Assignment 2: CoxPH

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Data Preparation

```
#install.packages("survival")
library(survival)
setwd("D:\\Code_Factory\\surv_anly\\2")
fmh <- read.table("framingham.csv",sep = ",", header = T)[,-1]
fmh$age2 <- (fmh$age^2)
```

Before answering the questions, I fit the 3 model first. Note that I need to specify the parameters `time` and `time2` treating `age` as interval data to accouts for left truncation.

```
Y1 = Surv(fmh$time_outcome, fmh$outcome==2)
model1 = coxph(Y1 ~ cursmoke + female + totchol + age +
               age2 + bmi + BPVar + heartrte + glucose, data = fmh)

Y2 = Surv(fmh$time_outcome, fmh$outcome==2)
model2 = coxph(Y2 ~ cursmoke + female + totchol + age +
               age2 + bmi + BPVar + heartrte + glucose +
                 cursmoke * female, data = fmh)

Y3 = Surv(fmh$age,fmh$age+fmh$time_outcome,fmh$outcome==2)
model3 = coxph(Y3 ~ cursmoke + female + totchol + bmi + BPVar +
                 heartrte + glucose, data = fmh)
```

Q1:

1. According to Model 1 and Model 3, what is the adjusted hazard ratio for smoking v.s. nonsmoking and its 99% confidence interval? Comment on the results.

```
summary(model1)
```

```
## Call:
## coxph(formula = Y1 ~ cursmoke + female + totchol + age + age2 +
##     bmi + BPVar + heartrte + glucose, data = fmh)
##
##   n= 2316, number of events= 268
##
##                coef  exp(coef)   se(coef)      z Pr(>|z|)
## cursmoke  0.6158862  1.8512965  0.1364219  4.515 6.34e-06 ***
## female   -0.2600370  0.7710230  0.1343975 -1.935  0.05301 .
## totchol  -0.0010885  0.9989121  0.0015596 -0.698  0.48520
## age       0.0229303  1.0231952  0.0888407  0.258  0.79632
## age2      0.0006872  1.0006874  0.0008581  0.801  0.42324
## bmi      -0.0087368  0.9913013  0.0208590 -0.419  0.67533
```

```
## BPVar     0.0185675  1.0187410  0.0060831  3.052  0.00227 **
## heartrte  0.0098384  1.0098870  0.0055760  1.764  0.07766 .
## glucose  -0.0011845  0.9988162  0.0050069 -0.237  0.81298
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##          exp(coef) exp(-coef) lower .95 upper .95
## cursmoke    1.8513     0.5402    1.4169     2.419
## female      0.7710     1.2970    0.5925     1.003
## totchol     0.9989     1.0011    0.9959     1.002
## age         1.0232     0.9773    0.8597     1.218
## age2        1.0007     0.9993    0.9990     1.002
## bmi         0.9913     1.0088    0.9516     1.033
## BPVar       1.0187     0.9816    1.0067     1.031
## heartrte    1.0099     0.9902    0.9989     1.021
## glucose     0.9988     1.0012    0.9891     1.009
##
## Concordance= 0.713  (se = 0.016 )
## Likelihood ratio test= 182.3  on 9 df,   p=<2e-16
## Wald test            = 190.9  on 9 df,   p=<2e-16
## Score (logrank) test = 225.6  on 9 df,   p=<2e-16
```

```
summary(model3)
```

```
## Call:
## coxph(formula = Y3 ~ cursmoke + female + totchol + bmi + BPVar +
##     heartrte + glucose, data = fmh)
##
##   n= 2316, number of events= 268
##
##               coef exp(coef)  se(coef)      z Pr(>|z|)
## cursmoke  0.633834  1.884824  0.135889  4.664  3.1e-06 ***
## female   -0.249708  0.779028  0.133869 -1.865  0.06214 .
## totchol  -0.001329  0.998672  0.001545 -0.860  0.38967
## bmi      -0.010427  0.989627  0.020827 -0.501  0.61661
## BPVar     0.019178  1.019363  0.006074  3.157  0.00159 **
## heartrte  0.009716  1.009763  0.005564  1.746  0.08078 .
## glucose  -0.002076  0.997926  0.005011 -0.414  0.67868
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##          exp(coef) exp(-coef) lower .95 upper .95
## cursmoke    1.8848     0.5306    1.4441     2.460
## female      0.7790     1.2837    0.5992     1.013
## totchol     0.9987     1.0013    0.9957     1.002
## bmi         0.9896     1.0105    0.9500     1.031
## BPVar       1.0194     0.9810    1.0073     1.032
## heartrte    1.0098     0.9903    0.9988     1.021
## glucose     0.9979     1.0021    0.9882     1.008
##
## Concordance= 0.621  (se = 0.018 )
## Likelihood ratio test= 46.8  on 7 df,   p=6e-08
## Wald test            = 45.22  on 7 df,   p=1e-07
## Score (logrank) test = 46.38  on 7 df,   p=7e-08
```

