# Sumatriptan versus caffeine for migraine

A decision tree example

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*2019-09-18*

## 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, node by node. In the formulation used by `rdecision`, each node is a potentially recursive structure which is allowed to have zero or more child nodes; any child nodes must have already been declared before their parent node is declared. This implies that a tree should be constructed from right to left, starting with leaf nodes which have no children (leaf nodes are synonymous with pathways in Briggs' terminology). The final node to be constructed is the left-most decision node in the model.

```
# Sumatriptan branch
leaf.a <- LeafNode$new("A", utility=1.0)
leaf.b <- LeafNode$new("B", utility=0.9)
leaf.c <- LeafNode$new("C", utility=-0.3)
leaf.d <- LeafNode$new("D", utility=0.1)
leaf.e <- LeafNode$new("E", utility=-0.3)

c.8 <- ChanceNode$new(
  p = list(0.998, 0.002),
  children = list(leaf.d, leaf.e),
  edgelabels = list("Relief", "Hospitalization"),
  costs = list(0, 1093.0)
)

c.4 <- ChanceNode$new(
  p = list(0.594, 0.406),
  children = list(leaf.a, leaf.b),
  edgelabels = list("No recurrence", "Recurrence relieved with 2nd dose"),
  costs = list(0, 16.10)
)

c.5 <- ChanceNode$new(
  p = list(0.920, 0.080),
  children = list(leaf.c, c.8),
  edgelabels = list("Endures attack", "ER"),
  costs = list(0, 63.16)
)
```

```
c.2 <- ChanceNode$new(
  p = list(0.558, 0.442),
  children = list(c.4, c.5),
  edgelabels = list("Relief", "No relief"),
  costs = list(0, 0)
)

# Caffeine/Ergotamine branch
leaf.f <- LeafNode$new("F", utility=1.0)
leaf.g <- LeafNode$new("G", utility=0.9)
leaf.h <- LeafNode$new("H", utility=-0.3)
leaf.i <- LeafNode$new("I", utility=0.1)
leaf.j <- LeafNode$new("J", utility=-0.3)

c.9 <- ChanceNode$new(
  p = list(0.998, 0.002),
  children = list(leaf.i, leaf.j),
  edgelabels = list("Relief", "Hospitalization"),
  costs = list(0, 1093.0)
)

c.6 <- ChanceNode$new(
  p = list(0.703, 0.297),
  children = list(leaf.f, leaf.g),
  edgelabels = list("No recurrence", "Recurrence relieved with 2nd dose"),
  costs = list(0, 1.32)
)

c.7 <- ChanceNode$new(
  p = list(0.920, 0.080),
  children = list(leaf.h, c.9),
  edgelabels = list("Endures attack", "ER"),
  costs = list(0, 63.13)
)

c.3 <- ChanceNode$new(
  p = list(0.379, 0.621),
  children = list(c.6, c.7),
  edgelabels = list("Relief", "No relief"),
  costs = list(0, 0)
)

# decision node
d.1 <- DecisionNode$new(
  children = list(c.2, c.3),
  edgelabels = list("Sumatriptan", "Caffeine/Ergotamine"),
  costs = list(16.10, 1.32)
)
```

## Running the model

The following code runs a single model scenario, using low-level functions to evaluate each pathway and decision option. The `path.apply` function applies a user-provided function to each node of every root-to-leaf path in the model. In the Sumatriptan model there are eight possible root-to-leaf paths, each of which begins with the decision node and ends with a leaf node. For example, pathway A involves a traversal of nodes `d.1`, `c.2`, `c.4` and `leaf.a`.

The argument to the function required by `path.apply` is simply an ordered list of nodes. The main challenge in computing, for example, the probability of following the path is to work out which branch of each chance node is linked to the next child node. For example when traversing the list of nodes for pathway A, at chance node `c.4` some effort is needed to establish which branch and p-value (0.594) leads to leaf A. For this reason several functions suitable for use with `path.apply` are provided by `rdecision`. The functions provided include

- `pathway.name` which returns the pathway name defined by its final leaf node;
- `pathway.choice` which returns the choice associated with the first decision node in the pathway;
- `pathway.probability` which returns the product of probabilities associated with the pathway;
- `pathway.cost` which returns the summed cost of traversing each node in the pathway.
- `pathway.utility` which returns the utility associated with the final leaf node of each pathway.

The following code extracts and calculates various features associated with each root-to-leaf node traversal, and puts them into a table.

```
RES <- data.frame(
  'Choice' = unlist(path.apply(d.1, FUN=pathway.choice)),
  'Pathway' = unlist(path.apply(d.1, FUN=pathway.name)),
  'Probability' = unlist(path.apply(d.1, FUN=pathway.probability)),
  'Cost' = unlist(path.apply(d.1, FUN=pathway.cost)),
  'ExpectedCost' = NA,
  'Utility' = unlist(path.apply(d.1, FUN=pathway.utility)),
  'ExpectedUtility' = NA
)
RES$ExpectedCost <- round(RES$Probability*RES$Cost,2)
RES$ExpectedUtility <- round(RES$Probability*RES$Utility,4)
```

## Model results

The results of the scenario model, using the code from the previous section, yields the following result:

| Choice | Pathway | Probability | Cost | ExpectedCost | Utility | ExpectedUtility |
|---|---|---|---|---|---|---|
| Sumatriptan | A | 0.3314520 | 16.10 | 5.34 | 1.0 | 0.3315 |
| Sumatriptan | B | 0.2265480 | 32.20 | 7.29 | 0.9 | 0.2039 |
| Sumatriptan | C | 0.4066400 | 16.10 | 6.55 | -0.3 | -0.1220 |
| Sumatriptan | D | 0.0352893 | 79.26 | 2.80 | 0.1 | 0.0035 |
| Sumatriptan | E | 0.0000707 | 1172.26 | 0.08 | -0.3 | 0.0000 |
| Caffeine/Ergotamine | F | 0.2664370 | 1.32 | 0.35 | 1.0 | 0.2664 |
| Caffeine/Ergotamine | G | 0.1125630 | 2.64 | 0.30 | 0.9 | 0.1013 |
| Caffeine/Ergotamine | H | 0.5713200 | 1.32 | 0.75 | -0.3 | -0.1714 |
| Caffeine/Ergotamine | I | 0.0495806 | 64.45 | 3.20 | 0.1 | 0.0050 |
| Caffeine/Ergotamine | J | 0.0000994 | 1157.45 | 0.12 | -0.3 | 0.0000 |

There are, as expected, eight root-to-leaf pathways, which `path.apply` has worked out itself from the model structure. The total probability, expected cost and expected utility for each choice can be calculated from the table as follows:

```
SUM <- aggregate(
  RES[,c('Probability', 'ExpectedCost', 'ExpectedUtility')],
  by = list(RES$Choice),
  FUN = sum
)
names(SUM) <- c('Choice', 'Probability', 'Expected Cost', 'Expected Utility')
```

which gives the following result, which is consistent with the result reported by Evans *et al* (1997).

| Choice | Probability | Expected Cost | Expected Utility |
|---|---|---|---|
| Caffeine/Ergotamine | 1 | 4.72 | 0.2013 |
| Sumatriptan | 1 | 22.06 | 0.4169 |

# 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.*