project

```r
library(markovchain)
```

```
## Package:  markovchain
## Version:  0.8.5-4
## Date:     2021-01-07
## BugReport: https://github.com/spedygiorgio/markovchain/issues
```

```r
library(tidyverse)
```

```
## -- Attaching packages ------------------------------------- tidyverse 1.3.0 --
```

```
## v ggplot2 3.3.2      v purrr   0.3.4
## v tibble  3.0.4      v dplyr   1.0.2
## v tidyr   1.1.2      v stringr 1.4.0
## v readr   1.3.1      v forcats 0.5.0
```

```
## -- Conflicts ---------------------------------------- tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
```

```r
dat <- read_csv('data/dtmc_data.csv', col_types = cols(
  index = col_double(),
  stay_date = col_date(format = ""),
  PTID = col_character(),
  first_covid_diag_date = col_date(format = ""),
  # hcq_usage_date = col_date(format = ""),
  medadm_drug_name_hcq_use = col_double(),
  CAREAREA = col_factor(),
  days_after_confirmation = col_double()
))
```

use matching before DTMC

```r
table(dat$CAREAREA)
```

```
## 
##                             UNKNOWN CARE AREA
##                                         55424
##                       MEDICAL OR SURGICAL UNIT
##                                          8589
##                          EMERGENCY DEPARTMENT
##                                         35875
##                               OTHER CARE AREA
##                                         44712
## CRITICAL CARE UNIT (CCU) / INTENSIVE CARE UNIT (ICU)
##                                         13431
##                            ANCILLARY SERVICES
##                                          3592
##                                    LABORATORY
##                                          2300
```

```
##                                       AMBULATORY SURGERY
##                                                      663
##                                           OPERATING ROOM
##                                                      927
##                                 CARDIAC CATHETERIZATION
##                                                      525
##                                          AMBULATORY CARE
##                                                     4195
##                                         OFFICE OR CLINIC
##                                                     1756
##                                        URGENT CARE UNIT
##                                                       30
##                                           TELEMETRY UNIT
##                                                      172
##                                       HOSPICE CARE AREA
##                                                       34
##                                          PSYCHIATRIC UNIT
##                                                       48
##                                         OBSERVATION CARE
##                                                      332
##         POST ANESTHESIA CARE UNIT (PACU) / RECOVERY ROOM
##                                                      210
##                                            DELIVERY ROOM
##                                                      116
##                                                  NURSERY
##                                                        1
##                                           PEDIATRIC UNIT
##                                                       18
##                                      REHABILITATION UNIT
##                                                       38
##                                            DAY CARE UNIT
##                                                       13
```

group those carearea to less categories

ICU: CRITICAL CARE UNIT (CCU) / INTENSIVE CARE UNIT (ICU)

high dependent unit: CARDIAC CATHETERIZATION URGENT CARE UNIT TELEMETRY UNIT
DELIVERY ROOM EMERGENCY DEPARTMENT OPERATING ROOM

Stable units: AMBULATORY CARE
AMBULATORY SURGERY MEDICAL OR SURGICAL UNIT PEDIATRIC UNIT PSYCHIATRIC UNIT
REHABILITATION UNIT SKILLED NURSING FACILITY (SNF) CARE AREA NURSERY POST ANES-
THESIA CARE UNIT (PACU) / RECOVERY ROOM HOSPICE CARE AREA LABORATORY DAY
CARE UNIT ANCILLARY SERVICES OTHER CARE AREA

Missing: UNKNOWN CARE AREA

[1] "OFFICE OR CLINIC" "UNKNOWN CARE AREA"
[3] "OTHER CARE AREA" "EMERGENCY DEPARTMENT"
[5] "LABORATORY" "ANCILLARY SERVICES"
[7] "URGENT CARE UNIT" "CRITICAL CARE UNIT (CCU) / INTENSIVE CARE UNIT (ICU)" [9]
"MEDICAL OR SURGICAL UNIT" "OBSERVATION CARE"
[11] "REHABILITATION UNIT" "PEDIATRIC UNIT"
[13] "AMBULATORY SURGERY" "TELEMETRY UNIT"
[15] "AMBULATORY CARE" "DELIVERY ROOM"
[17] "PSYCHIATRIC UNIT" "CARDIAC CATHETERIZATION"

