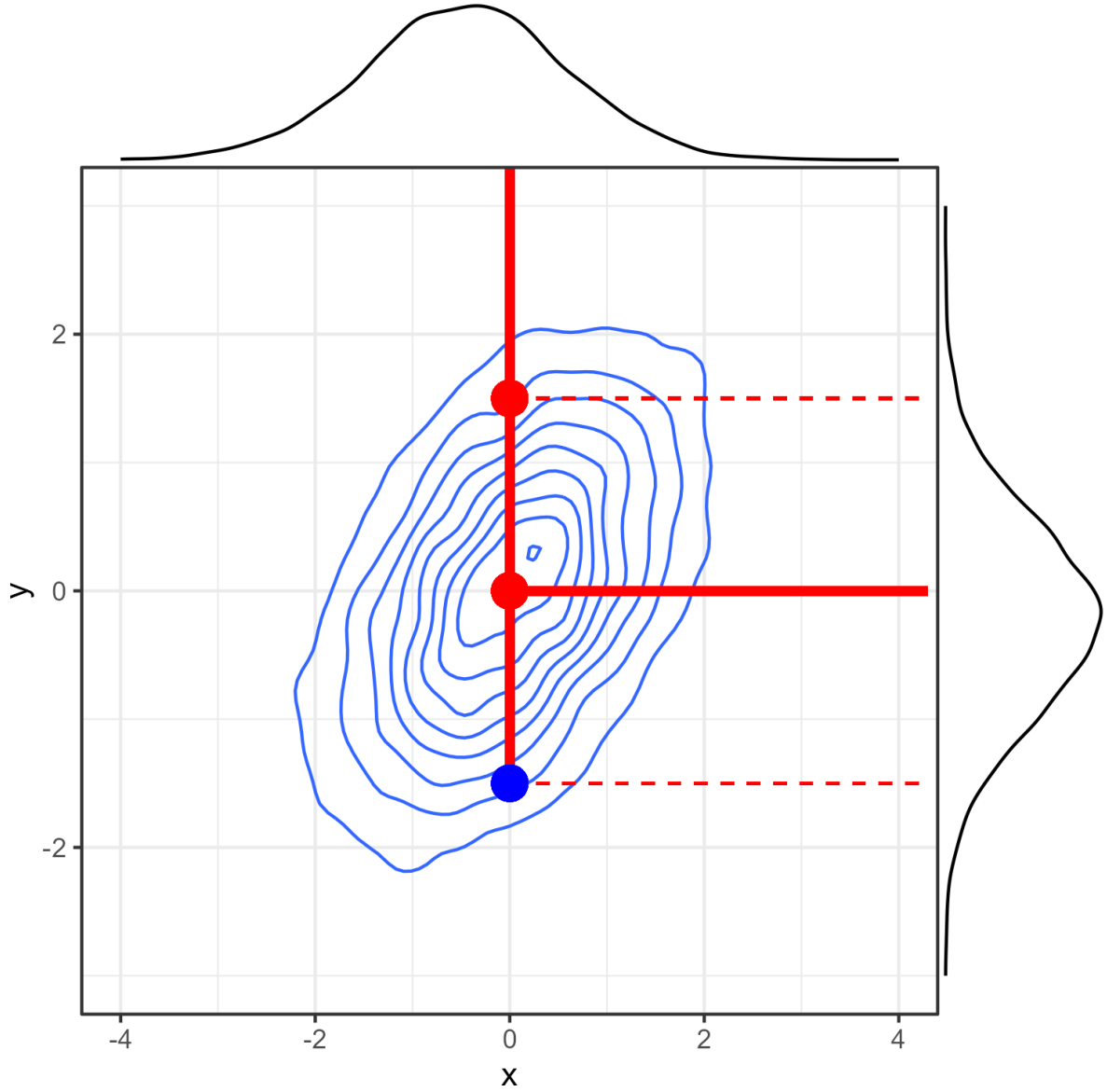

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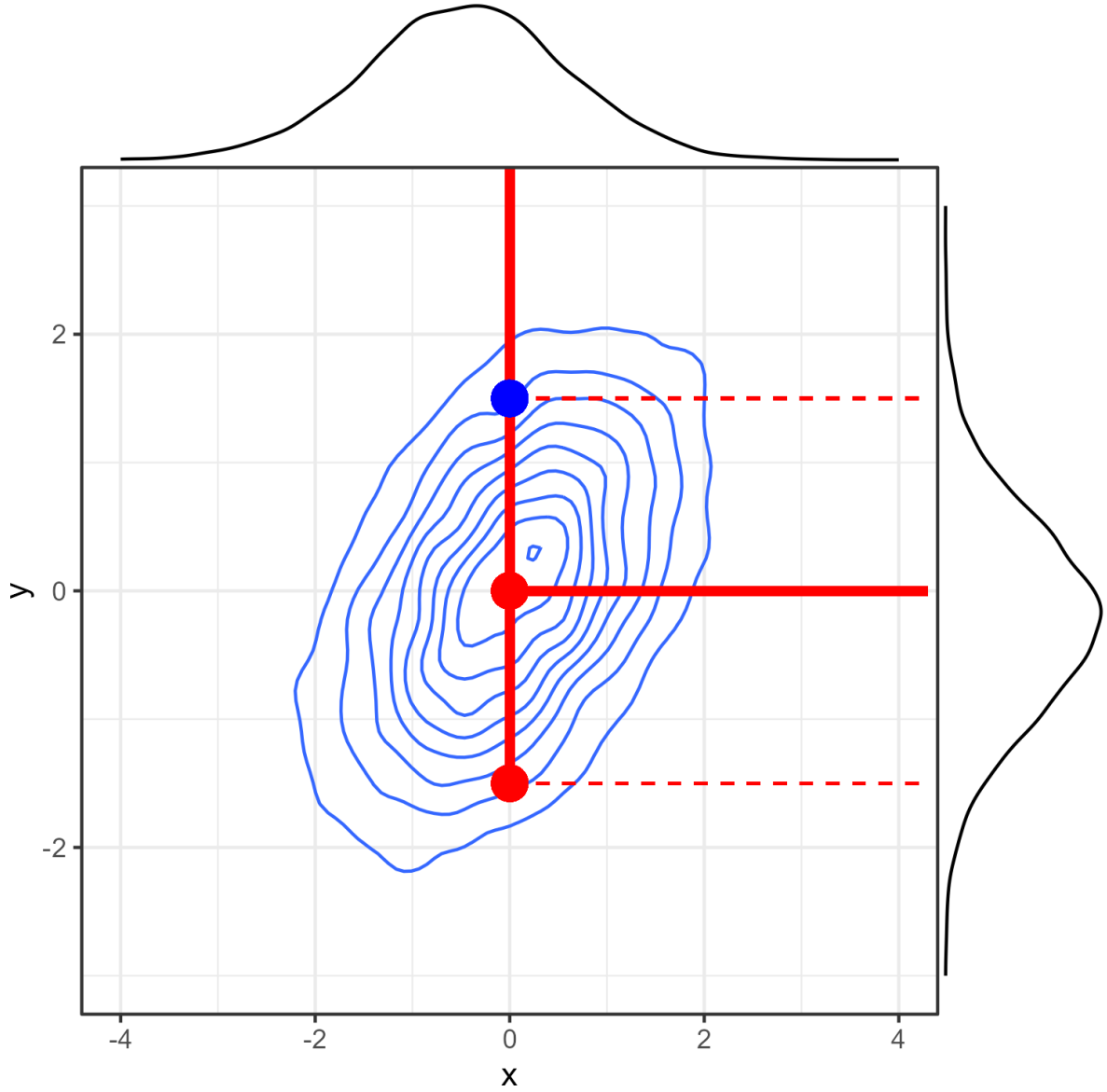

