Survival Analysis

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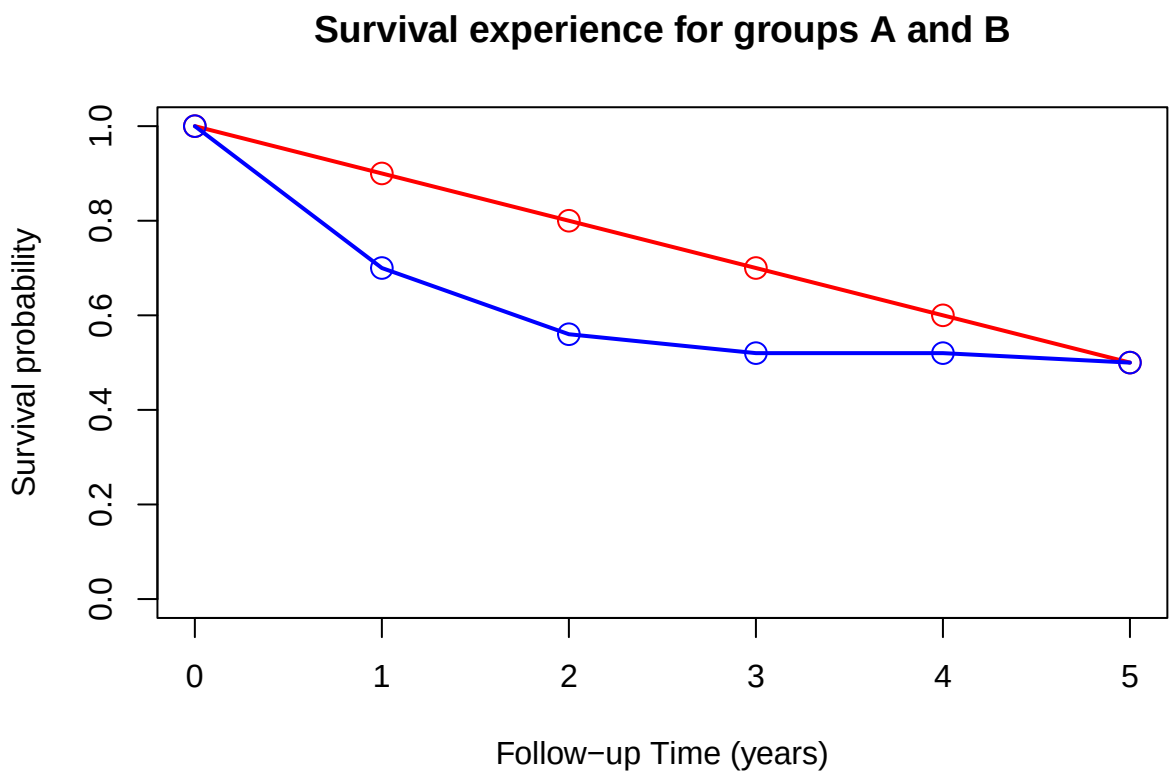
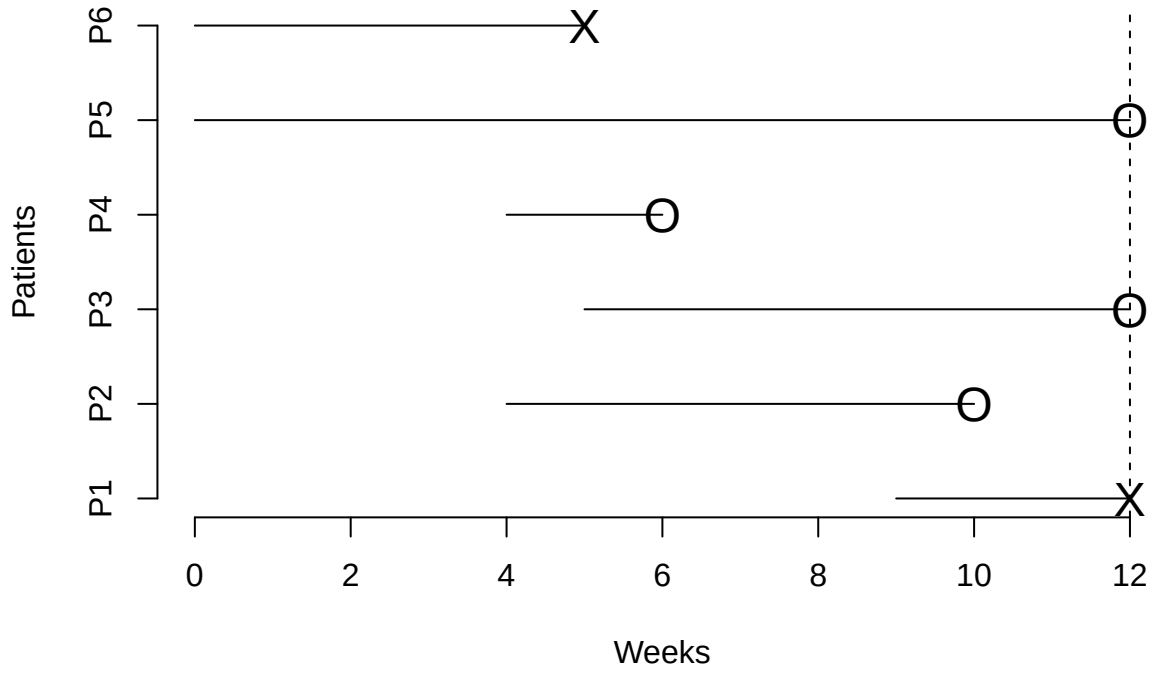
```
x <- c(0:5)
y.a <- seq(from=1,to=.5,length=6)
y.b <- c(1,.7,.56,.52,.52,.5)

plot(c(0,5), c(0,1), type='n', xlab='Follow-up Time (years)', ylab='Survival probability',
     main='Survival experience for groups A and B')
lines(x, y.a, col='red', lwd=2)
points(x, y.a, col='red', cex=1.5)
lines(x, y.b, col='blue', lwd=2)
points(x, y.b, col='blue', cex=1.5)
```




```
plot(c(0,12),c(1,6),axes=FALSE,xlab="Weeks",ylab="Patients",type="n")
axis(side=2,at=c(1:6),labels=c("P1","P2","P3","P4","P5","P6"))
axis(side=1,at=seq(0,12,2),labels=c("0","2","4","6","8","10","12"))

