

Model B : Estimation Results

Contents

Load environmet	2
Load data	2
Remove cases	2
Categorize covariates	4
Age diagnostic	5
Estimation prep	6
Specifications	7
Fitting functions	7
Support functions	8
Model	8
msm options	9
elect options	10
Model results	11
age	11
age at baseline	13
male	16
education	18
Session Info	21

Estimation results of **Model B**, specified by the following input:

```
q <- .01
# transition matrix
Q <- rbind( c(0, q, 0, q),
            c(q, 0, q, q),
            c(0, 0, 0, q),
            c(0, 0, 0, 0))
# misclassification matrix
E <- rbind( c( 0, 0, 0, 0),
            c( 0, 0, .1, 0),
            c( 0, 0, 0, 0),
            c( 0, 0, 0, 0) )
# transition names
qnames = c(
  "Healthy - Mild", # q12
  # "Healthy - Severe", # q13
  "Healthy - Dead", # q14
  "Mild - Healthy", # q21
  "Mild - Severe", # q23
  "Mild - Dead", # q24
  # "Severe - Healthy", # q31
  # "Severe - Mild", # q32
```

```
"Severe - Dead"    # q34
)
```

Load environmet

Save fitted models here :

```
[1] "./data/shared/derived/models/model-b/"
```

Load data

Before ms encoding:

	id	fu_year	died	age_bl	male	edu	age_death	age_at_visit	mmse	presumed_alive
5120	50402431	0	1	91.41136	FALSE	16	94.82272	91.41136	19	FALSE
5121	50402431	1	1	91.41136	FALSE	16	94.82272	92.33402	12	FALSE
5122	50402431	2	1	91.41136	FALSE	16	94.82272	93.34702	5	FALSE
5123	50402431	3	1	91.41136	FALSE	16	94.82272	94.34634	0	FALSE

After ms encoding

	id	fu_year	died	age_bl	male	edu	age	state	presumed_alive	mmse	firstobs
5120	50402431	0	1	91.41136	FALSE	16	91.41136	3	FALSE	19	1
5121	50402431	1	1	91.41136	FALSE	16	92.33402	3	FALSE	12	0
5122	50402431	2	1	91.41136	FALSE	16	93.34702	3	FALSE	5	0
5123	50402431	3	1	91.41136	FALSE	16	94.34634	3	FALSE	0	0
51201	50402431	NA	1	91.41136	FALSE	16	94.82272	4	FALSE	NA	0

Remove cases

```
#### 1) Remove observations with missing age
# Initial number of observations with missing age :
sum(is.na(ds_ms$age))
```

```
[1] 1
```

```
ds_clean <- ds_ms %>%
  dplyr::filter(!is.na(age))
# Resultant number of observations with missing age
sum(is.na(ds_clean$age))
```

```
[1] 0
```

```
#### 3) Remove subjects with only ONE observed data point
# Initial number of subjects who have *n* observed data points
ds_clean %>%
  dplyr::group_by(id) %>%
  dplyr::summarize(n_data_points = n()) %>%
  dplyr::group_by(n_data_points) %>%
  dplyr::summarize(n_people=n()) %>%
  print()
```

```
# A tibble: 17 × 2
  n_data_points n_people
      <int>      <int>
1           1         119
2           2         205
3           3         184
4           4         180
5           5         190
6           6         104
7           7         108
8           8         113
9           9         127
10          10         116
11          11         110
12          12          71
13          13          21
14          14          14
15          15          13
16          16          17
17          17           3
```

```
# Determine which ids have only a single observation
```

```
remove_ids <- ds_clean %>%
  dplyr::group_by(id) %>%
  dplyr::summarize(n_data_points = n()) %>%
  dplyr::arrange(n_data_points) %>%
  dplyr::filter(n_data_points==1) %>%
  dplyr::select(id)
```

```
remove_ids <- remove_ids$id
```

```
# How many subjects to be removed from the data set:
```

```
length(remove_ids)
```

```
[1] 119
```

```
ds_clean <- ds_clean %>%
  dplyr::filter(!(id %in% remove_ids))
# Resultant number of subjects who have *n* observed data points
ds_clean %>%
  dplyr::group_by(id) %>%
  dplyr::summarize(n_data_points = n()) %>%
  dplyr::group_by(n_data_points) %>%
  dplyr::summarize(n_people=n()) %>%
  print()
```

```
# A tibble: 16 × 2
  n_data_points n_people
      <int>      <int>
1           2         205
2           3         184
3           4         180
4           5         190
5           6         104
6           7         108
7           8         113
8           9         127
```

9	10	116
10	11	110
11	12	71
12	13	21
13	14	14
14	15	13
15	16	17
16	17	3

```
#### 3) Remove subjects with IMS at the first observation
# Initial view of subjects with intermediate missing state at first observation:
ids_firstobs_ims <- ds_clean %>%
  dplyr::filter(firstobs == TRUE & state == -1) %>%
  dplyr::select(id) %>% print()
```

```
      id
1 80333458
2 90214403
3 90447310
4 91804757
```

```
ids_firstobs_ims <- ids_firstobs_ims[, "id"]
ds_clean <- ds_clean %>%
  dplyr::filter(!id %in% ids_firstobs_ims)
# Resultant view of subjects with intermediate missing state at first observation:
ds_clean %>%
  dplyr::filter(firstobs == TRUE & state == -1) %>%
  dplyr::select(id) %>% print()
```

```
[1] id
<0 rows> (or 0-length row.names)
```

Categorize covariates

How education was categorized:

	educatF	edu	n
1	0-9 years	0	4
2	0-9 years	2	6
3	0-9 years	3	10
4	0-9 years	4	17
5	0-9 years	5	20
6	0-9 years	6	48
7	0-9 years	7	27
8	0-9 years	8	178
9	0-9 years	9	76
10	10-11 years	10	167
11	10-11 years	11	225
12	>11 years	12	2400
13	>11 years	13	862
14	>11 years	14	1199
15	>11 years	15	554
16	>11 years	16	2132

17	>11 years	17	486
18	>11 years	18	942
19	>11 years	19	255
20	>11 years	20	286
21	>11 years	21	207
22	>11 years	22	61
23	>11 years	23	37
24	>11 years	24	26
25	>11 years	25	11
26	>11 years	28	21