[19] "OPERATING ROOM"

```r
high_dependent_units <- c(
  'CARDIAC CATHETERIZATION',
  'URGENT CARE UNIT',
  'TELEMETRY UNIT',
  'DELIVERY ROOM',
  'EMERGENCY DEPARTMENT',
  'OPERATING ROOM')

other_hospital_units <- c(
  'AMBULATORY CARE',
  'AMBULATORY SURGERY',
  'MEDICAL OR SURGICAL UNIT',
  'PEDIATRIC UNIT',
  'PSYCHIATRIC UNIT',
  'REHABILITATION UNIT',
  'HOSPICE CARE AREA',
  'LABORATORY',
  'DAY CARE UNIT',
  'POST ANESTHESIA CARE UNIT (PACU) / RECOVERY ROOM',
  'ANCILLARY SERVICES',
  'OTHER CARE AREA',
  'SKILLED NURSING FACILITY (SNF) CARE AREA',
  'NURSERY')

long_term_medical_care_facilities <- c(
  'SKILLED NURSING FACILITY (SNF) CARE AREA',
  'NURSERY'
  )

dat <- dat %>% mutate(care_area=ifelse(CAREAREA == 'CRITICAL CARE UNIT (CCU) / INTENSIVE CARE UNIT (ICU
                                 ifelse(CAREAREA %in% high_dependent_units, 'high dependent units
                                 ifelse(CAREAREA %in% other_hospital_units, 'other hospita
```

```r
dat_HCQ <- dat %>% filter(medadm_drug_name_hcq_use == 1)
dat_no_HCQ <- dat %>% filter(medadm_drug_name_hcq_use == 0)
```

```r
# function used to create transition states vector for each of those patients
create_trans_states <- function(data) {
  ptids <- unique(data$PTID)
  lst <- list()
    for (ptid in ptids) {
      lst[[ptid]] <- pull(dat %>% filter(PTID == ptid) %>%
      select(care_area))
    }

  return(lst)
}

HCQ_patients <- create_trans_states(dat_HCQ)
no_HCQ_patients <- create_trans_states(dat_no_HCQ)

first_day_stay = vector()
for(i in 1:length(no_HCQ_patients)) {
```

