

# Survival Analysis

2025-08-30

```
library(survival)

data(veteran)

## Warning in data(veteran): data set 'veteran' not found

#0. Basic Analysis

veteran$trt <- factor(veteran$trt, labels = c("Standard", "Test"))
veteran$celltype <- factor(veteran$celltype,
                           labels = c("Squamous", "Small Cell", "Adeno",
                                       "Large"))

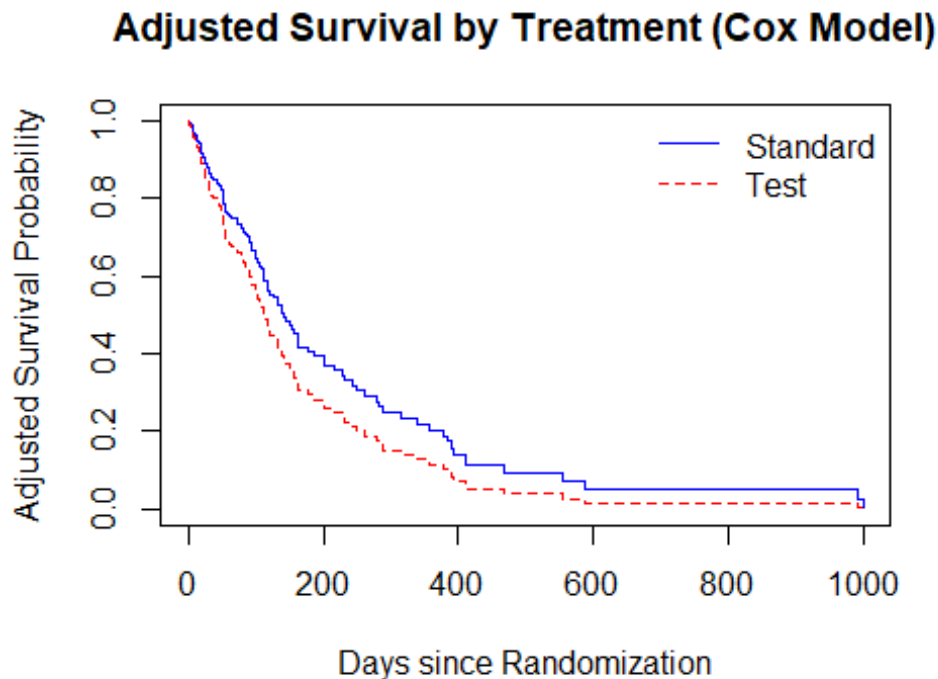
cox_model <- coxph(Surv(time, status) ~ trt + age + karno + celltype, data =
veteran)

cox_model

## Call:
## coxph(formula = Surv(time, status) ~ trt + age + karno + celltype,
##       data = veteran)
##
##              coef exp(coef) se(coef)      z      p
## trtTest          0.303048  1.353980  0.205656  1.474  0.1406
## age             -0.008903  0.991136  0.009224 -0.965  0.3345
## karno            -0.032685  0.967843  0.005409 -6.043 1.51e-09
## celltypeSmall Cell  0.856340  2.354528  0.271322  3.156  0.0016
## celltypeAdeno       1.178807  3.250494  0.296440  3.977 6.99e-05
## celltypeLarge        0.402332  1.495308  0.282544  1.424  0.1545
##
## Likelihood ratio test=61.98 on 6 df, p=1.779e-11
## n= 137, number of events= 128

newdata <- data.frame(
  trt = factor(c("Standard", "Test"), levels = levels(veteran$trt)),
  age = mean(veteran$age),
  karno = mean(veteran$karno),
  celltype = factor("Squamous", levels = levels(veteran$celltype))
)
fit_adj <- survfit(cox_model, newdata = newdata)
```

```
plot(fit_adj, col = c("blue","red"), lty = 1:2,
     xlab = "Days since Randomization",
     ylab = "Adjusted Survival Probability",
     main = "Adjusted Survival by Treatment (Cox Model)")
legend("topright", legend = c("Standard","Test"), col = c("blue","red"), lty
      = 1:2, bty = "n")
```



