Survival analysis

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June 26, 2019

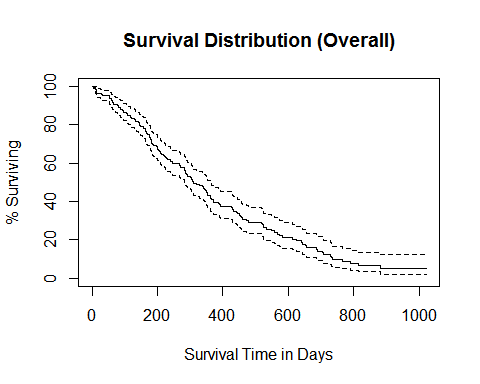
# Mayo Clinic Lung Cancer Data  
library(survival)  
  
# learn about the dataset  
help(lung)

## starting httpd help server ... done

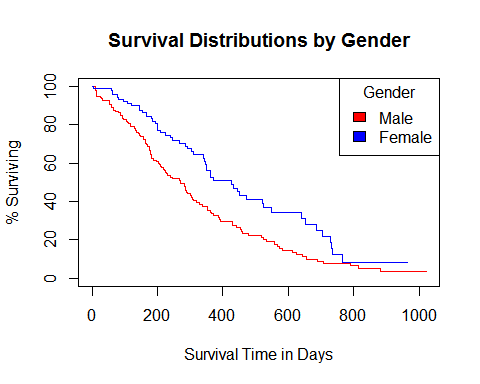
# create a Surv object  
survobj <- with(lung, Surv(time,status))  
  
# Plot survival distribution of the total sample  
# Kaplan-Meier estimator  
fit0 <- survfit(survobj~1, data=lung)  
summary(fit0)