Frequencies of categorized education :

```
# A tibble: 3 × 2
  educatF      n
  <fctr> <int>
1 0-9 years   386
2 10-11 years 392
3 >11 years  9479
```

Age diagnostic

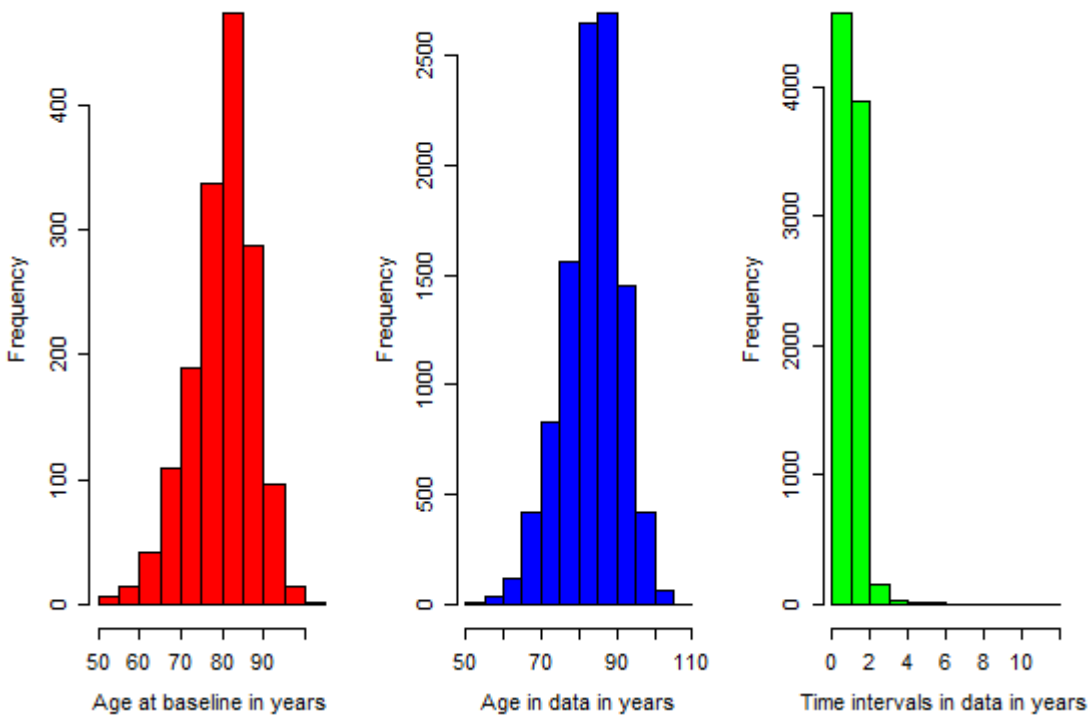
Minimum interval length : 0.00273785

Maximum interval length : 11.86858

Time intervals between observations within individuals:

	0%	25%	50%	75%	100%
	0.00	0.96	1.00	1.03	11.87

Graphs of age distribution :



Estimation prep

Number of subjects with intermediate missing state (-1) : 104

Number of subjects with right censored state (-2) : 46

Number of subjects with either IMS or RC state(s) : 149

Number of subjects with both IMS and RC state(s) : 1

Centering decisions :

The variable `age` is centered at : 75

The variable `age_bl` is centered at : 75

The following dataset will be passed to msm call (view for one person):

	id	age_bl	male	edu	educat	educatF	firstobs	fu_year	age	state
1	90544686	7.696783	0	12	1	>11 years	1	0	7.696783	1
2	90544686	7.696783	0	12	1	>11 years	0	1	8.682409	1

3	90544686	7.696783	0	12	1 >11 years	0	2	9.731006	1
4	90544686	7.696783	0	12	1 >11 years	0	3	10.689254	1
5	90544686	7.696783	0	12	1 >11 years	0	4	11.691307	1
6	90544686	7.696783	0	12	1 >11 years	0	5	12.709788	1
7	90544686	7.696783	0	12	1 >11 years	0	6	13.665298	1
8	90544686	7.696783	0	12	1 >11 years	0	7	14.678303	2
9	90544686	7.696783	0	12	1 >11 years	0	8	15.680356	1
10	90544686	7.696783	0	12	1 >11 years	0	9	16.709788	1

Subject count : 1572

Frequency of states at baseline

```
# A tibble: 3 × 3
  state count  pct
<dbl> <int> <dbl>
1     1  1189  0.76
2     2   281  0.18
3     3   102  0.06
```

State table:

	to					
from	-2	-1	1	2	3	4
-2	32	0	0	0	0	0
-1	0	25	27	13	26	47
1	32	59	4855	715	120	251
2	8	20	534	478	256	146
3	6	34	24	96	649	232

The initial values for estimation : 0.76 0.18 0.06 0

Specifications

Fitting functions

```
estimate_multistate <- function(
  model_name
  ,ds                # data object
  ,Q                 # Q-matrix of transitions
  ,E                 # misspecification matrix
  ,qnames            # names of the rows in the Q matrix
  ,cov_names         # string with covariate names
){
  covariates_ <- as.formula(paste0("~",cov_names))
  model <- msm(
    formula      = state ~ age,
    subject      = id,
    data         = ds,
    center       = FALSE,
    qmatrix      = Q,
```

```

    ematrix      = E,
    death        = TRUE,
    covariates    = covariates_,
    censor        = c(-1,-2),
    censor.states = list(c(1,2,3), c(1,2,3)),
    method        = method_,
    constraint     = constraint_,
    fixedpars     = fixedpars_,
    initprobs     = initprobs_,
    est.initprobs = TRUE,
    control       = list(trace=0,REPORT=1,maxit=1000,fnscale=10000)
  )
  # model <- paste0("test", covariates_)
  saveRDS(model, paste0(pathSaveFolder,model_name,".rds"))
  return(model)
}