#P6 - experiences event
```

```
lines(c(0:5),rep(6,6)); points(5,6,cex=1.5,pch="X");

#P5 - has censored survival time; study ends
lines(c(0:12),rep(5,13)); points(12,5,cex=1.5,pch="O");

#P4 - has censored survival time; withdrawn from study
lines(c(4:6),rep(4,3)); points(6,4,cex=1.5,pch="O");

#P3 - has censored survival time; study ends
lines(c(5:12),rep(3,8)); points(12,3,cex=1.5,pch="O");

#P2 - has censored survival time; lost
lines(c(4:10),rep(2,7)); points(10,2,cex=1.5,pch="O");

#P1 - experiences event
lines(c(9:12),rep(1,4)); points(12,1,cex=1.5,pch="X");

abline(v=12,lty=2) # end of study marker
```



Kaplan-Meier curves

```
library(survival); library(splines);
```

Kaplan-Meier curves

Remission data

```
surv <- data.frame(c(0,6,6,6,6,7,7,10,10,10,13,16,16,16,16,22,23,23,23,23,23,23),
                   c(0,1,1,1,0,1,0,1,0,0,1,1,0,0,0,1,1,0,0,0,0,0))
names(surv) <- c('time', 'status')
surv$x <- 'remission'
surv
```

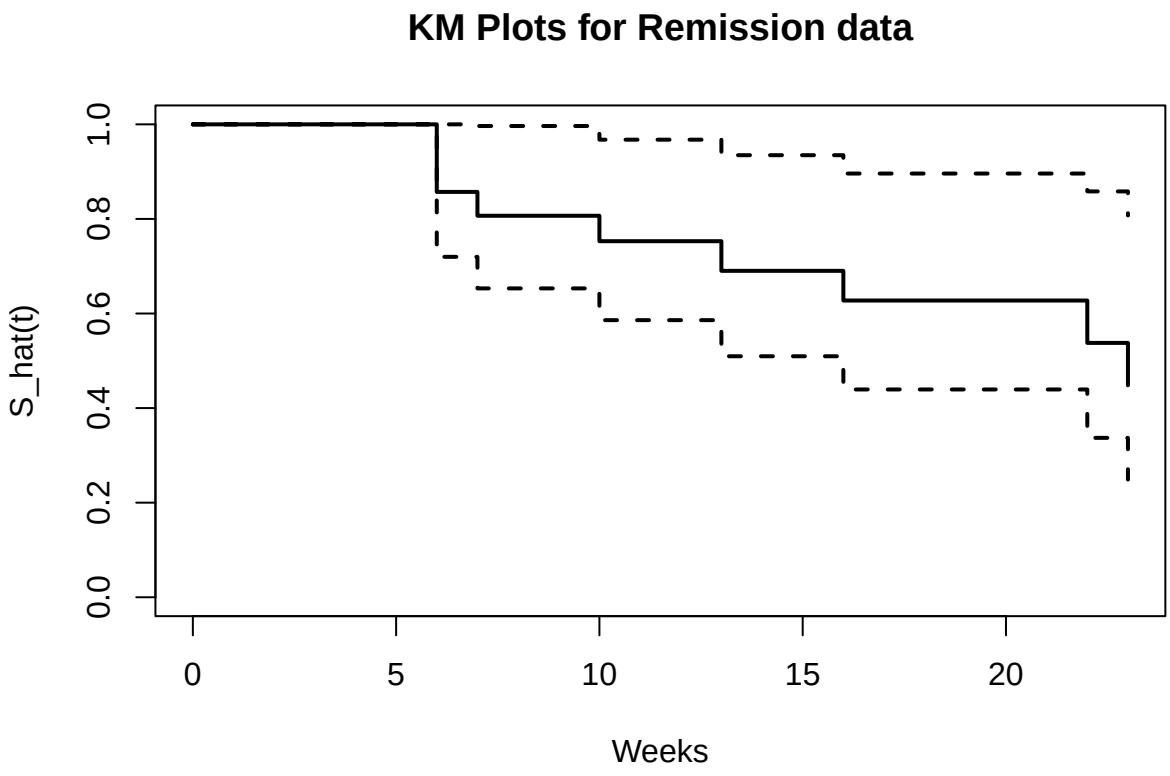
```
##    time status         x
## 1     0      0 remission
## 2     6      1 remission
## 3     6      1 remission
## 4     6      1 remission
## 5     6      0 remission
## 6     7      1 remission
## 7     7      0 remission
## 8    10      1 remission
## 9    10      0 remission
## 10   10      0 remission
## 11   13      1 remission
## 12   16      1 remission
## 13   16      0 remission
## 14   16      0 