Hw2

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```r
library(tidyverse)
```

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

## v ggplot2 3.3.3     v purrr   0.3.4
## v tibble  3.1.0     v dplyr   1.0.5
## v tidyr   1.1.3     v stringr 1.4.0
## v readr   1.4.0     v forcats 0.5.1

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

```r
library(eventtimedata)
library(survival)
```

Problem 1: The simulated trial has the following characteristics: - Participants will enter at a constant rate (i.e., uniform entry) beginning on January 1, 2021; enrollment will end 3 years later on December 31, 2023. Assume that enrollment time is measured in months. Assume that the entry times will be uniformly distributed over the enrollment period. Note that the dates are not as important as the length of the enrollment period. - Data collection will end and the data will be analyzed after 1 year of follow-up since the completion of enrollment. This is to ensure that the last patient enrolled will be followed for at least 1 year. - Assume that the trial will enroll a total of 200 participants. - Assume this is a simple trial with only one treatment (i.e., one group). - Assume that the failure time since entry follows an exponential distribution with rate lamda= 0.04. Assume that failure times are measured in months. - Assume that the only form of censoring will be administrative censoring; censoring will happen only for participants whose death has not been observed by the end of the data collection period.

The most efficient way to simulate the dataset is to, for each case, sample a uniformly distributed entry time and sample failure time from an exponential distribution, then use these to calculate the other items needed.

a) Compute the median survival time of the underlying (known) distribution (i.e., the exponential distribution with rate lamda = 0.04) S(t)= exp(-lamda*t) 0.5 = exp(-0.04*t) ln(0.5) = -0.04*t t= ln(0.5)/-0.04 t = 17.3

b) Run the simulation and check that the simulation behaves as expected by estimating the median survival time. Compare the estimated median survival time with the median survival time computed in (a).

ft is failure time et is enter time t is time in study

```r
set.seed(1234)

ft <- rexp(200, 0.04)
et <- runif(200, min = 0, max = 36)
t <- ft+et
c <- 48
x <- pmin(t, c)
survtime <- (x - et)

#coded 0 for death that hasn't been observed by end of study. 1 for else
death <- rep(1, length(t))
for (i in 1:length(t)){
  if (t[i] > 48){
   death[i] = 0
  }
}
```

```r
(simdat <- as.data.frame(cbind(et,x,death)))
```

```
##              et          x death
## 1   24.03237051 48.0000000     0
## 2   33.15298957 39.3219617     1
## 3    1.61962553  1.7841744     1
## 4    7.24077475 48.0000000     0
## 5   26.76653583 36.4461004     1
## 6    4.70004592  6.9487877     1
## 7   25.51980938 46.1218472     1
## 8   35.95794521 41.0233927     1
## 9   33.98086966 48.0000000     0
## 10  21.34454037 40.3552979     1
## 11  26.32664291 48.0000000     0
## 12  17.52243032 48.0000000     0
## 13  27.65347185 48.0000000     0
## 14   0.11323665 48.0000000     0
## 15  20.08588674 48.0000000     0
## 16  16.56919041 17.3623286     1
## 17  11.86974522 33.7937596     1
## 18  30.07712258 30.4424661     1
## 19  35.19725987 48.0000000     0
## 20  23.77853810 36.7620699     1
## 21   8.40869494 48.0000000     0
## 22  29.49121513 47.7008765     1
## 23  26.08865622 35.6771967     1
## 24  35.14885751 48.0000000     0
## 25   9.54406903 15.6350289     1
## 26  31.63752153 48.0000000     0
## 27  17.56401164 17.6638853     1
## 28  10.99685828 19.8515846     1
## 29  14.22349196 32.8306794     1
## 30  27.33622978 48.0000000     0
## 31   3.62885912 14.4924463     1
## 32  15.16894885 15.3962445     1
## 33  23.67951291 48.0000000     0
```

```
## 34  10.62950731 10.8261817      1
## 35   7.41551399 27.7706443      1
## 36   0.07728163  0.8026129      1
## 37   3.88233643 48.0000000      0
## 38   7.73521279 30.8733680      1
## 39   4.14553226  4.5729105      1
## 40  24.73773954 48.0000000      0
## 41   6.95780029 10.1862923      1
## 42  35.45718816 48.0000000      0
## 43  34.09336713 48.0000000      0
## 44  24.90145089 25.8609499      1
## 45  26.63610997 48.0000000      0
## 46  26.36785074 48.0000000      0
## 47  23.49354398 47.8866657      1
## 48   6.01366705 14.4384369      1
## 49  33.23451089 35.7058465      1
## 50  20.32577445 22.5392622      1
## 51  19.31384287 48.0000000      0
## 52   0.67837490  6.0653550      1
## 53  13.19038660 48.0000000      0
## 54  24.70472188 27.5881064      1
## 55  14.99863404 48.0000000      0
## 56  27.25294487 48.0000000      0
## 57  27.92861524 48.0000000      0
## 58  20.64913272 21.2283118      1
## 59   6.79315653 29.1417414      1
## 60  27.29755202 48.0000000      0
## 61   3.33659135 48.0000000      0
## 62  22.40490696 25.6587126      1
## 63  14.97287526 35.3273324      1
## 64  27.95439134 48.0000000      0
## 65  29.08090087 48.0000000      0
## 66  34.82266753 48.0000000      0
## 67   7.77251704 48.0000000      0
## 68  31.21232080 48.0000000      0
## 69  15.00904902 33.0073547      1
## 70  18.46903377 48.0000000      0
## 71  27.89774354 30.0086845      1
## 72   4.77155944  9.6089682      1
## 73  14.82867512 48.0000000      0
## 74  23.83371264 28.1926675      1
## 75  32.67791161 32.8406701      1
## 76  12.40169894 35.2486238      1
## 77   3.78875031 38.9327889      1
## 78  33.56445319 48.0000000      0
## 79   7.19759782 15.3038212      1
## 80   1.94465906  6.8318232      1
## 81  15.33024273 21.9173835      1
## 82  12.19664951 20.9086401      1
## 83   9.92164690 34.6889292      1
## 84  23.88565952 47.4004537      1
## 85  28.22025949 40.3002690      1
## 86  15.82910520 19.1274461      1
## 87  33.49165923 37.4529901      1
```

```
## 88   9.79945940 48.0000000      0
## 89  23.72504506 27.7914149      1
## 90  13.69041459 18.7852919      1
## 91  33.67406799 40.1827092      1
## 92  26.47803348 45.2793863      1
## 93  21.24325632 28.1081693      1
## 94  29.32748693 47.9162403      1
## 95  31.76671787 48.0000000      0
## 96  26.83588711 39.7003389      1
## 97  18.06449619 22.2780721      1
## 98  35.58605304 46.0280234      1
## 99  19.98964983 43.2719906      1
## 100 31.66926599 48.0000000      0
## 101 22.69581350 45.3266728      1
## 102 22.07575915 45.3798967      1
## 103  1.20993479 48.0000000      0
## 104  9.16922468  9.5540396      1
## 105 27.93487684 34.5569993      1
## 106 35.93682003 48.0000000      0
## 107 34.56426246 46.6927308      1
## 108 27.03343729 33.9790030      1
## 109 24.49813900 26.7208851      1
## 110  8.88791235 24.9804713      1
## 111 21.83626717 38.5714003      1
## 112 20.66294029 32.2995513      1
## 113  1.78541670 10.9411870      1
## 114 13.42152522 37.4995869      1
## 115 32.21164976 45.6044232      1
## 116 14.10378284 15.4192075      1
## 117 18.61002974 30.2251240      1
## 118  6.31008275 29.4053363      1
## 119  6.93379669 39.6798013      1
## 120 19.67431305 48.0000000      0
## 121 14.15235020 17.3591215      1
## 122 22.50710988 35.4101797      1
## 123 20.59937181 23.9384359      1
## 124  5.06228654 16.1299983      1
## 125 10.41378009 35.0608925      1
## 126  0.02203761 48.0000000      0
## 127 34.39309382 48.0000000      0
## 128 14.37875820 40.1919112      1
## 129 35.17392763 48.0000000      0
## 130 18.42387116 41.5949712      1
## 131 16.81780279 31.6704480      1
## 132 26.05807777 29.4060225      1
## 133  5.11464791 48.0000000      0
## 134 18.84880005 48.0000000      0
## 135 20.17516033 41.7390212      1
## 136 23.77234101 48.0000000      0
## 137 13.40156527 40.6823297      1
## 138  4.90147175 14.1186845      1
## 139  2.65971334  7.4909014      1
## 140 27.41443848 46.1317654      1
## 141 25.30061687 45.5835673      1
```