The column named `exp(coef)` shows the adjusted hazard ratio. The adjusted hazard ratio for smoking v.s. nonsmoking can be read from the `cursmoke` row. For Model 1, the adjusted hazard ratio is 1.841248. For Model3, the value is 1.884824.

99% CI is:

```
# model1 99% CI
l1 = exp(model1[["coefficients"]][["cursmoke"]] -
           qnorm(1 - (1 - 0.99)/2) * sqrt(model1[["var"]][1,1]))
u1 = exp(model1[["coefficients"]][["cursmoke"]] +
           qnorm(1 - (1 - 0.99)/2) * sqrt(model1[["var"]][1,1]))
print(paste0("Model 1 99% CI: [",as.character(l1) ,
             ",", as.character(u1), "]"))
```

```
## [1] "Model 1 99% CI: [1.30276193181086,2.63079438810832]"
```

```
# model3 99% CI
l3 = exp(model3[["coefficients"]][["cursmoke"]] -
           qnorm(1 - (1 - 0.99)/2) * sqrt(model1[["var"]][1,1]))
u3 = exp(model3[["coefficients"]][["cursmoke"]] +
           qnorm(1 - (1 - 0.99)/2) * sqrt(model1[["var"]][1,1]))
print(paste0("Model 3 99% CI: [",as.character(l3) ,
             ",", as.character(u3), "]"))
```

```
## [1] "Model 3 99% CI: [1.3263551250331,2.6784384271388]"
```

There is no significant difference between two estimation of hazard ratio 1.841248 and 1.884824, the standard errors of two estimation, 0.136181 and 0.135889 and their 99% CIs. Therefore, I infer that the modeling of the hazard ratio of smoking or not is basically equivalent in Model 1 and Model 3.

Q2:

2. According to Model 2, what is the adjusted hazard ratio for smoking female v.s. smoking male and its 99% confidence interval? What is the adjusted hazard ratio for nonsmoking female v.s. nonsmoking male and its 99% confidence interval? Comment on the results.

```
summary(model2)
```

```
## Call:
## coxph(formula = Y2 ~ cursmoke + female + totchol + age + age2 +
##     bmi + BPVar + heartrte + glucose + cursmoke * female, data = fmh)
##
##   n= 2316, number of events= 268
##
##                      coef  exp(coef)   se(coef)      z Pr(>|z|)
## cursmoke         0.4168311  1.5171463  0.1770947  2.354  0.01859 *
## female          -0.5311659  0.5879191  0.2099321 -2.530  0.01140 *
## totchol         -0.0009811  0.9990193  0.0015651 -0.627  0.53073
## age              0.0244768  1.0247788  0.0888175  0.276  0.78287
## age2             0.0006774  1.0006777  0.0008577  0.790  0.42960
## bmi             -0.0078800  0.9921510  0.0209773 -0.376  0.70718
## BPVar            0.0188447  1.0190234  0.0060903  3.094  0.00197 **
## heartrte         0.0096590  1.0097058  0.0055724  1.733  0.08303 .
## glucose         -0.0015077  0.9984935  0.0050036 -0.301  0.76318
## cursmoke:female  0.4333890  1.5424762  0.2583031  1.678  0.09338 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
##
##                 exp(coef) exp(-coef) lower .95 upper .95
## cursmoke           1.5171     0.6591    1.0722    2.1467
## female             0.5879     1.7009    0.3896    0.8872
## totchol            0.9990     1.0010    0.9960    1.0021
## age                1.0248     0.9758    0.8611    1.2196
## age2               1.0007     0.9993    0.9990    1.0024
## bmi                0.9922     1.0079    0.9522    1.0338
## BPVar              1.0190     0.9813    1.0069    1.0313
## heartrte           1.0097     0.9904    0.9987    1.0208
## glucose            0.9985     1.0015    0.9887    1.0083
## cursmoke:female    1.5425     0.6483    0.9297    2.5591
##
## Concordance= 0.714  (se = 0.016 )
## Likelihood ratio test= 185.1  on 10 df,   p=<2e-16
## Wald test            = 190.8  on 10 df,   p=<2e-16
## Score (logrank) test = 226.3  on 10 df,   p=<2e-16
```

Refer to EXAMPLE 3, P116 of textbook KK2012, the target harzard ratio can be calculated by:

$$\widehat{HR} = \exp\left[\sum_{i=1}^{3} \hat{\beta}_i \left(X_i^* - X_i\right)\right]$$

, where the three X_i stand for variables `cursmoke`, `female` and `cursmoke`×`female`.

