Provider Change: Survival Analysis

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Contents

Dependencies and Setup

If you already don't have it, install the packages required to run the analysis.

```
install.packages("kmi")
install.packages("mvna")
install.packages("etm")
install.packages("survival")
```

Now some setup is necessary:

```
library(kmi)
```

```
## Warning: package 'kmi' was built under R version 4.2.3
```

```
library(mvna)
```

```
## Warning: package 'mvna' was built under R version 4.2.3
```

```r
library(etm)
```

```
## Warning: package 'etm' was built under R version 4.2.3
```

```r
library(survival)

# read the CSV files
data_inpatient <- read.csv(params$inpatient_complete)
data_inpatient_sev <- read.csv(params$inpatient_severe)
data_inpatient_ns <- read.csv(params$inpatient_non_severe)

data_daypatient <- read.csv(params$daypatient_complete)
data_daypatient_sev <- read.csv(params$daypatient_severe)
data_daypatient_ns <- read.csv(params$daypatient_non_severe)

# aux variables
states <- c("0", "1", "2")
transitions <- c("0 1", "0 2", "1 2")
transition_matrix <- matrix(FALSE, 3, 3, dimnames = list(c(0, 1, 2), c(0, 1, 2)))
transition_matrix[1, 2:3] <- TRUE
transition_matrix[2, 3] <- TRUE
```

Tables

Table 2. Table of observed transitions

```r
# Inpatient stay table of possible transitions
knitr::kable(table(data_inpatient$from, data_inpatient$to), caption = "Table 2.a. Inpatient Stay - Compl
```

Table 1: Table 2.a. Inpatient Stay - Complete

	1	2	cens
0	763	245	169
1	0	104	659

```r
knitr::kable(table(data_inpatient_sev$from, data_inpatient_sev$to),
             caption = "Table 2.b. Inpatient Stay - SMI")
```

Table 2: Table 2.b. Inpatient Stay - SMI

	1	2	cens
0	431	180	59
1	0	77	354

```r
knitr::kable(table(data_inpatient_ns$from, data_inpatient_ns$to),
             caption = "Table 2.c. Inpatient Stay - non-SMI")
```

Table 3: Table 2.c. Inpatient Stay - non-SMI

	1	2	cens
0	332	65	110
1	0	27	305

```
# Daypatient care table of possible transitions
knitr::kable(table(data_daypatient$from, data_daypatient$to), caption = "Table 2.d. Daypatient Care - C
```

Table 4: Table 2.d. Daypatient Care - Complete

	1	2	cens
0	805	144	193
1	0	73	732

```
knitr::kable(table(data_daypatient_sev$from, data_daypatient_sev$to),
             caption = "Table 2.e. Daypatient Care - SMI")
```

Table 5: Table 2.e. Daypatient Care - SMI

	1	2	cens
0	471	92	67
1	0	54	417

```
knitr::kable(table(data_daypatient_ns$from, data_daypatient_ns$to),
             caption = "Table 2.f. Daypatient Care - non-SMI")
```