## Call: survfit(formula = survobj ~ 1, data = lung)  
##   
## time n.risk n.event survival std.err lower 95% CI upper 95% CI  
## 5 228 1 0.9956 0.00438 0.9871 1.000  
## 11 227 3 0.9825 0.00869 0.9656 1.000  
## 12 224 1 0.9781 0.00970 0.9592 0.997  
## 13 223 2 0.9693 0.01142 0.9472 0.992  
## 15 221 1 0.9649 0.01219 0.9413 0.989  
## 26 220 1 0.9605 0.01290 0.9356 0.986  
## 30 219 1 0.9561 0.01356 0.9299 0.983  
## 31 218 1 0.9518 0.01419 0.9243 0.980  
## 53 217 2 0.9430 0.01536 0.9134 0.974  
## 54 215 1 0.9386 0.01590 0.9079 0.970  
## 59 214 1 0.9342 0.01642 0.9026 0.967  
## 60 213 2 0.9254 0.01740 0.8920 0.960  
## 61 211 1 0.9211 0.01786 0.8867 0.957  
## 62 210 1 0.9167 0.01830 0.8815 0.953  
## 65 209 2 0.9079 0.01915 0.8711 0.946  
## 71 207 1 0.9035 0.01955 0.8660 0.943  
## 79 206 1 0.8991 0.01995 0.8609 0.939  
## 81 205 2 0.8904 0.02069 0.8507 0.932  
## 88 203 2 0.8816 0.02140 0.8406 0.925  
## 92 201 1 0.8772 0.02174 0.8356 0.921  
## 93 199 1 0.8728 0.02207 0.8306 0.917  
## 95 198 2 0.8640 0.02271 0.8206 0.910  
## 105 196 1 0.8596 0.02302 0.8156 0.906  
## 107 194 2 0.8507 0.02362 0.8056 0.898  
## 110 192 1 0.8463 0.02391 0.8007 0.894  
## 116 191 1 0.8418 0.02419 0.7957 0.891  
## 118 190 1 0.8374 0.02446 0.7908 0.887  
## 122 189 1 0.8330 0.02473 0.7859 0.883  
## 131 188 1 0.8285 0.02500 0.7810 0.879  
## 132 187 2 0.8197 0.02550 0.7712 0.871  
## 135 185 1 0.8153 0.02575 0.7663 0.867  
## 142 184 1 0.8108 0.02598 0.7615 0.863  
## 144 183 1 0.8064 0.02622 0.7566 0.859  
## 145 182 2 0.7975 0.02667 0.7469 0.852  
## 147 180 1 0.7931 0.02688 0.7421 0.848  
## 153 179 1 0.7887 0.02710 0.7373 0.844  
## 156 178 2 0.7798 0.02751 0.7277 0.836  
## 163 176 3 0.7665 0.02809 0.7134 0.824  
## 166 173 2 0.7577 0.02845 0.7039 0.816  
## 167 171 1 0.7532 0.02863 0.6991 0.811  
## 170 170 1 0.7488 0.02880 0.6944 0.807  
## 175 167 1 0.7443 0.02898 0.6896 0.803  
## 176 165 1 0.7398 0.02915 0.6848 0.799  
## 177 164 1 0.7353 0.02932 0.6800 0.795  
## 179 162 2 0.7262 0.02965 0.6704 0.787  
## 180 160 1 0.7217 0.02981 0.6655 0.783  
## 181 159 2 0.7126 0.03012 0.6559 0.774  
## 182 157 1 0.7081 0.03027 0.6511 0.770  
## 183 156 1 0.7035 0.03041 0.6464 0.766  
## 186 154 1 0.6989 0.03056 0.6416 0.761  
## 189 152 1 0.6943 0.03070 0.6367 0.757  
## 194 149 1 0.6897 0.03085 0.6318 0.753  
## 197 147 1 0.6850 0.03099 0.6269 0.749  
## 199 145 1 0.6803 0.03113 0.6219 0.744  
## 201 144 2 0.6708 0.03141 0.6120 0.735  
## 202 142 1 0.6661 0.03154 0.6071 0.731  
## 207 139 1 0.6613 0.03168 0.6020 0.726  
## 208 138 1 0.6565 0.03181 0.5970 0.722  
## 210 137 1 0.6517 0.03194 0.5920 0.717  
## 212 135 1 0.6469 0.03206 0.5870 0.713  
## 218 134 1 0.6421 0.03218 0.5820 0.708  
## 222 132 1 0.6372 0.03231 0.5769 0.704  
## 223 130 1 0.6323 0.03243 0.5718 0.699  
## 226 126 1 0.6273 0.03256 0.5666 0.694  
## 229 125 1 0.6223 0.03268 0.5614 0.690  
## 230 124 1 0.6172 0.03280 0.5562 0.685  
## 239 121 2 0.6070 0.03304 0.5456 0.675  
## 245 117 1 0.6019 0.03316 0.5402 0.670  
## 246 116 1 0.5967 0.03328 0.5349 0.666  
## 267 112 1 0.5913 0.03341 0.5294 0.661  
## 268 111 1 0.5860 0.03353 0.5239 0.656  
## 269 110 1 0.5807 0.03364 0.5184 0.651  
## 270 108 1 0.5753 0.03376 0.5128 0.645  
## 283 104 1 0.5698 0.03388 0.5071 0.640  
## 284 103 1 0.5642 0.03400 0.5014 0.635  
## 285 101 2 0.5531 0.03424 0.4899 0.624  
## 286 99 1 0.5475 0.03434 0.4841 0.619  
## 288 98 1 0.5419 0.03444 0.4784 0.614  
## 291 97 1 0.5363 0.03454 0.4727 0.608  
## 293 94 1 0.5306 0.03464 0.4669 0.603  
## 301 91 1 0.5248 0.03475 0.4609 0.597  
## 303 89 1 0.5189 0.03485 0.4549 0.592  
## 305 87 1 0.5129 0.03496 0.4488 0.586  
## 306 86 1 0.5070 0.03506 0.4427 0.581  
## 310 85 2 0.4950 0.03523 0.4306 0.569  
## 320 82 1 0.4890 0.03532 0.4244 0.563  
## 329 81 1 0.4830 0.03539 0.4183 0.558  
## 337 79 1 0.4768 0.03547 0.4121 0.552  
## 340 78 1 0.4707 0.03554 0.4060 0.546  
## 345 77 1 0.4646 0.03560 0.3998 0.540  
## 348 76 1 0.4585 0.03565 0.3937 0.534  
## 350 75 1 0.4524 0.03569 0.3876 0.528  
## 351 74 1 0.4463 0.03573 0.3815 0.522  
## 353 73 2 0.4340 0.03578 0.3693 0.510  
## 361 70 1 0.4278 0.03581 0.3631 0.504  
## 363 69 2 0.4154 0.03583 0.3508 0.492  
## 364 67 1 0.4092 0.03582 0.3447 0.486  
## 371 65 2 0.3966 0.03581 0.3323 0.473  
## 387 60 1 0.3900 0.03582 0.3258 0.467  
## 390 59 1 0.3834 0.03582 0.3193 0.460  
## 394 58 1 0.3768 0.03580 0.3128 0.454  
## 426 55 1 0.3700 0.03580 0.3060 0.447  
## 428 54 1 0.3631 0.03579 0.2993 0.440  
## 429 53 1 0.3563 0.03576 0.2926 0.434  
## 433 52 1 0.3494 0.03573 0.2860 0.427  
## 442 51 1 0.3426 0.03568 0.2793 0.420  
## 444 50 1 0.3357 0.03561 0.2727 0.413  
## 450 48 1 0.3287 0.03555 0.2659 0.406  
## 455 47 1 0.3217 0.03548 0.2592 0.399  
## 457 46 1 0.3147 0.03539 0.2525 0.392  
## 460 44 1 0.3076 0.03530 0.2456 0.385  
## 473 43 1 0.3004 0.03520 0.2388 0.378  
## 477 42 1 0.2933 0.03508 0.2320 0.371  
## 519 39 1 0.2857 0.03498 0.2248 0.363  
## 520 38 1 0.2782 0.03485 0.2177 0.356  
## 524 37 2 0.2632 0.03455 0.2035 0.340  
## 533 34 1 0.2554 0.03439 0.1962 0.333  
## 550 32 1 0.2475 0.03423 0.1887 0.325  
## 558 30 1 0.2392 0.03407 0.1810 0.316  
## 567 28 1 0.2307 0.03391 0.1729 0.308  
## 574 27 1 0.2221 0.03371 0.1650 0.299  
## 583 26 1 0.2136 0.03348 0.1571 0.290  
## 613 24 1 0.2047 0.03325 0.1489 0.281  
## 624 23 1 0.1958 0.03297 0.1407 0.272  
## 641 22 1 0.1869 0.03265 0.1327 0.263  
## 643 21 1 0.1780 0.03229 0.1247 0.254  
## 654 20 1 0.1691 0.03188 0.1169 0.245  
## 655 19 1 0.1602 0.03142 0.1091 0.235  
## 687 18 1 0.1513 0.03090 0.1014 0.226  
## 689 17 1 0.1424 0.03034 0.0938 0.216  
## 705 16 1 0.1335 0.02972 0.0863 0.207  
## 707 15 1 0.1246 0.02904 0.0789 0.197  
## 728 14 1 0.1157 0.02830 0.0716 0.187  
## 731 13 1 0.1068 0.02749 0.0645 0.177  
## 735 12 1 0.0979 0.02660 0.0575 0.167  
## 765 10 1 0.0881 0.02568 0.0498 0.156  
## 791 9 1 0.0783 0.02462 0.0423 0.145  
## 814 7 1 0.0671 0.02351 0.0338 0.133  
## 883 4 1 0.0503 0.02285 0.0207 0.123