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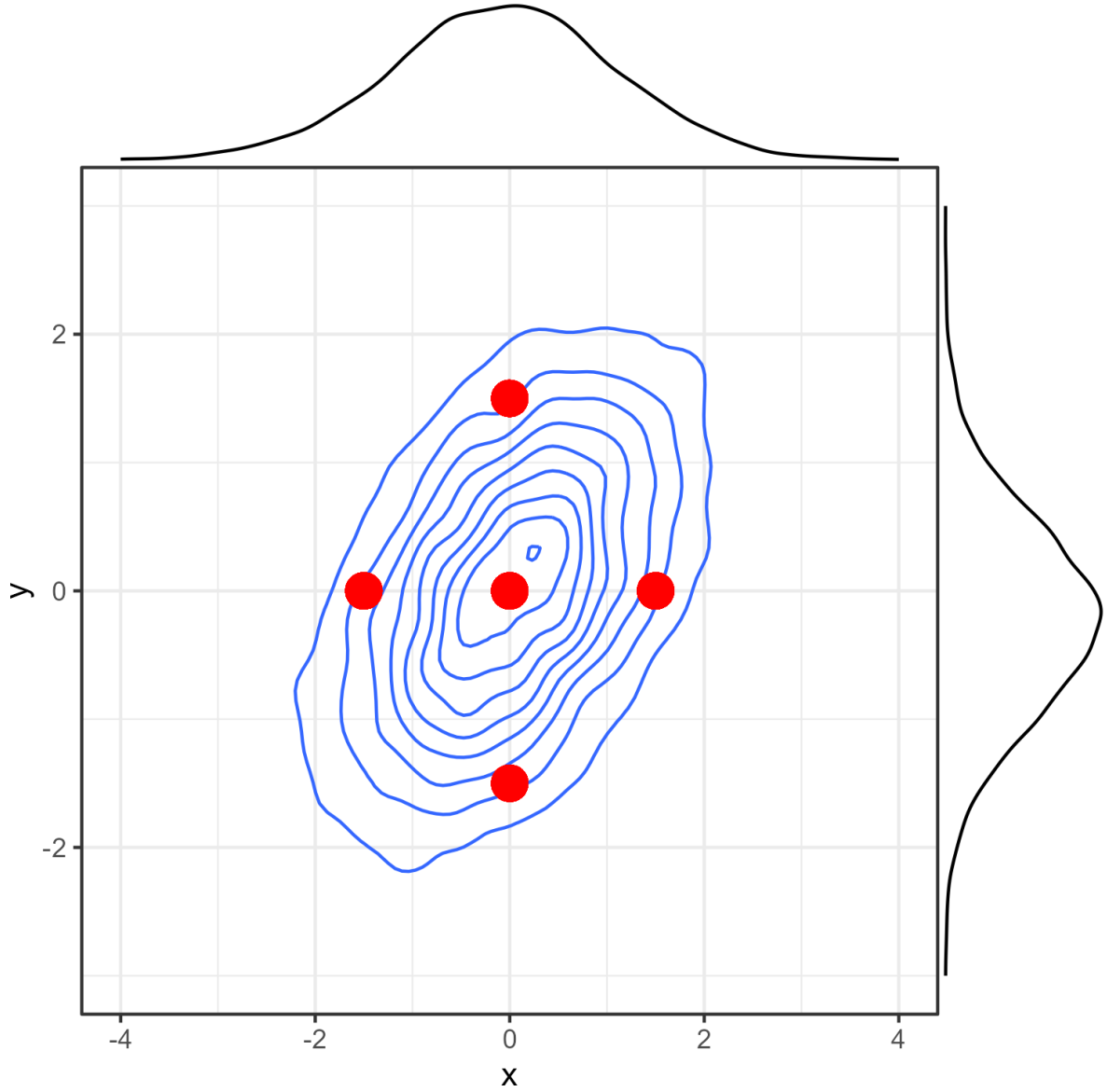