Table 6: Table 2.f. Daypatient Care - non-SMI

	1	2	cens
0	334	52	126
1	0	19	315

Table 3. Cox proportional hazards model (final State "Inpatient Stay")

```
# INPATIENT STAY
# initial to provider change 01
cox_inpatient.01 <- coxph(
  Surv(entry, exit, to == 1) ~ as.factor(severe)
  + as.factor(comorbidity)
  + I(age / 10)
  + as.factor(sex),
  data_inpatient,
  subset = from == 0
)
summary(cox_inpatient.01)
```

```
## Call:
## coxph(formula = Surv(entry, exit, to == 1) ~ as.factor(severe) +
##     as.factor(comorbidity) + I(age/10) + as.factor(sex), data = data_inpatient,
##     subset = from == 0)
##
##   n= 1177, number of events= 763
##
##                            coef exp(coef)  se(coef)      z Pr(>|z|)
## as.factor(severe)1     -0.326973  0.721103  0.076127 -4.295 1.75e-05 ***
## as.factor(comorbidity)1 -0.532796  0.586962  0.078773 -6.764 1.35e-11 ***
## I(age/10)               0.004203  1.004211  0.022099  0.190    0.849
## as.factor(sex)1         0.026225  1.026572  0.073847  0.355    0.722
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##                          exp(coef) exp(-coef) lower .95 upper .95
## as.factor(severe)1          0.7211     1.3868    0.6212    0.8371
## as.factor(comorbidity)1     0.5870     1.7037    0.5030    0.6850
## I(age/10)                   1.0042     0.9958    0.9616    1.0487
## as.factor(sex)1             1.0266     0.9741    0.8882    1.1864
##
## Concordance= 0.584  (se = 0.012 )
## Likelihood ratio test= 61.12  on 4 df,    p=2e-12
## Wald test            = 59.11  on 4 df,    p=4e-12
## Score (logrank) test = 59.94  on 4 df,    p=3e-12
```

```
cox.zph(cox_inpatient.01)
```

```
##                         chisq df      p
## as.factor(severe)     10.6586  1 0.0011
## as.factor(comorbidity)  5.4245  1 0.0199
## I(age/10)               2.6161  1 0.1058
## as.factor(sex)          0.0087  1 0.9257
## GLOBAL                 15.5940  4 0.0036
```

```r
# initial to inpatient stay 02
cox_inpatient.02 <- coxph(
  Surv(entry, exit, to == 2) ~ as.factor(severe)
  + as.factor(comorbidity)
  + I(age / 10)
  + as.factor(sex),
  data_inpatient,
  subset = from == 0
)
summary(cox_inpatient.02)
```

```
## Call:
## coxph(formula = Surv(entry, exit, to == 2) ~ as.factor(severe) +
##     as.factor(comorbidity) + I(age/10) + as.factor(sex), data = data_inpatient,
##     subset = from == 0)
##
##   n= 1177, number of events= 245
##
```

```
##                            coef exp(coef) se(coef)      z Pr(>|z|)
## as.factor(severe)1       0.44703   1.56367  0.14917  2.997  0.00273 **
## as.factor(comorbidity)1  0.61664   1.85269  0.13108  4.704 2.55e-06 ***
## I(age/10)               -0.10739   0.89817  0.04265 -2.518  0.01181 *
## as.factor(sex)1         -0.19989   0.81882  0.12982 -1.540  0.12363
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##                         exp(coef) exp(-coef) lower .95 upper .95
## as.factor(severe)1         1.5637     0.6395    1.1673    2.0947
## as.factor(comorbidity)1    1.8527     0.5398    1.4329    2.3954
## I(age/10)                  0.8982     1.1134    0.8261    0.9765
## as.factor(sex)1            0.8188     1.2213    0.6349    1.0561
##
## Concordance= 0.64  (se = 0.021 )
## Likelihood ratio test= 41.2  on 4 df,   p=2e-08
## Wald test            = 39.78  on 4 df,   p=5e-08
## Score (logrank) test = 40.35  on 4 df,   p=4e-08
```

```
cox.zph(cox_inpatient.02)
```

```
##                        chisq df       p
## as.factor(severe)      2.607  1 0.10641
## as.factor(comorbidity) 7.563  1 0.00596
## I(age/10)             11.524  1 0.00069
## as.factor(sex)         0.175  1 0.67572
## GLOBAL                19.551  4 0.00061
```

```r
# from provider change to inpatient stay 12
cox_inpatient.12 <- coxph(
  Surv(entry, exit, to == 2) ~ as.factor(severe)
  + as.factor(comorbidity)
  + I(age / 10)
  + as.factor(sex),
  data_inpatient,
  subset = from == 1
)
summary(cox_inpatient.12)
```

```
## Call:
## coxph(formula = Surv(entry, exit, to == 2) ~ as.factor(severe) +
##     as.factor(comorbidity) + I(age/10) + as.factor(sex), data = data_inpatient,
##     subset = from == 1)
##
##   n= 763, number of events= 104
##
##                            coef exp(coef) se(coef)      z Pr(>|z|)
## as.factor(severe)1       0.67776   1.96946  0.22499  3.012  0.00259 **
## as.factor(comorbidity)1 -0.72780   0.48297  0.22920 -3.175  0.00150 **
## I(age/10)               -0.08487   0.91863  0.06243 -1.359  0.17401
## as.factor(sex)1         -0.49122   0.61188  0.20105 -2.443  0.01456 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
## 
##                      exp(coef) exp(-coef) lower .95 upper .95
## as.factor(severe)1      1.9695     0.5078    1.2672    3.0610
## as.factor(comorbidity)1 0.4830     2.0705    0.3082    0.7569
## I(age/10)               0.9186     1.0886    0.8128    1.0382
## as.factor(sex)1         0.6119     1.6343    0.4126    0.9074
## 
## Concordance= 0.657  (se = 0.026 )
## Likelihood ratio test= 33  on 4 df,   p=1e-06
## Wald test            = 29.75  on 4 df,   p=5e-06
## Score (logrank) test = 30.96  on 4 df,   p=3e-06
```

```r
cox.zph(cox_inpatient.12)
```

```
##                          chisq df     p
## as.factor(severe)      0.31055  1 0.577
## as.factor(comorbidity) 3.44322  1 0.064
## I(age/10)              0.00787  1 0.929
## as.factor(sex)         1.87486  1 0.171
## GLOBAL                 5.86705  4 0.209
```

