Game of Thrones - Survival Analysis

Description

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- Date: 5 april 2020

Objectives

Target of this analysis is to study ...

Dataset description

Dataset downloaded from here

Game of Thrones mortality and survival dataset

Dataset posted on 13.06.2019, 10:25 by Reidar Lystad Benjamin Brown

This dataset includes data from Game of Thrones Seasons 1–8. The dataset comprises two separate datasets and an accompanying data dictionary. The character dataset contains 359 observations (i.e. characters) and 35 variables, including information about sociodemographics, exposures, and mortality. The episode dataset contains 73 observations (i.e. episodes) and 8 variables, including information about episode running time.

In this study we will use only the character dataset.

Character dataset

- Number of observations: 359.
- Outcome:
  - **exp_time_hrs** Survival time of character (calculated as the time between first apparition and death)
- Censoring indicator:
  - **dth_flag** = 0 if character is not dead by the end of the serie , = 1 otherwise
- Explanatory variables:

Data Preparation

load needed libraries

```
library(tidyverse)
library(survival)
library(ggfortify)
library(ggplot2)
library(broom)
library(survminer)
```

import datas from csv file:

```
setwd("C:/MY_DATAS/MyGit/GoT-Survival_Analysis")
raw_data =  read.csv("./GoT_dataset/character_data_S01-S08.csv")
dat = select(raw_data,name,exp_time_hrs,dth_flag,sex,religion,occupation,social_status,allegiance_last,a
dat = mutate(dat,
              sex = c("Male","Female")[match(sex, c(1,2))],
              religion = c("Great Stallion","Lord of Light","Faith of the Seven","Old Gods","Drowned God
              occupation = c("Silk collar","Boiled leather collar","Unknown/Unclear")[match(occupation,c
              social_status = c("Highborn","Lowborn")[match(social_status,c(1,2))],
              allegiance_last = c("Stark","Targaryen","Night's Watch","Lannister","Greyjoy","Bolton","Fr
              allegiance_switched = c("No","Yes")[match(allegiance_switched,c(1,2))],
              prominence = ifelse(prominence>3,"High",ifelse(prominence<1,"Low","Medium"))
              )
```

Data Exploration

Proportion of people dead before the end of the serie.

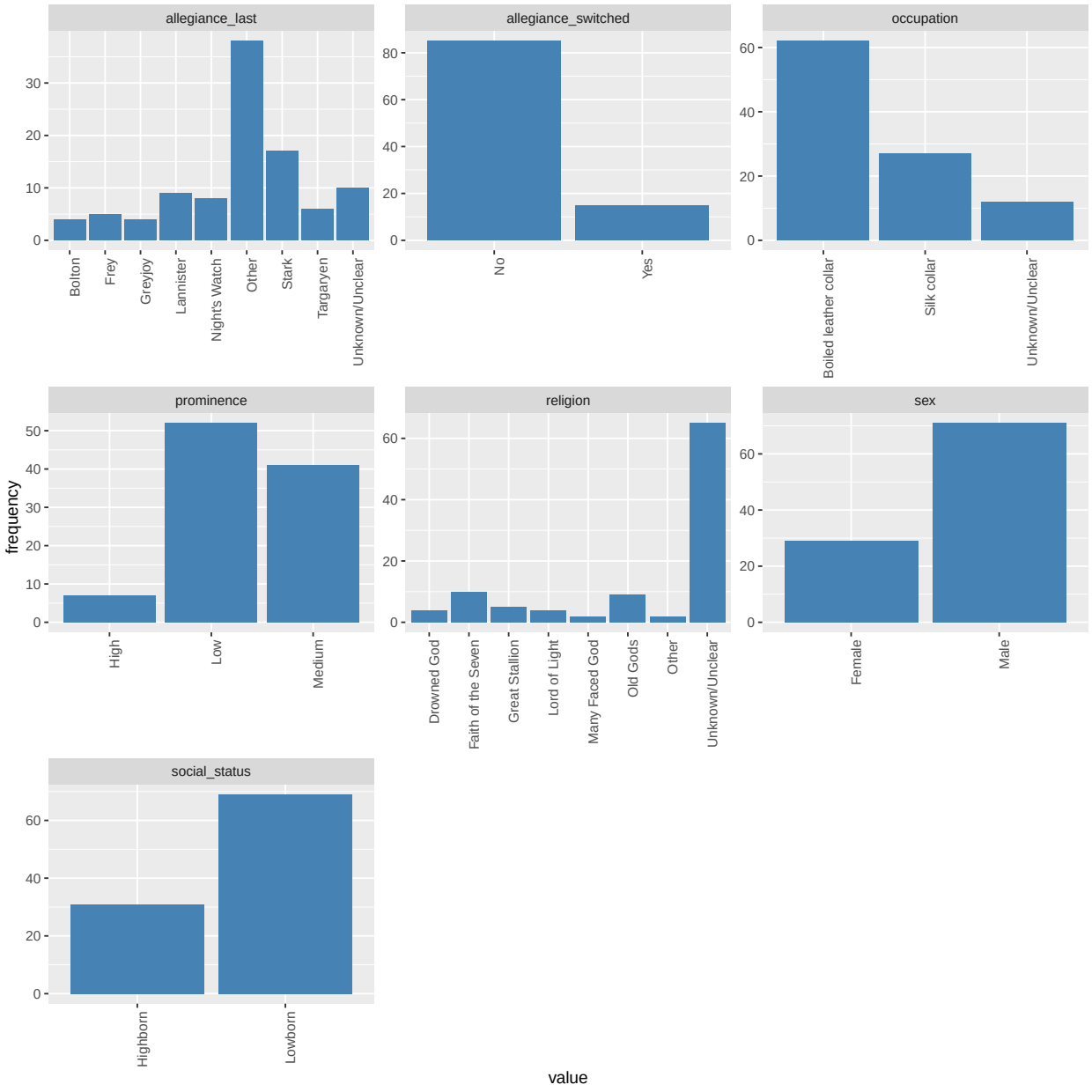
```
prop.table(table(dat$dth_flag))
```

```
##
##         0         1
## 0.4094708 0.5905292
```