3

```
  first_day_stay[i] = no_HCQ_patients[[i]][1]
}
```

```
no_HCQ_patients[1:10]
```

```
## $PT254611341
## [1] NA                                  "other hospital units or self-care"
##
## $PT413921534
##  [1] "high dependent units" "high dependent units" "high dependent units"
##  [4] NA                     NA                     NA
##  [7] NA                     NA                     NA
## [10] NA                     NA                     NA
## [13] NA                     NA                     NA
## [16] NA                     NA                     NA
## [19] NA                     NA                     NA
## [22] NA                     NA                     NA
## [25] NA                     NA                     NA
## [28] NA                     NA                     NA
## [31] NA
##
## $PT277747789
##  [1] "high dependent units"              "high dependent units"
##  [3] "high dependent units"              "other hospital units or self-care"
##  [5] "other hospital units or self-care" "other hospital units or self-care"
##  [7] "other hospital units or self-care" "other hospital units or self-care"
##  [9] "other hospital units or self-care" "other hospital units or self-care"
## [11] "other hospital units or self-care" "other hospital units or self-care"
## [13] "other hospital units or self-care" "other hospital units or self-care"
## [15] "other hospital units or self-care" "other hospital units or self-care"
## [17] "other hospital units or self-care" "other hospital units or self-care"
## [19] "other hospital units or self-care" "other hospital units or self-care"
## [21] "other hospital units or self-care" "other hospital units or self-care"
## [23] "other hospital units or self-care" "other hospital units or self-care"
## [25] "other hospital units or self-care" "other hospital units or self-care"
## [27] "other hospital units or self-care" "other hospital units or self-care"
## [29] "other hospital units or self-care" "other hospital units or self-care"
## [31] "other hospital units or self-care"
##
## $PT202846287
## [1] NA NA
##
## $PT249283846
##  [1] "high dependent units" "high dependent units" "high dependent units"
##  [4] "high dependent units" "high dependent units" "high dependent units"
##  [7] "high dependent units" "high dependent units" "high dependent units"
## [10] NA                     NA                     NA
## [13] NA                     NA                     "high dependent units"
## [16] NA
##
## $PT411742036
## [1] "ICU" "ICU"
##
## $PT265624106
```

```
##  [1] "other hospital units or self-care" "other hospital units or self-care"
##  [3] "other hospital units or self-care" "other hospital units or self-care"
##  [5] "other hospital units or self-care" "other hospital units or self-care"
##  [7] "other hospital units or self-care" "other hospital units or self-care"
##  [9] "other hospital units or self-care" "other hospital units or self-care"
## [11] "other hospital units or self-care" "other hospital units or self-care"
## [13] "other hospital units or self-care" "other hospital units or self-care"
## [15] "other hospital units or self-care" "other hospital units or self-care"
## [17] "other hospital units or self-care" "other hospital units or self-care"
## [19] "other hospital units or self-care" "other hospital units or self-care"
## [21] "other hospital units or self-care" "other hospital units or self-care"
## [23] "other hospital units or self-care" "other hospital units or self-care"
## [25] "other hospital units or self-care" "other hospital units or self-care"
## [27] "other hospital units or self-care" "other hospital units or self-care"
## [29] "other hospital units or self-care" "other hospital units or self-care"
## [31] "other hospital units or self-care"
##
## $PT412682057
##  [1] "ICU"                               "ICU"
##  [3] "ICU"                               "other hospital units or self-care"
##  [5] NA                                  NA
##  [7] NA                                  NA
##  [9] "other hospital units or self-care" "other hospital units or self-care"
## [11] "other hospital units or self-care" "other hospital units or self-care"
## [13] NA                                  "ICU"
## [15] "ICU"                               "ICU"
## [17] NA                                  NA
## [19] NA                                  NA
## [21] NA                                  NA
## [23] NA                                  NA
## [25] NA                                  NA
## [27] NA                                  NA
## [29] NA                                  NA
## [31] NA
##
## $PT349802348
## [1] "high dependent units"
##
## $PT560460142
##  [1] "high dependent units" "high dependent units" "high dependent units"
##  [4] "high dependent units" "high dependent units" "high dependent units"
##  [7] "high dependent units" "high dependent units" "high dependent units"
## [10] "high dependent units" "high dependent units" "high dependent units"
## [13] "high dependent units" "high dependent units" "high dependent units"
## [16] "high dependent units" "high dependent units" "high dependent units"
## [19] "high dependent units" "high dependent units" "high dependent units"
## [22] "high dependent units" "high dependent units" "high dependent units"
## [25] "high dependent units" "high dependent units" "high dependent units"
## [28] "high dependent units" "high dependent units" "high dependent units"
## [31] "high dependent units"
```

```r
createSequenceMatrix(HCQ_patients)
```

```
##                                     ICU high dependent units
## ICU                                5514                   13
```

```