Table 4. Cox proportional hazards model (final State "Daypatient Care")

```r
# DAYPATIENT CARE
# initial to provider change 01
cox_daypatient.01 <- coxph(
  Surv(entry, exit, to == 1) ~ as.factor(severe)
  + as.factor(comorbidity)
  + I(age / 10)
  + as.factor(sex),
  data_daypatient,
  subset = from == 0
)
summary(cox_daypatient.01)
```

```
## Call:
## coxph(formula = Surv(entry, exit, to == 1) ~ as.factor(severe) +
##     as.factor(comorbidity) + I(age/10) + as.factor(sex), data = data_daypatient,
##     subset = from == 0)
## 
##   n= 1142, number of events= 805
## 
##                              coef exp(coef)  se(coef)      z Pr(>|z|)
## as.factor(severe)1       -0.147015  0.863281  0.074311 -1.978   0.0479 *
## as.factor(comorbidity)1  -0.415378  0.660091  0.076536 -5.427 5.72e-08 ***
## I(age/10)                 0.008767  1.008806  0.021554  0.407   0.6842
## as.factor(sex)1          -0.051525  0.949780  0.071443 -0.721   0.4708
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## 
##                      exp(coef) exp(-coef) lower .95 upper .95
```

```
## as.factor(severe)1         0.8633    1.1584    0.7463    0.9986
## as.factor(comorbidity)1    0.6601    1.5149    0.5681    0.7669
## I(age/10)                  1.0088    0.9913    0.9671    1.0523
## as.factor(sex)1            0.9498    1.0529    0.8257    1.0925
##
## Concordance= 0.562  (se = 0.012 )
## Likelihood ratio test= 33.24  on 4 df,   p=1e-06
## Wald test            = 32.02  on 4 df,   p=2e-06
## Score (logrank) test = 32.37  on 4 df,   p=2e-06
```

```r
cox.zph(cox_daypatient.01)
```

```
##                          chisq df     p
## as.factor(severe)        4.942  1 0.026
## as.factor(comorbidity)   5.693  1 0.017
## I(age/10)                0.754  1 0.385
## as.factor(sex)           0.606  1 0.436
## GLOBAL                  10.849  4 0.028
```

```r
# initial to daypatient care 02
cox_daypatient.02 <- coxph(
  Surv(entry, exit, to == 2) ~ as.factor(severe)
  + as.factor(comorbidity)
  + I(age / 10)
  + as.factor(sex),
  data_daypatient,
  subset = from == 0
)
summary(cox_daypatient.02)
```

```
## Call:
## coxph(formula = Surv(entry, exit, to == 2) ~ as.factor(severe) +
##     as.factor(comorbidity) + I(age/10) + as.factor(sex), data = data_daypatient,
##     subset = from == 0)
##
##   n= 1142, number of events= 144
##
##                              coef exp(coef) se(coef)      z Pr(>|z|)
## as.factor(severe)1        0.07768   1.08077  0.17980  0.432 0.665735
## as.factor(comorbidity)1   0.60032   1.82271  0.17077  3.515 0.000439 ***
## I(age/10)                -0.20208   0.81703  0.05608 -3.603 0.000314 ***
## as.factor(sex)1           0.09543   1.10013  0.16958  0.563 0.573633
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##                          exp(coef) exp(-coef) lower .95 upper .95
## as.factor(severe)1           1.081     0.9253    0.7598     1.537
## as.factor(comorbidity)1      1.823     0.5486    1.3042     2.547
## I(age/10)                    0.817     1.2239    0.7320     0.912
## as.factor(sex)1              1.100     0.9090    0.7890     1.534
##
## Concordance= 0.641  (se = 0.024 )
## Likelihood ratio test= 26.57  on 4 df,   p=2e-05
```

```
## Wald test            = 25.54  on 4 df,    p=4e-05
## Score (logrank) test = 26.13  on 4 df,    p=3e-05
```

```r
cox.zph(cox_daypatient.02)
```

```
##                       chisq df     p
## as.factor(severe)     0.319  1 0.572
## as.factor(comorbidity) 0.575  1 0.448
## I(age/10)             4.661  1 0.031
## as.factor(sex)        0.136  1 0.712
## GLOBAL                6.886  4 0.142
```

```r
# from provider change to daypatient care 12
cox_daypatient.12 <- coxph(
  Surv(entry, exit, to == 2) ~ as.factor(severe)
  + as.factor(comorbidity)
  + I(age / 10)
  + as.factor(sex),
  data_daypatient,
  subset = from == 1
)
summary(cox_daypatient.12)
```

```
## Call:
## coxph(formula = Surv(entry, exit, to == 2) ~ as.factor(severe) +
##     as.factor(comorbidity) + I(age/10) + as.factor(sex), data = data_daypatient,
##     subset = from == 1)
##
##   n= 805, number of events= 73
##
##                             coef exp(coef) se(coef)      z Pr(>|z|)
## as.factor(severe)1       0.63146   1.88036  0.27023  2.337   0.0194 *
## as.factor(comorbidity)1 -0.06646   0.93570  0.24352 -0.273   0.7849
## I(age/10)                0.03005   1.03050  0.07125  0.422   0.6732
## as.factor(sex)1         -0.19654   0.82157  0.23864 -0.824   0.4102
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##                         exp(coef) exp(-coef) lower .95 upper .95
## as.factor(severe)1         1.8804     0.5318    1.1072     3.193
## as.factor(comorbidity)1    0.9357     1.0687    0.5806     1.508
## I(age/10)                  1.0305     0.9704    0.8962     1.185
## as.factor(sex)1            0.8216     1.2172    0.5146     1.312
##
## Concordance= 0.596  (se = 0.034 )
## Likelihood ratio test= 7.16  on 4 df,    p=0.1
## Wald test            = 6.6  on 4 df,   p=0.2
## Score (logrank) test = 6.81  on 4 df,    p=0.1
```

```r
cox.zph(cox_daypatient.12)
```

```
##                       chisq df       p
```

```
## as.factor(severe)        0.542  1 0.4614
## as.factor(comorbidity)  6.113  1 0.0134
## I(age/10)               5.086  1 0.0241
## as.factor(sex)          3.935  1 0.0473
## GLOBAL                  14.917  4 0.0049
```