1. In the first case, the placebo subject:

$$\boldsymbol{X}^* = (X_1^* = 1,\ X_2^* = 1,\ X_3^* = 1 \times 1 = 1)$$

   Treated subject:

$$\boldsymbol{X} = (X_1 = 1,\ X_2 = 0,\ X_3 = 1 \times 0 = 0)$$

Hazard Ratio of the first case:

$$\begin{aligned}
\widehat{HR}_1 &= \exp\left[\hat{\beta}_1 \times (1-1) + \hat{\beta}_2 \times (1-0) + \hat{\beta}_3 \times (1 \times 1 - 0 \times 0)\right] && (1)\\
&= \exp\left[\hat{\beta}_2 + \hat{\beta}_3\right] && (2)\\
&= \exp\left[0.4168311 \times (1-1) - 0.5311659 \times (1-0) + 0.4333890 \times (1 \times 1 - 0 \times 0)\right] && (3)\\
&= 0.9020232 && (4)
\end{aligned}$$

By the covariance matrix provided by the model parameters, I can obtain the standard error of HR_1.

```
est1 = model2[["coefficients"]][["female"]] +
  model2[["coefficients"]][["cursmoke:female"]]
exp(est1)
```

```
## [1] 0.9068512
```

```
sd1 = sqrt(model2[["var"]][2,2] +
             model2[["var"]][10,10]+2*model2[["var"]][2,10])
# model2 99% CI 1
l2.1 = exp(est1 - qnorm(1 - (1 - 0.99)/2) * sd1)
u2.1 = exp(est1 + qnorm(1 - (1 - 0.99)/2) * sd1)
print(paste0("Model 2 99% CI 1: [",as.character(l2.1) ,
             ",", as.character(u2.1), "]"))
```

```
## [1] "Model 2 99% CI 1: [0.594512787000936,1.3832825738248]"
```

2. In the second case, the placebo subject:

$$\boldsymbol{X}^* = (X_1^* = 0,\ X_2^* = 1,\ X_3^* = 0 \times 1 = 0)$$

Treated subject:

$$\boldsymbol{X} = (X_1 = 0,\ X_2 = 0,\ X_3 = 0 \times 0 = 0)$$

Hazard Ratio of the second case:

$$\begin{aligned}
\widehat{HR}_2 &= \exp\left[\hat{\beta}_1 \times (0-0) + \hat{\beta}_2 \times (1-0) + \hat{\beta}_3 \times (1 \times 0 - 0 \times 0)\right] && (5)\\
&= \exp \hat{\beta}_2 && (6)\\
&= \exp(-0.5311659) && (7)\\
&= 0.5879191 && (8)
\end{aligned}$$

By the covariance matrix provided by the model parameters, I can obtain the standard error of HR_2.

```
est2 = model2[["coefficients"]][["female"]]
exp(est2)
```

```
## [1] 0.5879191
```

```
sd2 = sqrt(model2[["var"]][2,2])
# model2 99% CI 1
l2.2 = exp(est2 - qnorm(1 - (1 - 0.99)/2) * sd2)
u2.2 = exp(est2 + qnorm(1 - (1 - 0.99)/2) * sd2)
print(paste0("Model 2 99% CI 1: [",as.character(l2.2)
             , ",", as.character(u2.2), "]"))
```

```
## [1] "Model 2 99% CI 1: [0.342352223044991,1.00962946775261]"
```

Both CIs include 1, indicating that under 99% significance we can not infer that the risks of smoking female v.s. smoking male are different. The conclusion is same when considering nonsmoking female v.s. nonsmoking male. However, the point estimation of HR in the first case is closer to 1 than the second case. So the conclusion about the first case is more reliable.

Q3:

3. Draw the adjusted survival curves using Model 1 for smoking subjects v.s. non-smoking subjects, where all other risk factors are set to the overall means respectively. Comment on the plot.