–> roughly 40% of censored datas, 60% of the characters in the study are dead before the end of the serie

Show explanatory variables composition:

```
d_plot = dat %>%
  select(-name,-exp_time_hrs,-dth_flag) %>%
  gather() %>%
  group_by(key) %>%
  count(value) %>%
  mutate(frequency=round(`n`/sum(`n`)*100,0)) %>%
  arrange(desc(key),desc(frequency))

d_plot %>% ggplot(aes(x=value, y=frequency)) +
    facet_wrap(~ key, scales = "free") +
    geom_bar(stat="identity", fill="steelblue") +
    theme(axis.text.x = element_text(angle = 90, hjust = 1))
```



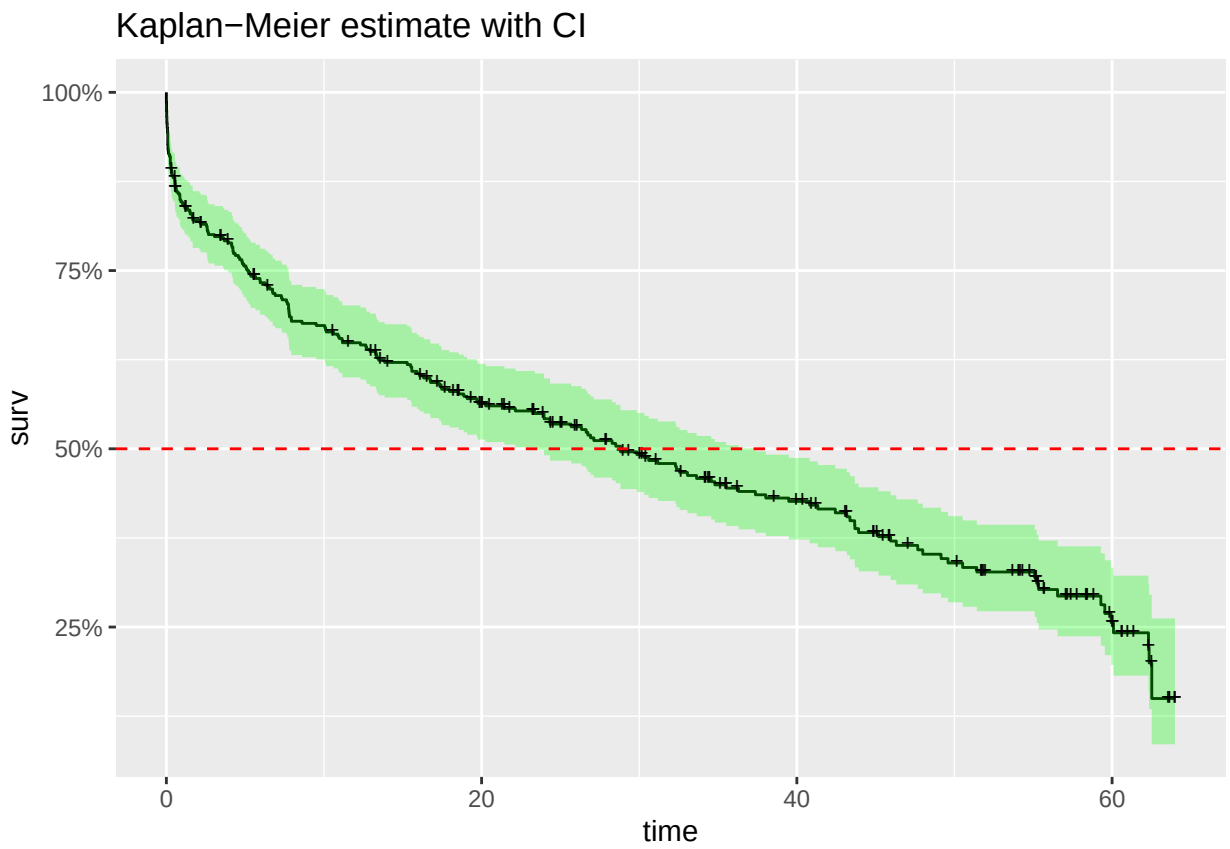
–> 65% of the population have not known or unclear religion –> Careful to check if meaningful –> most are Boiled leather collar –> 70% are lowborn

Global survival overview

Kaplan-Meyer estimator

- First look at outcome:

```
fit.KM = survfit(Surv(exp_time_hrs, dth_flag) ~ 1, data = dat)
autoplot(fit.KM,conf.int.fill = "#00FF00") +
  geom_hline(yintercept=.5, linetype="dashed", color = "red")+ ggtitle("Kaplan-Meier estimate with CI")
```



Median Survival Time: 28.8hrs - As a character, you would have 50% of change to stay alive up to 28.8hrs

```
fit.KM
```

```
## Call: survfit(formula = Surv(exp_time_hrs, dth_flag) ~ 1, data = dat)
##
##       n  events  median 0.95LCL 0.95UCL
##   359.0   212.0    28.8    23.4    37.4
```