#### #####1. Kaplan Meir Curves by Tumor Type

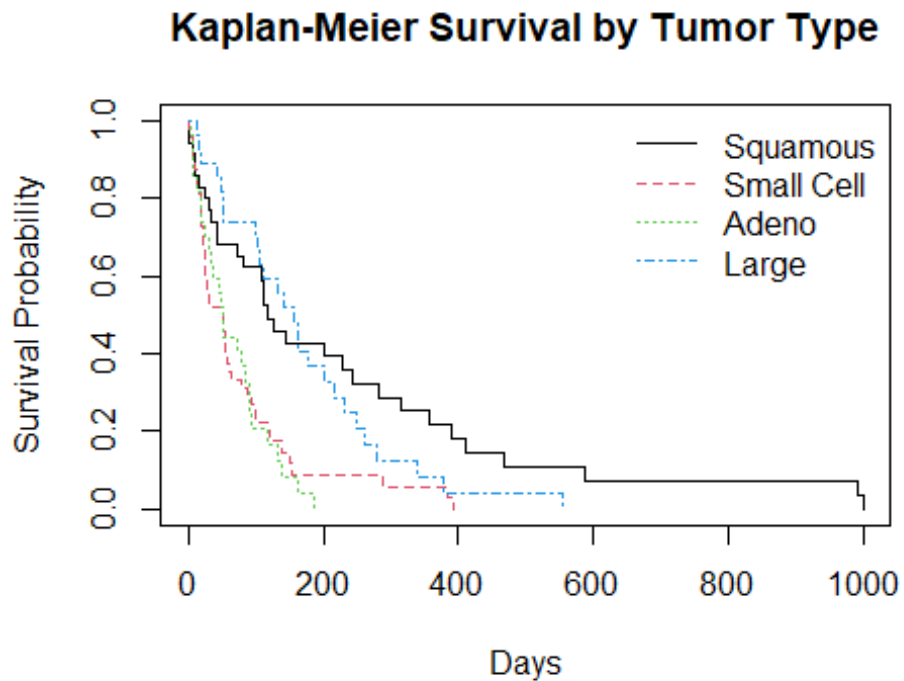
```
km_cell <- survfit(Surv(time, status) ~ celltype, data = veteran)

km_cell

## Call: survfit(formula = Surv(time, status) ~ celltype, data = veteran)
##
##              n events median 0.95LCL 0.95UCL
## celltype=Squamous   35     31   118     82    314
## celltype=Small Cell  48     45    51     25     63
## celltype=Adeno       27     26    51     35     92
## celltype=Large       27     26   156    105    231

plot(km_cell, col = 1:4, lty = 1:4, xlab = "Days", ylab = "Survival
Probability",
     main = "Kaplan-Meier Survival by Tumor Type")
```

```
legend("topright", legend = levels(veteran$celltype), col = 1:4, lty = 1:4,
bty = "n")
```

