Cost-Effectiveness and Decision Modeling in R

Decision Tree Exercise

The DARTH workgroup

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- Jalal H, Pechlivanoglou P, Krijkamp E, Alarid-Escudero F, Enns E, Hunink MG. An Overview of R in Health Decision Sciences. Med Decis Making. 2017; 37(3): 735-746. https://journals.sagepub.com/doi/abs/10.1177/0272989X16686559
- Krijkamp EM, Alarid-Escudero F, Enns EA, Jalal HJ, Hunink MGM, Pechlivanoglou P. Microsimulation modeling for health decision sciences using R: A tutorial. Med Decis Making. 2018;38(3):400–22. https://journals.sagepub.com/doi/abs/10.1177/0272989X18754513
- Krijkamp EM, Alarid-Escudero F, Enns E, Pechlivanoglou P, Hunink MM, Jalal H. A Multidimensional Array Representation of State-Transition Model Dynamics. Med Decis Making. 2020 Online first. https://doi.org/10.1177/0272989X19893973

Exercise I: Treatment for Viral encephalitis – A Decision Tree

Viral encephalitis can be caused by herpes viruses (HVE) or other viruses (OVE). Herpes viruses cause approximately 52% of cases of viral encephalitis. Without treatment, the risk of complications (death or severe sequelae) for HVE is 71%; for OVE, the risk is only 1%. A drug, vidarabine, decreases the likelihood of complications due to HVE from 71% down to 36%. However, among OVE patients, treatment with vidarabine is associated with severe side effects, increasing the risk of complications from the 1% baseline to 20%. It is possible to obtain a definitive diagnosis of HVE by means of a brain biopsy, but the procedure itself also has a 5% probability of inducing complications.

You are tasked with evaluating the healthcare costs and benefits associated with three possible management strategies (no treatment, vidarabine treatment, or brain biopsy followed by vidarabine treatment for those who are diagnosed with HVE). Benefits will be measured in terms of quality-adjusted life-years (QALYs).

The healthcare cost of a case of viral encephalitis without complications is $1,200; however, if complications occur, the cost rises to $9,000. The cost of vidarabine treatment is $9,500, while a brain biopsy is a $25,000 procedure.

A patient who recovers from viral encephalitis without complications has an average of 20 remaining QALYs; however, a patient who experiences complications has an average of 19 remaining QALYs. Since a brain biopsy is an unpleasant procedure, patients who undergo it also experience a one-time loss of 0.01 QALYs regardless of the outcome of the biopsy.

Parameters are summarized in Table 1. Use the code template provided in "HVE_DecisitionTree_Template.Rmd" as a starting point for this exercise.

Tasks

1. Sketch out the decision tree, with a particular focus on the outcome values (costs and QALYs) at terminal nodes.
2. The code template contains calculations for the "No Treatment" strategy. Write code that calculates the expected outcomes for the two other strategies.
3. Use the `calculate_icers()` function from the `dampack` package to calculate the incremental costs, QALYs, and ICERs of each strategy. Type "`?calculate_icers()`" to see function documentation.

Table I: Input parameters

Parameter	R name	Value
Prevalence of HVE	`p_HVE`	0.52
Probability of complications (death or sequelae) without treatment		
- HVE	`p_HVE_comp`	0.71
- OVE	`p_OVE_comp`	0.01
Probability of complications (death or sequelae) with vidarabine treatment		
- HVE	`p_HVE_comp_tx`	0.36
- OVE	`p_OVE_comp_tx`	0.20
Probability of complications due to brain biopsy	`p_biopsy_comp`	0.05
Quality-adjusted life-years (QALYs)		
- Remaining QALYs without VE complications	`q_VE`	20
- Remaining QALYs with VE complications	`q_VE_comp`	19
- QALY loss due to brain biopsy	`q_loss_biopsy`	-0.01
Healthcare costs		

Parameter	R name	Value
- Cost of viral encephalitis without complications	`c_VE`	$1,200
- Cost of viral encephalitis with complications	`c_VE_comp`	$9,000
- Vidarabine treatment	`c_tx`	$9,500
- Brain biopsy	`c_biopsy`	$25,000

Exercise II: Probabilistic sensitivity analysis of the Decision Tree model

This exercise continues based on the HVE decision tree from Exercise I. In this exercise, you will do a probabilistic sensitivity analysis (PSA) with 1000 simulations (`n_sim`). The Table describes the distributions for the variables you used in the previous exercise.

Tasks

4. Change some input values and to see if/how the expected outcomes under each strategy change (One-way and two-way sensitivity analyses).
5. Create the `calculate_ce_out` `R` function of the decision tree model in the file "Functions_decision_tree_HVE.R".
6. Create a function called `gen_psa` to sample values for the uncertain parameters using the appropriate distributions. Hint: package `truncnorm` deals with truncated normal distributions.
7. Open the file "decision_tree_HVE_SA_template.R" and conduct a probabilistic Cost-Effectiveness analysis of treatment vs no-treatment.
8. Create histograms of model inputs.
9. Create a cost-effectiveness plane to present discounted costs and QALYs.
10. Create the cost-effectiveness acceptability curves (CEAC) and frontier (CEAF) for the treatment comparison assuming WTP thresholds of \$0 to \$300,000.
11. Create the expected loss curves (ELCs) plot
12. Create an expected value of perfect information (EVPI) plot.

Table II: Input parameters for probabilistic analysis

Parameter	Distribution	Distribution values
Prevalence of HVE	Beta	$\alpha = 30,\ \beta = 170$
Probability of complications (death or sequelae) without treatment		
- HVE	Beta	$\alpha = 30,\ \beta = 170$
- OVE	Beta	$\alpha = 30,\ \beta = 170$
Probability of complications (death or sequelae) with vidarabine treatment		
- HVE	Beta	$\alpha = 30,\ \beta = 170$
- OVE	Beta	$\alpha = 30,\ \beta = 170$
Probability of complications due to brain biopsy	Beta	$\alpha = 30,\ \beta = 170$
Quality-adjusted life-years (QALYs)		

Parameter	**Distribution**	**Distribution values**
- Remaining QALYs without VE complications	Normal	$\mu = log(3),\ \sigma = 0.01$
- Remaining QALYs with VE complications	Normal	$\mu = log(3),\ \sigma = 0.01$
- QALY loss due to brain biopsy	Tr. Normal	$\mu = 1.00,\ \sigma = 0.01,\ b = 1$
Healthcare costs		
- Cost of viral encephalitis without complications	Gamma	shape = 100.0, scale = 20.0
- Cost of viral encephalitis with complications	Gamma	shape = 100.0, scale = 20.0
- Vidarabine treatment	Gamma	shape = 100.0, scale = 20.0
- Brain biopsy	Gamma	shape = 100.0, scale = 20.0