```
## 142 27.50022942 48.0000000      0
## 143  5.65402530  8.8080926      1
## 144 21.57640583 40.1406536      1
## 145 27.48030432 48.0000000      0
## 146 32.85550758 37.3313348      1
## 147 11.08875059 12.0913088      1
## 148 23.65437151 40.8861083      1
## 149 12.16096664 48.0000000      0
## 150 21.75301375 48.0000000      0
## 151  3.02238068 48.0000000      0
## 152 21.80402048 48.0000000      0
## 153 21.45279695 33.8339863      1
## 154 24.08108938 48.0000000      0
## 155 28.83755866 41.7854685      1
## 156 30.79641187 48.0000000      0
## 157  1.80503676 16.7781722      1
## 158 24.27962707 48.0000000      0
## 159 30.45215874 30.7700862      1
## 160 26.87033943 42.9317718      1
## 161 29.86431854 32.1021474      1
## 162  4.60440453 23.6015295      1
## 163 28.58790377 48.0000000      0
## 164 12.79821288 42.0444877      1
## 165 34.13094017 48.0000000      0
## 166 33.48569181 45.3772684      1
## 167 21.32800377 41.7339457      1
## 168  3.97779351 26.2891207      1
## 169 28.21807684 44.2558918      1
## 170 21.66562587 29.4233025      1
## 171  3.17787912 36.8570264      1
## 172 23.66144192 27.8742078      1
## 173 11.95491373 24.8524872      1
## 174 30.07508515 39.7584532      1
## 175  8.91983974 48.0000000      0
## 176 13.08927322 40.7178029      1
## 177 33.28735081 40.9818713      1
## 178 20.26864828 40.9006213      1
## 179 29.04715287 31.4699253      1
## 180  1.40143466 14.8422230      1
## 181  1.43371575  8.4908451      1
## 182 22.77154688 48.0000000      0
## 183  8.60712383 47.4810409      1
## 184  9.09090008 48.0000000      0
## 185 22.48648200 48.0000000      0
## 186 14.60483284 47.7749524      1
## 187 28.74503063 48.0000000      0
## 188  4.22866588 20.9558083      1
## 189 35.80190213 48.0000000      0
## 190 23.39486382 26.0505492      1
## 191 23.60199353 48.0000000      0
## 192 26.90926645 48.0000000      0
## 193 18.51383565 39.0714877      1
## 194 13.69188419 26.4092992      1
## 195 22.00709773 25.3844840      1
```

```
## 196 34.77601156 48.0000000     0
## 197  7.77091202 37.5161773     1
## 198 26.95497707 48.0000000     0
## 199 15.56552285 20.2815722     1
## 200 29.82946460 30.4222724     1
```

```r
KM <- survfit(Surv(survtime, death) ~ 1, data = simdat)

KM
```

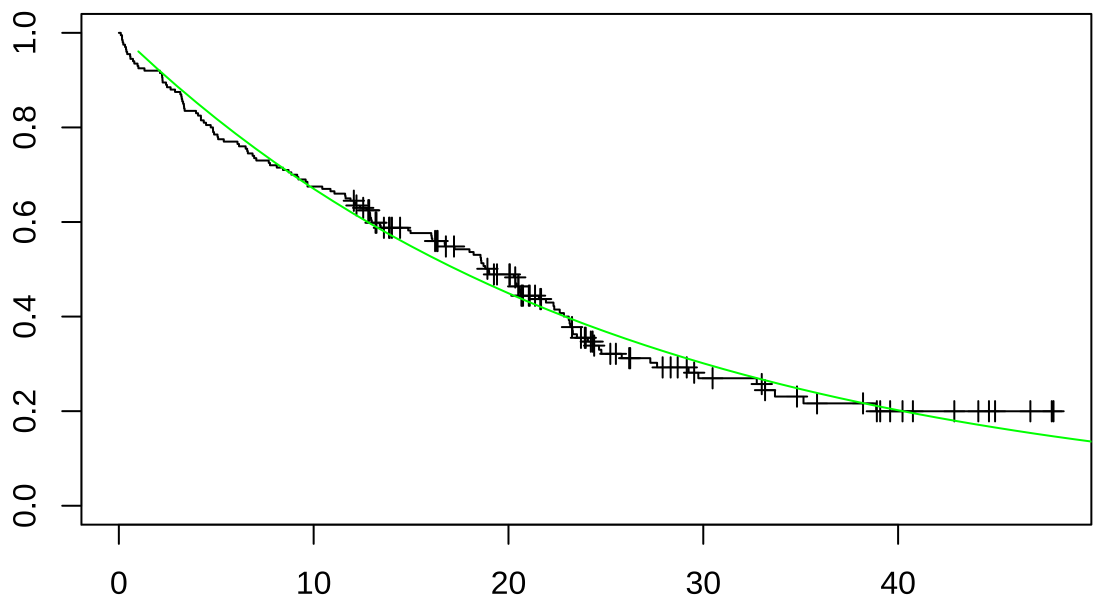
```
## Call: survfit(formula = Surv(survtime, death) ~ 1, data = simdat)
##
##       n  events  median 0.95LCL 0.95UCL
##   200.0   132.0    19.0    16.1    22.3
```

The median survival time is 19 months for my simulation. There is a 2 month difference between my simulation and the median survival time calculated in part a.

c) Use the nonparametric estimation method (e.g., the Kaplan–Meier estimator) to plot the survival curve. Since the parameters of the survival distribution in the simulation are known, we can do a graphical comparison with the underlying distribution. Add the (known) survival distribution to the figure. Comment on the appearance of the survival curves.

```r
KM <- survfit(Surv(survtime, death) ~ 1, data = simdat)

r <- seq(from = 1, to = 200)
exp <- exp(-0.04*r)
plot(KM, mark.time = TRUE, conf.int = FALSE, xlim=c(0,48))
lines(exp, col="green")
```



ANS: The two curves are very similar in appearance. The expoential function seems to be a good fit for the simulation data.

Problem 2: Installing packages:

```
#install.packages("devtools")
#library(devtools)
#install.packages(c("survival", "km.ci", "KMsurv", "gsDesign", "Hmisc"))
#devtools::install_github("dave-harrington/eventtimedata")
```

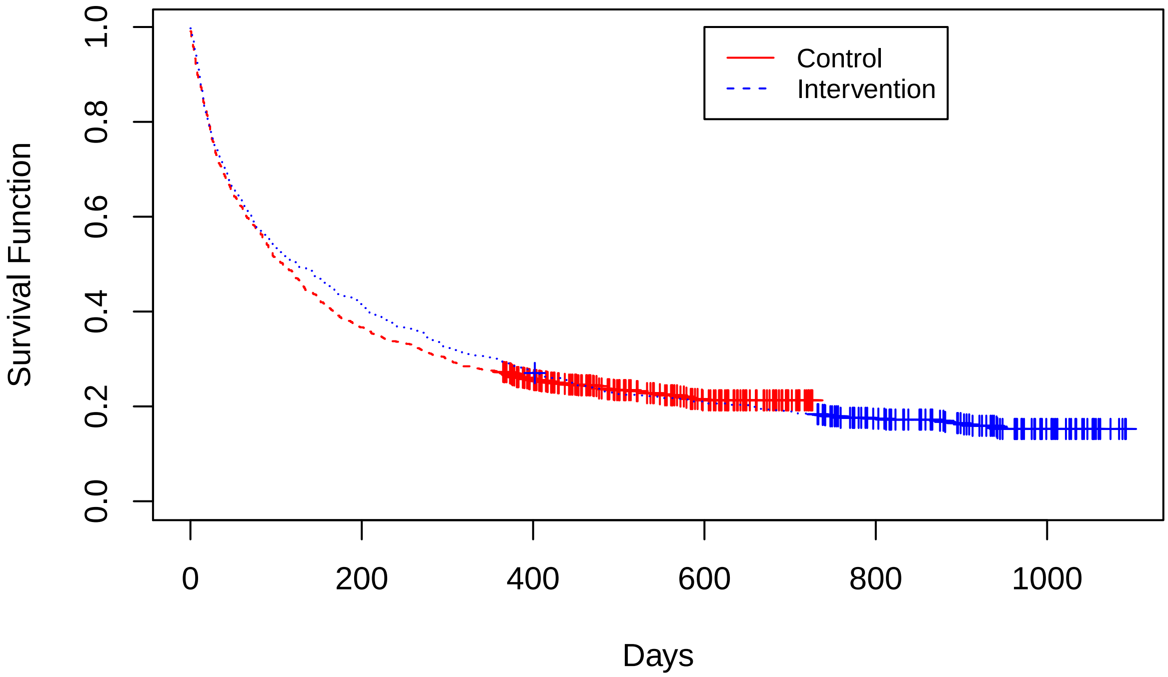
Loading Data

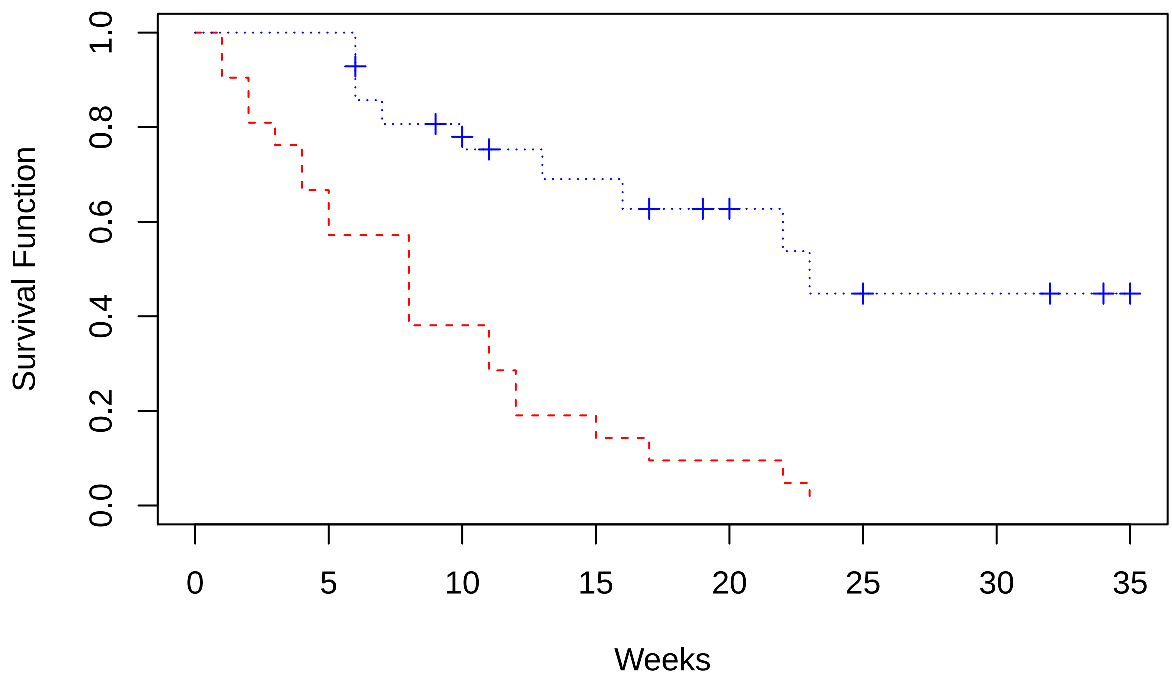
```
data(nursing.home)
```

(a) Using the Kaplan–Meier estimator, provide a graph of the estimated survival function for length of stay for each of the two groups defined by the intervention variable rx. Length of stay is the variable stay, and the indicator for discharge is the numeric variable cens.

```
KM2 <- survfit(Surv(stay, cens) ~ rx, data = nursing.home)

plot(KM2, lty = 2:3, mark.time = TRUE, xlab = "Days", ylab = "Survival Function", col=c("red", "blue"))
legend(x = 600, y = 1, legend=c("Control", "Intervention"), col=c("red", "blue"), lty=1:2, cex=0.8)
```


Control
Intervention
Survival Function
0.0
0.2
0.4
0.6
0.8
1.0
0
200
400
600
800
1000
Days



b) Comment on the appearance of the survival curves produced in (a). Why are the length of the two curves different?

ANS: The length of the two curves are different because the last person in the intervention group left the nursing home whereas the last person in the control group stayed until the end of the study duration.

c) Estimate the median survival time for each group. Compare them based on their 95% confidence intervals.

```
KM2
```

```
## Call: survfit(formula = Surv(stay, cens) ~ rx, data = nursing.home)
##
##                    n events median 0.95LCL 0.95UCL
## rx=Control       889    684    108      92     127
## rx=Intervention 712    595    123     100     156
```

ANS: The summary above shows the median survival time (number of days stayed) for the Control group is 108 days and is 123 for the Intervention group. 95% of the time, the true median survival time for the control group will lie between 92 and 127 days and 95% of the time, the true median survival time for the intervention group will lie between 100 and 156 days. The interval is wider for the Intervention group than the Control group, however they both overlap in containing values ranging from 100-127 days. Since the two confidence intervals overlap, they can be said to not show a significant difference between the two groups.

d) Estimate the survival rate at time = 100 days and the 95% confidence intervals for each group. Compare the estimated survival rates based on their 95% confidence intervals.

```r
KM2sum <- summary(KM2)


(est.surv = summary(KM2, time = 100))
```

```
## Call: survfit(formula = Surv(stay, cens) ~ rx, data = nursing.home)
##
##                 rx=Control
##         time       n.risk      n.event     survival      std.err lower 95% CI
##     100.0000     458.0000     436.0000       0.5096       0.0168       0.4777
## upper 95% CI
##       0.5435
##
##                 rx=Intervention
##         time       n.risk      n.event     survival      std.err lower 95% CI
##     100.0000     382.0000     332.0000       0.5337       0.0187       0.4983
## upper 95% CI
##       0.5716
```

When t = 100, the estimated survival function for the control is 0.510 and the confidence interval is between (0.478, 0.544). The interval (0.478, 0.544) will contain the true survival rate at 100 days with 95% confidence for the control group. when t = 100, the estimated survival function for the intervention group is 0.534 and the confidence interval is between. The interval (0.498, 0.572) will contain the true survival rate at 100 days with 95% confidence for the intervention group. Both intervals contain overlapping values of 0.498 to 0.544; this indicates the two groups are likely not significantly different.