Table 5. Cox proportional hazards of Transition 1 -> 2 (Explorative Analysis of Covariates)

```
# INPATIENT STAY
# from provider change to inpatient stay 12
summary(cox_inpatient.12)
```

```
## Call:
## coxph(formula = Surv(entry, exit, to == 2) ~ as.factor(severe) +
##     as.factor(comorbidity) + I(age/10) + as.factor(sex), data = data_inpatient,
##     subset = from == 1)
##
##   n= 763, number of events= 104
##
##                            coef exp(coef) se(coef)      z Pr(>|z|)
## as.factor(severe)1       0.67776   1.96946  0.22499  3.012  0.00259 **
## as.factor(comorbidity)1 -0.72780   0.48297  0.22920 -3.175  0.00150 **
## I(age/10)               -0.08487   0.91863  0.06243 -1.359  0.17401
## as.factor(sex)1         -0.49122   0.61188  0.20105 -2.443  0.01456 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##                         exp(coef) exp(-coef) lower .95 upper .95
## as.factor(severe)1         1.9695     0.5078    1.2672    3.0610
## as.factor(comorbidity)1    0.4830     2.0705    0.3082    0.7569
## I(age/10)                  0.9186     1.0886    0.8128    1.0382
## as.factor(sex)1            0.6119     1.6343    0.4126    0.9074
##
## Concordance= 0.657  (se = 0.026 )
## Likelihood ratio test= 33  on 4 df,   p=1e-06
## Wald test           = 29.75  on 4 df,   p=5e-06
## Score (logrank) test = 30.96  on 4 df,   p=3e-06
```

```
cox.zph(cox_inpatient.12)
```

```
##                          chisq df     p
## as.factor(severe)      0.31055  1 0.577
## as.factor(comorbidity) 3.44322  1 0.064
## I(age/10)              0.00787  1 0.929
## as.factor(sex)         1.87486  1 0.171
## GLOBAL                 5.86705  4 0.209
```

```
# DAYPATIENT CARE
summary(cox_daypatient.12)
```

```
## Call:
## coxph(formula = Surv(entry, exit, to == 2) ~ as.factor(severe) +
##     as.factor(comorbidity) + I(age/10) + as.factor(sex), data = data_daypatient,
##     subset = from == 1)
##
##   n= 805, number of events= 73
##
##                             coef exp(coef) se(coef)       z Pr(>|z|)
## as.factor(severe)1       0.63146   1.88036  0.27023  2.337   0.0194 *
## as.factor(comorbidity)1 -0.06646   0.93570  0.24352 -0.273   0.7849
## I(age/10)                0.03005   1.03050  0.07125  0.422   0.6732
## as.factor(sex)1         -0.19654   0.82157  0.23864 -0.824   0.4102
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##                         exp(coef) exp(-coef) lower .95 upper .95
## as.factor(severe)1         1.8804     0.5318    1.1072     3.193
## as.factor(comorbidity)1    0.9357     1.0687    0.5806     1.508
## I(age/10)                  1.0305     0.9704    0.8962     1.185
## as.factor(sex)1            0.8216     1.2172    0.5146     1.312
##
## Concordance= 0.596  (se = 0.034 )
## Likelihood ratio test= 7.16  on 4 df,   p=0.1
## Wald test            = 6.6  on 4 df,   p=0.2
## Score (logrank) test = 6.81  on 4 df,   p=0.1
```

```r
cox.zph(cox_daypatient.12)
```

```
##                        chisq df      p
## as.factor(severe)      0.542  1 0.4614
## as.factor(comorbidity) 6.113  1 0.0134
## I(age/10)              5.086  1 0.0241
## as.factor(sex)         3.935  1 0.0473
## GLOBAL                14.917  4 0.0049
```

```r
# testing the Markov assumption for INPATIENT STAY
coxph(Surv(entry, exit, to == "2") ~ entry,
      data = subset(data_inpatient, from == "1"))
```

Markov Assumption tests

```
## Call:
## coxph(formula = Surv(entry, exit, to == "2") ~ entry, data = subset(data_inpatient,
##     from == "1"))
##
##            coef  exp(coef)   se(coef)      z     p
## entry -3.367e-05  1.000e+00  6.171e-04 -0.055 0.956
##
## Likelihood ratio test=0  on 1 df, p=0.9564
## n= 763, number of events= 104
```

```
# testing the Markov assumption for DAYPATIENT CARE
coxph(Surv(entry, exit, to == "2") ~ entry,
      data = subset(data_daypatient, from == "1"))
```

```
## Call:
## coxph(formula = Surv(entry, exit, to == "2") ~ entry, data = subset(data_daypatient,
##     from == "1"))
##
##            coef  exp(coef)   se(coef)      z      p
## entry -0.0012696  0.9987312  0.0007553 -1.681 0.0928
##
## Likelihood ratio test=3.16  on 1 df, p=0.07527
## n= 805, number of events= 73
```

Table 6. Time dependent covariates

```
# time-dep covariates for INPATIENT STAY
time_cox_inpatient <- coxph(
  Surv(entry, exit, to == 2) ~ as.factor(from) + as.factor(severe) +
    as.factor(comorbidity) + I(age / 10) +
    as.factor(sex),
  data_inpatient
)
summary(time_cox_inpatient)
```

```
## Call:
## coxph(formula = Surv(entry, exit, to == 2) ~ as.factor(from) +
##     as.factor(severe) + as.factor(comorbidity) + I(age/10) +
##     as.factor(sex), data = data_inpatient)
##
##   n= 1940, number of events= 349
##
##                            coef exp(coef) se(coef)      z Pr(>|z|)
## as.factor(from)1        -0.95929   0.38316  0.13408 -7.155 8.39e-13 ***
## as.factor(severe)1       0.52560   1.69147  0.12369  4.249 2.14e-05 ***
## as.factor(comorbidity)1  0.22684   1.25463  0.10841  2.092 0.036406 *
## I(age/10)               -0.11844   0.88831  0.03555 -3.331 0.000865 ***
## as.factor(sex)1         -0.25221   0.77708  0.10901 -2.314 0.020692 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##                         exp(coef) exp(-coef) lower .95 upper .95
## as.factor(from)1           0.3832     2.6099    0.2946    0.4983
## as.factor(severe)1         1.6915     0.5912    1.3273    2.1555
## as.factor(comorbidity)1    1.2546     0.7971    1.0145    1.5517
## I(age/10)                  0.8883     1.1257    0.8285    0.9524
## as.factor(sex)1            0.7771     1.2869    0.6276    0.9622
##
## Concordance= 0.64  (se = 0.016 )
## Likelihood ratio test= 112.9  on 5 df,   p=<2e-16
## Wald test            = 104.1  on 5 df,   p=<2e-16
## Score (logrank) test = 108.6  on 5 df,   p=<2e-16
```

```
# time-dep covariates for DAYPATIENT CARE
time_cox_daypatient <- coxph(
  Surv(entry, exit, to == 2) ~ as.factor(from) + as.factor(severe)
  + as.factor(comorbidity) + I(age / 10) +
    as.factor(sex),
  data_daypatient
)
summary(time_cox_daypatient)
```

```
## Call:
## coxph(formula = Surv(entry, exit, to == 2) ~ as.factor(from) +
##     as.factor(severe) + as.factor(comorbidity) + I(age/10) +
##     as.factor(sex), data = data_daypatient)
##
##   n= 1947, number of events= 217
##
##                            coef exp(coef) se(coef)      z Pr(>|z|)
## as.factor(from)1       -0.88746   0.41170  0.17257 -5.143 2.71e-07 ***
## as.factor(severe)1      0.29007   1.33653  0.14707  1.972  0.04858 *
## as.factor(comorbidity)1 0.36893   1.44618  0.13740  2.685  0.00725 **
## I(age/10)              -0.12927   0.87874  0.04398 -2.939  0.00329 **
## as.factor(sex)1         0.03558   1.03623  0.13716  0.259  0.79529
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##                         exp(coef) exp(-coef) lower .95 upper .95
## as.factor(from)1           0.4117     2.4289    0.2936    0.5774
## as.factor(severe)1         1.3365     0.7482    1.0018    1.7831
## as.factor(comorbidity)1    1.4462     0.6915    1.1048    1.8931
## I(age/10)                  0.8787     1.1380    0.8062    0.9579
## as.factor(sex)1            1.0362     0.9650    0.7920    1.3558
##
## Concordance= 0.617  (se = 0.021 )
## Likelihood ratio test= 51.04  on 5 df,    p=8e-10
## Wald test             = 48.3  on 5 df,    p=3e-09
## Score (logrank) test = 49.44  on 5 df,    p=2e-09
```