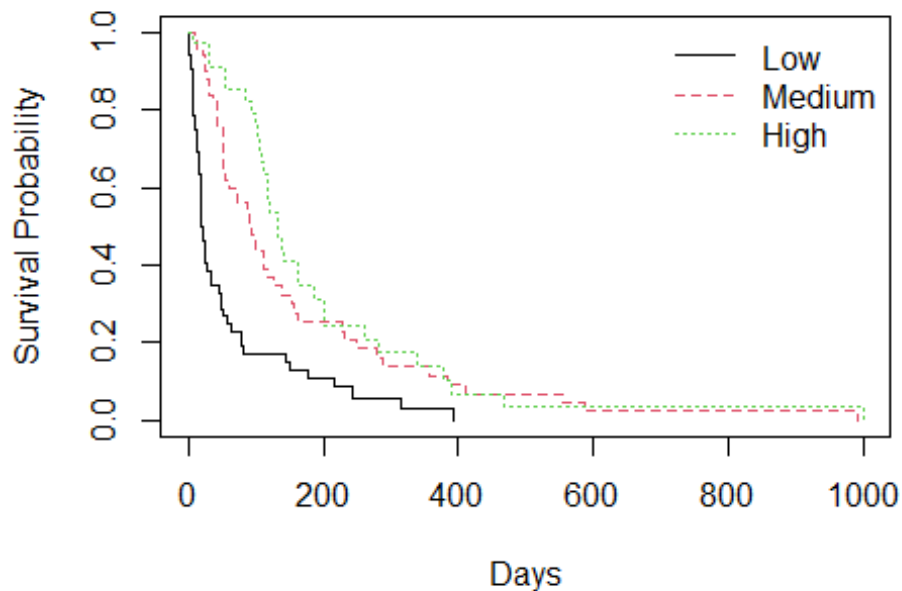


#### #####2. Survival by Karnofsky Performance Score

```
veteran$karno_group <- cut(veteran$karno, breaks=c(0,50,70,100),
labels=c("Low","Medium","High"))

km_karno <- survfit(Surv(time, status) ~ karno_group, data = veteran)
plot(km_karno, col=1:3, lty=1:3, xlab="Days", ylab="Survival Probability",
main="Survival by Karnofsky Score Group")
legend("topright", legend=levels(veteran$karno_group), col=1:3, lty=1:3,
bty="n")
```

## Survival by Karnofsky Score Group



### #####3. Interaction Between Treatment and Tumor Type

```
cox_inter <- coxph(Surv(time, status) ~ trt * celltype + age + karno, data =
veteran)
summary(cox_inter)
```

```
## Call:
## coxph(formula = Surv(time, status) ~ trt * celltype + age + karno,
##       data = veteran)
##
##    n= 137, number of events= 128
##
##              coef exp(coef)  se(coef)      z Pr(>|z|)
## trtTest          -0.306555  0.735978  0.396437 -0.773  0.43936
## celltypeSmall Cell   0.358050  1.430538  0.339436  1.055  0.29150
## celltypeAdeno        1.207385  3.344728  0.452701  2.667  0.00765
##
## celltypeLarge       -0.056709  0.944869  0.393839 -0.144  0.88551
## age                 -0.007791  0.992240  0.009086 -0.857  0.39120
## karno               -0.032797  0.967735  0.005567 -5.892 3.83e-09
##
## trtTest:celltypeSmall Cell  1.146539  3.147282  0.516914  2.218  0.02655 *
## trtTest:celltypeAdeno      0.151854  1.163991  0.591096  0.257  0.79725
## trtTest:celltypeLarge      0.875872  2.400967  0.567560  1.543  0.12278
```

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##               exp(coef) exp(-coef) lower .95 upper .95
## trtTest          0.7360      1.3587    0.3384    1.6007
## celltypeSmall Cell  1.4305    0.6990    0.7355    2.7825
## celltypeAdeno      3.3447    0.2990    1.3773    8.1227
## celltypeLarge      0.9449    1.0583    0.4367    2.0446
## age              0.9922    1.0078    0.9747    1.0101
## karno            0.9677    1.0333    0.9572    0.9784
## trtTest:celltypeSmall Cell  3.1473    0.3177    1.1427    8.6683
## trtTest:celltypeAdeno      1.1640    0.8591    0.3654    3.7076
## trtTest:celltypeLarge      2.4010    0.4165    0.7894    7.3029
##
## Concordance= 0.733 (se = 0.021 )
## Likelihood ratio test= 68.44 on 9 df,  p=3e-11
## Wald test              = 65.78 on 9 df,  p=1e-10
## Score (logrank) test = 71.75 on 9 df,  p=7e-12
```

**#####4. # Example patient: 65 years old, High Karnofsky, Small Cell**

```
new_patient <- data.frame(
  trt = factor("Standard", levels=c("Standard", "Test")),
  age = 65,
  karno = 80,
  celltype = factor("Small Cell", levels=levels(veteran$celltype))
)
```