```
## Call: survfit(formula = Surv(stay, cens) ~ 1, data = intervention.dat)
##
##       n  events  median 0.95LCL 0.95UCL
##     712     595     123     100     156
```

```
## Call: survfit(formula = Surv(stay, cens) ~ 1, data = intervention.dat)
##
##  time n.risk n.event survival std.err lower 95% CI upper 95% CI
##     0    712       2    0.997 0.00198        0.993        1.000
##     1    710       7    0.987 0.00419        0.979        0.996
##     2    703       7    0.978 0.00555        0.967        0.988
##     3    696       5    0.971 0.00634        0.958        0.983
##     4    691       8    0.959 0.00741        0.945        0.974
##     5    683       9    0.947 0.00842        0.930        0.963
##     6    674       5    0.940 0.00893        0.922        0.957
##     7    669       6    0.931 0.00949        0.913        0.950
##     8    663       5    0.924 0.00992        0.905        0.944
##     9    658      10    0.910 0.01072        0.889        0.931
##    10    648       7    0.900 0.01123        0.879        0.923
##    11    641       9    0.888 0.01184        0.865        0.911
##    12    632       8    0.876 0.01233        0.853        0.901
##    13    624       4    0.871 0.01257        0.846        0.896
##    14    620      10    0.857 0.01313        0.831        0.883
##    15    610       9    0.844 0.01359        0.818        0.871
```

```
##    16    601        8    0.833 0.01398         0.806         0.861
##    17    593        7    0.823 0.01430         0.795         0.852
##    18    586        6    0.815 0.01456         0.787         0.844
##    19    580        4    0.809 0.01473         0.781         0.838
##    20    576        2    0.806 0.01481         0.778         0.836
##    21    574        7    0.796 0.01509         0.767         0.826
##    22    567        6    0.788 0.01532         0.758         0.819
##    23    561        5    0.781 0.01550         0.751         0.812
##    24    556        6    0.772 0.01571         0.742         0.804
##    25    550        5    0.765 0.01588         0.735         0.797
##    26    545        3    0.761 0.01598         0.731         0.793
##    27    542        6    0.753 0.01617         0.722         0.785
##    28    536        2    0.750 0.01623         0.719         0.782
##    29    534        4    0.744 0.01635         0.713         0.777
##    30    530        3    0.740 0.01644         0.709         0.773
##    32    527        3    0.736 0.01652         0.704         0.769
##    33    524        5    0.729 0.01666         0.697         0.762
##    34    519        3    0.725 0.01674         0.693         0.758
##    35    516        4    0.719 0.01684         0.687         0.753
##    37    512        6    0.711 0.01699         0.678         0.745
##    38    506        1    0.709 0.01702         0.677         0.743
##    39    505        3    0.705 0.01709         0.672         0.739
##    40    502        3    0.701 0.01716         0.668         0.735
##    41    499        4    0.695 0.01725         0.662         0.730
##    42    495        2    0.692 0.01730         0.659         0.727
##    43    493        4    0.687 0.01738         0.654         0.722
##    44    489        4    0.681 0.01746         0.648         0.716
##    45    485        3    0.677 0.01753         0.643         0.712
##    46    482        3    0.673 0.01758         0.639         0.708
##    47    479        2    0.670 0.01762         0.636         0.705
##    48    477        4    0.664 0.01770         0.631         0.700
##    49    473        2    0.662 0.01773         0.628         0.697
##    51    471        4    0.656 0.01780         0.622         0.692
##    52    467        2    0.653 0.01784         0.619         0.689
##    54    465        1    0.652 0.01786         0.618         0.688
##    55    464        2    0.649 0.01789         0.615         0.685
##    56    462        3    0.645 0.01794         0.610         0.681
##    57    459        2    0.642 0.01797         0.608         0.678
##    58    457        1    0.640 0.01798         0.606         0.677
##    59    456        3    0.636 0.01803         0.602         0.673
##    60    453        2    0.633 0.01806         0.599         0.670
##    61    451        4    0.628 0.01812         0.593         0.664
##    62    447        3    0.624 0.01816         0.589         0.660
##    63    444        4    0.618 0.01821         0.583         0.655
##    65    440        2    0.615 0.01823         0.580         0.652
##    66    438        2    0.612 0.01826         0.578         0.649
##    67    436        1    0.611 0.01827         0.576         0.648
##    68    435        1    0.610 0.01828         0.575         0.646
##    69    434        3    0.605 0.01832         0.570         0.642
##    70    431        1    0.604 0.01833         0.569         0.641
##    71    430        7    0.594 0.01840         0.559         0.631
##    72    423        1    0.593 0.01841         0.558         0.630
##    73    422        2    0.590 0.01843         0.555         0.627
##    74    420        4    0.584 0.01847         0.549         0.622
```

```
##    75    416          1     0.583 0.01848          0.548          0.620
##    76    415          2     0.580 0.01850          0.545          0.617
##    77    413          2     0.577 0.01851          0.542          0.615
##    78    411          1     0.576 0.01852          0.541          0.613
##    80    410          2     0.573 0.01854          0.538          0.611
##    81    408          2     0.570 0.01855          0.535          0.608
##    83    406          3     0.566 0.01857          0.531          0.604
##    86    403          3     0.562 0.01859          0.527          0.599
##    89    400          2     0.559 0.01861          0.524          0.597
##    90    398          1     0.558 0.01861          0.522          0.595
##    91    397          1     0.556 0.01862          0.521          0.594
##    92    396          4     0.551 0.01864          0.515          0.588
##    93    392          1     0.549 0.01865          0.514          0.587
##    94    391          1     0.548 0.01865          0.512          0.586
##    95    390          3     0.544 0.01867          0.508          0.581
##    96    387          1     0.542 0.01867          0.507          0.580
##    98    386          3     0.538 0.01868          0.503          0.576
##    99    383          1     0.537 0.01869          0.501          0.574
##   100    382          2     0.534 0.01870          0.498          0.572
##   101    380          1     0.532 0.01870          0.497          0.570
##   102    379          2     0.529 0.01871          0.494          0.567
##   104    377          1     0.528 0.01871          0.493          0.566
##   105    376          2     0.525 0.01871          0.490          0.563
##   106    374          2     0.522 0.01872          0.487          0.560
##   108    372          3     0.518 0.01873          0.483          0.556
##   109    369          1     0.517 0.01873          0.481          0.555
##   111    368          1     0.515 0.01873          0.480          0.553
##   113    367          1     0.514 0.01873          0.479          0.552
##   115    366          2     0.511 0.01873          0.476          0.549
##   116    364          2     0.508 0.01874          0.473          0.547
##   118    362          1     0.507 0.01874          0.472          0.545
##   119    361          1     0.506 0.01874          0.470          0.544
##   120    360          1     0.504 0.01874          0.469          0.542
##   123    359          4     0.499 0.01874          0.463          0.537
##   125    355          1     0.497 0.01874          0.462          0.535
##   126    354          2     0.494 0.01874          0.459          0.533
##   127    352          1     0.493 0.01874          0.458          0.531
##   130    351          1     0.492 0.01874          0.456          0.530
##   135    350          1     0.490 0.01873          0.455          0.528
##   137    349          1     0.489 0.01873          0.453          0.527
##   138    348          1     0.487 0.01873          0.452          0.525
##   139    347          1     0.486 0.01873          0.451          0.524
##   142    346          1     0.485 0.01873          0.449          0.523
##   143    345          2     0.482 0.01873          0.446          0.520
##   144    343          5     0.475 0.01871          0.439          0.513
##   146    338          2     0.472 0.01871          0.437          0.510
##   147    336          1     0.471 0.01871          0.435          0.509
##   148    335          1     0.469 0.01870          0.434          0.507
##   153    334          3     0.465 0.01869          0.430          0.503
##   155    331          1     0.463 0.01869          0.428          0.502
##   156    330          2     0.461 0.01868          0.425          0.499
##   159    328          2     0.458 0.01867          0.423          0.496
##   161    326          1     0.456 0.01867          0.421          0.495
##   162    325          2     0.454 0.01866          0.419          0.492
```