According to the question, thhe pattern should be:

```
# fit model 1 stratified by cursmoke to get the adjusted survival curves
model1s = coxph(Y1 ~ strata(cursmoke) + female + totchol + age +
                age2 + bmi + BPVar + heartrte + glucose, data = fmh)

pattern = data.frame(female = mean(fmh$female), totchol = mean(fmh$totchol),
                     age = mean(fmh$age), age2 = mean(fmh$age2), bmi = mean(fmh$bmi),
                     BPVar = mean(fmh$BPVar), heartrte = mean(fmh$heartrte),
                     glucose = mean(fmh$glucose))


summary(survfit(model1s, newdata = pattern))
```

```
## Call: survfit(formula = model1s, newdata = pattern)
##
```

```
##                cursmoke=0
##    time n.risk n.event survival  std.err lower 95% CI upper 95% CI
##   0.476   1078       1    0.999 0.000575        0.998        1.000
##   0.641   1077       1    0.999 0.000816        0.997        1.000
##   0.914   1076       1    0.998 0.001002        0.996        1.000
##   1.963   1047       1    0.998 0.001167        0.995        1.000
##   2.716    998       1    0.997 0.001331        0.994        1.000
##   3.833    984       1    0.996 0.001487        0.993        0.999
##   4.003    942       1    0.996 0.001643        0.993        0.999
##   4.249    894       1    0.995 0.001804        0.991        0.999
##   4.312    893       1    0.994 0.001953        0.990        0.998
##   4.783    889       1    0.994 0.002093        0.989        0.998
##   4.805    888       1    0.993 0.002225        0.988        0.997
##   5.161    887       1    0.992 0.002351        0.987        0.997
##   5.517    886       1    0.991 0.002471        0.986        0.996
##   5.881    864       1    0.991 0.002597        0.985        0.996
##   6.001    833       1    0.990 0.002728        0.984        0.995
##   6.557    797       1    0.989 0.002868        0.983        0.995
##   6.571    796       1    0.988 0.003002        0.982        0.994
##   6.587    795       1    0.987 0.003132        0.981        0.993
##   6.749    794       1    0.986 0.003257        0.980        0.993
##   6.773    793       1    0.985 0.003378        0.979        0.992
##   7.121    792       1    0.985 0.003496        0.978        0.991
##   7.211    790       1    0.984 0.003611        0.977        0.991
##   7.411    789       1    0.983 0.003724        0.976        0.990
##   8.118    728       1    0.982 0.003855        0.974        0.990
##   8.159    721       1    0.981 0.003986        0.973        0.989
##   8.282    715       1    0.980 0.004115        0.972        0.988
##   8.463    714       1    0.979 0.004241        0.971        0.987
##   8.575    712       1    0.978 0.004364        0.970        0.987
##   8.813    711       1    0.977 0.004484        0.968        0.986
##   9.388    708       2    0.975 0.004720        0.966        0.984
##   9.473    706       1    0.974 0.004834        0.965        0.984
##   9.550    705       1    0.973 0.004946        0.963        0.983
##   9.555    704       1    0.972 0.005057        0.962        0.982
##  10.021    660       1    0.971 0.005182        0.961        0.981
##  10.053    655       1    0.970 0.005306        0.960        0.980
##  10.141    649       1    0.969 0.005430        0.958        0.980
##  10.212    644       1    0.968 0.005554        0.957        0.979
##  10.798    643       1    0.967 0.005676        0.956        0.978
##  11.050    641       1    0.966 0.005795        0.954        0.977
##  11.937    608       1    0.964 0.005931        0.953        0.976
##  12.238    585       1    0.963 0.006077        0.951        0.975
##  12.364    583       1    0.962 0.006222        0.950        0.974
##  12.493    582       1    0.961 0.006364        0.948        0.973
##  12.507    581       1    0.959 0.006504        0.947        0.972
##  12.805    579       1    0.958 0.006641        0.945        0.971
##  12.821    578       1    0.957 0.006776        0.944        0.970
##  13.076    576       1    0.956 0.006909        0.942        0.969
##  13.922    562       1    0.954 0.007047        0.941        0.968
##  14.048    549       1    0.953 0.007188        0.939        0.967
##  14.070    546       1    0.952 0.007328        0.937        0.966
##  14.086    545       1    0.950 0.007468        0.936        0.965
##  14.379    534       1    0.949 0.007615        0.934        0.964
```