Survival vs Explanatory variables

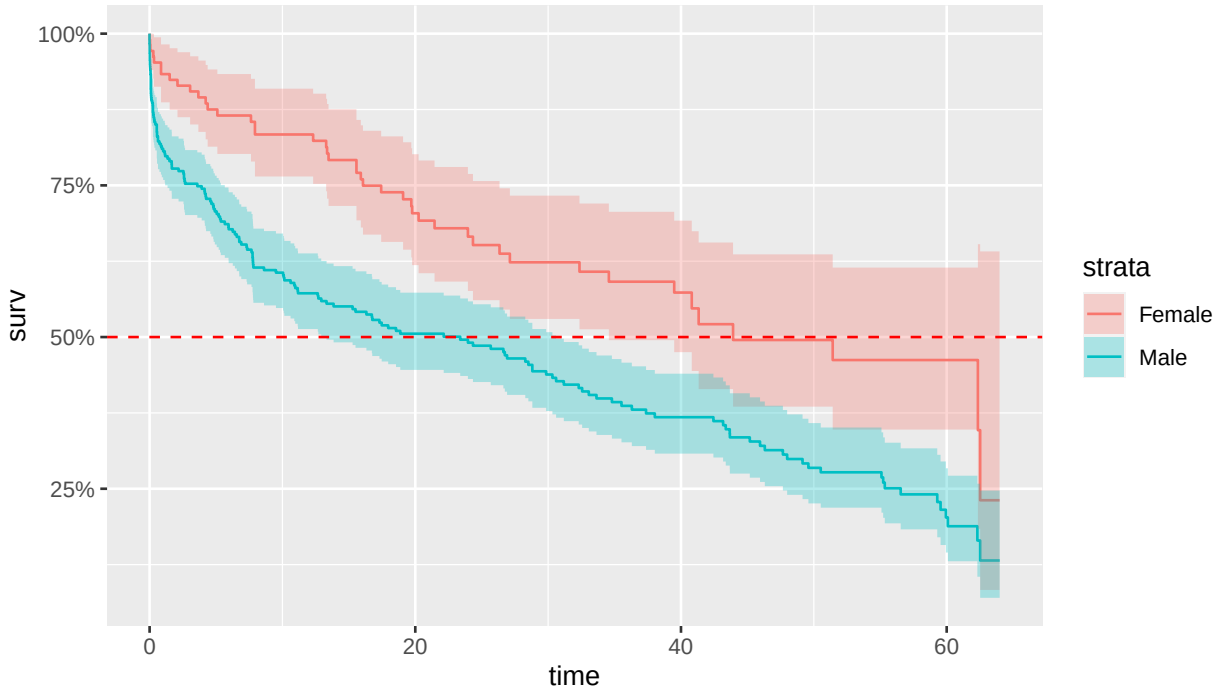
Used functions

```
plot_KM <- function(df,col,CI=TRUE){
  fit = survfit(Surv(df$exp_time_hrs, df$dth_flag) ~ df[,col])
  autoplot(fit,conf.int=CI,censor=FALSE) +
    geom_hline(yintercept=.5, linetype="dashed", color = "red")
}

print_medians <- function(df,col){
  fit = survfit(Surv(df$exp_time_hrs, df$dth_flag) ~ df[,col])
  infos_fit = surv_median(fit)
  infos_fit = infos_fit %>%
    mutate(strata=substr(strata,11,100))
```

```
  cat("Medians:\n")
  cat(sprintf("%*s %*s %*s\n",25,"Group",15,"Median",20,"Conf.Interval"))
  fit.conf=paste("( ",infos_fit$lower,";",infos_fit$upper," )",sep="")
  cat(sprintf("%*s %*s %*s\n",25,infos_fit$strata,15,infos_fit$median,20,fit.conf))
}

print_cox <- function(df,col){
  fit_cox = coxph(Surv(df$exp_time_hrs, df$dth_flag) ~ df[,col])
  x = tidy(fit_cox)
  cox.ref = fit_cox$xlevels[[1]][1]
  cox.term = substr(x$term,10,100)
  cox.hr = round(exp(x$estimate),2)
  cox.hr.conflow = round(exp(x$conf.low),2)
  cox.hr.confhigh = round(exp(x$conf.high),2)
  cat("Cox Regression:\n")
  cat(sprintf("%*s %*s %*s\n",25,"Group",15,"Hazard Ratio",20,"Conf.Interval"))
  cat(sprintf("%*s %*s %*s\n",25,cox.ref,15,"(Reference)",20,"-"))
  cox.conf=paste("( ",cox.hr.conflow,";",cox.hr.confhigh," )",sep="")
  cat(sprintf("%*s %*s %*s\n",25,cox.term,15,cox.hr,20,cox.conf))
  y = glance(fit_cox)
  cox.lrt = ifelse(y$p.value.log<0.01,formatC(y$p.value.log, format = "e", digits = 2),formatC(y$p.valu
  cat(paste("\nLikelihood Ratio Test:",cox.lrt))
}
```

- How is gender influencing survival time ?

```
plot_KM(dat,"sex")
```



```
print_cox(dat,"sex")
```

```
## Cox Regression:
##                      Group    Hazard Ratio        Conf.Interval
##                     Female     (Reference)                    -
##                       Male            1.87        ( 1.34;2.61 )
##
## Likelihood Ratio Test: 9.46e-05
```

Likelihood ratio test (LRT) pvalue is very small, proving that there is a significant difference between male and female survival time.