Figures

Figure 2. Cumulative hazards and transition probabilities from State - 1 to

State - 2

```
mvna.inpatient_sev <- mvna(data_inpatient_sev, states, transition_matrix, "cens")
mvna.daypatient_sev <- mvna(data_daypatient_sev, states, transition_matrix, "cens")
mvna.inpatient_ns <- mvna(data_inpatient_ns, states, transition_matrix, "cens")
mvna.daypatient_ns <- mvna(data_daypatient_ns, states, transition_matrix, "cens")

etm.inpatient_sev <- etm(
  data_inpatient_sev,
  states,
  transition_matrix,
```

```r
    "cens",
    s = 0
)
etm.daypatient_sev <- etm(
    data_daypatient_sev,
    states,
    transition_matrix,
    "cens",
    s = 0
)
etm.inpatient_ns <- etm(
    data_inpatient_ns,
    states,
    transition_matrix,
    "cens",
    s = 0
)
etm.daypatient_ns <- etm(
    data_daypatient_ns,
    states,
    transition_matrix,
    "cens",
    s = 0
)

par(mfrow = c(1, 2))
plot(
    mvna.inpatient_sev,
    tr.choice = c("1 2"),
    col = "red",
    cex = 1.5,
    xlab = "",
    ylab = "",
    lwd = 1.8,
    legend = FALSE,
    cex.axis = 1.5,
    ylim = c(0, 1)
)
lines(
    mvna.inpatient_ns,
    tr.choice = c("1 2"),
    col = "green",
    cex = 1.5,
    lwd = 2.5
)
lines(
    mvna.daypatient_sev,
    tr.choice = c("1 2"),
    col = "blue",
    cex = 1.5,
    lwd = 2.5
)
lines(
```

```r
  mvna.daypatient_ns,
  tr.choice = c("1 2"),
  col = "yellow",
  cex = 1.5,
  lwd = 2.5
)
par(family = "sans")
mtext(
  "Cumulative Hazard",
  side = 2,
  line = 3,
  font = 2,
  cex = 1.6
)
mtext(
  "Days",
  side = 1,
  line = 3,
  font = 2,
  cex = 1.6
)
legend(
  0.90,
  0.95,
  legend = c(
    'Inpatient:SMI',
    'Inpatient:non-SMI',
    'Daypatient:SMI',
    'Daypatient:non-SMI'
  ),
  col = c('red', 'green', 'blue', 'yellow'),
  lty = 1,
  cex = 1.5,
  lwd = 2,
  y.intersp = 1,
  xjust = 0
)

#transition probability
plot(
  etm.inpatient_sev,
  tr.choice = c("1 2"),
  col = "red",
  cex = 1.5,
  xlab = "",
  ylab = "",
  lwd = 1.8,
  legend = FALSE,
  cex.axis = 1.5
)
lines(
  etm.inpatient_ns,
  tr.choice = c("1 2"),
```

```r
    col = "green",
    cex = 1.5,
    lwd = 2.5
)
lines(
  etm.daypatient_sev,
  tr.choice = c("1 2"),
  col = "blue",
  cex = 1.5,
  lwd = 2.5
)
lines(
  etm.daypatient_ns,
  tr.choice = c("1 2"),
  col = "yellow",
  cex = 1.5,
  lwd = 2.5
)
par(family = "sans")
mtext(
  "Transition Probability",
  side = 2,
  line = 3,
  font = 2,
  cex = 1.6
)
mtext(
  "Days",
  side = 1,
  line = 3,
  font = 2,
  cex = 1.6
)
legend(
  0.90,
  0.95,
  legend = c(
    'Inpatient:SMI',
    'Inpatient:non-SMI',
    'Daypatient:SMI',
    'Daypatient:non-SMI'
  ),
  col = c('red', 'green', 'blue', 'yellow'),
  lty = 1,
  cex = 1.5,
  lwd = 2,
  y.intersp = 1,
  xjust = 0
)
```
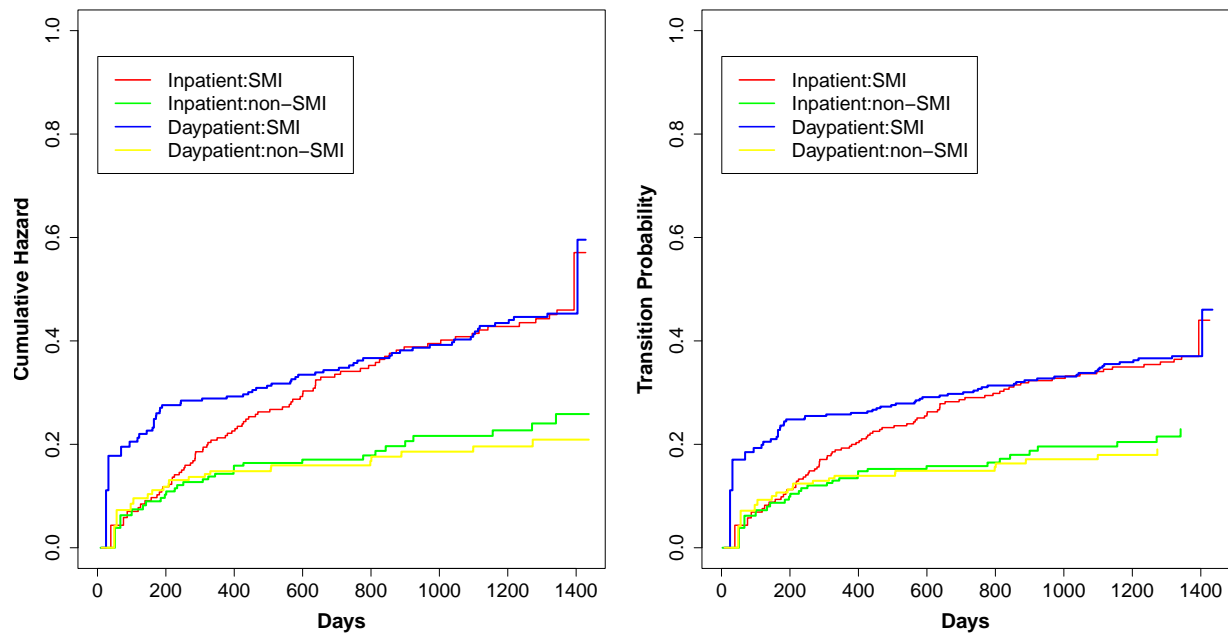
```r
summary(mvna.inpatient_sev)
```