```
pred_fit <- survfit(cox_model, newdata=new_patient)
```

```
pred_df <- data.frame(
  Days = pred_fit$time,
  Survival_Prob = pred_fit$surv
)
head(pred_df, 10)
```

```
##   Days Survival_Prob
## 1     1    0.9947330
## 2     2    0.9920779
## 3     3    0.9893866
## 4     4    0.9866384
## 5     7    0.9781729
## 6     8    0.9663327
## 7    10    0.9602260
## 8    11    0.9571350
## 9    12    0.9509391
## 10   13    0.9446440
```

```

median_surv <- summary(pred_fit)$table["median"]
median_surv

## median
##      133

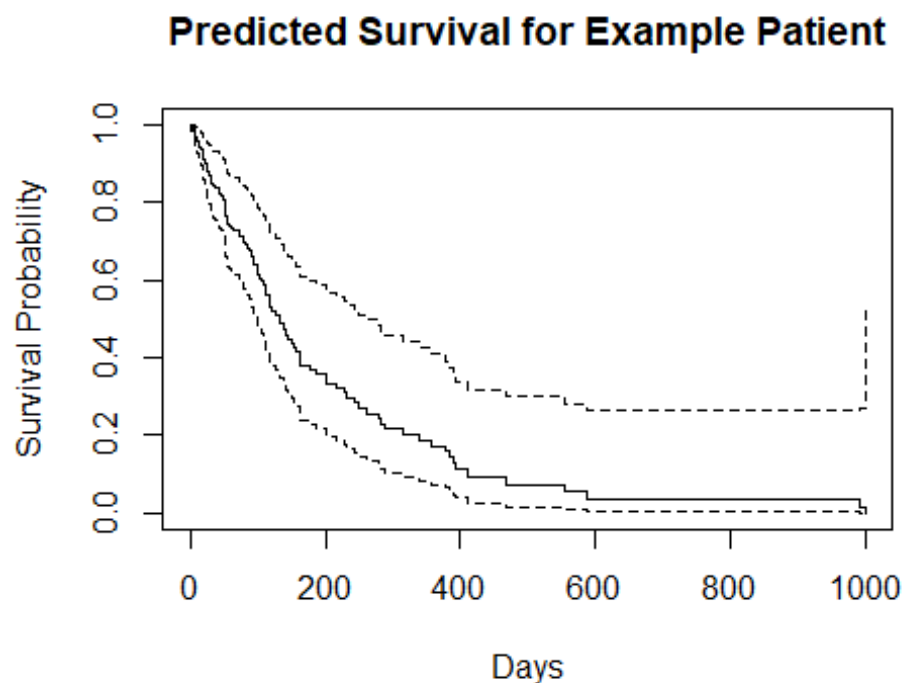
lp <- predict(cox_model, newdata=new_patient, type="lp")

HR <- exp(lp)
HR

##           1
## 1.101063

plot(pred_fit, xlab="Days", ylab="Survival Probability", main="Predicted
Survival for Example Patient")

```



#### ####5. Forest Plot of Hazard Ratios

```

hr <- exp(coef(cox_model))
lower <- exp(confint(cox_model)[,1])
upper <- exp(confint(cox_model)[,2])
vars <- names(hr)