!!!! Hazard ration is 1.87, meaning that male have 1.87 more chances to be killes than women

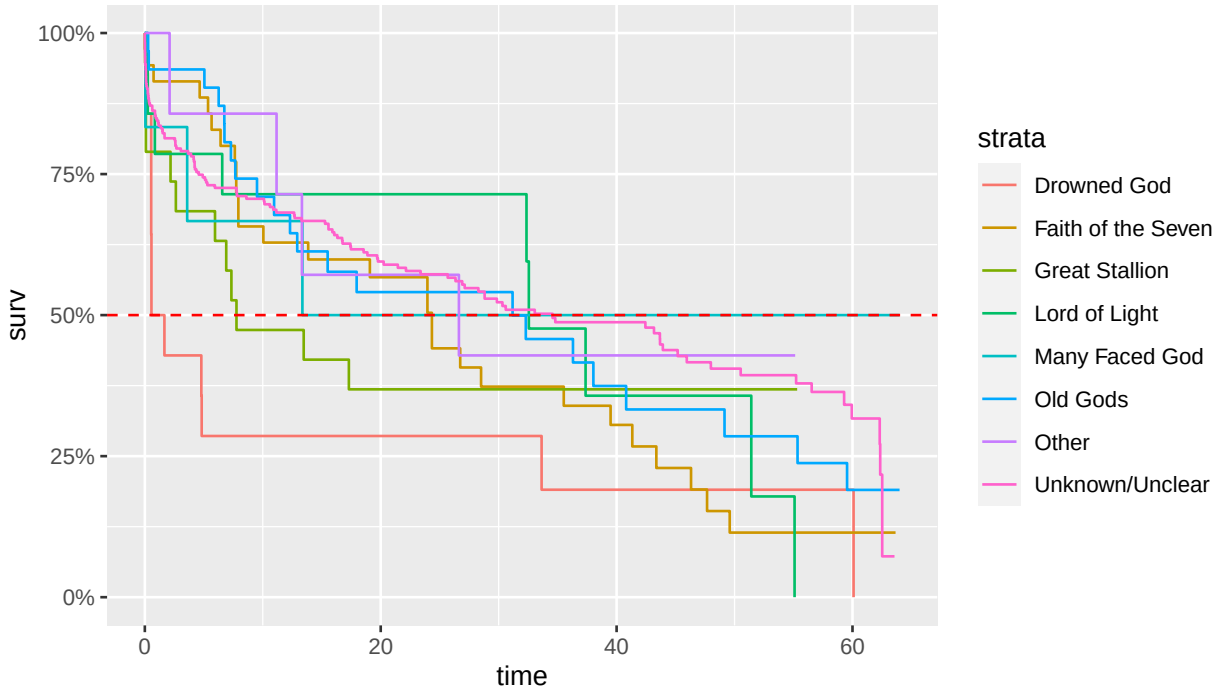
Here are the median survival time for each category:

```
print_medians(dat,"sex")
```

```
## Medians:
##                      Group          Median        Conf.Interval
##                     Female           43.92         ( 34.57;NA )
##                       Male           23.38       ( 13.32;30.6 )
```

- How is religion survival time ?

```
plot_KM(dat,"religion",FALSE)
```



```
print_cox(dat,"religion")
```

```
## Cox Regression:
##                      Group    Hazard Ratio        Conf.Interval
##               Drowned God     (Reference)                    -
##        Faith of the Seven            0.58        ( 0.29;1.15 )
##             Great Stallion            0.62         ( 0.28;1.38 )
##              Lord of Light            0.47          ( 0.2;1.13 )
##             Many Faced God             0.3         ( 0.08;1.07 )
##                   Old Gods            0.44         ( 0.21;0.88 )
##                      Other             0.4         ( 0.13;1.25 )
##            Unknown/Unclear             0.4         ( 0.22;0.73 )
##
## Likelihood Ratio Test: 0.14
```

Cox regression LRT pvalue is quite large and $> 5\%$ pointing that there is no significant difference between religions

One thing that can be noted from the graph is that the "Drowned God" religion has a median survival time very low...