## high dependent units                          62              6022
## other hospital units or self-care  148                         111
##                                    other hospital units or self-care
## ICU                                                            332
## high dependent units                                           281
## other hospital units or self-care                            18803
```

```
fit.hcq.mle <- markovchainFit(data = HCQ_patients, method = 'mle')
```

```
(markovchain <- fit.hcq.mle$estimate)
```

```
## MLE Fit
##  A  3 - dimensional discrete Markov Chain defined by the following states:
##  ICU, high dependent units, other hospital units or self-care
##  The transition matrix  (by rows)  is defined as follows:
##                                    ICU high dependent units
## ICU                          0.941116231        0.002218809
## high dependent units         0.009740770        0.946111548
## other hospital units or self-care 0.007764138    0.005823104
##                                    other hospital units or self-care
## ICU                                                      0.05666496
## high dependent units                                     0.04414768
## other hospital units or self-care                        0.98641276
```

```
fit.hcq.mle$standardError
```

```
##                                      ICU high dependent units
## ICU                          0.0126738885        0.0006153868
## high dependent units         0.0012370790        0.0121919162
## other hospital units or self-care 0.0006382082    0.0005527045
##                                    other hospital units or self-care
## ICU                                                      0.003109894
## high dependent units                                     0.002633630
## other hospital units or self-care                        0.007193580
```

```
fit.hcq.mle$lowerEndpointMatrix
```

```
##                                      ICU high dependent units
## ICU                          0.916275861        0.001012672
## high dependent units         0.007316139        0.922215826
## other hospital units or self-care 0.006513273    0.004739822
##                                    other hospital units or self-care
## ICU                                                      0.05056968
## high dependent units                                     0.03898586
## other hospital units or self-care                        0.97231360
```

```
fit.hcq.mle$upperEndpointMatrix
```

```
##                                      ICU high dependent units
## ICU                          0.965956602        0.003424945
## high dependent units         0.012165401        0.970007269
## other hospital units or self-care 0.009015003    0.006906385
##                                    other hospital units or self-care
## ICU                                                      0.06276024
## high dependent units                                     0.04930950
## other hospital units or self-care                        1.00000000
```

```r
# mcDf <- as(markovchain, 'data.frame')
# mcNew <- as(mcDf, 'igraph')
```

```r
fit.nohcq.mle <- markovchainFit(data = no_HCQ_patients, method = 'mle')
```

```r
fit.nohcq.mle$estimate
```

```
## MLE Fit
##  A  3 - dimensional discrete Markov Chain defined by the following states:
##  ICU, high dependent units, other hospital units or self-care
##  The transition matrix  (by rows)  is defined as follows:
##                                             ICU high dependent units
## ICU                                  0.928734235         0.005774198
## high dependent units                 0.007542272         0.946327089
## other hospital units or self-care    0.005577122         0.012087858
##                                      other hospital units or self-care
## ICU                                                           0.06549157
## high dependent units                                          0.04613064
## other hospital units or self-care                             0.98233502
```

```r
fit.nohcq.mle$standardError
```

```
##                                              ICU high dependent units
## ICU                                  0.0118795443        0.0009366987
## high dependent units                 0.0005143787        0.0057617246
## other hospital units or self-care    0.0003701666        0.0005449627
##                                      other hospital units or self-care
## ICU                                                          0.003154618
## high dependent units                                         0.001272116
## other hospital units or self-care                            0.004912719
```

```r
fit.nohcq.mle$lowerEndpointMatrix
```

```
##                                              ICU high dependent units
## ICU                                  0.905450751         0.003938302
## high dependent units                 0.006534108         0.935034314
## other hospital units or self-care    0.004851608         0.011019751
##                                      other hospital units or self-care
## ICU                                                           0.05930863
## high dependent units                                          0.04363734
## other hospital units or self-care                             0.97270627
```

```r
fit.nohcq.mle$upperEndpointMatrix
```

```
##                                              ICU high dependent units
## ICU                                  0.952017719         0.007610095
## high dependent units                 0.008550436         0.957619864
## other hospital units or self-care    0.006302635         0.013155966
##                                      other hospital units or self-care
## ICU                                                           0.07167451
## high dependent units                                          0.04862394
## other hospital units or self-care                             0.99196378
```