```
##   164    323        3   0.449 0.01864         0.414         0.488
##   165    320        1   0.448 0.01864         0.413         0.486
##   167    319        1   0.447 0.01863         0.412         0.485
##   168    318        2   0.444 0.01862         0.409         0.482
##   169    316        1   0.442 0.01861         0.407         0.480
##   170    315        1   0.441 0.01861         0.406         0.479
##   171    314        1   0.440 0.01860         0.405         0.478
##   172    313        2   0.437 0.01859         0.402         0.475
##   175    311        1   0.435 0.01858         0.400         0.473
##   178    310        2   0.433 0.01857         0.398         0.471
##   184    308        1   0.431 0.01856         0.396         0.469
##   185    307        1   0.430 0.01855         0.395         0.468
##   189    306        1   0.428 0.01855         0.394         0.466
##   190    305        1   0.427 0.01854         0.392         0.465
##   192    304        1   0.426 0.01853         0.391         0.463
##   193    303        1   0.424 0.01852         0.389         0.462
##   195    302        3   0.420 0.01850         0.385         0.458
##   198    299        2   0.417 0.01848         0.382         0.455
##   199    297        1   0.416 0.01847         0.381         0.454
##   201    296        2   0.413 0.01845         0.378         0.451
##   202    294        2   0.410 0.01843         0.376         0.448
##   203    292        2   0.407 0.01841         0.373         0.445
##   205    290        1   0.406 0.01840         0.371         0.444
##   206    289        1   0.404 0.01839         0.370         0.442
##   207    288        2   0.402 0.01837         0.367         0.439
##   208    286        2   0.399 0.01835         0.364         0.437
##   209    284        2   0.396 0.01833         0.362         0.434
##   214    282        1   0.395 0.01832         0.360         0.432
##   215    281        1   0.393 0.01831         0.359         0.431
##   216    280        1   0.392 0.01829         0.358         0.429
##   218    279        1   0.390 0.01828         0.356         0.428
##   222    278        1   0.389 0.01827         0.355         0.427
##   223    277        2   0.386 0.01825         0.352         0.424
##   224    275        2   0.383 0.01822         0.349         0.421
##   227    273        1   0.382 0.01821         0.348         0.419
##   230    272        1   0.381 0.01820         0.347         0.418
##   232    271        1   0.379 0.01818         0.345         0.417
##   233    270        1   0.378 0.01817         0.344         0.415
##   234    269        1   0.376 0.01816         0.342         0.414
##   237    268        2   0.374 0.01813         0.340         0.411
##   238    266        1   0.372 0.01812         0.338         0.409
##   240    265        1   0.371 0.01810         0.337         0.408
##   241    264        2   0.368 0.01807         0.334         0.405
##   243    262        1   0.367 0.01806         0.333         0.404
##   250    261        1   0.365 0.01804         0.331         0.402
##   253    260        1   0.364 0.01803         0.330         0.401
##   261    259        1   0.362 0.01801         0.329         0.399
##   262    258        1   0.361 0.01800         0.327         0.398
##   263    257        1   0.360 0.01798         0.326         0.397
##   265    256        1   0.358 0.01797         0.325         0.395
##   269    255        1   0.357 0.01795         0.323         0.394
##   271    254        1   0.355 0.01794         0.322         0.392
##   273    253        2   0.353 0.01790         0.319         0.389
##   274    251        4   0.347 0.01784         0.314         0.384
```

```
##   275   247   1   0.346 0.01782   0.312   0.382
##   277   246   2   0.343 0.01779   0.310   0.379
##   278   244   1   0.341 0.01777   0.308   0.378
##   279   243   1   0.340 0.01775   0.307   0.377
##   283   242   1   0.338 0.01773   0.305   0.375
##   288   241   1   0.337 0.01772   0.304   0.374
##   290   240   1   0.336 0.01770   0.303   0.372
##   291   239   3   0.331 0.01764   0.299   0.368
##   293   236   2   0.329 0.01760   0.296   0.365
##   294   234   1   0.327 0.01758   0.295   0.364
##   295   233   1   0.326 0.01756   0.293   0.362
##   296   232   1   0.324 0.01755   0.292   0.361
##   301   231   1   0.323 0.01753   0.290   0.359
##   305   230   1   0.322 0.01751   0.289   0.358
##   306   229   1   0.320 0.01749   0.288   0.356
##   309   228   1   0.319 0.01746   0.286   0.355
##   310   227   1   0.317 0.01744   0.285   0.354
##   312   226   1   0.316 0.01742   0.284   0.352
##   314   225   1   0.315 0.01740   0.282   0.351
##   317   224   1   0.313 0.01738   0.281   0.349
##   318   223   1   0.312 0.01736   0.280   0.348
##   322   222   1   0.310 0.01734   0.278   0.346
##   328   221   1   0.309 0.01732   0.277   0.345
##   330   220   1   0.308 0.01730   0.275   0.343
##   335   219   1   0.306 0.01727   0.274   0.342
##   344   218   2   0.303 0.01723   0.271   0.339
##   350   216   1   0.302 0.01721   0.270   0.338
##   352   215   1   0.301 0.01718   0.269   0.336
##   358   214   1   0.299 0.01716   0.267   0.335
##   360   213   1   0.298 0.01714   0.266   0.333
##   362   212   1   0.296 0.01711   0.265   0.332
##   363   211   1   0.295 0.01709   0.263   0.330
##   364   210   1   0.294 0.01707   0.262   0.329
##   366   209   1   0.292 0.01704   0.261   0.328
##   369   208   1   0.291 0.01702   0.259   0.326
##   372   207   1   0.289 0.01699   0.258   0.325
##   374   206   1   0.288 0.01697   0.257   0.323
##   377   205   2   0.285 0.01692   0.254   0.320
##   381   203   1   0.284 0.01689   0.252   0.319
##   384   202   1   0.282 0.01687   0.251   0.317
##   386   201   1   0.281 0.01684   0.250   0.316
##   389   200   1   0.279 0.01682   0.248   0.314
##   393   199   1   0.278 0.01679   0.247   0.313
##   394   198   1   0.277 0.01677   0.246   0.312
##   397   197   3   0.272 0.01669   0.242   0.307
##   399   194   1   0.271 0.01666   0.240   0.306
##   402   193   1   0.270 0.01663   0.239   0.304
##   403   191   1   0.268 0.01660   0.238   0.303
##   410   190   1   0.267 0.01658   0.236   0.301
##   411   189   1   0.265 0.01655   0.235   0.300
##   412   188   1   0.264 0.01652   0.234   0.298
##   413   187   1   0.263 0.01649   0.232   0.297
##   418   186   1   0.261 0.01646   0.231   0.296
##   422   185   1   0.260 0.01644   0.229   0.294
```

```
##    433    184       1    0.258 0.01641        0.228        0.293
##    434    183       1    0.257 0.01638        0.227        0.291
##    439    182       3    0.253 0.01629        0.223        0.287
##    444    179       2    0.250 0.01623        0.220        0.284
##    448    177       1    0.248 0.01620        0.219        0.282
##    449    176       1    0.247 0.01617        0.217        0.281
##    450    175       1    0.246 0.01614        0.216        0.279
##    452    174       1    0.244 0.01611        0.215        0.278
##    461    173       1    0.243 0.01608        0.213        0.276
##    465    172       1    0.241 0.01604        0.212        0.275
##    466    171       1    0.240 0.01601        0.211        0.274
##    470    170       1    0.239 0.01598        0.209        0.272
##    472    169       1    0.237 0.01595        0.208        0.271
##    478    168       2    0.234 0.01588        0.205        0.268
##    481    166       2    0.232 0.01582        0.203        0.265
##    492    164       2    0.229 0.01575        0.200        0.262
##    497    162       2    0.226 0.01568        0.197        0.259
##    505    160       1    0.224 0.01565        0.196        0.257
##    525    159       1    0.223 0.01561        0.194        0.256
##    530    158       1    0.222 0.01558        0.193        0.254
##    545    157       1    0.220 0.01554        0.192        0.253
##    549    156       1    0.219 0.01550        0.190        0.251
##    553    155       1    0.217 0.01547        0.189        0.250
##    570    154       1    0.216 0.01543        0.188        0.248
##    574    153       1    0.215 0.01540        0.186        0.247
##    584    152       1    0.213 0.01536        0.185        0.246
##    585    151       1    0.212 0.01532        0.184        0.244
##    586    150       1    0.210 0.01529        0.182        0.243
##    599    149       2    0.208 0.01521        0.180        0.240
##    602    147       1    0.206 0.01517        0.178        0.238
##    625    146       1    0.205 0.01513        0.177        0.237
##    628    145       1    0.203 0.01509        0.176        0.235
##    651    144       1    0.202 0.01506        0.174        0.234
##    653    143       1    0.200 0.01502        0.173        0.232
##    654    142       1    0.199 0.01498        0.172        0.231
##    663    141       1    0.198 0.01494        0.170        0.229
##    664    140       1    0.196 0.01490        0.169        0.228
##    665    139       1    0.195 0.01486        0.168        0.226
##    674    138       1    0.193 0.01482        0.166        0.225
##    679    137       1    0.192 0.01478        0.165        0.223
##    686    136       1    0.191 0.01473        0.164        0.222
##    697    135       1    0.189 0.01469        0.162        0.220
##    708    134       1    0.188 0.01465        0.161        0.219
##    709    133       2    0.185 0.01457        0.158        0.216
##    726    131       1    0.184 0.01452        0.157        0.214
##    736    127       1    0.182 0.01448        0.156        0.213
##    741    124       1    0.181 0.01444        0.154        0.211
##    743    121       1    0.179 0.01439        0.153        0.210
##    757    111       1    0.178 0.01436        0.152        0.208
##    758    110       1    0.176 0.01432        0.150        0.206
##    792     96       1    0.174 0.01428        0.148        0.204
##    811     91       1    0.172 0.01425        0.146        0.202
##    870     72       1    0.170 0.01425        0.144        0.200
##    881     67       2    0.165 0.01427        0.139        0.195
```