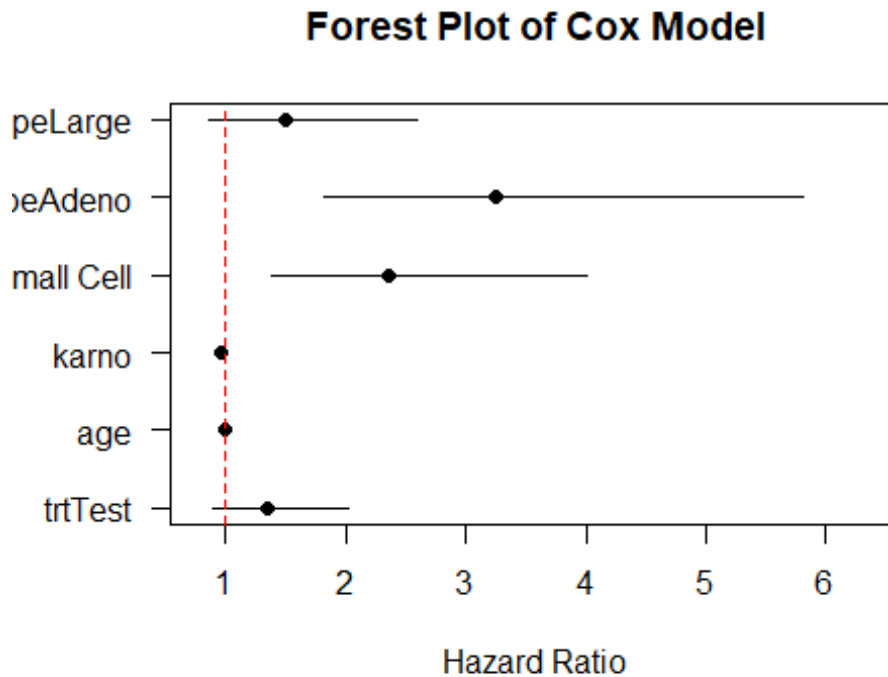
plot(hr, 1:length(hr), xlim=c(min(lower)*0.9, max(upper)*1.1), pch=19,
yaxt="n",

```

```

      xlab="Hazard Ratio", ylab="", main="Forest Plot of Cox Model")
axis(2, at=1:length(hr), labels=vars, las=1)
segments(lower, 1:length(hr), upper, 1:length(hr))
abline(v=1, col="red", lty=2)

```



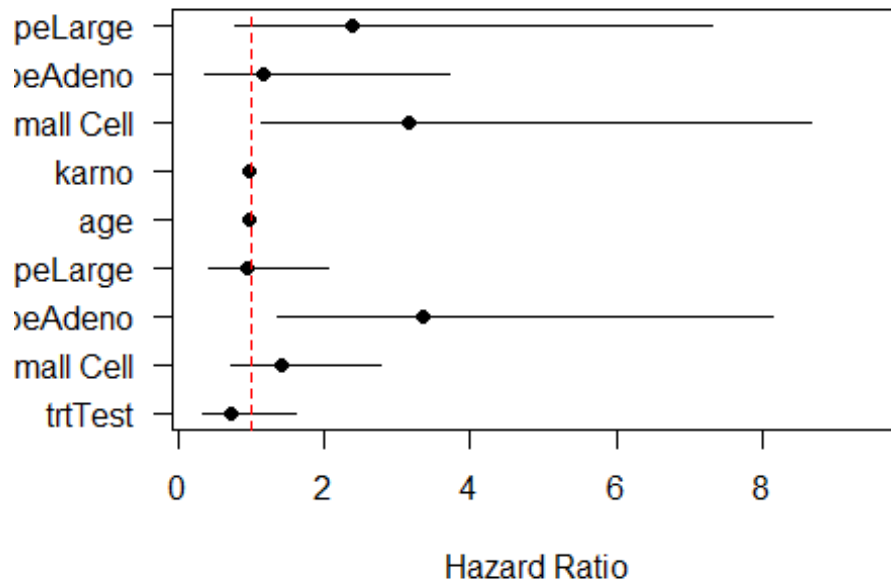
```

hr <- exp(coef(cox_inter))
lower <- exp(confint(cox_inter)[,1])
upper <- exp(confint(cox_inter)[,2])
vars <- names(hr)

plot(hr, 1:length(hr), xlim=c(min(lower)*0.9, max(upper)*1.1), pch=19,
      yaxt="n",
      xlab="Hazard Ratio", ylab="", main="Forest Plot of Cox Model")
axis(2, at=1:length(hr), labels=vars, las=1)
segments(lower, 1:length(hr), upper, 1:length(hr))
abline(v=1, col="red", lty=2)

```

### Forest Plot of Cox Model



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