#simulation

```r
transition_matrix <- matrix(c(0.90, 0.08, 0.02,
                              0.02, 0.9, 0.08,
```

```r
                           0.01, 0.01, 0.98),nrow=3,byrow=TRUE)

sim_tran_matrix <- new("markovchain", states=c("ICU","high dependent units", 'other hospital units or s
                transitionMatrix=transion_matrix,
                name="simpleMc")
```

check simulation sequence for one patient

```r
# (sim_seq <- rmarkovchain(n = 30, object = sim_tran_matrix, t0 = 'ICU'))
```

```r
#Here begins the parameter estimation part
set.seed(994)
upperlmt <- matrix(0, nrow=3, ncol=3)
lowerlmt <- matrix(0, nrow=3, ncol=3)
emat <- matrix(0, nrow=3, ncol=3)
er <- 0
count_of_within_CI <- 0
totol_checks <- 0
# do simulation for 100 times
for (i in 1:1000){
  sim_seq_list <- list()
  for (j in 1:3000) {
    # generate simulation data
    inital_status <- sample(c('ICU', 'high dependent units', 'other hospital units or self-care'), 1, p
    sim_seq_list[[j]] <- rmarkovchain(n = 30, object = sim_tran_matrix, t0 = inital_status)
  }

  # fit the current simulation data
  mkfit <- markovchainFit(data = sim_seq_list, method = 'mle', confidencelevel = 0.95)

  # get the fitted results
  upperlmt_temp <-mkfit$upperEndpointMatrix
  lowerlmt_temp <- mkfit$lowerEndpointMatrix
  emat_temp <- mkfit$estimate@transitionMatrix
  er_temp <- mkfit$standardError

  # sum the fitted result
  upperlmt <- upperlmt + upperlmt_temp
  lowerlmt <- lowerlmt + lowerlmt_temp
  emat <- emat + emat_temp
  er <- er + er_temp

  # check the fitted result of current simulation data within in the CI
  count_of_within_CI_temp <- c(lowerlmt_temp < transion_matrix & transion_matrix < upperlmt_temp)
  # transfer the boolean to numeric
  count_of_within_CI_temp_numeric <- as.numeric(count_of_within_CI_temp)
  #
  num_of_checks <- as.numeric(!is.na(count_of_within_CI_temp_numeric))
  # count the total number of check for whether CI cover the true parameters
  totol_checks <- totol_checks + num_of_checks
  # count the total number of check the CI cover the true parameters
  count_of_within_CI <- count_of_within_CI + count_of_within_CI_temp_numeric
}
```

```
upperlmt <- upperlmt/100
lowerlmt <- lowerlmt/100
emat <- emat/100
er <- er/100
#got the overall lower and upper as (0.166, 0.756, 0.198, 0.645), (0.217, 0.861, 0.314, 0.843), er as (
cp <- count_of_within_CI/totol_checks
```