plot(fit0, xlab="Survival Time in Days",  
 ylab="% Surviving", yscale=100,  
 main="Survival Distribution (Overall)")



# Compare the survival distributions of men and women  
fit1 <- survfit(survobj~sex,data=lung)  
  
# plot the survival distributions by sex  
plot(fit1, xlab="Survival Time in Days",  
 ylab="% Surviving", yscale=100, col=c("red","blue"),  
 main="Survival Distributions by Gender")  
legend("topright", title="Gender", c("Male", "Female"),  
 fill=c("red", "blue"))



# test for difference between male and female  
# survival curves (logrank test)  
survdiff(survobj~sex, data=lung)

## Call:  
## survdiff(formula = survobj ~ sex, data = lung)  
##   
## N Observed Expected (O-E)^2/E (O-E)^2/V  
## sex=1 138 112 91.6 4.55 10.3  
## sex=2 90 53 73.4 5.68 10.3  
##   
## Chisq= 10.3 on 1 degrees of freedom, p= 0.001

# predict male survival from age and medical scores  
MaleMod <- coxph(survobj~age+ph.ecog+ph.karno+pat.karno,  
 data=lung, subset=sex==1)  
  
# display results  
MaleMod

## Call:  
## coxph(formula = survobj ~ age + ph.ecog + ph.karno + pat.karno,   
## data = lung, subset = sex == 1)  
##   
## coef exp(coef) se(coef) z p  
## age 0.022465 1.022719 0.012216 1.839 0.0659  
## ph.ecog 0.665452 1.945370 0.225712 2.948 0.0032  
## ph.karno 0.025553 1.025883 0.011778 2.170 0.0300  
## pat.karno -0.011059 0.989002 0.008892 -1.244 0.2136  
##   
## Likelihood ratio test=17.87 on 4 df, p=0.001311  
## n= 134, number of events= 108   
## (4 observations deleted due to missingness)

# evaluate the proportional hazards assumption  
cox.zph(MaleMod)

## rho chisq p  
## age 0.00534 0.00363 0.952  
## ph.ecog 0.02851 0.09155 0.762  
## ph.karno 0.16922 2.43462 0.119  
## pat.karno 0.02988 0.12793 0.721  
## GLOBAL NA 5.62951 0.229