```
##   900     61       1    0.162 0.01429        0.136        0.193
##   911     56       1    0.159 0.01433        0.133        0.190
##   941     48       1    0.156 0.01441        0.130        0.187
##   942     46       1    0.152 0.01449        0.127        0.184

## Call: survfit(formula = Surv(stay, cens) ~ 1, data = control.dat)
##
##       n  events  median 0.95LCL 0.95UCL
##     889     684     108      92     127

## Call: survfit(formula = Surv(stay, cens) ~ 1, data = control.dat)
##
##  time n.risk n.event survival std.err lower 95% CI upper 95% CI
##     0    889       8    0.991 0.00317        0.985        0.997
##     1    881      15    0.974 0.00532        0.964        0.985
##     2    866      10    0.963 0.00634        0.951        0.975
##     3    856       4    0.958 0.00670        0.945        0.972
##     4    852       9    0.948 0.00743        0.934        0.963
##     5    843      13    0.934 0.00835        0.917        0.950
##     6    830      10    0.922 0.00897        0.905        0.940
##     7    820      12    0.909 0.00965        0.890        0.928
##     8    808       9    0.899 0.01012        0.879        0.919
##     9    799       6    0.892 0.01041        0.872        0.913
##    10    793       5    0.886 0.01064        0.866        0.907
##    11    788       7    0.879 0.01096        0.857        0.900
##    12    781       5    0.873 0.01117        0.851        0.895
##    13    776      13    0.858 0.01170        0.836        0.882
##    14    763       8    0.849 0.01200        0.826        0.873
##    15    755       7    0.841 0.01225        0.818        0.866
##    16    748       4    0.837 0.01239        0.813        0.862
##    17    744       6    0.830 0.01259        0.806        0.855
##    18    738       7    0.822 0.01282        0.798        0.848
##    19    731       7    0.814 0.01304        0.789        0.840
##    20    724       9    0.804 0.01331        0.779        0.831
##    21    715       6    0.798 0.01348        0.772        0.824
##    22    709       6    0.791 0.01364        0.764        0.818
##    23    703       8    0.782 0.01385        0.755        0.809
##    24    695       5    0.776 0.01398        0.749        0.804
##    25    690      12    0.763 0.01427        0.735        0.791
##    26    678       4    0.758 0.01436        0.731        0.787
##    27    674       7    0.750 0.01452        0.722        0.779
##    28    667       5    0.745 0.01462        0.717        0.774
##    29    662       9    0.735 0.01481        0.706        0.764
##    30    653       4    0.730 0.01489        0.701        0.760
##    31    649       5    0.724 0.01499        0.696        0.754
##    32    644       7    0.717 0.01512        0.688        0.747
##    33    637       3    0.713 0.01517        0.684        0.744
##    34    634       3    0.710 0.01522        0.681        0.740
##    35    631       3    0.706 0.01527        0.677        0.737
##    36    628       1    0.705 0.01529        0.676        0.736
##    37    627       3    0.702 0.01534        0.672        0.733
##    38    624       5    0.696 0.01542        0.667        0.727
##    39    619       6    0.690 0.01552        0.660        0.721
##    40    613       4    0.685 0.01558        0.655        0.716
```

```
##    41    609       3    0.682 0.01562        0.652        0.713
##    42    606       2    0.679 0.01565        0.649        0.711
##    43    604       2    0.677 0.01568        0.647        0.709
##    44    602       6    0.670 0.01577        0.640        0.702
##    45    596       3    0.667 0.01581        0.637        0.699
##    46    593       4    0.663 0.01586        0.632        0.694
##    47    589       7    0.655 0.01595        0.624        0.687
##    48    582       4    0.650 0.01600        0.620        0.682
##    49    578       2    0.648 0.01602        0.617        0.680
##    50    576       2    0.646 0.01604        0.615        0.678
##    51    574       3    0.642 0.01608        0.612        0.675
##    53    571       3    0.639 0.01611        0.608        0.671
##    54    568       6    0.632 0.01617        0.601        0.665
##    55    562       2    0.630 0.01619        0.599        0.662
##    56    560       3    0.627 0.01622        0.596        0.659
##    57    557       3    0.623 0.01625        0.592        0.656
##    59    554       1    0.622 0.01626        0.591        0.655
##    60    553       2    0.620 0.01628        0.589        0.653
##    61    551       5    0.614 0.01633        0.583        0.647
##    62    546       5    0.609 0.01637        0.577        0.641
##    63    541       2    0.606 0.01639        0.575        0.639
##    64    539       3    0.603 0.01641        0.572        0.636
##    65    536       2    0.601 0.01643        0.569        0.634
##    66    534       3    0.597 0.01645        0.566        0.630
##    68    531       2    0.595 0.01646        0.564        0.628
##    69    529       3    0.592 0.01649        0.560        0.625
##    70    526       1    0.591 0.01649        0.559        0.624
##    71    525       2    0.588 0.01651        0.557        0.622
##    72    523       4    0.584 0.01653        0.552        0.617
##    73    519       1    0.583 0.01654        0.551        0.616
##    74    518       1    0.582 0.01654        0.550        0.615
##    75    517       2    0.579 0.01656        0.548        0.613
##    76    515       4    0.575 0.01658        0.543        0.608
##    77    511       1    0.574 0.01659        0.542        0.607
##    78    510       2    0.571 0.01660        0.540        0.605
##    80    508       2    0.569 0.01661        0.538        0.603
##    81    506       2    0.567 0.01662        0.535        0.600
##    82    504       4    0.562 0.01664        0.531        0.596
##    84    500       7    0.555 0.01667        0.523        0.588
##    85    493       4    0.550 0.01669        0.518        0.584
##    86    489       1    0.549 0.01669        0.517        0.583
##    88    488       2    0.547 0.01670        0.515        0.580
##    89    486       5    0.541 0.01671        0.509        0.575
##    90    481       1    0.540 0.01672        0.508        0.574
##    91    480       7    0.532 0.01673        0.500        0.566
##    92    473       2    0.530 0.01674        0.498        0.564
##    94    471       3    0.526 0.01675        0.495        0.560
##    95    468       1    0.525 0.01675        0.493        0.559
##    96    467       7    0.517 0.01676        0.486        0.551
##    97    460       2    0.515 0.01676        0.483        0.549
##   100    458       5    0.510 0.01677        0.478        0.544
##   102    453       1    0.508 0.01677        0.477        0.542
##   103    452       3    0.505 0.01677        0.473        0.539
##   105    449       2    0.503 0.01677        0.471        0.537
```