remission
## 15   16      0 remission
## 16   22      1 remission
## 17   23      1 remission
## 18   23      0 remission
## 19   23      0 remission
## 20   23      0 remission
## 21   23      0 remission
## 22   23      0 remission
```

```
f <- survfit(Surv(time, status) ~ x, type= 'kaplan-meier', data = surv)
summary(f)
```

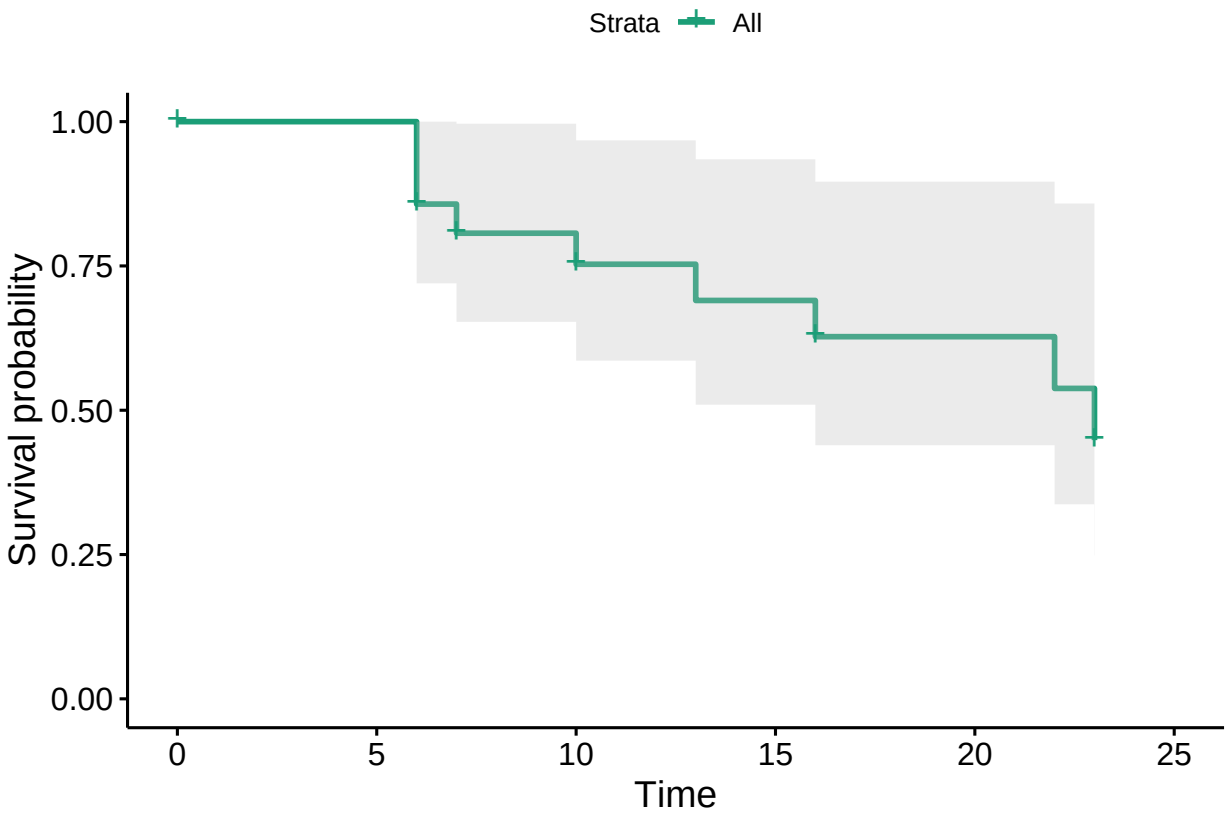
Kaplan-Meier curves for remission data

```
## Call: survfit(formula = Surv(time, status) ~ x, data = surv, type = "kaplan-meier")
##
##  time n.risk n.event survival std.err lower 95% CI upper 95% CI
##     6     21       3    0.857  0.0764        0.720        1.000
##     7     17       1    0.807  0.0869        0.653        0.996