```

Support functions

```

get_crude_Q <- function(ds, Q, cov_names){
  formula_ <- as.formula(paste0("state ~ ",cov_names))
  Q_crude <- crudeinits.msm(
    formula = formula_,
    subject = id,
    qmatrix = Q,
    data = ds,
    censor      = c(-1,-2),
    censor.states = list(c(1,2,3), c(1,2,3))
  )
  return(Q_crude)
}

msm_summary <- function(model){
  cat("\n-2loglik =", model$minus2loglik,"\n")
  cat("Convergence code =", model$opt$convergence,"\n")
  p <- model$opt$par
  p.se <- sqrt(diag(solve(1/2*model$opt$hessian)))
  print(cbind(p=round(p,digits),
              se=round(p.se,digits),"Wald ChiSq"=round((p/p.se)^2,digits),
              "Pr>ChiSq"=round(1-pchisq((p/p.se)^2,df=1),digits)),
        quote=FALSE)
}

```

Model

```

q <- .01
# transition matrix
Q <- rbind( c(0, q, 0, q),
            c(q, 0, q, q),
            c(0, 0, 0, q),

```



```

      c(0, 0, 0, 0))
# misclassification matrix
E <- rbind( c( 0, 0, 0, 0),
            c( 0, 0, .1, 0),
            c( 0, 0, 0, 0),
            c( 0, 0, 0, 0) )
# transition names
qnames = c(
  "Healthy - Mild",    # q12
  # "Healthy - Severe", # q13
  "Healthy - Dead",    # q14
  "Mild - Healthy",    # q21
  "Mild - Severe",     # q23
  "Mild - Dead",       # q24
  # "Severe - Healthy", # q31
  # "Severe - Mild",   # q32
  "Severe - Dead"      # q34
)

```

msm options

```

digits = 2
method_ = "BFGS"      # alternatively, if does not converge "Nedler-Mead"
constraint_ = NULL    # additional model constraints
fixedpars_ = NULL     # fixed parameters
initprobs_ = initial_probabilities

```

```

# turn this chunk OFF when printing the report
# compile model objects with msm() call
# each model will be saved in the specified folder, namely pathSaveFolder
(Q_crude <- get_crude_Q(ds, Q, "age"))

```

```

      [,1]      [,2]      [,3]      [,4]
[1,] -0.1569916  0.1141470  0.0000000  0.04284465
[2,]  0.3504402 -0.6212645  0.1696731  0.10115125
[3,]  0.0000000  0.0000000 -0.2434208  0.24342081
[4,]  0.0000000  0.0000000  0.0000000  0.00000000

```

```

# estimate_multistate("mB1", ds, Q_crude, E, qnames, cov_names = "age")
# (Q_crude <- get_crude_Q(ds, Q, "age + age_bl"))
# estimate_multistate("mB2", ds, Q_crude, E, qnames, cov_names = "age + age_bl")
# (Q_crude <- get_crude_Q(ds, Q, "age + age_bl + male"))
# estimate_multistate("mB3", ds, Q_crude, E, qnames, cov_names = "age + age_bl + male")
# (Q_crude <- get_crude_Q(ds, Q, "age + age_bl + male + educat"))
# estimate_multistate("mB4", ds, Q_crude, E, qnames, cov_names = "age + age_bl + male + educat")

```

```

# assemble the list object with the results of msm estimation
models <- list()
models[["age"]][["msm"]] <- readRDS(paste0(pathSaveFolder, 'mB1.rds'))
models[["age_bl"]][["msm"]] <- readRDS(paste0(pathSaveFolder, 'mB2.rds'))
models[["male"]][["msm"]] <- readRDS(paste0(pathSaveFolder, 'mB3.rds'))
models[["educat"]][["msm"]] <- readRDS(paste0(pathSaveFolder, 'mB4.rds'))

```

elect options

```
alive_states <- c(1,2,3)
ds_alive <- ds[ds$state %in% alive_states,]
fixedpars <- fixedpars_
age_min <- 0
age_max <- 35
age_bl <- 0
male <- 0
educat <- 0

replication_n <- 1000
time_scale <- "years"
grid_par <- .5

# turn this chunk OFF when printing the report
# for(model_ in names(models) ){
#   # determine covariate list
#   if(model_=="age"){covar_list = list(age=age_min)}
#   if(model_=="age_bl"){covar_list = list(age=age_min, age_bl=age_bl)}
#   if(model_=="male"){covar_list = list(age=age_min, age_bl=age_bl, male=male)}
#   if(model_=="educat"){covar_list = list(age=age_min, age_bl=age_bl, male=male, educat=educat)}
#   # compute LE
#   models[[model_]][["LE"]] <- elect(
#     model = models[[model_]][["msm"]], # fitted msm model
#     b.covariates = covar_list, # list with specified covarites values
#     statedistdata = ds_alive, # data for distribution of living states
#     time.scale.msm = time_scale, # time scale in multi-state model ("years", ...)
#     h = grid_par, # grid parameter for integration
#     age.max = age_max, # assumed maximum age in years
#     S = replication_n # number of simulation cycles
#   )
#   # models[[model_]][["LE"]] <- models[["msm"]][[model_]]
# }
# #save models estimated by elect() in a external object for faster access in the future
# saveRDS(models, paste0(pathSaveFolder,"models.rds"))

models <- readRDS(paste0(pathSaveFolder,"models.rds"))
# inspect created object
lapply(models, names)

$age
[1] "msm" "LE"

$age_bl
[1] "msm" "LE"

$male
[1] "msm" "LE"

$educat
[1] "msm" "LE"
```

```
$edu
[1] "msm" "LE"
```

Model results

age

summary

```
-2loglik = 15059.61
Convergence code = 0
```

	p	se	Wald	ChiSq	Pr>ChiSq
qbase	-2.12	0.07	865.97		0.00
qbase	-4.13	0.17	558.14		0.00
qbase	-0.29	0.08	12.28		0.00
qbase	-2.19	0.15	199.54		0.00
qbase	-3.06	0.35	78.06		0.00
qbase	-2.12	0.18	134.20		0.00
qcov	0.08	0.01	160.84		0.00
qcov	0.08	0.01	31.93		0.00
qcov	-0.02	0.01	7.44		0.01
qcov	0.05	0.01	23.01		0.00
qcov	0.06	0.02	6.34		0.01
qcov	0.07	0.01	33.05		0.00
p	-2.15	0.09	589.75		0.00
initp	-1.33	0.06	433.56		0.00
initp	-2.85	0.13	480.86		0.00

solution

Call:

```
msm(formula = state ~ age, subject = id, data = ds, qmatrix = Q,          ematrix = E, covariates = covariate)
```