Confidence Intervals for Cumulative Hazards

```
## Transition 0 -> 1
##   time   na var.aalen lower upper n.risk n.event
##      0 0.00      0.00  0.00  0.00    670       0
##    205 0.52      0.00  0.45  0.59    307       1
##    447 0.98      0.00  0.87  1.10    148       0
##    893 1.59      0.01  1.41  1.80     53       0
##   1296 2.65      0.06  2.20  3.18      5       0
##   1410 2.85      0.10  2.29  3.55      2       0
##
## Transition 0 -> 2
##   time   na var.aalen lower upper n.risk n.event
##      0 0.00      0.00  0.00  0.00    670       0
##    205 0.19      0.00  0.15  0.24    307       0
##    447 0.40      0.00  0.33  0.48    148       0
##    893 0.74      0.01  0.61  0.91     53       0
##   1296 1.87      0.11  1.31  2.67      5       0
##   1410 2.96      0.54  1.82  4.81      2       1
##
## Transition 1 -> 2
##   time   na var.aalen lower upper n.risk n.event
##     12 0.00      0.00  0.00  0.00      1       0
##    206 0.12      0.00  0.05  0.27    213       0
##    448 0.25      0.00  0.16  0.39    212       0
##    897 0.39      0.00  0.28  0.53    162       1
```

```
## 1300 0.44     0.00  0.33  0.59   127        0
## 1426 0.57     0.02  0.37  0.89     1        0
```

```
summary(mvna.daypatient_sev)
```

```
## Transition 0 -> 1
##  time    na var.aalen lower upper n.risk n.event
##     0 0.00      0.00  0.00  0.00    630       0
##   210 0.58      0.00  0.51  0.66    287       2
##   469 1.19      0.00  1.07  1.33    134       2
##   973 1.86      0.01  1.65  2.09     54       0
##  1326 3.74      0.17  3.00  4.65      3       0
##  1428 3.74      0.17  3.00  4.65      1       0
##
## Transition 0 -> 2
##  time    na var.aalen lower upper n.risk n.event
##     0 0.00      0.00  0.00  0.00    630       0
##   210 0.11      0.00  0.08  0.14    287       0
##   469 0.21      0.00  0.16  0.27    134       0
##   973 0.38      0.00  0.28  0.50     54       0
##  1326 1.41      0.20  0.75  2.64      3       1
##  1428 1.91      0.45  0.95  3.81      1       0
##
## Transition 1 -> 2
##  time    na var.aalen lower upper n.risk n.event
##    12 0.00      0.00  0.00  0.00      1       0
##   211 0.28      0.02  0.11  0.71    218       0
##   469 0.31      0.02  0.13  0.72    241       0
##   972 0.39      0.02  0.20  0.77    184       1
##  1324 0.45      0.02  0.25  0.82    150       0
##  1418 0.60      0.04  0.31  1.14      2       0
```

```
summary(mvna.inpatient_ns)
```

```
## Transition 0 -> 1
##  time    na var.aalen lower upper n.risk n.event
##     0 0.00      0.00  0.00  0.00    507       0
##   144 0.36      0.00  0.31  0.43    281       1
##   296 0.89      0.00  0.78  1.02    133       2
##   588 1.59      0.01  1.38  1.84     43       0
##   843 1.89      0.02  1.62  2.21     25       0
##  1100 4.60      0.62  3.29  6.43      2       1
##
## Transition 0 -> 2
##  time    na var.aalen lower upper n.risk n.event
##     0 0.00      0.00  0.00  0.00    507       0
##   144 0.08      0.00  0.06  0.12    281       0
##   296 0.17      0.00  0.13  0.23    133       0
##   588 0.32      0.00  0.23  0.45     43       0
##   843 0.43      0.01  0.29  0.62     25       0
##  1100 0.50      0.01  0.33  0.78      2       0
##
## Transition 1 -> 2
```

```
##  time   na var.aalen lower upper n.risk n.event
##     9 0.00         0  0.00  0.00      1       0
##   169 0.09         0  0.03  0.26    139       0
##   381 0.14         0  0.07  0.29    192       0
##   785 0.18         0  0.10  0.32    120       0
##  1247 0.23         0  0.14  0.37     77       0
##  1423 0.26         0  0.16  0.41      2       0
```

```
summary(mvna.daypatient_ns)
```

```
## Transition 0 -> 1
##  time   na var.aalen lower upper n.risk n.event
##     0 0.00      0.00  0.00  0.00    512       0
##   154 0.37      0.00  0.31  0.43    285       1
##   310 0.90      0.00  0.79  1.04    128       1
##   601 1.53      0.01  1.33  1.76     50       0
##   889 1.82      0.02  1.56  2.11     29       0
##  1105 4.30      0.55  3.07  6.03      1       0
##
## Transition 0 -> 2
##  time   na var.aalen lower upper n.risk n.event
##     0 0.00      0.00  0.00  0.00    512       0
##   154 0.06      0.00  0.04  0.09    285       0
##   310 0.14      0.00  0.10  0.19    128       0
##   601 0.22      0.00  0.15  0.33     50       0
##   889 0.33      0.00  0.22  0.50     29       0
##  1105 0.70      0.07  0.32  1.50      1       0
##
## Transition 1 -> 2
##  time   na var.aalen lower upper n.risk n.event
##    12 0.00         0  0.00  0.00      1       0
##   182 0.11         0  0.04  0.30    143       0
##   397 0.15         0  0.07  0.32    187       0
##   820 0.18         0  0.09  0.34    116       0
##  1280 0.21         0  0.12  0.38     75       0
##  1428 0.21         0  0.12  0.38      2       0
```

```
summary(etm.inpatient_sev, tr.choice = c("1 2"))
```