```
##  14.741    523       1    0.947 0.007768        0.932        0.963
##  15.107    521       1    0.946 0.007920        0.930        0.961
##  15.411    511       1    0.944 0.008075        0.929        0.960
##  15.666    504       1    0.943 0.008232        0.927        0.959
##  16.088    491       1    0.941 0.008396        0.925        0.958
##  16.301    481       1    0.940 0.008567        0.923        0.957
##  16.482    476       1    0.938 0.008737        0.921        0.955
##  16.712    470       1    0.936 0.008910        0.919        0.954
##  16.786    469       1    0.935 0.009081        0.917        0.953
##  16.972    466       1    0.933 0.009251        0.915        0.951
##  17.123    464       1    0.931 0.009419        0.913        0.950
##  17.205    461       1    0.929 0.009586        0.911        0.948
##  17.881    450       1    0.928 0.009757        0.909        0.947
##  17.982    448       1    0.926 0.009926        0.907        0.946
##  18.234    441       1    0.924 0.010098        0.904        0.944
##  18.267    439       1    0.922 0.010271        0.902        0.943
##  18.639    419       1    0.920 0.010460        0.900        0.941
##  18.743    416       1    0.918 0.010652        0.898        0.939
##  18.992    413       1    0.916 0.010844        0.895        0.938
##  19.012    412       1    0.914 0.011036        0.893        0.936
##  19.269    410       1    0.912 0.011227        0.891        0.935
##  19.444    407       1    0.910 0.011419        0.888        0.933
##  19.474    406       1    0.908 0.011607        0.886        0.931
##  19.578    403       1    0.906 0.011793        0.883        0.929
##  19.691    402       1    0.904 0.011977        0.881        0.928
##  20.156    393       1    0.902 0.012169        0.878        0.926
##  20.359    384       1    0.900 0.012370        0.876        0.924
##  20.676    373       1    0.897 0.012579        0.873        0.922
##  20.726    372       1    0.895 0.012785        0.870        0.920
##  20.871    370       1    0.893 0.012990        0.868        0.919
##  21.536    360       1    0.890 0.013201        0.865        0.917
##  21.585    359       1    0.888 0.013407        0.862        0.915
##  21.938    348       1    0.886 0.013621        0.859        0.913
##  22.133    342       1    0.883 0.013836        0.856        0.911
##  22.571    332       1    0.880 0.014064        0.853        0.908
##  22.653    331       1    0.878 0.014287        0.850        0.906
##  22.700    330       1    0.875 0.014505        0.847        0.904
##  22.719    329       1    0.873 0.014721        0.844        0.902
##  23.748    313       1    0.870 0.014956        0.841        0.900
##  23.792    311       1    0.867 0.015188        0.838        0.898
##  23.825    310       1    0.865 0.015415        0.835        0.895
##  23.923    307       1    0.862 0.015643        0.832        0.893
##
##                cursmoke=1
##    time n.risk n.event survival  std.err lower 95% CI upper 95% CI
##   0.159   1238       1    0.999 0.000649        0.998        1.000
##   0.906   1237       1    0.999 0.000919        0.997        1.000
##   0.928   1236       1    0.998 0.001127        0.996        1.000
##   1.177   1235       1    0.997 0.001302        0.995        1.000
##   1.941   1219       1    0.997 0.001462        0.994        1.000
##   2.157   1185       1    0.996 0.001616        0.993        0.999
##   2.264   1174       1    0.995 0.001760        0.992        0.999
##   2.338   1172       1    0.995 0.001894        0.991        0.998
##   2.428   1171       1    0.994 0.002021        0.990        0.998
```