##    10     15       1    0.753  0.0963        0.586        0.968
##    13     12       1    0.690  0.1068        0.510        0.935
##    16     11       1    0.627  0.1141        0.439        0.896
##    22      7       1    0.538  0.1282        0.337        0.858
##    23      6       1    0.448  0.1346        0.249        0.807
```

```
plot(f, lwd=2, xlab='Weeks', ylab='S_hat(t)', main='KM Plots for Remission data')
```




```
#install.packages("survminer")
library(survminer)

ggsurvplot(f, linetype = "strata", conf.int = TRUE, pval = TRUE, palette = "Dark2")
```

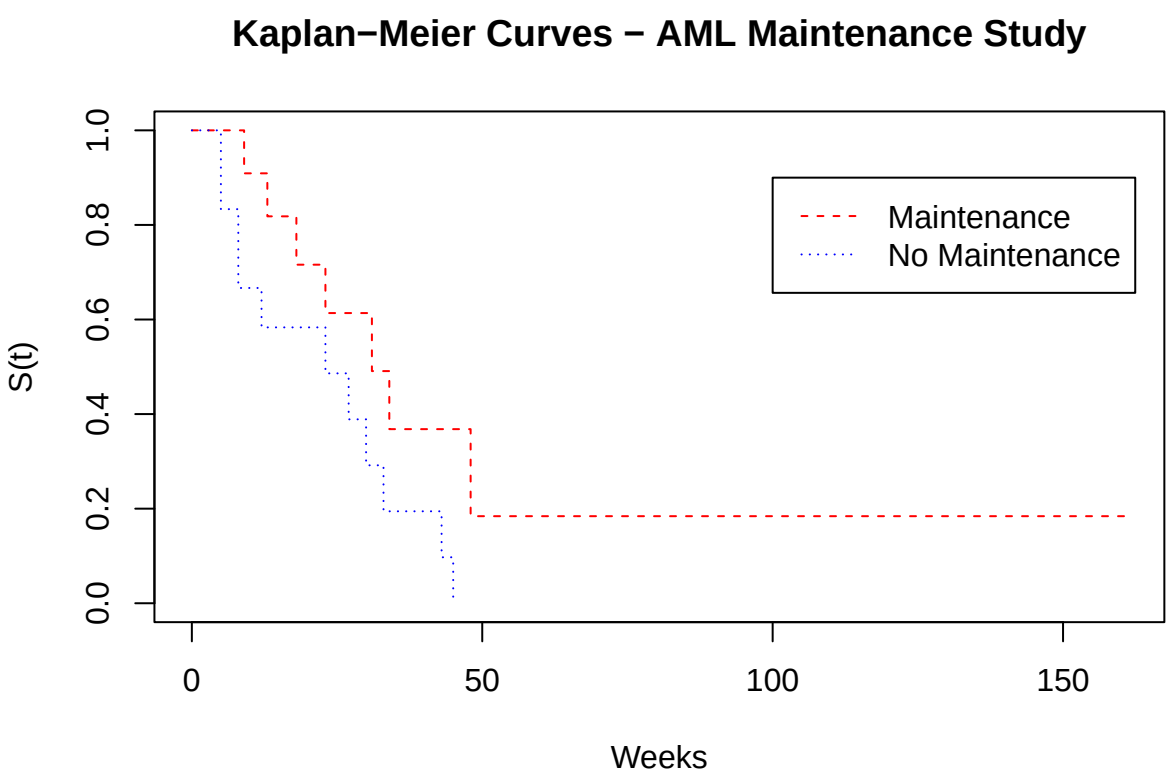



```
survdiff(Surv(time, status) ~ x, data = aml)
```

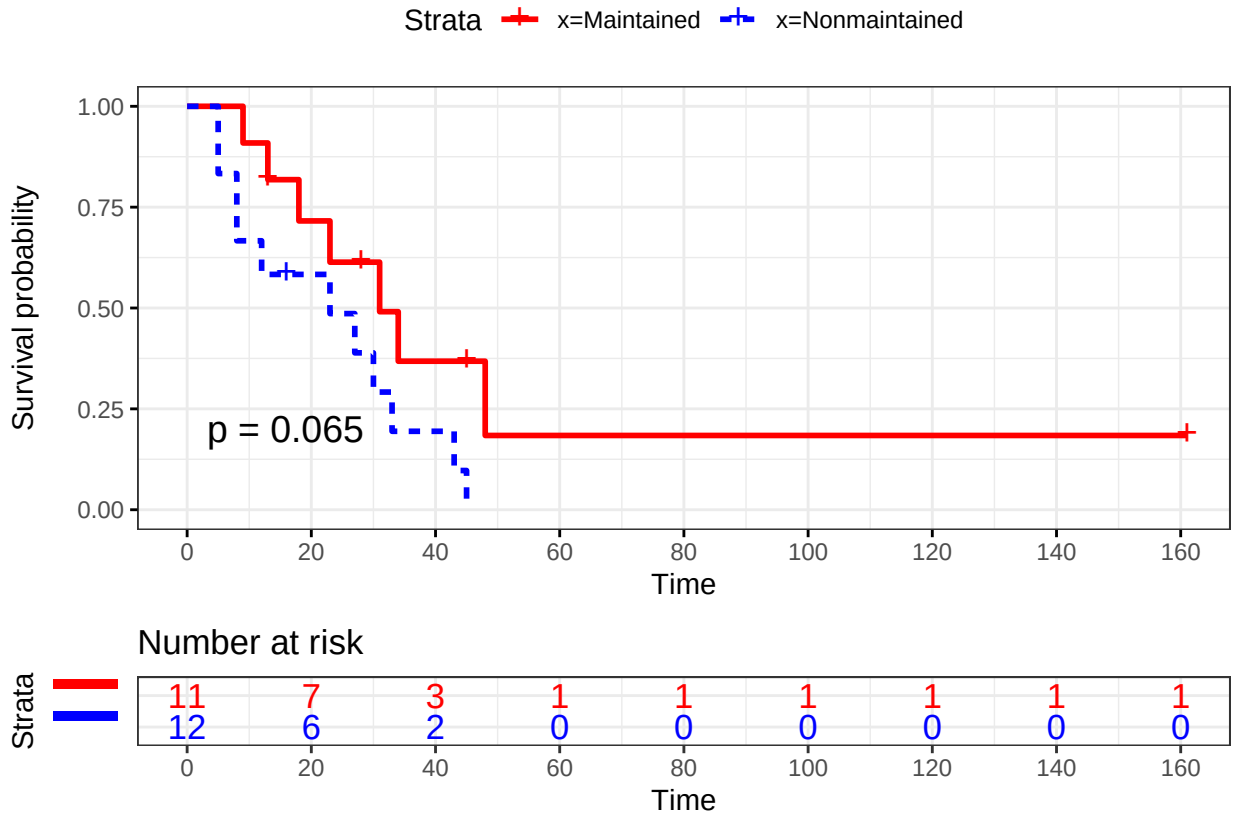