Confidence Intervals for Transition Probabilities for SMI and non-SMI groups

```
## Transition 1 2
##            P time         var      lower      upper n.risk n.event
##  0.00000000    9 0.000000000 0.00000000 0.0000000      0       0
##  0.08819044  145 0.002071189 0.00000000 0.1773890    160       0
##  0.17071310  294 0.002025078 0.08251303 0.2589132    227       0
##  0.26677434  631 0.001897834 0.18139020 0.3521585    187       1
##  0.33216728 1007 0.001818827 0.24857930 0.4157552    147       0
##  0.43996992 1426 0.005769734 0.29109348 0.5888464      1       0
```

```r
summary(etm.daypatient_sev, tr.choice = c("1 2"))
```

```
## Transition 1 2
##           P time         var        lower       upper n.risk n.event
##   0.0000000    9 0.000000000 0.00000000 0.0000000      0       0
##   0.2049622  141 0.012119736 0.00000000 0.4207340    153       0
##   0.2548183  281 0.010843359 0.05072437 0.4589122    249       0
##   0.2912483  636 0.009914309 0.09609347 0.4864031    223       0
##   0.3310555 1018 0.008956960 0.14556209 0.5165489    189       0
##   0.4603788 1434 0.012859626 0.23811832 0.6826393      0       0
```

```r
summary(etm.inpatient_ns, tr.choice = c("1 2"))
```

```
## Transition 1 2
##            P time         var        lower       upper n.risk n.event
##   0.00000000    3 0.000000000 0.00000000 0.0000000      0       0
##   0.07257377  105 0.001960069 0.00000000 0.1593466     94       0
##   0.10433836  211 0.002024954 0.01614097 0.1925357    163       0
##   0.13444213  388 0.002037626 0.04596922 0.2229150    192       0
##   0.16473164  777 0.002050120 0.07598790 0.2534754    123       1
##   0.22935012 1341 0.002335872 0.13462338 0.3240769     55       1
```

```r
summary(etm.daypatient_ns, tr.choice = c("1 2"))
```

```
## Transition 1 2
##            P time         var        lower       upper n.risk n.event
##   0.00000000    9 0.000000000 0.00000000 0.0000000      0       0
##   0.09269235  112 0.002539270 0.00000000 0.1914572    102       0
##   0.12411761  219 0.002558800 0.02497365 0.2232616    154       0
##   0.13907760  399 0.002545619 0.04018934 0.2379659    188       0
##   0.15578601  798 0.002542352 0.05696121 0.2546108    121       1
##   0.19029621 1273 0.002632053 0.08974312 0.2908493     76       1
```