```
##   2.590   1169       1    0.993 0.002140        0.989        0.997
##   3.217   1167       1    0.993 0.002254        0.988        0.997
##   3.277   1165       1    0.992 0.002363        0.987        0.997
##   3.745   1160       1    0.991 0.002469        0.986        0.996
##   3.751   1159       1    0.990 0.002571        0.985        0.996
##   3.819   1153       1    0.990 0.002672        0.985        0.995
##   3.877   1147       1    0.989 0.002771        0.984        0.995
##   3.948   1135       1    0.988 0.002868        0.983        0.994
##   3.981   1126       1    0.988 0.002964        0.982        0.993
##   4.014   1112       1    0.987 0.003063        0.981        0.993
##   4.235   1075       1    0.986 0.003168        0.980        0.992
##   4.501   1069       1    0.985 0.003270        0.979        0.992
##   4.515   1067       1    0.984 0.003370        0.978        0.991
##   4.632   1066       1    0.984 0.003467        0.977        0.990
##   4.876   1064       1    0.983 0.003563        0.976        0.990
##   4.969   1063       1    0.982 0.003657        0.975        0.989
##   5.060   1061       1    0.981 0.003749        0.974        0.989
##   5.144   1060       1    0.980 0.003838        0.973        0.988
##   5.150   1059       1    0.980 0.003926        0.972        0.987
##   5.309   1056       1    0.979 0.004013        0.971        0.987
##   5.331   1055       1    0.978 0.004099        0.970        0.986
##   5.363   1054       1    0.977 0.004183        0.969        0.985
##   5.602   1051       1    0.976 0.004265        0.968        0.985
##   5.862   1032       1    0.976 0.004350        0.967        0.984
##   6.073    988       1    0.975 0.004444        0.966        0.983
##   6.215    978       1    0.974 0.004539        0.965        0.983
##   6.261    977       1    0.973 0.004632        0.964        0.982
##   6.376    972       1    0.972 0.004723        0.963        0.981
##   6.853    970       1    0.971 0.004814        0.962        0.981
##   7.064    969       1    0.970 0.004902        0.961        0.980
##   7.414    968       1    0.969 0.004989        0.960        0.979
##   7.699    963       1    0.968 0.005076        0.959        0.978
##   8.104    914       1    0.967 0.005172        0.957        0.978
##   8.167    909       1    0.967 0.005268        0.956        0.977
##   8.194    907       1    0.966 0.005362        0.955        0.976
##   8.512    898       1    0.965 0.005457        0.954        0.975
##   8.569    896       1    0.964 0.005552        0.953        0.975
##   8.578    895       1    0.963 0.005644        0.952        0.974
##   9.166    890       1    0.962 0.005737        0.950        0.973
##   9.251    888       1    0.961 0.005829        0.949        0.972
##   9.284    887       1    0.960 0.005920        0.948        0.971
##   9.777    872       1    0.959 0.006013        0.947        0.970
##   9.908    852       1    0.958 0.006111        0.946        0.970
##   9.922    851       1    0.956 0.006207        0.944        0.969
##   9.925    850       1    0.955 0.006302        0.943        0.968
##  10.108    826       1    0.954 0.006403        0.942        0.967
##  10.114    825       1    0.953 0.006502        0.941        0.966
##  10.207    821       1    0.952 0.006601        0.939        0.965
##  10.393    818       1    0.951 0.006700        0.938        0.964
##  10.396    817       1    0.950 0.006797        0.937        0.963
##  10.423    816       1    0.949 0.006894        0.935        0.962
##  10.645    814       1    0.948 0.006989        0.934        0.961
##  10.790    812       1    0.947 0.007083        0.933        0.961
##  10.899    811       1    0.945 0.007178        0.931        0.960
```

