Example Markov Model By Sonnenberg and Beck

Monte-Carlo / Discrete Event Simulation

Andrew J. Sims

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Introduction

The vignette is an example of solving a three-state Markov model using a Monte-Carlo, or discrete event simulation, approach. The example is provided by Sonnenberg and Beck (1993) in their Figure 3 and Table 1.

Model construction

The model is designed with a data frame, `states`, describing the three states, the initial prevalance in each state, and the transition matrix (`incidence`). There are no time-limited states and that matrix is filled with zeros.

```
# model parameters
nStates <- 3
state <- data.frame(
  name = c("Well", "Disabled", "Dead"),
  hasCycleLimit = c(FALSE, FALSE, FALSE),
  cycleLimit = c(NA, NA, NA),
  annualCost = c(0, 0, 0),
  entryCost = c(0, 0, 0),
  utility = c(1.0, 0.7, 0.0),
  group = c(0,0,0)
)
prevalence <- c(1.0, 0.0, 0.0)
incidence <- matrix(c(c(NA,  0.2, 0.2),
                      c(0.0,  NA, 0.4),
                      c(0.0, 0.0,  NA)),
                    nrow=nStates, byrow=TRUE
)
Tp <- matrix(rep(0, nStates*nStates), nrow=nStates, byrow=TRUE)
discount <- 0.0
```

The parameters of the simulation are defined as follows, to replicate the results of Sonneberg and Beck (1993, Table 2).

```
# simulation parameters
nPatients <- 10000
nCyclesPerYear <- 1
nYears <- 24
nCycles <- nYears*nCyclesPerYear
```

Running the model

The following call runs the model for 24 cycles (24 years).

```
# solve the model using Monte-Carlo method...
ms <- des(nStates=nStates,
          nGroups = 0,
          nPatients = nPatients,
          nCyclesPerYear = nCyclesPerYear,
          nCycles = nCycles,
          state = state,
          group = NA,
          prevalence = prevalence,
          Ip = incidence,
          Tp = Tp,
          Gp = NA,
          discount = discount,
          stub=NA)
```

The summary output from the model is in the following table. Note that the results differ slighly from Sonnenberg and Beck's Table 2, because the model has been solved using discrete event simulation, and half-cycle correction has been applied.

Cycle	Well	Disabled	Dead	Total	Utility
1	7995.5	1014.5	990.0	10000	8705.65
2	4796.0	2234.0	2970.0	10000	15065.45
3	2880.5	2339.0	4780.5	10000	19583.25
4	1742.5	1996.5	6261.0	10000	22723.30
5	1062.0	1529.5	7408.5	10000	24855.95
6	641.5	1121.5	8237.0	10000	26282.50
7	391.0	793.0	8816.0	10000	27228.60
8	242.5	551.5	9206.0	10000	27857.15
9	149.0	390.5	9460.5	10000	28279.50
10	89.5	271.0	9639.5	10000	28558.70
11	54.5	178.5	9767.0	10000	28738.15
12	31.5	116.0	9852.5	10000	28850.85
13	16.0	77.0	9907.0	10000	28920.75
14	8.5	50.0	9941.5	10000	28964.25
15	5.5	30.5	9964.0	10000	28991.10
16	3.5	20.5	9976.0	10000	29008.95
17	2.0	13.5	9984.5	10000	29020.40
18	0.5	9.0	9990.5	10000	29027.20
19	0.0	6.0	9994.0	10000	29031.40
20	0.0	4.0	9996.0	10000	29034.20
21	0.0	3.0	9997.0	10000	29036.30
22	0.0	2.0	9998.0	10000	29037.70
23	0.0	1.5	9998.5	10000	29038.75
24	0.0	1.0	9999.0	10000	29039.45

Sonnenberg, Frank A., and J. Robert Beck. 1993. "Markov Models in Medical Decision Making: A Practical Guide." *Medical Decision Making*. https://doi.org/10.1177/0272989X9301300409.