Sumatriptan versus caffeine for migraine

A decision tree example

Andrew J. Sims

April 2020

Introduction

This vignette is an example of modelling a decision tree using the `rdecision` package. It is based on the example given by Briggs (2006, Box 2.3) which itself is based on a decision tree which compared oral Sumatriptan versus oral caffeine/Ergotamine for migraine (Evans et al. 1997).

Creating the model

The following code constructs the decision tree. In the formulation used by `rdecision`, a decision tree is a form of *arborescence*, a directed graph of nodes and edges, with a single root and a unique path from the root to each leaf node. Decision trees comprise three types of node: decision, chance and leaf nodes and two types of edge: actions (whose sources are decision nodes) and reactions (whose sources are chance nodes).

```
# Time horizon
th <- as.difftime(48, units="hours")

# model variables for cost
c.sumatriptan <- 16.10
c.caffeine <- 1.32
c.ED <- 63.16
c.admission <- 1093

# Sumatriptan branch
ta <- LeafNode$new("A", utility=1.0, interval=th)
tb <- LeafNode$new("B", utility=0.9, interval=th)
c3 <- ChanceNode$new("c3")
e1 <- Reaction$new(c3, ta, p=0.594, label="No recurrence")
e2 <- Reaction$new(c3, tb, p=0.406, cost=c.sumatriptan,
                   label="Recurrence relieved with 2nd dose")

td <- LeafNode$new("D", utility=0.1, interval=th)
te <- LeafNode$new("E", utility=-0.3, interval=th)
c7 <- ChanceNode$new("c7")
e3 <- Reaction$new(c7, td, p=0.998, label="Relief")
e4 <- Reaction$new(c7, te, p=0.002, cost=c.admission, label="Hospitalization")

tc <- LeafNode$new("C", utility=-0.3, interval=th)
c4 <- ChanceNode$new("c4")
e5 <- Reaction$new(c4, tc, p=0.920, label="Endures attack")
```

```
e6 <- Reaction$new(c4, c7, p=0.080, cost=c.ED, label="Emergency Department")

c1 <- ChanceNode$new("c1")
e7 <- Reaction$new(c1, c3, p=0.558, label="Relief")
e8 <- Reaction$new(c1, c4, p=0.442, label="No relief")

# Caffeine/Ergotamine branch
tf <- LeafNode$new("F", utility=1.0, interval=th)
tg <- LeafNode$new("G", utility=0.9, interval=th)
c5 <- ChanceNode$new("c5")
e9 <- Reaction$new(c5, tf, p=0.703, label="No recurrence")
e10 <- Reaction$new(c5, tg, p=0.297, cost=c.caffeine,
                    label="Recurrence relieved with 2nd dose")

ti <- LeafNode$new("I", utility=0.1, interval=th)
tj <- LeafNode$new("J", utility=-0.3, interval=th)
c8 <- ChanceNode$new("c8")
e11 <- Reaction$new(c8, ti, p=0.998, label="Relief")
e12 <- Reaction$new(c8, tj, p=0.002, cost=c.admission, label="Hospitalization")

th <- LeafNode$new("H", utility=-0.3, interval=th)
c6 <- ChanceNode$new("c6")
e13 <- Reaction$new(c6, th, p=0.920, label="Endures attack")
e14 <- Reaction$new(c6, c8, p=0.080, cost=c.ED, label="Emergency Department")

c2 <- ChanceNode$new("c2")
expect_equal(c2$label(), "c2")
e15 <- Reaction$new(c2, c5, p=0.379, label="Relief")
e16 <- Reaction$new(c2, c6, p=0.621, label="No relief")

# decision node
d1 <- DecisionNode$new("d1")
expect_equal(d1$label(), "d1")
e17 <- Action$new(d1, c1, cost=c.sumatriptan, label="Sumatriptan")
e18 <- Action$new(d1, c2, cost=c.caffeine, label="Caffeine/Ergotamine")

# create lists of nodes and edges
V <- list(
  d1, c1, c2, c3, c4, c5, c6, c7, c8,
  ta, tb, tc, td, te, tf, tg, th, ti, tj
)
E <- list(
  e1, e2, e3, e4, e5, e6, e7, e8, e9, e10, e11, e12, e13, e14, e15, e16, e17, e18
)
# tree
DT <- DecisionTree$new(V,E)
```

Running the model

The method `evaluate` of decision tree objects computes the probability, cost and utility of each *strategy* for the model. A strategy is a unanimous prescription of the actions at each decision node. In this example there is a single decision node with two actions, and the strategies are simply the two forms of treatment to be

compared. More complex decision trees are also possible.

The paths traversable for a particular strategy can be evaluated individually using the method `evaluate_strategy`. In `rdecision` a strategy is defined as a set with one action edge per decision node. It is necessary to call the method `evaluate_strategy` only if information about each pathway is required; normally it is sufficient to call `evaluate` which will automatically identify all possible strategies in a decision tree and evaluate them.

Model results

The evaluation of each pathway, for each strategy, yields the following table:

d1	Probability	Path.Cost	Path.Utility	Leaf	Cost	Utility
Sumatriptan	0.3315	16.10	1.0	A	5.34	0.3315
Sumatriptan	0.2265	32.20	0.9	B	7.29	0.2039
Sumatriptan	0.4066	16.10	-0.3	C	6.55	-0.1220
Sumatriptan	0.0353	79.26	0.1	D	2.80	0.0035
Sumatriptan	0.0001	1172.26	-0.3	E	0.08	0.0000
Caffeine/Ergotamine	0.2664	1.32	1.0	F	0.35	0.2664
Caffeine/Ergotamine	0.1126	2.64	0.9	G	0.30	0.1013
Caffeine/Ergotamine	0.5713	1.32	-0.3	H	0.75	-0.1714
Caffeine/Ergotamine	0.0496	64.48	0.1	I	3.20	0.0050
Caffeine/Ergotamine	0.0001	1157.48	-0.3	J	0.12	0.0000

There are, as expected, ten pathways (5 per strategy). The expected cost and expected utility for each choice can be calculated from the table above, or by invoking the `evaluate` method of a decision tree object. This gives the following result, consistent with that reported by Evans *et al* (1997).

d1	Cost	Utility
Sumatriptan	22.06	0.41686
Caffeine/Ergotamine	4.71	0.20128

References

Briggs, Andrew, Karl Claxton, and Mark Sculpher. 2006. *Decision Modelling for Health Economic Evaluation.* Oxford, UK: Oxford University Press.

Evans, Kenneth W., John A. Boan, John L. Evans, and Ashfaq Shuaib. 1997. "Economic Evaluation of Oral Sumatriptan Compared with Oral Caffeine/Ergotamine for Migraine." *Pharmacoeconomics* 12 (5): 565–77.