```
##    107    447          1     0.502 0.01677          0.470          0.536
##    108    446          3     0.498 0.01677          0.467          0.532
##    109    443          1     0.497 0.01677          0.465          0.531
##    110    442          2     0.495 0.01677          0.463          0.529
##    111    440          1     0.494 0.01677          0.462          0.528
##    112    439          1     0.493 0.01677          0.461          0.527
##    113    438          1     0.492 0.01677          0.460          0.526
##    114    437          2     0.489 0.01677          0.458          0.523
##    115    435          2     0.487 0.01676          0.455          0.521
##    118    433          2     0.485 0.01676          0.453          0.519
##    119    431          2     0.483 0.01676          0.451          0.517
##    120    429          3     0.479 0.01675          0.447          0.513
##    121    426          2     0.477 0.01675          0.445          0.511
##    122    424          5     0.471 0.01674          0.440          0.505
##    123    419          1     0.470 0.01674          0.439          0.504
##    125    418          1     0.469 0.01674          0.437          0.503
##    126    417          2     0.467 0.01673          0.435          0.501
##    127    415          1     0.466 0.01673          0.434          0.500
##    128    414          3     0.462 0.01672          0.431          0.496
##    129    411          2     0.460 0.01672          0.428          0.494
##    130    409          2     0.458 0.01671          0.426          0.492
##    131    407          3     0.454 0.01670          0.423          0.488
##    132    404          2     0.452 0.01669          0.421          0.486
##    133    402          3     0.449 0.01668          0.417          0.483
##    134    399          3     0.445 0.01667          0.414          0.479
##    137    396          1     0.444 0.01667          0.413          0.478
##    139    395          2     0.442 0.01666          0.411          0.476
##    140    393          1     0.441 0.01665          0.409          0.475
##    141    392          1     0.440 0.01665          0.408          0.474
##    143    391          2     0.438 0.01664          0.406          0.471
##    144    389          1     0.436 0.01663          0.405          0.470
##    146    388          1     0.435 0.01663          0.404          0.469
##    147    387          2     0.433 0.01662          0.402          0.467
##    148    385          4     0.429 0.01660          0.397          0.462
##    149    381          3     0.425 0.01658          0.394          0.459
##    150    378          1     0.424 0.01657          0.393          0.458
##    151    377          2     0.422 0.01656          0.391          0.456
##    152    375          2     0.420 0.01655          0.388          0.453
##    155    373          2     0.417 0.01654          0.386          0.451
##    156    371          2     0.415 0.01653          0.384          0.449
##    159    369          1     0.414 0.01652          0.383          0.448
##    160    368          2     0.412 0.01651          0.381          0.445
##    161    366          2     0.409 0.01649          0.378          0.443
##    162    364          2     0.407 0.01648          0.376          0.441
##    163    362          1     0.406 0.01647          0.375          0.440
##    164    361          2     0.404 0.01646          0.373          0.437
##    165    359          1     0.403 0.01645          0.372          0.436
##    166    358          1     0.402 0.01644          0.371          0.435
##    167    357          1     0.400 0.01643          0.370          0.434
##    168    356          3     0.397 0.01641          0.366          0.431
##    169    353          2     0.395 0.01639          0.364          0.428
##    170    351          1     0.394 0.01639          0.363          0.427
##    172    350          2     0.391 0.01637          0.361          0.425
##    174    348          3     0.388 0.01634          0.357          0.421
```

```
##   176   345       2   0.386 0.01633       0.355        0.419
##   180   343       2   0.384 0.01631       0.353        0.417
##   182   341       2   0.381 0.01629       0.351        0.415
##   185   339       1   0.380 0.01628       0.350        0.413
##   187   338       2   0.378 0.01626       0.347        0.411
##   189   336       2   0.376 0.01624       0.345        0.409
##   190   334       2   0.373 0.01622       0.343        0.407
##   191   332       1   0.372 0.01621       0.342        0.406
##   193   331       1   0.371 0.01620       0.341        0.404
##   194   330       1   0.370 0.01619       0.340        0.403
##   196   329       1   0.369 0.01618       0.339        0.402
##   197   328       1   0.368 0.01617       0.337        0.401
##   198   327       1   0.367 0.01616       0.336        0.400
##   202   326       1   0.366 0.01615       0.335        0.399
##   204   325       3   0.362 0.01612       0.332        0.395
##   205   322       1   0.361 0.01611       0.331        0.394
##   207   321       2   0.359 0.01609       0.329        0.392
##   209   319       1   0.358 0.01608       0.328        0.391
##   211   318       3   0.354 0.01604       0.324        0.387
##   212   315       1   0.353 0.01603       0.323        0.386
##   214   314       1   0.352 0.01602       0.322        0.385
##   215   313       1   0.351 0.01601       0.321        0.384
##   217   312       1   0.350 0.01600       0.320        0.383
##   221   311       1   0.349 0.01598       0.319        0.381
##   222   310       1   0.348 0.01597       0.318        0.380
##   223   309       1   0.346 0.01596       0.317        0.379
##   224   308       1   0.345 0.01595       0.315        0.378
##   225   307       1   0.344 0.01593       0.314        0.377
##   226   306       1   0.343 0.01592       0.313        0.376
##   227   305       1   0.342 0.01591       0.312        0.375
##   231   304       1   0.341 0.01590       0.311        0.373
##   232   303       1   0.340 0.01588       0.310        0.372
##   234   302       2   0.337 0.01586       0.308        0.370
##   240   300       1   0.336 0.01585       0.307        0.369
##   244   299       1   0.335 0.01583       0.306        0.368
##   250   298       1   0.334 0.01582       0.304        0.367
##   252   297       2   0.332 0.01579       0.302        0.364
##   256   295       1   0.331 0.01578       0.301        0.363
##   258   294       1   0.330 0.01577       0.300        0.362
##   259   293       1   0.328 0.01575       0.299        0.361
##   260   292       2   0.326 0.01572       0.297        0.359
##   261   290       2   0.324 0.01570       0.295        0.356
##   262   288       1   0.323 0.01568       0.294        0.355
##   267   287       1   0.322 0.01567       0.292        0.354
##   268   286       1   0.321 0.01565       0.291        0.353
##   269   285       1   0.319 0.01564       0.290        0.352
##   270   284       2   0.317 0.01561       0.288        0.349
##   276   282       2   0.315 0.01558       0.286        0.347
##   277   280       2   0.313 0.01555       0.284        0.345
##   279   278       1   0.312 0.01553       0.283        0.344
##   281   277       1   0.310 0.01552       0.281        0.342
##   282   276       1   0.309 0.01550       0.280        0.341
##   283   275       1   0.308 0.01549       0.279        0.340
##   285   274       1   0.307 0.01547       0.278        0.339
```

```
##   290    273        1    0.306 0.01546        0.277         0.338
##   293    272        1    0.305 0.01544        0.276         0.337
##   296    271        1    0.304 0.01542        0.275         0.335
##   297    270        2    0.301 0.01539        0.273         0.333
##   298    268        2    0.299 0.01536        0.271         0.331
##   302    266        2    0.297 0.01532        0.268         0.329
##   303    264        1    0.296 0.01531        0.267         0.327
##   306    263        2    0.294 0.01527        0.265         0.325
##   307    261        1    0.292 0.01526        0.264         0.324
##   310    260        1    0.291 0.01524        0.263         0.323
##   311    259        1    0.290 0.01522        0.262         0.322
##   315    258        2    0.288 0.01519        0.260         0.319
##   317    256        2    0.286 0.01515        0.258         0.317
##   318    254        1    0.285 0.01513        0.256         0.316
##   326    253        2    0.282 0.01510        0.254         0.314
##   328    251        1    0.281 0.01508        0.253         0.312
##   332    250        1    0.280 0.01506        0.252         0.311
##   337    249        1    0.279 0.01504        0.251         0.310
##   340    248        1    0.278 0.01502        0.250         0.309
##   342    247        1    0.277 0.01500        0.249         0.308
##   351    246        1    0.276 0.01499        0.248         0.307
##   355    245        1    0.274 0.01497        0.247         0.305
##   358    244        1    0.273 0.01495        0.246         0.304
##   365    243        1    0.272 0.01493        0.244         0.303
##   370    235        2    0.270 0.01489        0.242         0.301
##   374    232        1    0.269 0.01487        0.241         0.300
##   375    230        2    0.266 0.01483        0.239         0.297
##   376    227        1    0.265 0.01482        0.238         0.296
##   379    224        2    0.263 0.01478        0.235         0.293
##   380    222        1    0.262 0.01476        0.234         0.292
##   387    216        1    0.260 0.01474        0.233         0.291
##   390    212        1    0.259 0.01472        0.232         0.290
##   394    209        1    0.258 0.01470        0.231         0.288
##   396    207        1    0.257 0.01468        0.230         0.287
##   400    204        1    0.255 0.01467        0.228         0.286
##   405    197        1    0.254 0.01465        0.227         0.285
##   409    193        1    0.253 0.01463        0.226         0.283
##   416    189        1    0.252 0.01462        0.224         0.282
##   420    186        1    0.250 0.01460        0.223         0.280
##   428    179        1    0.249 0.01458        0.222         0.279
##   435    176        1    0.247 0.01457        0.220         0.278
##   439    174        1    0.246 0.01456        0.219         0.276
##   451    166        1    0.244 0.01454        0.218         0.275
##   470    150        1    0.243 0.01454        0.216         0.273
##   475    144        1    0.241 0.01453        0.214         0.271
##   476    143        2    0.238 0.01452        0.211         0.268
##   483    137        1    0.236 0.01452        0.209         0.266
##   494    130        1    0.234 0.01452        0.207         0.264
##   519    112        1    0.232 0.01454        0.205         0.262
##   526    109        1    0.230 0.01457        0.203         0.260
##   527    108        1    0.228 0.01459        0.201         0.258
##   547    102        1    0.226 0.01461        0.199         0.256
##   549    100        1    0.223 0.01464        0.196         0.254
##   569     89        1    0.221 0.01469        0.194         0.252
```