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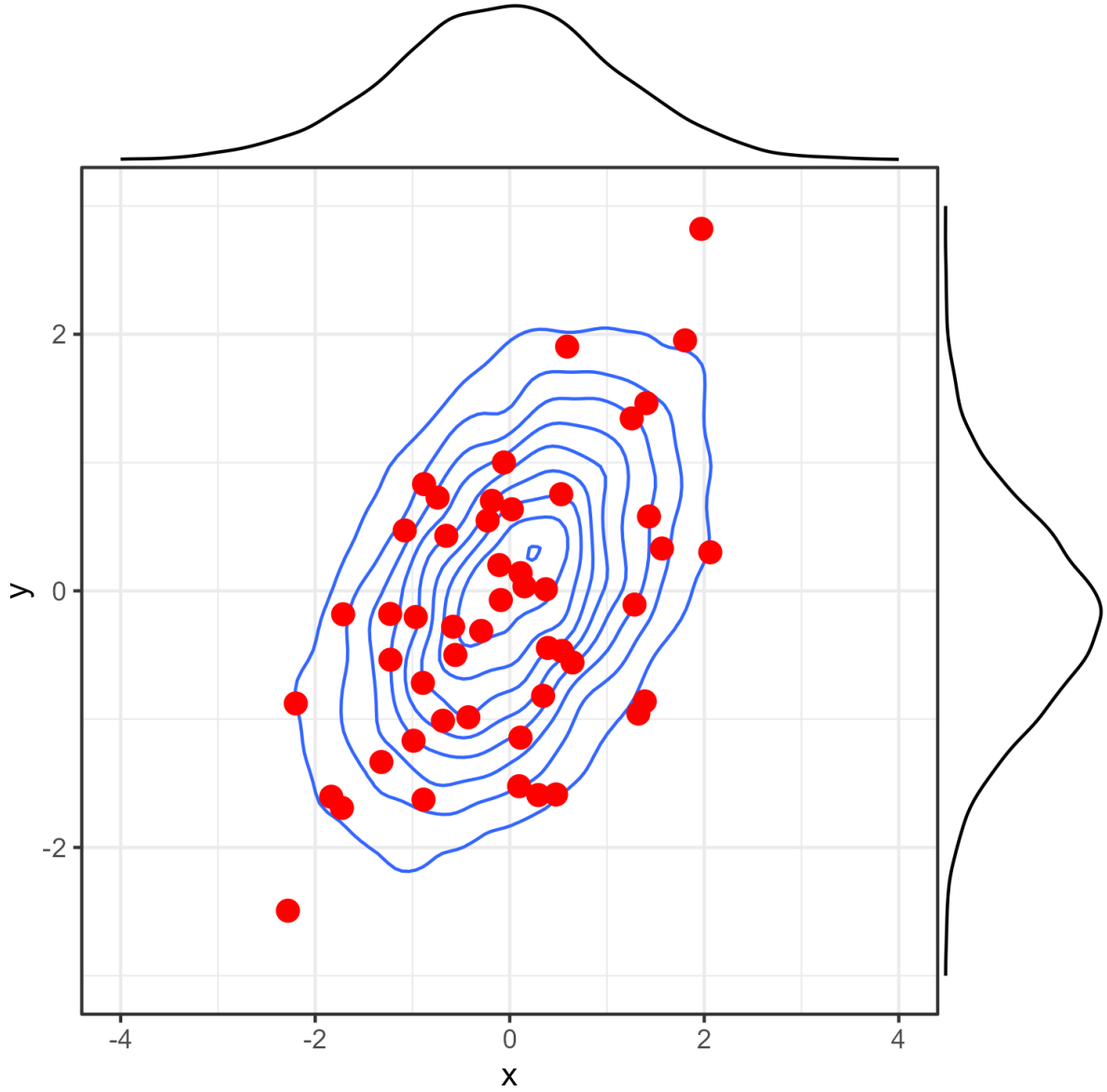
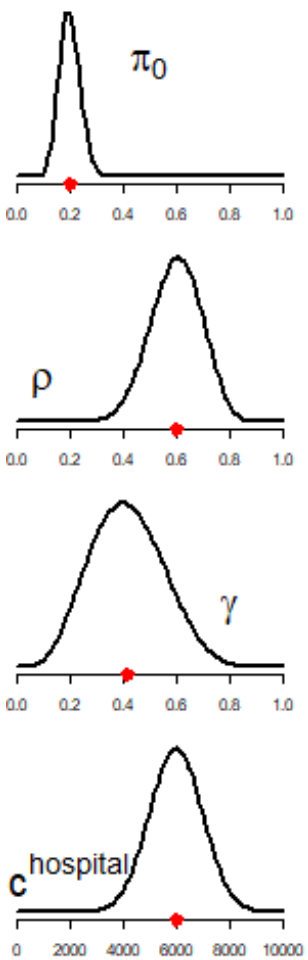
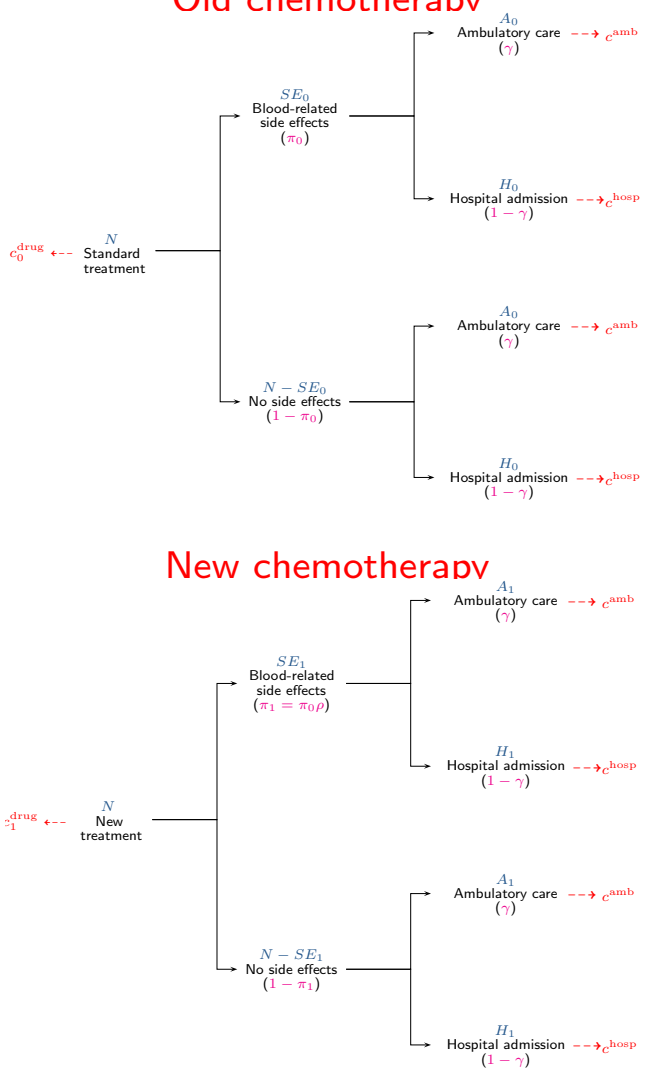