Maximum likelihood estimates

Baselines are with covariates set to 0

Transition intensities with hazard ratios for each covariate

	Baseline	age
State 1 - State 1	-0.13609 (-0.15443,-0.11992)	
State 1 - State 2	0.11996 (0.10416, 0.13816)	1.0814 (1.0684,1.0946)
State 1 - State 4	0.01613 (0.01145, 0.02271)	1.0869 (1.0559,1.1187)
State 2 - State 1	0.74949 (0.63785, 0.88065)	0.9802 (0.9662,0.9944)
State 2 - State 2	-0.90846 (-1.04359,-0.79082)	
State 2 - State 3	0.11212 (0.08276, 0.15189)	1.0560 (1.0328,1.0798)
State 2 - State 4	0.04685 (0.02376, 0.09239)	1.0615 (1.0133,1.1119)
State 3 - State 3	-0.11946 (-0.17114,-0.08339)	
State 3 - State 4	0.11946 (0.08339, 0.17114)	1.0674 (1.0439,1.0914)

```
Warning in res[plabs == "pbase"][unique(states[plabs == "p"])] <- 1/(1 + : number of items to replace is 0
of replacement length
```

Warning in res[plabs == "pbase"][unique(states[plabs == "p"])] <- 1/(1 + : number of items to replace is
of replacement length

Misclassification probabilities

```

      Baseline
Obs State 2 | State 2 0
Obs State 3 | State 2 0.1041 (0.08898,0.1215)

```

Initial state occupancy probabilities

```

      Estimate      LCL      UCL
State 1 0.75681606 0.73449835 0.77726093
State 2 0.19930412 0.17966161 0.22057570
State 3 0.04387982 0.03430043 0.05598259
State 4 0.00000000 0.00000000 0.00000000

```

```

-2 * log-likelihood: 15059.61
[Note, to obtain old print format, use "printold.msm"]

```

ELECT summary

```

-----
ELECT summary
-----

```

Covariates values in the multi-state model:

age

0

Covariates in the state-distribution model:

age

Life expectancies:Using simulation with 1000 replications

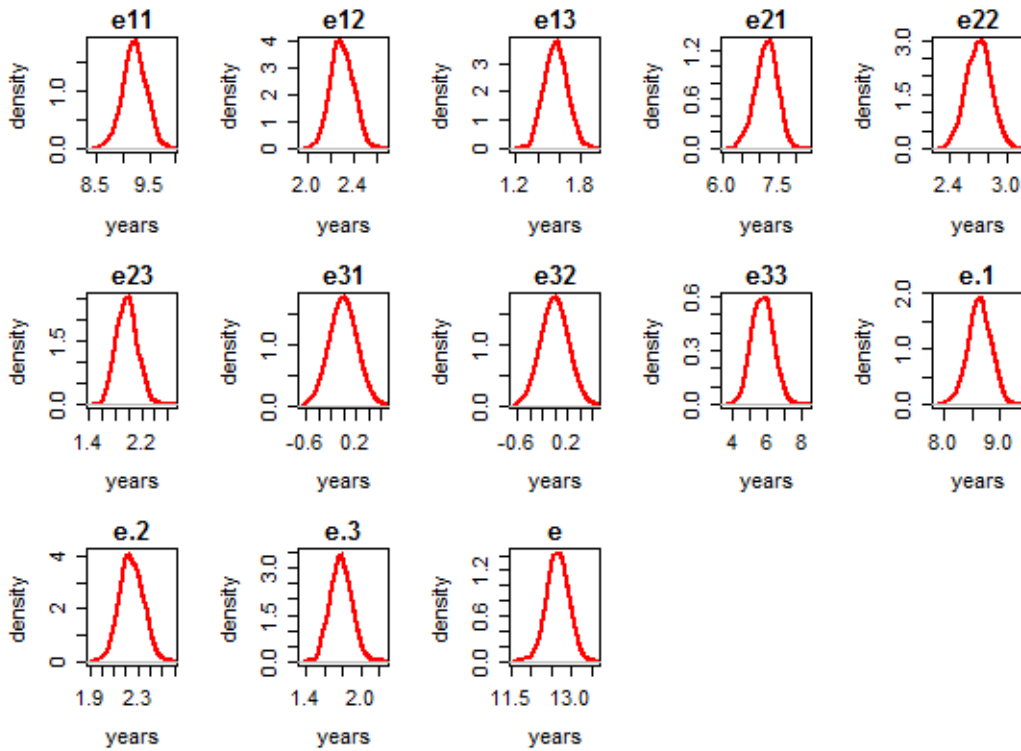
Point estimates, and mean, SEs, and quantiles from simulation:

```

      pnt      mn      se 0.025q 0.5q 0.975q
e11  9.26  9.23 0.22   8.78  9.24  9.64
e12  2.33  2.31 0.10   2.12  2.30  2.49
e13  1.58  1.57 0.10   1.38  1.57  1.77
e21  7.23  7.20 0.30   6.55  7.21  7.73
e22  2.74  2.71 0.13   2.45  2.71  2.95
e23  2.00  1.99 0.15   1.71  1.99  2.30
e31  0.00  0.00 0.00   0.00  0.00  0.00
e32  0.00  0.00 0.00   0.00  0.00  0.00
e33  5.75  5.76 0.62   4.62  5.75  6.98
e.1  8.67  8.64 0.21   8.21  8.65  9.04
e.2  2.27  2.25 0.09   2.07  2.24  2.44
e.3  1.79  1.79 0.11   1.57  1.79  2.01
e   12.73 12.68 0.27  12.16 12.68 13.18
-----