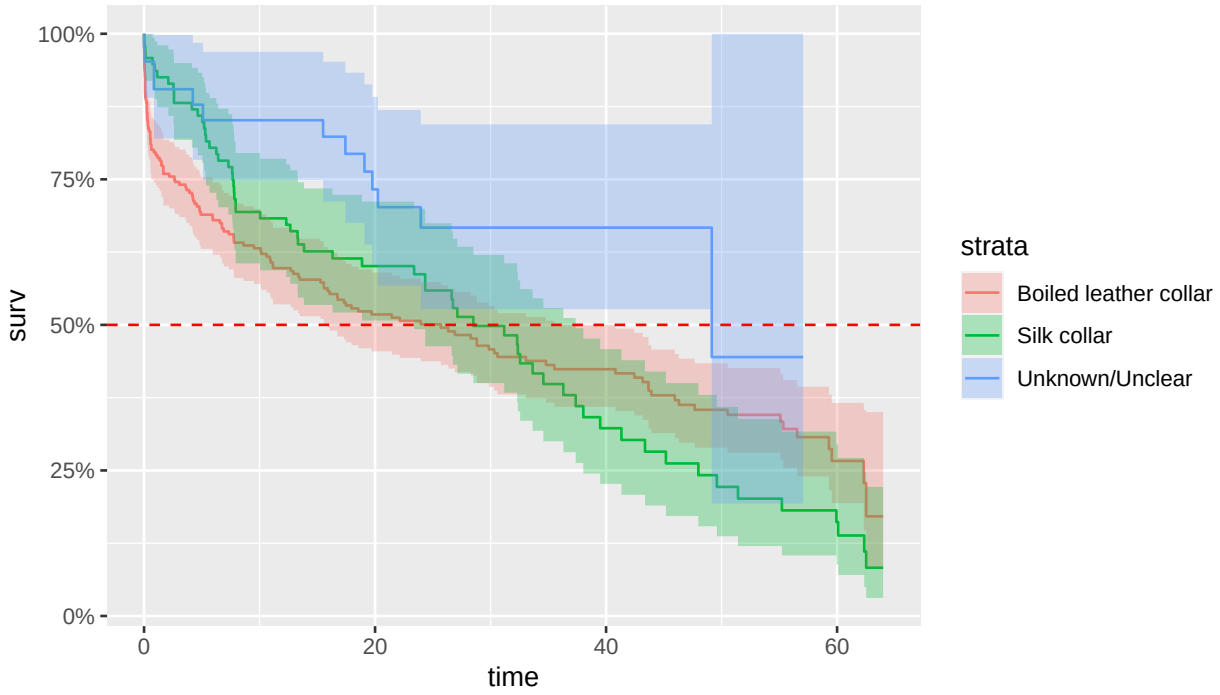
If you were of this religion, you would have only 50% chance to survive after 1.11hrs ! (pretty scary)

```
print_medians(dat,"religion")
```

```
## Medians:
##                      Group          Median        Conf.Interval
##               Drowned God            1.11           ( 0.54;NA )
##         Faith of the Seven           24.34       ( 10.05;41.33 )
##              Great Stallion            7.77           ( 5.95;NA )
##               Lord of Light           32.56          ( 32.36;NA )
##              Many Faced God           13.36           ( 3.59;NA )
##                    Old Gods           31.18       ( 12.31;55.34 )
##                       Other           26.63          ( 11.17;NA )
##             Unknown/Unclear           34.57       ( 26.34;47.99 )
```

- How is occupation influencing ?

```
plot_KM(dat,"occupation")
```




```
print_cox(dat,"occupation")
```

```
## Cox Regression:
##                       Group    Hazard Ratio        Conf.Interval
##     Boiled leather collar     (Reference)                    -
##                Silk collar            1.03        ( 0.76;1.39 )
##             Unknown/Unclear            0.48        ( 0.27;0.85 )
##
## Likelihood Ratio Test: 0.014
```

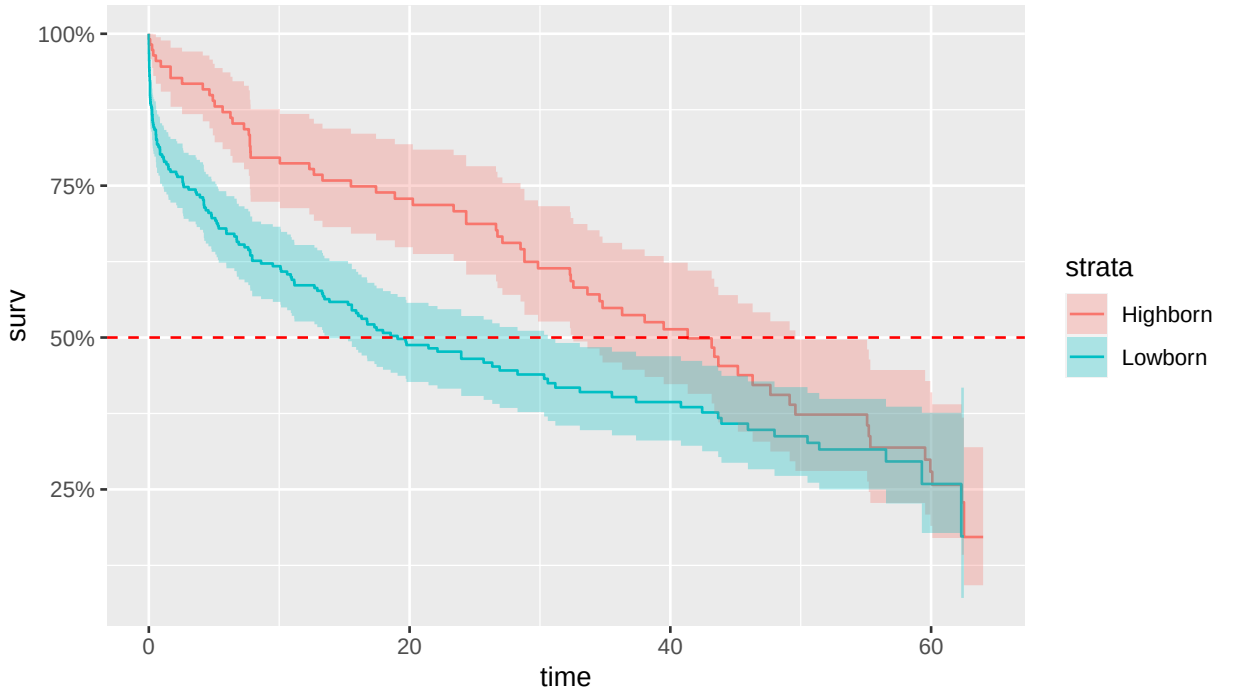
LRT pvalue is $< 5\%$, we can say that at least one group is significantly different from other. It's certainly due to the group 'Unknown/Unclear' which has an hazard ratio close to 0.5, the 2 others are very close (HR ~ 1). this can be also seen on the medians were CI are overlapping.

```
print_medians(dat,"occupation")
```

```
## Medians:
##                       Group          Median        Conf.Interval
##     Boiled leather collar           25.68      ( 15.57;40.81 )
##                Silk collar           28.51      ( 23.38;37.37 )
##             Unknown/Unclear           49.15         ( 49.15;NA )
```