4. Uncertainty analysis

Parameters



Model structure



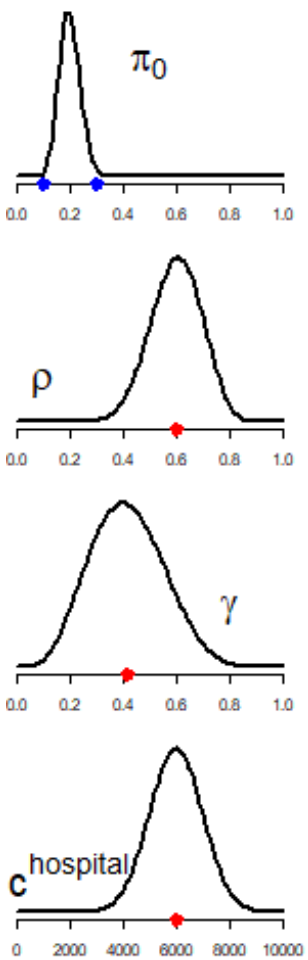
Decision analysis

Old chemotherapy	
Benefits	Costs

New chemotherapy	
Benefits	Costs

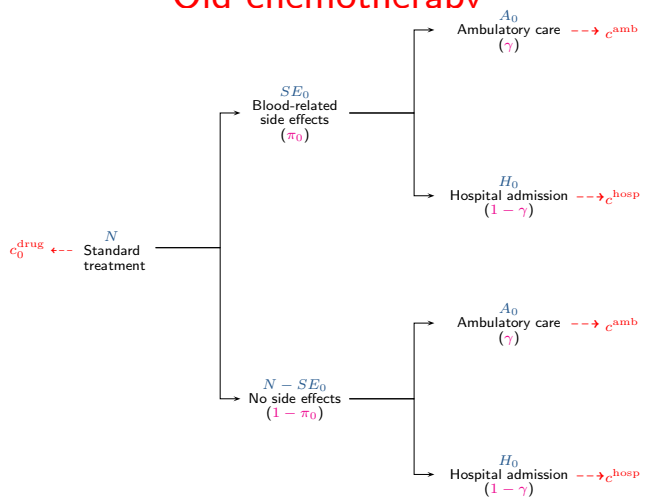
4. Uncertainty analysis

Parameters

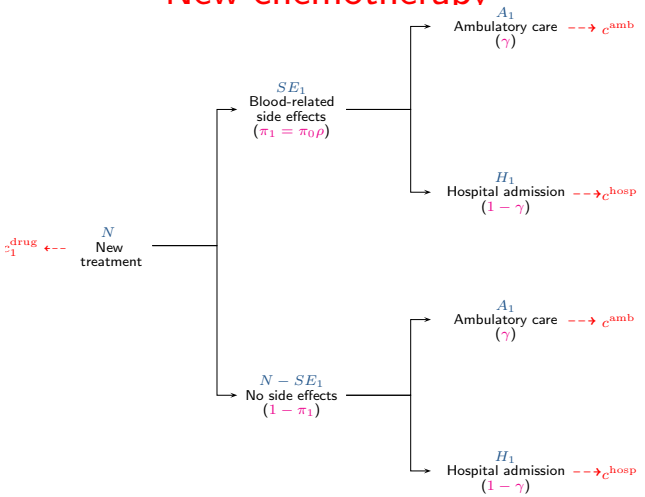


Model structure

Old chemotherapy



New chemotherapy



Decision analysis