```

plots



age at baseline

summary

```
-2loglik = 15026.84
Convergence code = 0
```

	p	se	Wald ChiSq	Pr>ChiSq
qbase	-2.02	0.08	679.18	0.00
qbase	-4.25	0.20	447.08	0.00
qbase	-0.19	0.09	4.94	0.03
qbase	-2.25	0.16	196.77	0.00
qbase	-3.10	0.34	81.39	0.00
qbase	-2.22	0.19	132.69	0.00
qcov	0.04	0.01	6.96	0.01
qcov	0.12	0.03	13.74	0.00
qcov	-0.07	0.02	16.64	0.00
qcov	0.08	0.02	12.07	0.00
qcov	0.11	0.04	6.46	0.01
qcov	0.09	0.02	20.14	0.00
qcov	0.05	0.01	13.09	0.00
qcov	-0.04	0.03	1.47	0.23
qcov	0.06	0.02	10.64	0.00
qcov	-0.03	0.02	1.49	0.22
qcov	-0.07	0.05	2.30	0.13
qcov	-0.04	0.02	2.65	0.10

```
p      -2.15 0.09      588.84      0.00
initp -1.33 0.06      433.67      0.00
initp -2.83 0.13      487.60      0.00
```

solution

Call:

```
msm(formula = state ~ age, subject = id, data = ds, qmatrix = Q,      ematrix = E, covariates = covariates)
```

Maximum likelihood estimates

Baselines are with covariates set to 0

Transition intensities with hazard ratios for each covariate

	Baseline	age	age_bl
State 1 - State 1	-0.14696 (-0.168443,-0.12821)		
State 1 - State 2	0.13272 (0.114020, 0.15449)	1.0361 (1.0092,1.0638)	1.0519 (1.0234,1.081)
State 1 - State 4	0.01423 (0.009598, 0.02111)	1.1269 (1.0579,1.2004)	0.9605 (0.8999,1.025)
State 2 - State 1	0.82371 (0.694275, 0.97728)	0.9317 (0.9006,0.9639)	1.0628 (1.0246,1.102)
State 2 - State 2	-0.97424 (-1.130972,-0.83923)		
State 2 - State 3	0.10552 (0.077071, 0.14448)	1.0812 (1.0346,1.1299)	0.9720 (0.9287,1.017)
State 2 - State 4	0.04500 (0.022944, 0.08827)	1.1185 (1.0260,1.2194)	0.9332 (0.8534,1.020)
State 3 - State 3	-0.10897 (-0.158895,-0.07473)		
State 3 - State 4	0.10897 (0.074732, 0.15889)	1.0985 (1.0544,1.1445)	0.9652 (0.9249,1.007)

Warning in res[plabs == "pbase"][unique(states[plabs == "p"])] <- 1/(1 + : number of items to replace is
of replacement length

Warning in res[plabs == "pbase"][unique(states[plabs == "p"])] <- 1/(1 + : number of items to replace is
of replacement length

Misclassification probabilities

	Baseline
Obs State 2 State 2	0
Obs State 3 State 2	0.1041 (0.08896,0.1215)

Initial state occupancy probabilities

	Estimate	LCL	UCL
State 1	0.75610249	0.73399586	0.77561052
State 2	0.19930454	0.18017069	0.22017770
State 3	0.04459297	0.03486444	0.05662713
State 4	0.00000000	0.00000000	0.00000000

-2 * log-likelihood: 15026.84

[Note, to obtain old print format, use "printold.msm"]

ELECT summary

```
-----
ELECT summary
-----
```

Covariates values in the multi-state model:

```

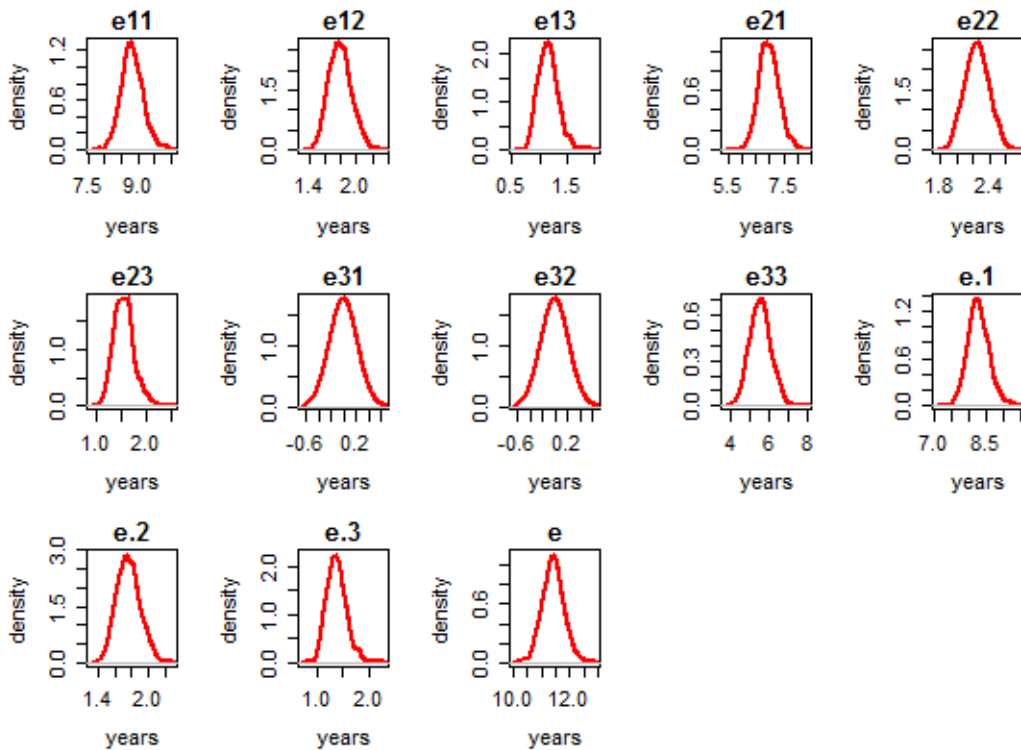
age age_bl
0 0
Covariates in the state-distribution model:
age

Life expectancies:Using simulation with 1000 replications

Point estimates, and mean, SEs, and quantiles from simulation:
      pnt    mn   se 0.025q 0.5q 0.975q
e11  8.87  8.83 0.32  8.23  8.81  9.50
e12  1.83  1.80 0.14  1.55  1.79  2.09
e13  1.17  1.16 0.18  0.87  1.15  1.56
e21  7.03  6.98 0.35  6.34  6.97  7.76
e22  2.29  2.25 0.14  1.99  2.25  2.53
e23  1.58  1.57 0.20  1.22  1.56  2.04
e31  0.00  0.00 0.00  0.00  0.00  0.00
e32  0.00  0.00 0.00  0.00  0.00  0.00
e33  5.58  5.58 0.55  4.54  5.58  6.69
e.1  8.32  8.28 0.31  7.71  8.26  8.92
e.2  1.80  1.77 0.13  1.53  1.76  2.04
e.3  1.39  1.39 0.18  1.08  1.38  1.79
e   11.51 11.43 0.37 10.75 11.43 12.18
-----