Prediction

```
predict <- function(transMatrix, n, init_state) {
  status <- init_state
  # record the cumulative sum of length of stay for those three states from day 1 to day 30
  count <- matrix(status, byrow = T, nrow = 1, dimnames = list(c(), c('ICU', 'high dependent units', 'o
  df <- data.frame()
  df <- rbind(df, count)
  for (i in 1:(n - 1)) {
    status <- status %*% transMatrix
    count <- count + status
    df <- rbind(df, count)
  }

  df['day'] <- 1:30
  df <- df %>% select(c('day', 'ICU', 'high dependent units', 'other hospital units or self-care'))

  return(df)
}
```

```
(no_hcq_other <- predict(fit.nohcq.mle$estimate@transitionMatrix, 30, c(0, 0, 1)))
```

```
##    day          ICU high dependent units other hospital units or self-care
## 1    1 0.000000000           0.00000000                          1.000000
## 2    2 0.005577122           0.01208786                          1.982335
## 3    3 0.016326557           0.03543346                          2.948240
## 4    4 0.031872974           0.06926382                          3.898863
## 5    5 0.051868362           0.11285917                          4.835272
## 6    6 0.075990040           0.16554928                          5.758461
## 7    7 0.103938805           0.22671000                          6.669351
## 8    8 0.135437217           0.29576015                          7.568803
## 9    9 0.170228015           0.37215850                          8.457613
## 10  10 0.208072644           0.45540103                          9.336526
## 11  11 0.248749888           0.54501839                         10.206232
## 12  12 0.292054609           0.64057348                         11.067372
## 13  13 0.337796571           0.74165924                         11.920544
## 14  14 0.385799359           0.84789658                         12.766304
## 15  15 0.435899368           0.95893245                         13.605168
## 16  16 0.487944871           1.07443807                         14.437617
## 17  17 0.541795155           1.19410721                         15.264098
## 18  18 0.597319718           1.31765468                         16.085026
## 19  19 0.654397523           1.44481486                         16.900788
## 20  20 0.712916316           1.57534039                         17.711743
## 21  21 0.772771979           1.70900084                         18.518227
## 22  22 0.833867945           1.84558163                         19.320550
## 23  23 0.896114644           1.98488289                         20.119002
```

```
## 24  24 0.959428996              2.12671843                             20.913853
## 25  25 1.023733940              2.27091488                             21.705351
## 26  26 1.088957996              2.41731072                             22.493731
## 27  27 1.155034858              2.56575550                             23.279210
## 28  28 1.221903022              2.71610912                             24.061988
## 29  29 1.289505432              2.86824104                             24.842254
## 30  30 1.357789161              3.02202969                             25.620181
```

```r
predict(fit.hcq.mle$estimate@transitionMatrix, 30, c(0, 0, 1))
```

```
##    day          ICU high dependent units other hospital units or self-care
## 1    1 0.000000000               0.000000000                      1.000000
## 2    2 0.007764138               0.005823104                      1.986413
## 3    3 0.022786461               0.017093620                      2.960120
## 4    4 0.044593993               0.033460115                      3.921946
## 5    5 0.072744587               0.054593844                      4.872662
## 6    6 0.106824915               0.080187285                      5.812988
## 7    7 0.146448587               0.109952770                      6.743599
## 8    8 0.191254398               0.143621200                      7.665124
## 9    9 0.240904684               0.180940846                      8.578154
## 10  10 0.295083787               0.221676227                      9.483240
## 11  11 0.353496623               0.265607061                     10.380896
## 12  12 0.415867340               0.312527283                     11.271605
## 13  13 0.481938060               0.362244127                     12.155818
## 14  14 0.551467716               0.414577266                     13.033955
## 15  15 0.624230946               0.469358010                     13.906411
## 16  16 0.700017080               0.526428554                     14.773554
## 17  17 0.778629171               0.585641275                     15.635730
## 18  18 0.859883111               0.646858074                     16.493259
## 19  19 0.943606788               0.709949764                     17.346443
## 20  20 1.029639303               0.774795489                     18.195565
## 21  21 1.117830246               0.841282192                     19.040888
## 22  22 1.208039005               0.909304108                     19.882657
## 23  23 1.300134131               0.978762295                     20.721104
## 24  24 1.393992741               1.049564190                     21.556443
## 25  25 1.489499959               1.121623204                     22.388877
## 26  26 1.586548393               1.194858329                     23.218593
## 27  27 1.685037648               1.269193783                     24.045769
## 28  28 1.784873873               1.344558671                     24.870567
## 29  29 1.885969330               1.420886668                     25.693144
## 30  30 1.988241996               1.498115728                     26.513642
```

```r
no_hcq_other <- predict(fit.nohcq.mle$estimate@transitionMatrix, 30, c(0, 0, 1))
hcq_other <- predict(fit.hcq.mle$estimate@transitionMatrix, 30, c(0, 0, 1))
comb <- cbind(no_hcq_other, hcq_other)
colnames(comb) <- c('day', 'ICU no hcq', 'high dependent units no hcq', 'other hospital units or self-ca
                    'high dependent units', 'other hospital units or self-care')
comb <- comb %>% select('day', 'ICU no hcq', 'ICU', 'high dependent units no hcq', 'high dependent unit

write.csv(comb, 'data/other.csv')
```

```r
no_hcq_icu <- predict(fit.nohcq.mle$estimate@transitionMatrix, 30, c(1, 0, 0))
hcq_icu <- predict(fit.hcq.mle$estimate@transitionMatrix, 30, c(1, 0, 0))
comb <- cbind(no_hcq_icu, hcq_icu)
colnames(comb) <- c('day', 'ICU no hcq', 'high dependent units no hcq', 'other hospital units or self-ca
```

```
                            'high dependent units', 'other hospital units or self-care')
comb <- comb %>% select('day', 'ICU no hcq', 'ICU', 'high dependent units no hcq', 'high dependent units

write.csv(comb, 'data/icu.csv')
```

```
no_hcq_high <- predict(fit.nohcq.mle$estimate@transitionMatrix, 30, c(0, 1, 0))
hcq_high <- predict(fit.hcq.mle$estimate@transitionMatrix, 30, c(0, 1, 0))
comb <- cbind(no_hcq_high, hcq_high)
colnames(comb) <- c('day', 'ICU no hcq', 'high dependent units no hcq', 'other hospital units or self-ca
                            'high dependent units', 'other hospital units or self-care')
comb <- comb %>% select('day', 'ICU no hcq', 'ICU', 'high dependent units no hcq', 'high dependent units

write.csv(comb, 'data/high.csv')
```

```
(sim_seq <- rmarkovchain(n = 30, object = sim_tran_matrix, t0 = 'ICU'))
```

```
##  [1] "ICU"                   "ICU"                   "ICU"
##  [4] "ICU"                   "ICU"                   "ICU"
##  [7] "ICU"                   "ICU"                   "ICU"
## [10] "high dependent units"  "high dependent units"  "high dependent units"
## [13] "high dependent units"  "ICU"                   "ICU"
## [16] "ICU"                   "ICU"                   "ICU"
## [19] "ICU"                   "ICU"                   "ICU"
## [22] "ICU"                   "ICU"                   "ICU"
## [25] "ICU"                   "ICU"                   "ICU"
## [28] "ICU"                   "ICU"                   "ICU"
```