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New chemotherapy	
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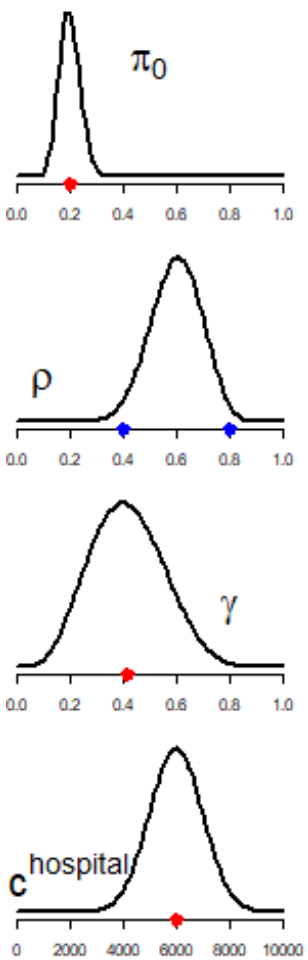

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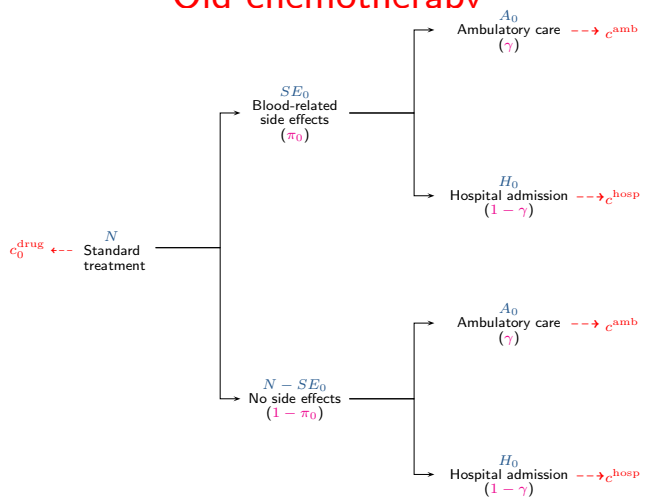
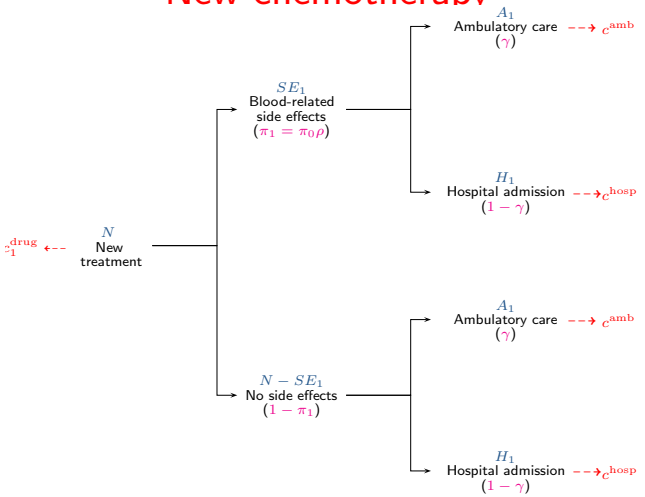


New chemotherapy



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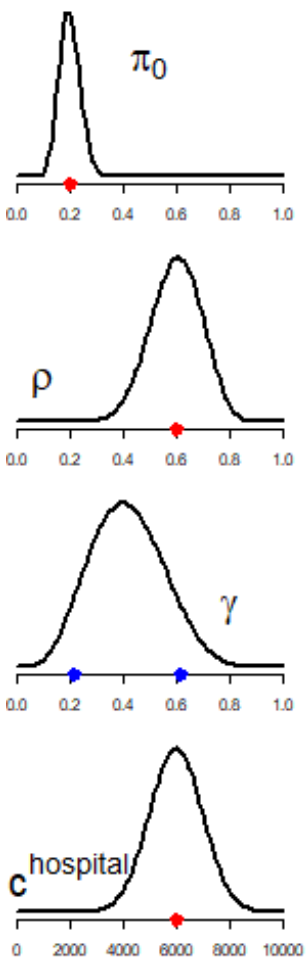