–> Is social_status influencing ?

```
plot_KM(dat,"social_status")
```




```
print_cox(dat,"social_status")
```

```
## Cox Regression:
##                     Group    Hazard Ratio        Conf.Interval
##                  Highborn     (Reference)                    -
##                   Lowborn            1.49        ( 1.11;2.01 )
##
## Likelihood Ratio Test: 6.77e-03
```

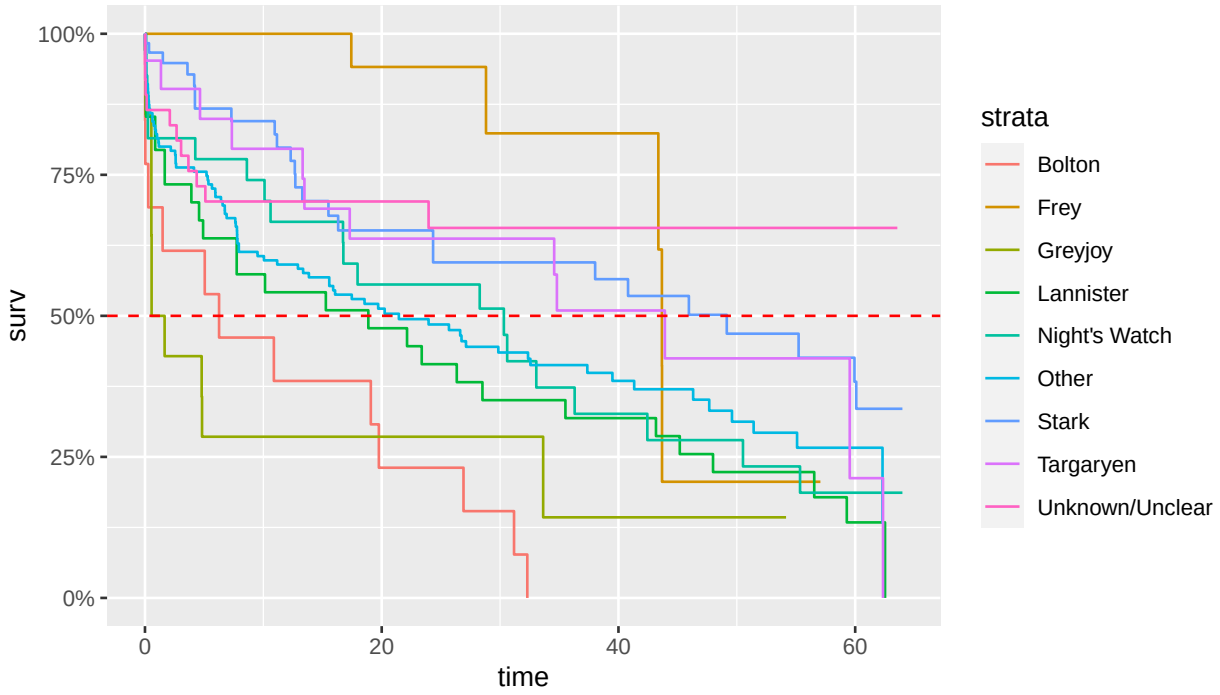
Again LRT pvalue is <5%, meaning that to be highborn or lowborn is significantly differnt in terms of survival time in GoT.

```
print_medians(dat,"social_status")
```

```
## Medians:
##                     Group          Median        Conf.Interval
##                  Highborn           41.33      ( 32.56;49.59 )
##                   Lowborn           19.08       ( 13.85;30.6 )
```

–> Is the last allegiance made influencing ?

```
plot_KM(dat,"allegiance_last",FALSE)
```




```
print_cox(dat,"allegiance_last")
```

```
## Cox Regression:
##                      Group    Hazard Ratio        Conf.Interval
##                     Bolton     (Reference)                    -
##                       Frey            0.14        ( 0.05;0.37 )
##                     Greyjoy            0.89          ( 0.4;1.99 )
##                   Lannister             0.5        ( 0.26;0.96 )
##               Night's Watch            0.39        ( 0.19;0.79 )
##                       Other             0.4        ( 0.22;0.72 )
##                       Stark            0.22        ( 0.11;0.43 )
##                   Targaryen            0.29        ( 0.13;0.64 )
##              Unknown/Unclear             0.2        ( 0.09;0.43 )
##
## Likelihood Ratio Test: 2.69e-06
```

LRT pvalue is $< 5\%$, we can say that at least one group is significantly different from other.

If you allegiance goes to 'Bolton', then you have 0% of chance to be present during all the show. But if you follow the 'Greyjoy', the you're median survival time is only of 1.11hrs...