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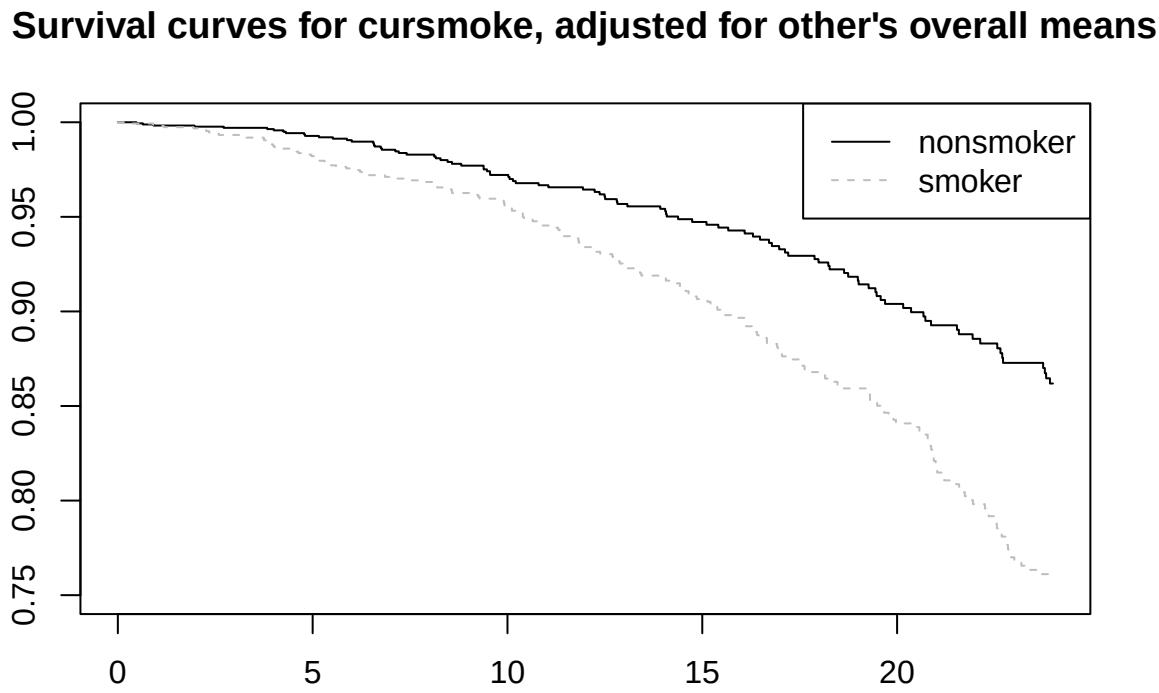
##  11.231    810       1    0.944 0.007271        0.930        0.959
##  11.302    809       1    0.943 0.007363        0.929        0.958
##  11.340    808       1    0.942 0.007454        0.928        0.957
##  11.348    806       1    0.941 0.007545        0.926        0.956
##  11.436    805       1    0.940 0.007635        0.925        0.955
##  11.655    799       1    0.939 0.007724        0.924        0.954
##  11.822    789       1    0.937 0.007815        0.922        0.953
##  11.830    788       1    0.936 0.007904        0.921        0.952
##  11.929    778       1    0.935 0.007996        0.920        0.951
##  11.934    777       1    0.934 0.008086        0.918        0.950
##  12.230    751       1    0.933 0.008185        0.917        0.949
##  12.277    749       1    0.932 0.008283        0.915        0.948
##  12.381    748       1    0.930 0.008380        0.914        0.947
##  12.690    745       1    0.929 0.008475        0.913        0.946
##  12.712    744       1    0.928 0.008571        0.911        0.945
##  12.824    743       1    0.927 0.008664        0.910        0.944
##  12.882    741       1    0.925 0.008758        0.908        0.943
##  13.040    739       1    0.924 0.008852        0.907        0.942
##  13.087    738       1    0.923 0.008945        0.905        0.941
##  13.347    731       1    0.922 0.009041        0.904        0.939
##  13.402    730       1    0.920 0.009136        0.903        0.938
##  13.435    729       1    0.919 0.009230        0.901        0.937
##  13.958    708       1    0.918 0.009330        0.900        0.936
##  14.064    698       1    0.916 0.009431        0.898        0.935
##  14.324    685       1    0.915 0.009536        0.896        0.934
##  14.426    683       1    0.913 0.009641        0.895        0.933
##  14.554    681       1    0.912 0.009744        0.893        0.931
##  14.571    680       1    0.911 0.009846        0.892        0.930
##  14.650    678       1    0.909 0.009948        0.890        0.929
##  14.773    676       1    0.908 0.010049        0.888        0.928
##  14.861    674       1    0.907 0.010149        0.887        0.927
##  15.132    672       1    0.905 0.010249        0.885        0.925
##  15.211    671       1    0.904 0.010348        0.884        0.924
##  15.307    670       1    0.902 0.010446        0.882        0.923
##  15.387    667       1    0.901 0.010543        0.880        0.922
##  15.483    664       1    0.899 0.010640        0.879        0.921
##  15.587    662       1    0.898 0.010737        0.877        0.919
##  15.863    646       1    0.897 0.010837        0.876        0.918
##  16.093    634       1    0.895 0.010939        0.874        0.917
##  16.096    633       1    0.894 0.011041        0.872        0.916
##  16.112    631       1    0.892 0.011143        0.871        0.914
##  16.298    620       1    0.891 0.011249        0.869        0.913
##  16.323    619       1    0.889 0.011354        0.867        0.912
##  16.405    614       1    0.888 0.011462        0.865        0.910
##  16.444    611       1    0.886 0.011569        0.864        0.909
##  16.657    607       1    0.884 0.011678        0.862        0.908
##  16.660    606       1    0.883 0.011785        0.860        0.906
##  16.920    599       1    0.881 0.011896        0.858        0.905
##  16.939    597       1    0.880 0.012008        0.856        0.903
##  17.040    595       1    0.878 0.012119        0.854        0.902
##  17.046    594       1    0.876 0.012229        0.853        0.901
##  17.303    592       1    0.875 0.012339        0.851        0.899
##  17.487    586       1    0.873 0.012450        0.849        0.898
##  17.541    585       1    0.871 0.012559        0.847        0.896
```