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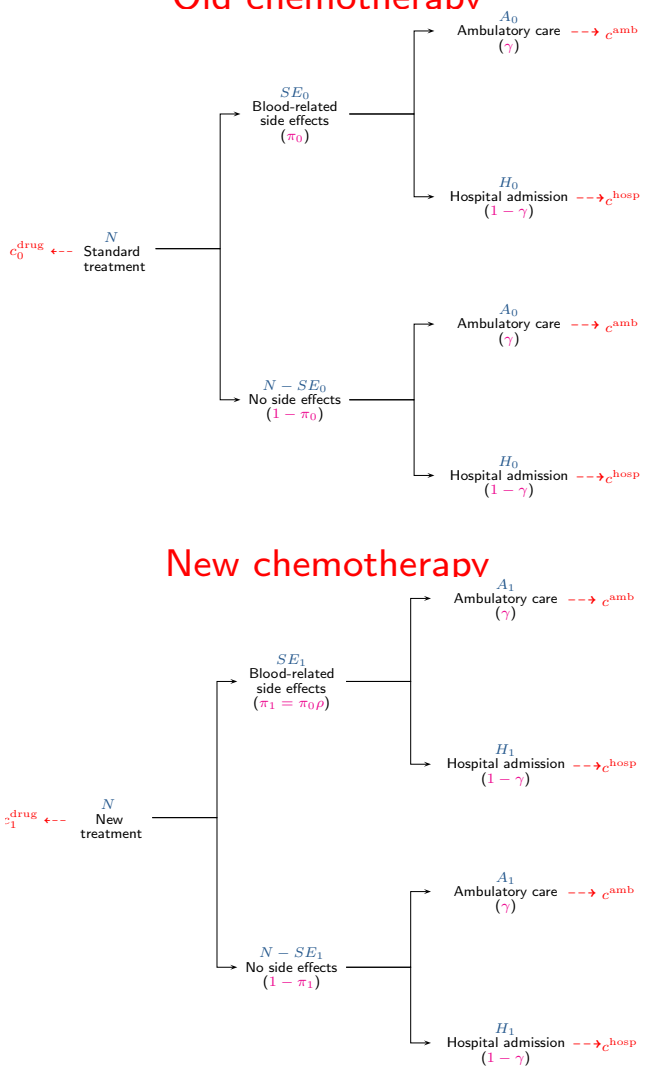

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New chemotherapy	
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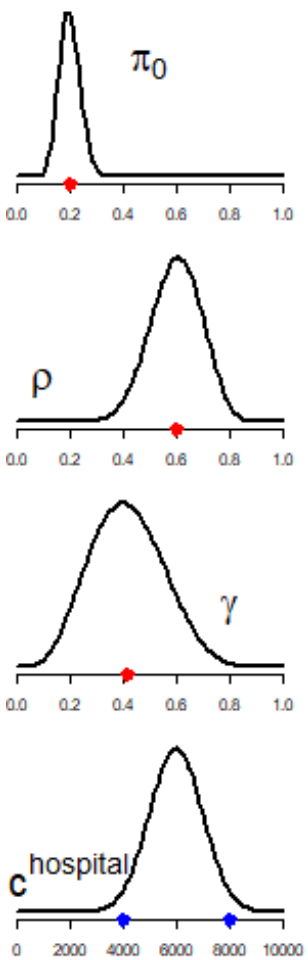

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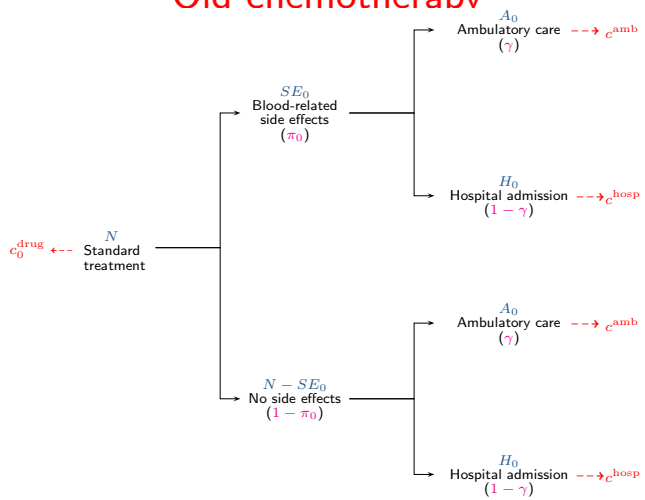

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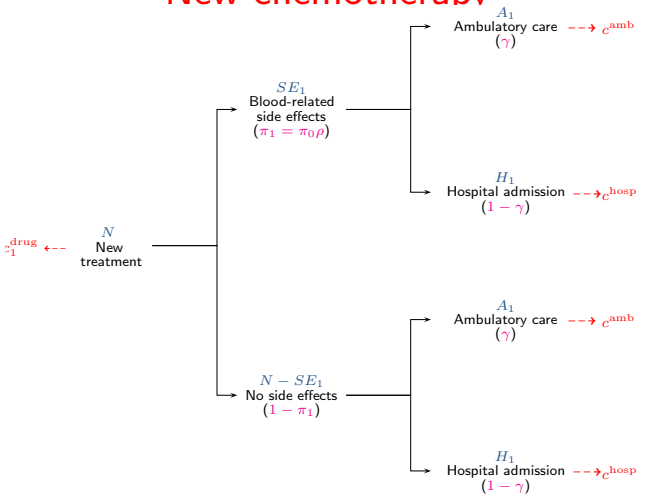

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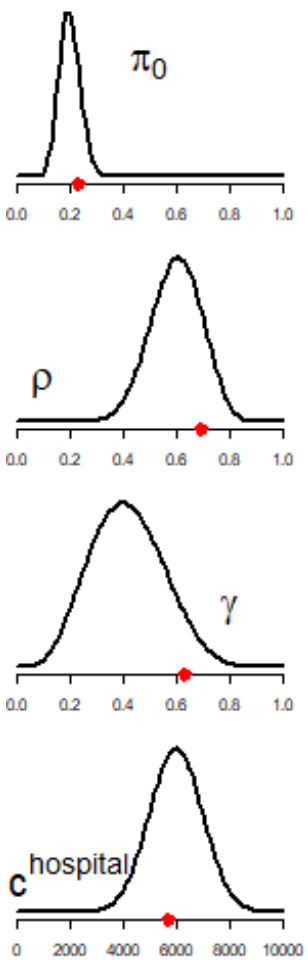