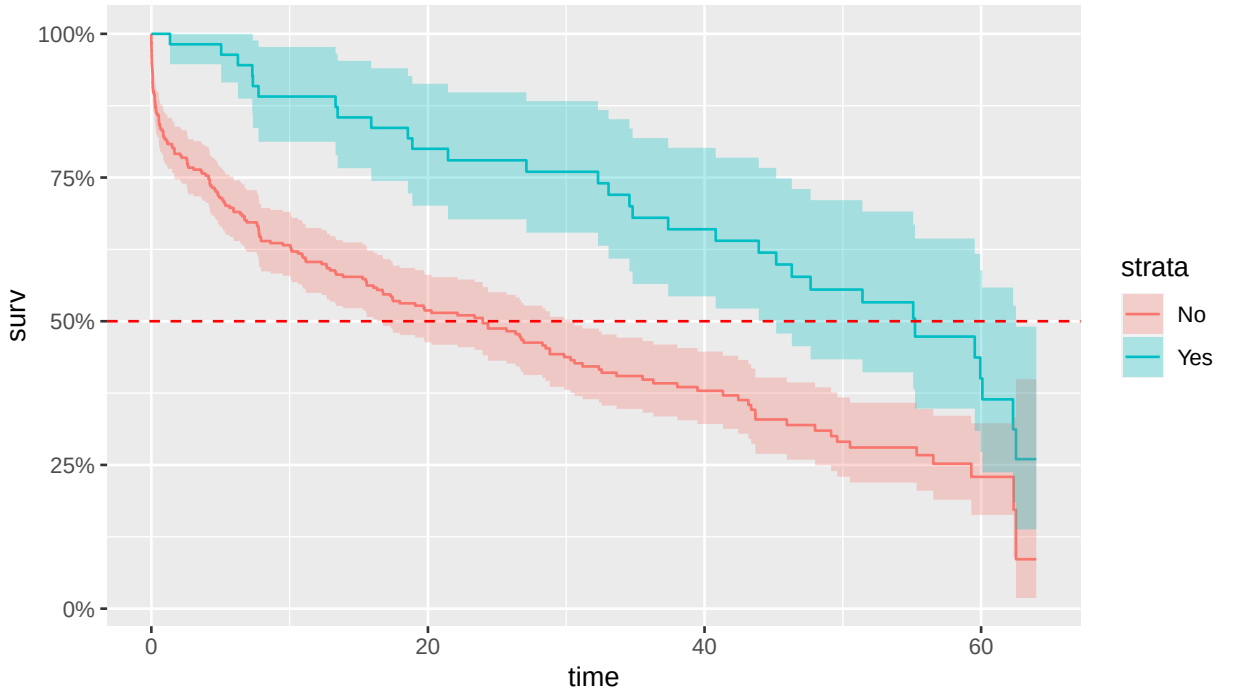
```
print_medians(dat,"allegiance_last")
```

```
## Medians:
##                      Group          Median        Conf.Interval
##                     Bolton            6.26          ( 0.28;NA )
##                       Frey           43.67         ( 43.37;NA )
##                     Greyjoy            1.11          ( 0.54;NA )
##                   Lannister           18.87        ( 4.91;43.17 )
##               Night's Watch           30.32       ( 16.73;50.52 )
```

```
##                       Other           21.45      ( 13.36;37.37 )
##                       Stark           49.15         ( 24.34;NA )
##                   Targaryen           43.92          ( 17.3;NA )
##             Unknown/Unclear              NA            ( NA;NA )
```

–> Is the fact to have switched allegiance during the serie influencing ?

```
plot_KM(dat,"allegiance_switched")
```




```
print_cox(dat,"allegiance_switched")
```

```
## Cox Regression:
##                       Group    Hazard Ratio        Conf.Interval
##                          No     (Reference)                    -
##                         Yes            0.48        ( 0.32;0.71 )
##
## Likelihood Ratio Test: 7.05e-05
```

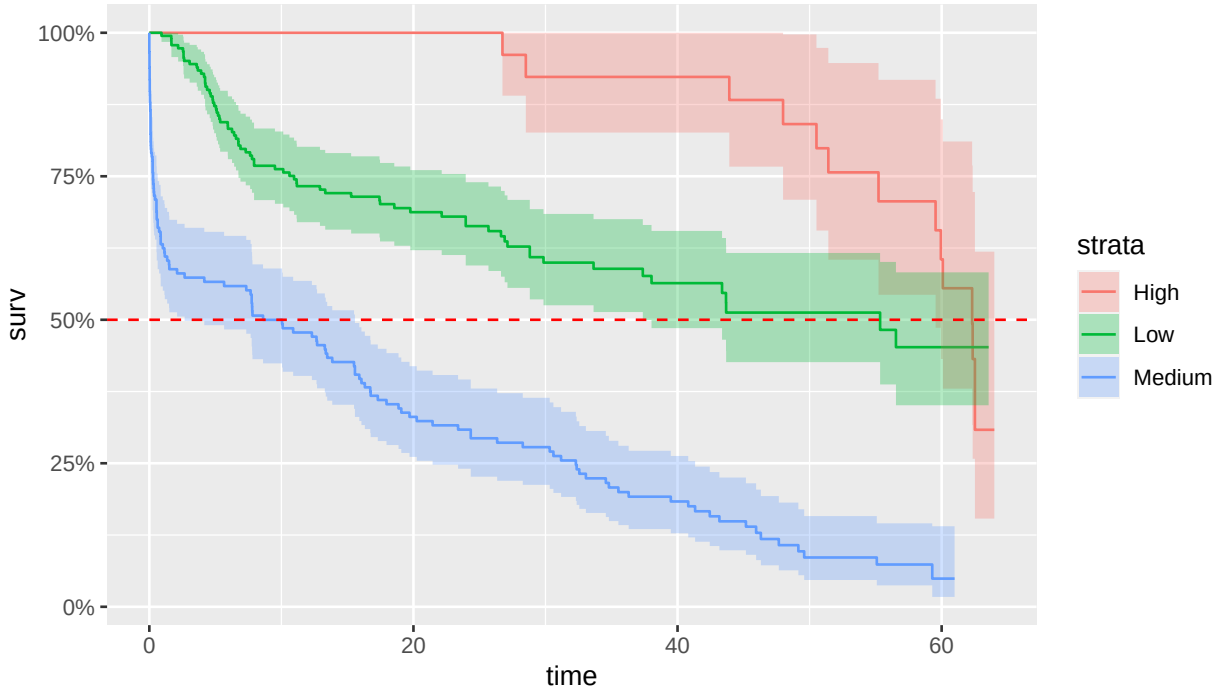
pvalue $< 5\%$, the change in allegiance has a real impact on the characters survival times. it seems, that in GoT, if you want to maximize your chances to survive, you have to not be too strict with your allegiance.

```
print_medians(dat,"allegiance_switched")
```

```
## Medians:
##                       Group          Median        Conf.Interval
##                          No           23.96       ( 16.32;30.32 )
##                         Yes           55.22       ( 45.18;62.52 )
```