```
## 578 85 1 0.218 0.01474 0.191 0.249
## 582 83 1 0.216 0.01480 0.189 0.247
## 597 75 1 0.213 0.01488 0.186 0.244
```

```
## [1] 726
```

```
## [1] 1092
```

Problem 3: Load data

```
data(lymphoma.prognosis)
```

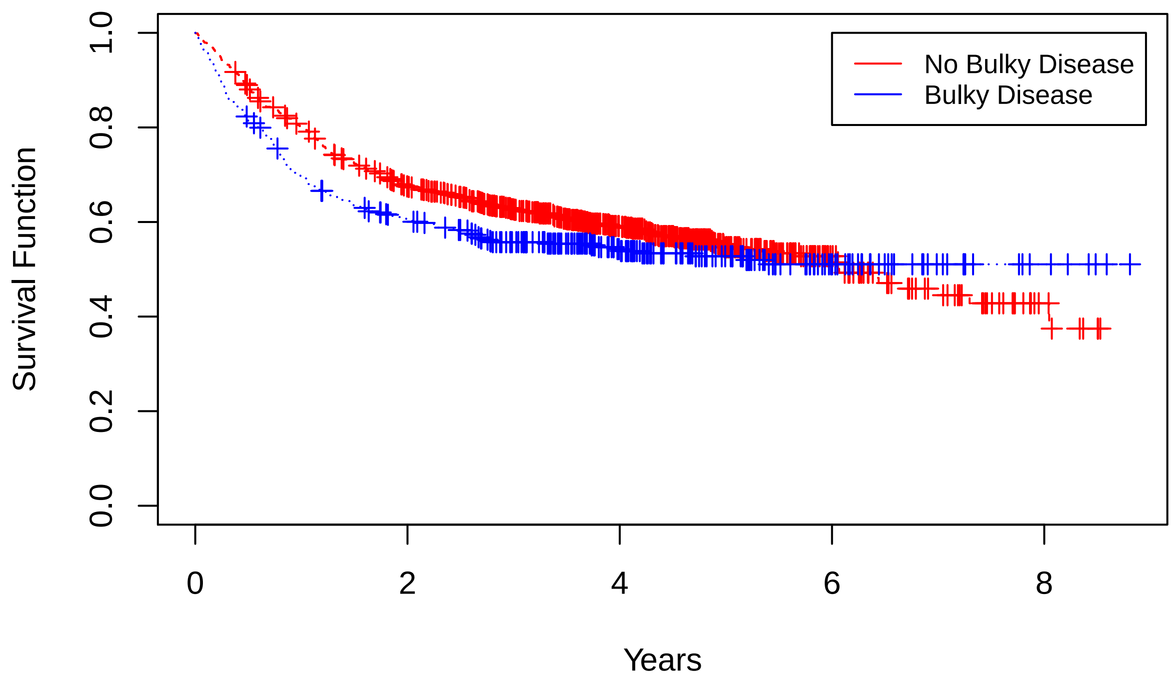
a) Estimate the survival probability by status of bulky disease. Bulky disease is coded in the numeric variable BULK, with 1 denoting not present and 2 denoting present. Be careful about the coding of the status variable SURVIVAL. Display the estimated survival curves.

```
#SURVIVAL description: Numeric; status of survival. 1 = alive, 2 = dead, 3 = lost to follow-up.
died <- lymphoma.prognosis$SURVIVAL - 1
died[died == 2] = 0 #recoding those lost to follow-up as censored
lymphoma.prognosis$died <- died


#survfn, Kapple Meir est for status of bulky disease
(KM3 <- survfit(Surv(SURVTIME, died) ~ BULK, data = lymphoma.prognosis))
```

```
## Call: survfit(formula = Surv(SURVTIME, died) ~ BULK, data = lymphoma.prognosis)
##
##          n events median 0.95LCL 0.95UCL
## BULK=1 961    409   6.07    5.45      NA
## BULK=2 424    194     NA    3.95      NA
```

```
#plot the curves
plot(KM3, lty = 2:3, mark.time = TRUE, xlab = "Years", ylab = "Survival Function", col=c("red", "blue")
legend(x = 6, y = 1, legend=c("No Bulky Disease", "Bulky Disease"), col=c("red", "blue"), lty=1, cex=0.
```



b) Do the data appear to satisfy the proportional hazards assumption? ANS: No because the survival curves appear to overlap at around 5 years.

c) Using a log-rank statistic, test for significant differences in survival in patients with bulky disease versus those who do not have bulky disease. State precisely the null and alternative hypotheses that are being tested. Interpret the outputs.

```
survdiff(Surv(SURVTIME, died) ~ BULK, data = lymphoma.prognosis)
```

```
## Call:
## survdiff(formula = Surv(SURVTIME, died) ~ BULK, data = lymphoma.prognosis)
##
##           N Observed Expected (O-E)^2/E (O-E)^2/V
## BULK=1 961      409      429     0.943      3.28
## BULK=2 424      194      174     2.327      3.28
##
##  Chisq= 3.3  on 1 degrees of freedom, p= 0.07
```

H0 is beta1 = 0 The survival rate in patients who have bulky disease and those who don't is the same HA is beta1 != 0 the survival rate in patients who have bulky disease and those who don't is not the same

Since the p value is > 0.05, we fail to reject the null and say that the survival rate in patients who have bulky disease and those who don't is the same.

d) The validity of the p-value from a log-rank test does not require that the data satisfy proportional hazards, but the test does lose power for some settings in which the hazards are not proportional.

Comment on the effect of absence of proportional hazards on the outcome of the test. ANS: When the power of the test decreases, we are more likely to fail to reject a null hypothesis that is actually false. In this situation, we failed to reject a null hypothesis and since the data does not satisfy the proportional hazards, this likely increased the p-value to a point where we failed to reject the null.

e) In the Fleming–Harrington tests, setting the parameters rho = 1, gamma = 0 produces a generalized Wilcoxon test which emphasizes early differences. Re-do part (c) with such a test. How does it change the outcome? Explain why.

```r
survdiff(Surv(SURVTIME, died) ~ BULK, data = lymphoma.prognosis, rho = 1)
```

```
## Call:
## survdiff(formula = Surv(SURVTIME, died) ~ BULK, data = lymphoma.prognosis,
##     rho = 1)
##
##          N Observed Expected (O-E)^2/E (O-E)^2/V
## BULK=1 961      312      334      1.52      6.55
## BULK=2 424      158      136      3.73      6.55
##
##  Chisq= 6.5  on 1 degrees of freedom, p= 0.01
```

ANS: After running the Fleming-Harrington tests by setting rho = 1 and gamma = 0, this puts weight to the earlier differences, which would make sense in the situation since there are clear differences in the curves before the half way point. The p-value on the Fleming Harrington test is < 0.01 which means we reject the null hypothesis and conclude there's enough evidence to prove the survival time for patients with and without Bulky disease is the same.