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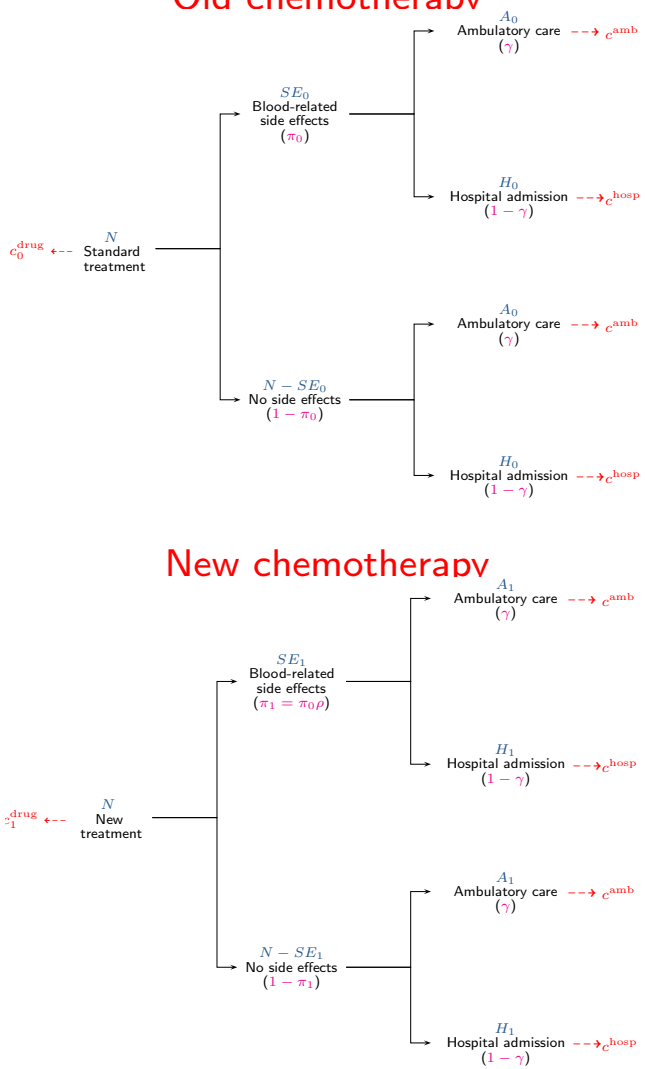

Decision analysis

Old chemotherapy	
Benefits	Costs
741	670 382.1

New chemotherapy	
Benefits	Costs
732	1 131 978

4. Uncertainty analysis

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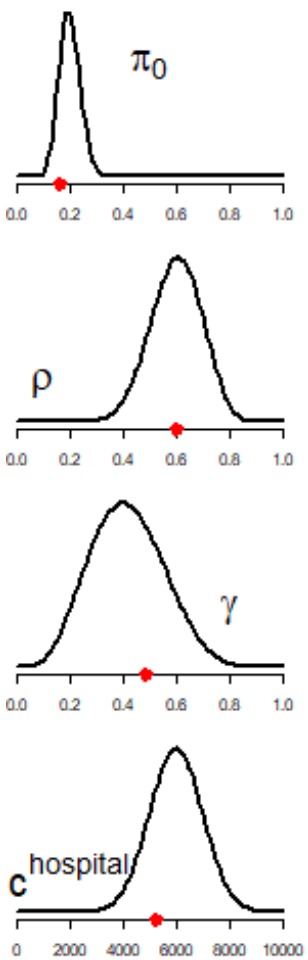

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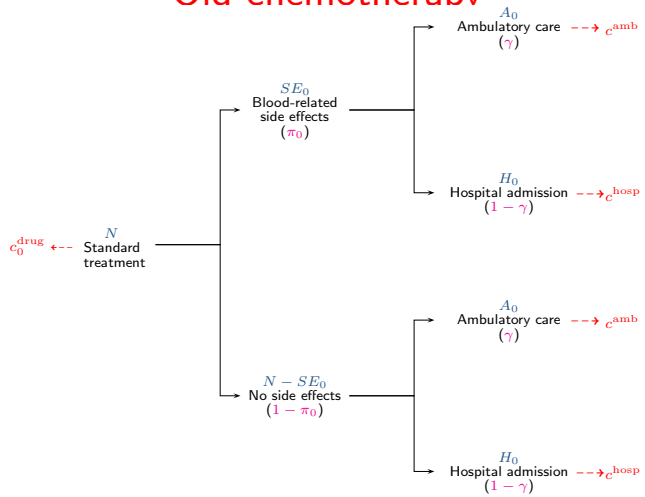
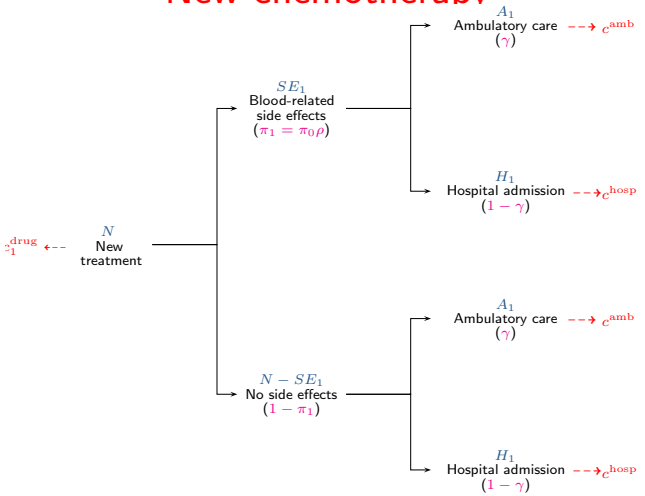