```
##  17.624    580       1    0.870 0.012669        0.845        0.895
##  17.626    579       1    0.868 0.012778        0.843        0.893
##  18.029    569       1    0.866 0.012888        0.841        0.892
##  18.152    564       1    0.865 0.012999        0.839        0.890
##  18.220    560       1    0.863 0.013110        0.837        0.889
##  18.470    553       2    0.859 0.013335        0.834        0.886
##  19.206    541       1    0.857 0.013454        0.832        0.884
##  19.299    540       1    0.856 0.013574        0.829        0.883
##  19.305    539       2    0.852 0.013811        0.825        0.879
##  19.488    536       1    0.850 0.013927        0.823        0.878
##  19.595    533       1    0.848 0.014043        0.821        0.876
##  19.669    530       1    0.846 0.014160        0.819        0.875
##  19.781    526       1    0.845 0.014275        0.817        0.873
##  19.904    523       1    0.843 0.014392        0.815        0.871
##  19.970    521       1    0.841 0.014511        0.813        0.870
##  20.392    504       1    0.839 0.014636        0.811        0.868
##  20.572    502       1    0.837 0.014761        0.808        0.866
##  20.583    501       1    0.835 0.014885        0.806        0.865
##  20.786    499       2    0.831 0.015130        0.802        0.861
##  20.843    497       1    0.829 0.015251        0.800        0.859
##  20.873    495       1    0.827 0.015371        0.797        0.858
##  20.903    493       1    0.825 0.015491        0.795        0.856
##  20.928    491       1    0.823 0.015609        0.793        0.854
##  20.942    490       1    0.821 0.015727        0.791        0.852
##  20.991    488       1    0.819 0.015848        0.788        0.851
##  20.994    487       1    0.817 0.015967        0.786        0.849
##  21.029    486       1    0.815 0.016085        0.784        0.847
##  21.188    482       1    0.813 0.016203        0.782        0.845
##  21.207    481       1    0.811 0.016320        0.779        0.843
##  21.514    476       1    0.809 0.016439        0.777        0.841
##  21.593    474       1    0.807 0.016557        0.775        0.840
##  21.599    472       1    0.804 0.016674        0.772        0.838
##  21.739    468       1    0.802 0.016792        0.770        0.836
##  21.826    466       1    0.800 0.016908        0.768        0.834
##  21.947    462       1    0.798 0.017025        0.765        0.832
##  22.253    457       1    0.796 0.017142        0.763        0.830
##  22.267    456       1    0.794 0.017257        0.761        0.828
##  22.349    453       1    0.792 0.017372        0.758        0.827
##  22.483    448       1    0.790 0.017488        0.756        0.825
##  22.554    447       1    0.787 0.017603        0.754        0.823
##  22.560    446       1    0.785 0.017717        0.751        0.821
##  22.650    443       1    0.783 0.017831        0.749        0.819
##  22.683    442       1    0.781 0.017945        0.747        0.817
##  22.782    439       1    0.779 0.018059        0.744        0.815
##  22.812    438       1    0.777 0.018172        0.742        0.813
##  22.845    435       1    0.774 0.018285        0.739        0.811
##  22.858    434       1    0.772 0.018395        0.737        0.809
##  22.880    433       1    0.770 0.018505        0.735        0.807
##  23.009    431       1    0.768 0.018617        0.732        0.805
##  23.190    428       1    0.766 0.018728        0.730        0.803
##  23.354    427       1    0.763 0.018838        0.727        0.801
##  23.677    418       1    0.761 0.018950        0.725        0.799
##  23.893    407       1    0.759 0.019068        0.722        0.797
```

```
plot(survfit(model1s, newdata = pattern), conf.int=F,
     lty = c("solid", "dashed"), col=c("black","grey"),
     main = "Survival curves for cursmoke, adjusted for other's overall means",
     ylim = c(0.75,1))
legend("topright", c("nonsmoker", "smoker"), lty=c("solid","dashed"),
       col=c("black","grey"))
```



After adjusting for the overall means, we can see from the graph that the survival curve of smokers is significantly decreasing faster than nonsmoker, indicating that smoking or not is a effective factor towards hypertension.