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).

```r
# 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	8014.0	1004.0	982.0	10000	8716.80
2	4823.5	2223.0	2953.5	10000	15096.40
3	2881.0	2309.5	4809.5	10000	19594.05
4	1709.5	1966.5	6324.0	10000	22680.10
5	1018.5	1515.5	7466.0	10000	24759.45
6	614.0	1101.0	8285.0	10000	26144.15
7	376.0	785.0	8839.0	10000	27069.65
8	223.0	543.0	9234.0	10000	27672.75
9	130.0	371.0	9499.0	10000	28062.45
10	74.5	253.5	9672.0	10000	28314.40
11	41.0	168.0	9791.0	10000	28473.00
12	24.5	116.5	9859.0	10000	28579.05
13	15.0	81.5	9903.5	10000	28651.10
14	10.0	50.0	9940.0	10000	28696.10
15	6.0	29.5	9964.5	10000	28722.75
16	3.5	18.5	9978.0	10000	28739.20
17	2.0	13.5	9984.5	10000	28750.65
18	1.5	10.0	9988.5	10000	28759.15
19	1.0	7.5	9991.5	10000	28765.40
20	1.0	5.0	9994.0	10000	28769.90
21	1.0	3.5	9995.5	10000	28773.35
22	0.5	3.0	9996.5	10000	28775.95
23	0.0	2.0	9998.0	10000	28777.35
24	0.0	1.0	9999.0	10000	28778.05

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.