```

plots



male

summary

-2loglik = 14977.86

Convergence code = 0

	p	se	Wald	ChiSq	Pr>ChiSq
qbase	-2.10	0.08	667.99		0.00
qbase	-4.38	0.21	437.79		0.00
qbase	-0.23	0.09	5.94		0.01
qbase	-2.23	0.17	179.55		0.00
qbase	-3.29	0.38	74.60		0.00
qbase	-2.47	0.21	132.89		0.00
qcov	0.04	0.01	6.79		0.01
qcov	0.13	0.03	15.41		0.00
qcov	-0.07	0.02	15.98		0.00
qcov	0.09	0.02	14.44		0.00
qcov	0.09	0.05	4.06		0.04
qcov	0.11	0.02	27.79		0.00
qcov	0.05	0.01	13.23		0.00
qcov	-0.05	0.03	2.12		0.15
qcov	0.06	0.02	10.04		0.00
qcov	-0.04	0.02	2.46		0.12
qcov	-0.05	0.05	0.87		0.35
qcov	-0.05	0.02	5.80		0.02
qcov	0.33	0.09	13.14		0.00
qcov	0.45	0.23	3.77		0.05
qcov	0.12	0.11	1.30		0.25
qcov	-0.16	0.16	1.08		0.30
qcov	0.64	0.28	5.13		0.02
qcov	0.43	0.14	9.23		0.00
p	-2.15	0.09	589.03		0.00
initp	-1.33	0.06	434.12		0.00
initp	-2.84	0.13	486.43		0.00

solution

Call:

msm(formula = state ~ age, subject = id, data = ds, qmatrix = Q, ematrix = E, covariates = covariates)

Maximum likelihood estimates

Baselines are with covariates set to 0

Transition intensities with hazard ratios for each covariate

	Baseline	age	age_bl	male
State 1 - State 1	-0.13442 (-0.155254,-0.11639)			
State 1 - State 2	0.12190 (0.103921, 0.14300)	1.0357 (1.0087,1.0635)	1.0523 (1.0238,1.0817)	1.3930 (1.3630,1.4230)
State 1 - State 4	0.01252 (0.008307, 0.01887)	1.1332 (1.0646,1.2062)	0.9528 (0.8927,1.0169)	1.5623 (1.5223,1.6023)
State 2 - State 1	0.79683 (0.663817, 0.95650)	0.9327 (0.9014,0.9651)	1.0612 (1.0229,1.1009)	1.1290 (1.0890,1.1690)
State 2 - State 2	-0.94185 (-1.104543,-0.80312)			
State 2 - State 3	0.10788 (0.077894, 0.14942)	1.0892 (1.0422,1.1383)	0.9642 (0.9212,1.0091)	0.8497 (0.8067,0.8927)


```

State 2 - State 4  0.03714 ( 0.017591, 0.07841) 1.0979 (1.0026,1.2024) 0.9558 (0.8692,1.0511) 1.8957 (1
State 3 - State 3 -0.08480 (-0.128998,-0.05574)
State 3 - State 4  0.08480 ( 0.055742, 0.12900) 1.1198 (1.0737,1.1679) 0.9489 (0.9093,0.9903) 1.5390 (1

```

```

Warning in res[plabs == "pbase"][unique(states[plabs == "p"])] <- 1/(1 + : number of items to replace i
of replacement length

```

```

Warning in res[plabs == "pbase"][unique(states[plabs == "p"])] <- 1/(1 + : number of items to replace i
of replacement length

```

Misclassification probabilities

```

          Baseline
Obs State 2 | State 2 0
Obs State 3 | State 2 0.1042 (0.08905,0.1216)

```

Initial state occupancy probabilities

```

          Estimate      LCL      UCL
State 1 0.75644307 0.7336018 0.77663358
State 2 0.19914669 0.1799655 0.22019658
State 3 0.04441024 0.0350617 0.05654718
State 4 0.00000000 0.0000000 0.00000000

```

```

-2 * log-likelihood: 14977.86
[Note, to obtain old print format, use "printold.msm"]

```

ELECT summary

```

-----
ELECT summary
-----

```

Covariates values in the multi-state model:

```

  age age_bl  male
    0      0      0

```

Covariates in the state-distribution model:

```

  age

```

Life expectancies:Using simulation with 1000 replications

Point estimates, and mean, SEs, and quantiles from simulation:

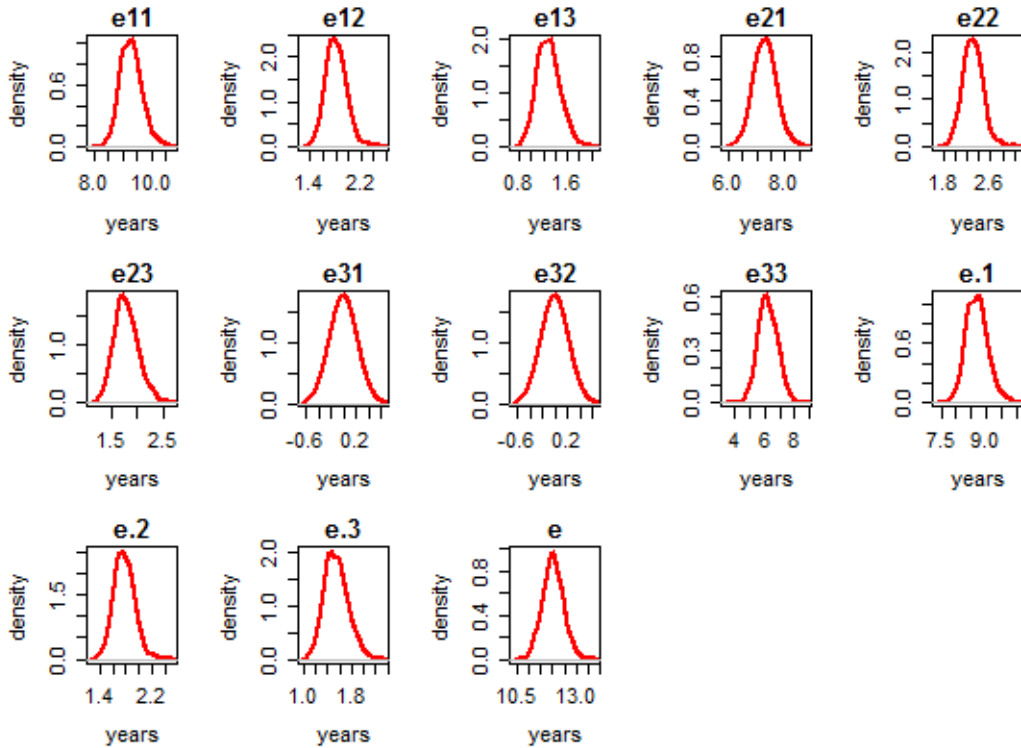
```

      pnt    mn   se 0.025q  0.5q 0.975q
e11  9.35  9.29 0.37  8.63  9.28 10.09
e12  1.85  1.81 0.16  1.51  1.80  2.13
e13  1.31  1.29 0.19  0.96  1.28  1.68
e21  7.40  7.31 0.40  6.52  7.31  8.13
e22  2.34  2.30 0.17  1.98  2.29  2.64
e23  1.81  1.80 0.22  1.41  1.78  2.28
e31  0.00  0.00 0.00  0.00  0.00  0.00
e32  0.00  0.00 0.00  0.00  0.00  0.00
e33  6.24  6.26 0.65  5.02  6.22  7.54
e.1  8.76  8.70 0.35  8.08  8.69  9.47
e.2  1.82  1.78 0.15  1.50  1.77  2.08
e.3  1.57  1.55 0.19  1.22  1.54  1.96

```

e 12.15 12.04 0.43 11.20 12.03 12.90

plots



education

summary

```
-2loglik = 14965.72
Convergence code = 0
```

	p	se	Wald	ChiSq	Pr>ChiSq
qbase	-1.87	0.11	265.81	0.00	
qbase	-4.32	0.32	186.83	0.00	
qbase	-0.23	0.11	4.07	0.04	
qbase	-2.15	0.19	125.35	0.00	
qbase	-3.47	0.49	49.52	0.00	
qbase	-2.38	0.22	112.26	0.00	
qcov	0.04	0.01	6.79	0.01	
qcov	0.12	0.03	14.88	0.00	
qcov	-0.07	0.02	16.22	0.00	
qcov	0.08	0.02	14.06	0.00	
qcov	0.10	0.05	4.23	0.04	
qcov	0.11	0.02	28.29	0.00	
qcov	0.05	0.01	12.34	0.00	
qcov	-0.05	0.03	1.87	0.17	

```

qcov  0.06 0.02      10.14      0.00
qcov -0.03 0.02       2.14      0.14
qcov -0.05 0.05       1.08      0.30
qcov -0.05 0.02       5.71      0.02
qcov  0.33 0.09      12.92      0.00
qcov  0.49 0.23       4.41      0.04
qcov  0.12 0.11       1.30      0.25
qcov -0.14 0.16       0.81      0.37
qcov  0.57 0.30       3.63      0.06
qcov  0.44 0.14       9.66      0.00
qcov -0.25 0.09       7.31      0.01
qcov -0.09 0.27       0.11      0.74
qcov  0.02 0.11       0.03      0.87
qcov -0.10 0.14       0.56      0.45
qcov  0.25 0.44       0.33      0.56
qcov -0.15 0.12       1.39      0.24
p      -2.15 0.09     588.76      0.00
initp -1.33 0.06     433.80      0.00
initp -2.83 0.13     486.75      0.00

```

solution

Call:

```
msm(formula = state ~ age, subject = id, data = ds, qmatrix = Q,      ematrix = E, covariates = covariates)
```

Maximum likelihood estimates

Baselines are with covariates set to 0

Transition intensities with hazard ratios for each covariate

	Baseline	age	age_bl	male
State 1 - State 1	-0.16778 (-0.205801,-0.13679)			
State 1 - State 2	0.15445 (0.123388, 0.19334)	1.0360 (1.0088,1.0640)	1.0510 (1.0222,1.0805)	1.3914 (1.0000,1.7828)
State 1 - State 4	0.01333 (0.007177, 0.02476)	1.1327 (1.0632,1.2067)	0.9546 (0.8931,1.0204)	1.6254 (1.0000,2.6181)
State 2 - State 1	0.79401 (0.634537, 0.99357)	0.9317 (0.9001,0.9643)	1.0617 (1.0233,1.1015)	1.1304 (0.9999,1.2709)
State 2 - State 2	-0.94182 (-1.146462,-0.77370)			
State 2 - State 3	0.11662 (0.080061, 0.16989)	1.0880 (1.0411,1.1371)	0.9662 (0.9228,1.0117)	0.8667 (0.7999,0.9335)
State 2 - State 4	0.03118 (0.011869, 0.08192)	1.1008 (1.0046,1.2063)	0.9492 (0.8603,1.0472)	1.7758 (1.0000,3.1622)
State 3 - State 3	-0.09296 (-0.144258,-0.05990)			
State 3 - State 4	0.09296 (0.059902, 0.14426)	1.1218 (1.0753,1.1703)	0.9490 (0.9091,0.9906)	1.5593 (1.0000,2.4142)
	educat			
State 1 - State 1				
State 1 - State 2	0.7751 (0.6445,0.9323)			
State 1 - State 4	0.9152 (0.5427,1.5433)			
State 2 - State 1	1.0175 (0.8271,1.2518)			
State 2 - State 2				
State 2 - State 3	0.9007 (0.6848,1.1847)			
State 2 - State 4	1.2886 (0.5450,3.0466)			
State 3 - State 3				
State 3 - State 4	0.8635 (0.6765,1.1022)			

```
Warning in res[plabs == "pbase"][unique(states[plabs == "p"])] <- 1/(1 + : number of items to replace is 0
of replacement length
```

```
Warning in res[plabs == "pbase"][unique(states[plabs == "p"])] <- 1/(1 + : number of items to replace i
of replacement length
```