Kaplan-Meier curves for AML Maintenance data

```
## Call:
## survdiff(formula = Surv(time, status) ~ x, data = aml)
##
##                  N Observed Expected (O-E)^2/E (O-E)^2/V
## x=Maintained    11        7    10.69      1.27       3.4
## x=Nonmaintained 12       11     7.31      1.86       3.4
##
##  Chisq= 3.4  on 1 degrees of freedom, p= 0.07
```

```
leukemia.surv <- survfit(Surv(time, status) ~ x, data = aml)
plot(leukemia.surv, lty = 2:3,xlab="Weeks",ylab="S(t)",col=c("red", "blue"))
legend(100, .9, c("Maintenance", "No Maintenance"), lty = 2:3, col=c("red", "blue"))
title("Kaplan-Meier Curves - AML Maintenance Study")
```




```
ggsurvplot(leukemia.surv, linetype = "strata", conf.int = FALSE, pval = TRUE,
           risk.table = TRUE, risk.table.y.text.col = TRUE, risk.table.y.text = FALSE,
           risk.table.height = 0.25, risk.table.col = "strata",
           break.time.by = 20,
           ggtheme = theme_bw(),
           palette = c("red", "blue"))
```



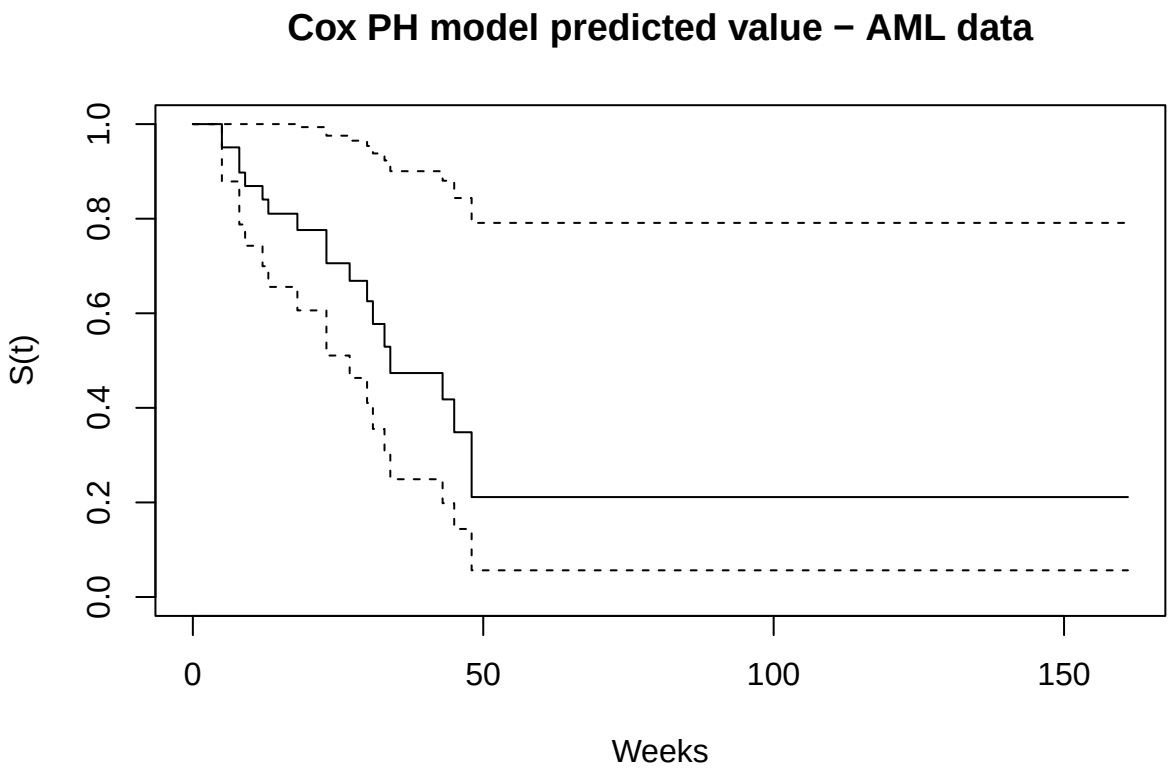
Cox Proportional-Hazards regression model for AML Maintenance data

```
fit <- coxph( Surv(time,status)~x,data=aml)
summary(fit)
```

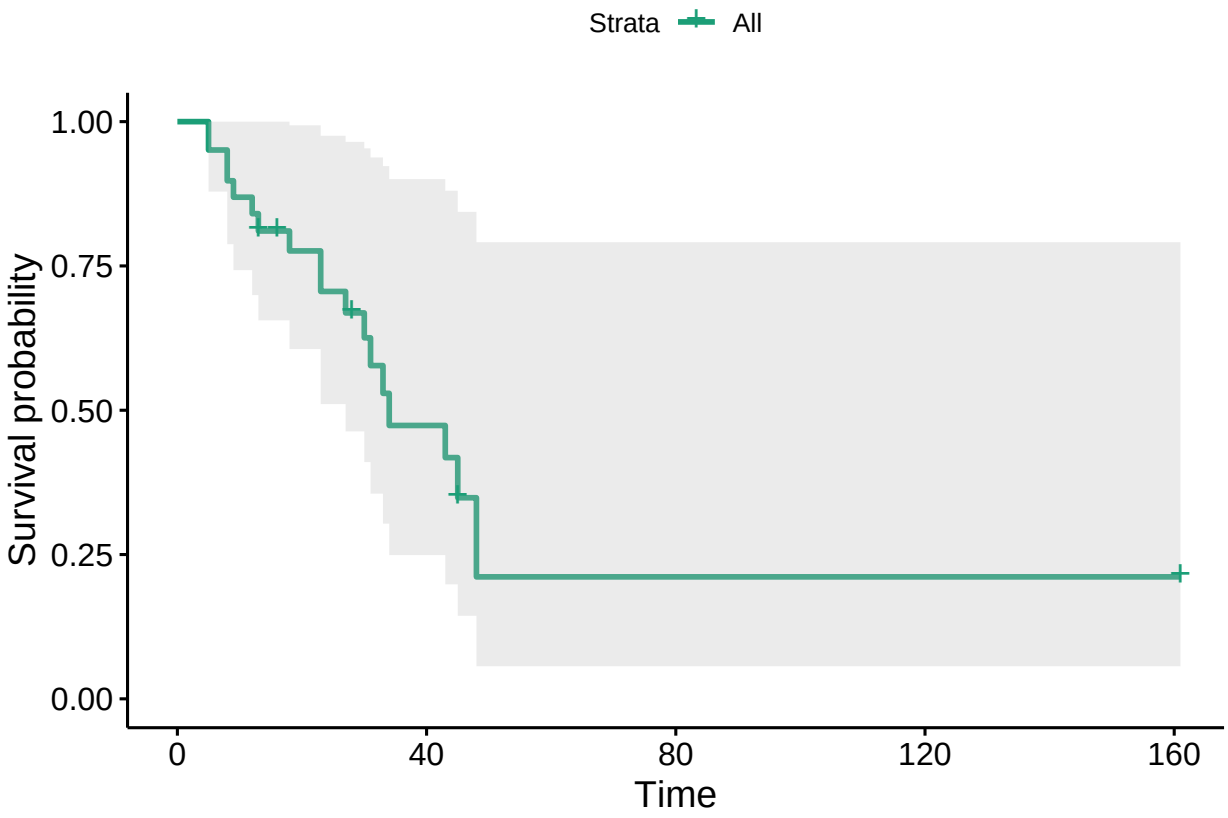
```
## Call:
## coxph(formula = Surv(time, status) ~ x, data = aml)
##
##   n= 23, number of events= 18
##
##                   coef exp(coef) se(coef)     z Pr(>|z|)
## xNonmaintained 0.9155    2.4981   0.5119 1.788   0.0737 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##                exp(coef) exp(-coef) lower .95 upper .95
## xNonmaintained     2.498     0.4003    0.9159     6.813
##
## Concordance= 0.619  (se = 0.063 )
## Likelihood ratio test= 3.38  on 1 df,   p=0.07
## Wald test            = 3.2  on 1 df,   p=0.07
## Score (logrank) test = 3.42  on 1 df,   p=0.06
```

Cox Proportional-Hazards regression model for AML Maintenance data

```
plot(survfit(fit),xlab="Weeks",ylab="S(t)",main="Cox PH model predicted value - AML data")
```




```
ggsurvplot(survfit(fit, data=aml), conf.int = TRUE, palette = "Dark2")
```


Strata
All
1.00
0.75
0.50
0.25
0.00
Survival probability
0
40
80
120
160
Time