Figure 3. Cumulative hazards and transition probabilities of the complete model

```r
# fulldata event: Inpatient stay
# nelson-aalen estimator of cumulative incidences
par(mfrow = c(1, 2), family = "sans")
line_colors <- c("darkgrey", "darkgreen", "darkred")

mvna.inpatient <- mvna(data_inpatient, states, transition_matrix, "cens")
summary(mvna.inpatient)

plot(
  mvna.inpatient,
  col = line_colors,
  ylim = c(0, 5),
  xlab = "Days",
  font.lab = 2,
  lty = 1,
```

```r
    lwd = 3,
    legend = F,
    cex.lab = 1.6,
    cex.axis = 1.5
)
mtext(
    "Event: Inpatient Stay",
    side = 3,
    line = 1,
    adj = 0,
    font = 2,
    cex = 1.6
)
legend(
    "topleft",
    inset = c(0.05, 0.05),
    legend = transitions,
    col = line_colors,
    lty = 1,
    lwd = 3,
    cex = 1.7,
    bty = "o"
)

# aalen-johansen estimator of transition probabilities
etm.inpatient <- etm(
    data_inpatient,
    states,
    transition_matrix,
    "cens",
    s = 0,
    covariance = F
)
summary(etm.inpatient)

plot(
    etm.inpatient,
    tr.choice = transitions,
    col = line_colors,
    xlab = "Days",
    lty = 1,
    lwd = 3,
    font.lab = 2,
    legend = F,
    cex.lab = 1.6,
    cex.axis = 1.5
)
legend(
    "topleft",
    inset = c(0.05, 0.05),
    legend = transitions,
    col = line_colors,
    lty = 1,
```
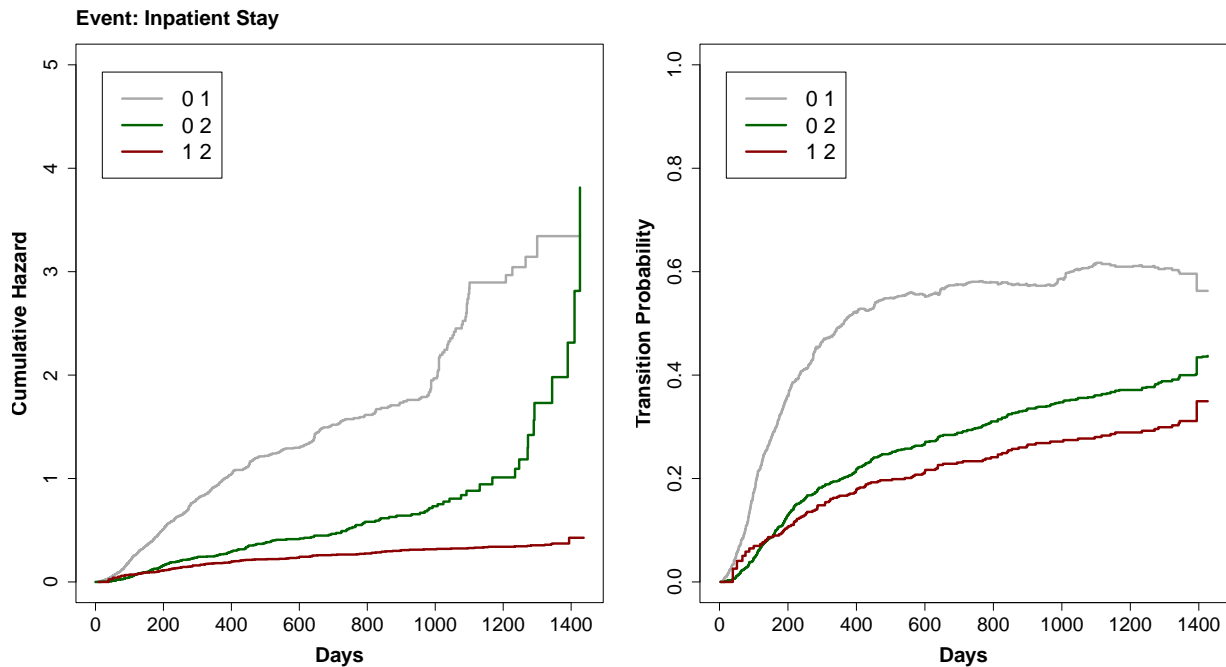
```
  lwd = 3,
  cex = 1.7,
  bty = "o"
)
```

Event: Inpatient Stay


```
# fulldata event: Daypatient care
# nelson-aalen estimator of cumulative incidences
par(mfrow = c(1, 2), family = "sans")
mvna.daypatient <- mvna(data_daypatient, states, transition_matrix, "cens")
summary(mvna.daypatient)

plot(
  mvna.daypatient,
  col = line_colors,
  ylim = c(0, 5),
  xlab = "Days",
  font.lab = 2,
  lty = 1,
  lwd = 3,
  legend = F,
  cex.lab = 1.6,
  cex.axis = 1.5
)
mtext(
  "Event: Daypatient Care",
  side = 3,
  line = 1,
  adj = 0,
  font = 2,
  cex = 1.6
```

```r
)
legend(
  "topleft",
  inset = c(0.05, 0.05),
  legend = transitions,
  col = line_colors,
  lty = 1,
  lwd = 3,
  cex = 1.7,
  bty = "o"
)

# aalen-johansen estimator of transition probablities
etm.daypatient <- etm(
  data_daypatient,
  states,
  transition_matrix,
  "cens",
  s = 0,
  covariance = F
)
summary(etm.daypatient)

plot(
  etm.daypatient,
  tr.choice = transitions,
  col = line_colors,
  xlab = "Days",
  lty = 1,
  lwd = 3,
  font.lab = 2,
  legend = F,
  cex.lab = 1.6,
  cex.axis = 1.5
)
legend(
  "topleft",
  inset = c(0.05, 0.05),
  legend = transitions,
  col = line_colors,
  lty = 1,
  lwd = 3,
  cex = 1.7,
  bty = "o"
)
```

Event: Daypatient Care