Misclassification probabilities

```

Baseline
Obs State 2 | State 2 0
Obs State 3 | State 2 0.1042 (0.08904,0.1216)
```

Initial state occupancy probabilities

```

Estimate      LCL      UCL
State 1 0.75627049 0.73396526 0.77637390
State 2 0.19927786 0.17984784 0.22039809
State 3 0.04445165 0.03500507 0.05651733
State 4 0.00000000 0.00000000 0.00000000
```

```
-2 * log-likelihood: 14965.72
```

```
[Note, to obtain old print format, use "printold.msm"]
```

ELECT summary

```
-----
ELECT summary
-----
```

Covariates values in the multi-state model:

```

age age_bl  male educat
  0      0      0      0
```

Covariates in the state-distribution model:

```
age
```

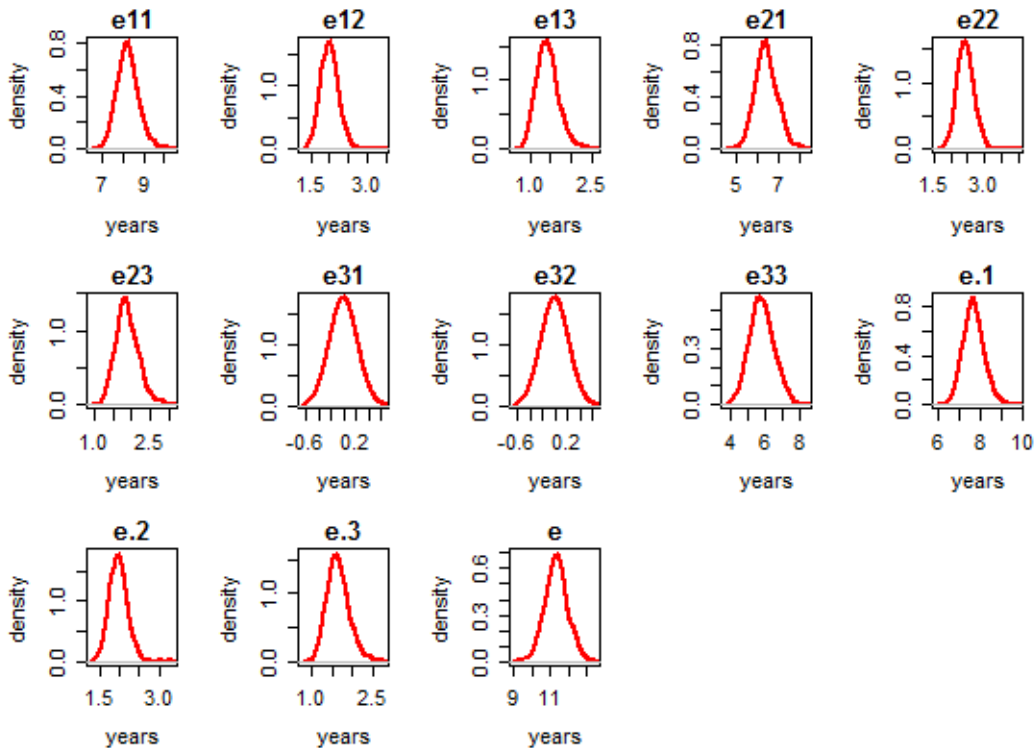
Life expectancies:Using simulation with 1000 replications

Point estimates, and mean, SEs, and quantiles from simulation:

```

pnt    mn    se 0.025q 0.5q 0.975q
e11  8.33  8.24 0.51   7.31  8.22   9.33
e12  2.07  2.02 0.23   1.58  2.01   2.49
e13  1.45  1.43 0.26   1.00  1.41   1.98
e21  6.56  6.46 0.50   5.56  6.43   7.46
e22  2.51  2.45 0.24   1.99  2.44   2.94
e23  1.92  1.90 0.30   1.37  1.87   2.55
e31  0.00  0.00 0.00   0.00  0.00   0.00
e32  0.00  0.00 0.00   0.00  0.00   0.00
e33  5.84  5.84 0.69   4.57  5.83   7.25
e.1  7.80  7.72 0.48   6.85  7.69   8.75
e.2  2.03  1.97 0.22   1.56  1.97   2.43
e.3  1.68  1.66 0.26   1.20  1.64   2.23
e   11.51 11.36 0.60  10.22 11.36  12.55
-----
```

plots



Session Info

```
sessionInfo()
```

```
R version 3.3.1 (2016-06-21)
```

```
Platform: x86_64-w64-mingw32/x64 (64-bit)
```

```
Running under: Windows 10 x64 (build 14393)
```

```
locale:
```

```
[1] LC_COLLATE=English_United States.1252 LC_CTYPE=English_United States.1252
```

```
LC_MONETARY=English_U
```

```
[4] LC_NUMERIC=C
```

```
LC_TIME=English_United States.1252
```

```
attached base packages:
```

```
[1] stats      graphics  grDevices  utils      datasets  methods    base
```

```
other attached packages:
```

```
[1] msm_1.6.1    magrittr_1.5 nnet_7.3-12 knitr_1.14
```

```
loaded via a namespace (and not attached):
```

```
[1] Rcpp_0.12.6      formatR_1.4      nloptr_1.0.4      plyr_1.8.4        tools_3.3.1      dig
[7] lme4_1.1-12      evaluate_0.9      tibble_1.2        gtable_0.2.0      nlme_3.1-128     lat
[13] mgcv_1.8-14      Matrix_1.2-7.1    DBI_0.5           yaml_2.1.13       parallel_3.3.1   Spa
[19] mvtnorm_1.0-5    expm_0.999-0      dplyr_0.5.0       stringr_1.1.0     MatrixModels_0.4-1 gri
[25] R6_2.1.3         survival_2.39-5    rmarkdown_1.0     minqa_1.2.4       ggplot2_2.1.0    car
[31] scales_0.4.0     htmltools_0.3.5    splines_3.3.1     MASS_7.3-45       assertthat_0.1   pbk
```

[37] testit_0.5

colorspace_1.2-6

quantreg_5.26

stringi_1.1.1

lazyeval_0.2.0

mun