New chemotherapy



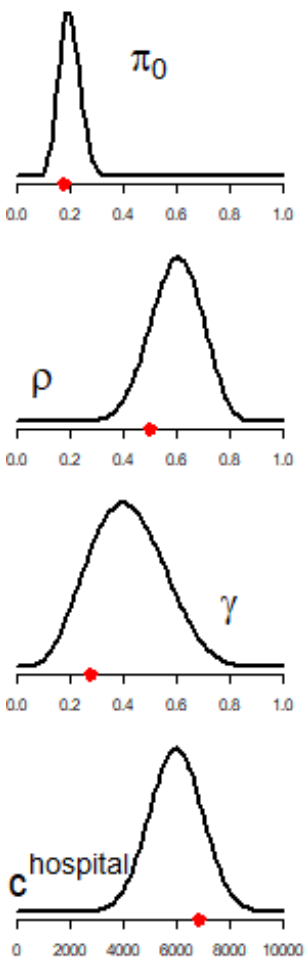
Decision analysis

Old chemotherapy	
Benefits	Costs
741	670 382.1
699	871 273.3

New chemotherapy	
Benefits	Costs
732	1 131 978
664	1 325 654

4. Uncertainty analysis

Parameters



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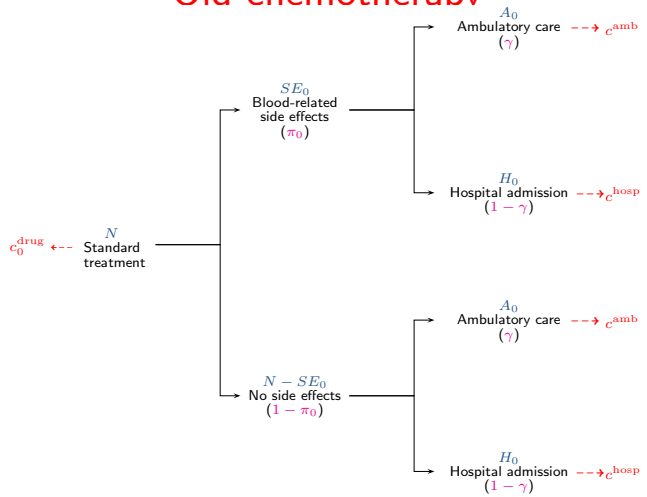
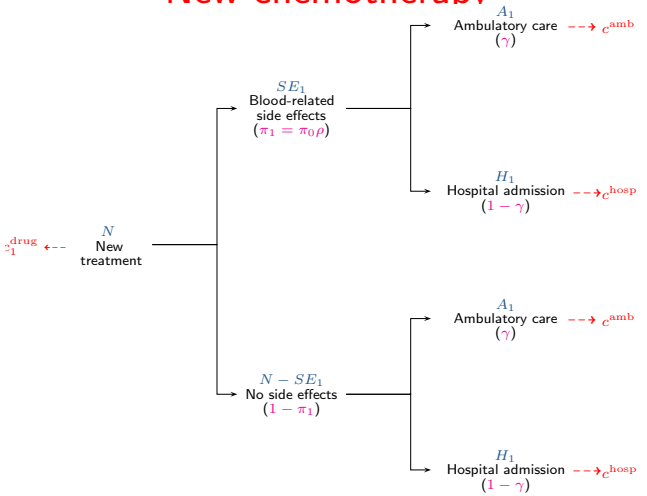


New chemotherapy



Decision analysis

Old chemotherapy	
Benefits	Costs
741	670 382.1
699	871 273.3
...	...
726	425 822.2
716.2	**790 381.2**

New chemotherapy	
Benefits	Costs
732	1 131 978
664	1 325 654
...	...
811	766 411.4
774.5	**1 066 849.8**

$$\text{ICER} = \frac{276\,468.6}{58.3} = 6\,497.1$$

Is this *all* we need?

(see VoI)

- The CEAC only deals with the **probability** of making the "right decision"
- But it does not account for the **payoff/penalty** associated with making the "wrong" one!

Is this *all* we need?

(see Vol)

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- **Example 1**: Intervention $t = 1$ is the most cost-effective, given current evidence
  - $\Pr(t = 1 \text{ is cost-effective}) = 0.51$
  - If we get it wrong: Increase in costs = £3
    Decrease in effectiveness = 0.000001 QALYs
  - Large uncertainty/negligible consequences $\Rightarrow$ **can afford uncertainty**

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  - If we get it wrong: Increase in costs = £3
    Decrease in effectiveness = 0.000001 QALYs
  - Large uncertainty/negligible consequences ⇒ **can afford uncertainty**

- **Example 2**: Intervention $t = 1$ is the most cost-effective, given current evidence
  - $\Pr(t = 1 \text{ is cost-effective}) = 0.999$
  - If we get it wrong: Increase in costs = £1 000 000 000
    Decrease in effectiveness = 999999 QALYs
  - Tiny uncertainty/dire consequences ⇒ **probably should think about it...**