–> Is prominence influencing ?

```
plot_KM(dat,"prominence")
```




```
print_cox(dat,"prominence")
```

```
## Cox Regression:
##                      Group    Hazard Ratio        Conf.Interval
##                       High     (Reference)                    -
##                        Low            1.93        ( 1.04;3.59 )
##                     Medium            6.58        ( 3.57;12.13 )
##
## Likelihood Ratio Test: 6.29e-21
```

Very significant difference, sounds logic for characters with high prominence (stars of the show), that producers decided no to kill them at the begining of the show so their survival time is higher than others. It seems more surprising to me, that people with low prominence have a higher survival time than the ones in the middle.

```
print_medians(dat,"prominence")
```

```
## Medians:
##                      Group          Median        Conf.Interval
##                       High           62.31         ( 59.54;NA )
##                          Low         55.34          ( 37.37;NA )
##                     Medium            8.61        ( 2.67;15.57 )
```

Build a model of Survival time in GoT

```
dat_model = select(dat,-name)
Model_Full = coxph(Surv(exp_time_hrs,dth_flag)~.,data=dat_model)
MAIC = step(Model_Full)
```

```
## Start:  AIC=2081.15
## Surv(exp_time_hrs, dth_flag) ~ sex + religion + occupation +
##     social_status + allegiance_last + allegiance_switched + prominence
##
##                        Df    AIC
## - religion              7 2077.9
## <none>                    2081.2
## - occupation            2 2082.1
## - allegiance_last       8 2083.2
## - social_status         1 2084.4
## - sex                   1 2086.7
## - allegiance_switched   1 2092.6
## - prominence            2 2168.5
##
## Step:  AIC=2077.87
## Surv(exp_time_hrs, dth_flag) ~ sex + occupation + social_status +
##     allegiance_last + allegiance_switched + prominence
##
##                        Df    AIC
## <none>                    2077.9
## - occupation            2 2078.1
## - social_status         1 2080.7
## - sex                   1 2083.5
## - allegiance_last       8 2087.5
## - allegiance_switched   1 2088.1
## - prominence            2 2160.6
```

```
MAIC
```

```
## Call:
## coxph(formula = Surv(exp_time_hrs, dth_flag) ~ sex + occupation +
##     social_status + allegiance_last + allegiance_switched + prominence,
##     data = dat_model)
##
##                                   coef exp(coef) se(coef)      z        p
## sexMale                         0.4911    1.6342   0.1843  2.664 0.007716
## occupationSilk collar           0.1324    1.1415   0.1960  0.676 0.499338
## occupationUnknown/Unclear      -0.5210    0.5939   0.3270 -1.594 0.111040
## social_statusLowborn            0.4307    1.5383   0.1976  2.179 0.029336
## allegiance_lastFrey            -0.3664    0.6932   0.5616 -0.652 0.514091
## allegiance_lastGreyjoy          0.4012    1.4937   0.4343  0.924 0.355595
## allegiance_lastLannister       -0.4836    0.6165   0.3531 -1.370 0.170766
## allegiance_lastNight's Watch   -0.9885    0.3721   0.3740 -2.643 0.008219
## allegiance_lastOther           -0.4750    0.6219   0.3118 -1.524 0.127623
## allegiance_lastStark           -1.0955    0.3344   0.3581 -3.059 0.002219
## allegiance_lastTargaryen       -0.5221    0.5933   0.4209 -1.240 0.214836
```

```
## allegiance_lastUnknown/Unclear -1.0134    0.3630   0.4222 -2.400 0.016378
## allegiance_switchedYes         -0.7464    0.4741   0.2251 -3.316 0.000914
## prominenceLow                   0.0581    1.0598   0.3503  0.166 0.868295
## prominenceMedium                1.4650    4.3275   0.3300  4.439 9.03e-06
##
## Likelihood ratio test=157.1  on 15 df, p=< 2.2e-16
## n= 359, number of events= 212
```

Predict from model for some characters and compare with observed datas

```
d_new = dat %>%
  filter(name %in% c("Arya Stark","Jaime Lannister","Theon Greyjoy","Jon Snow","Eddard Stark","Ramsay Bo
  select(-exp_time_hrs,-dth_flag)

z = list()

for(i in 1:nrow(d_new)) {
    row <- d_new[i,]
    p_s = survfit(MAIC,newdata = row)
    z = c(z,list(p_s))
}
names(z)=d_new$name

ggsurvplot_combine(z,
           conf.int = FALSE,
           risk.table = FALSE,
           pval = FALSE,
           censor = FALSE,
           surv.median.line = "hv",
           ggtheme = theme_gray())
```

```
## Warning: Vectorized input to `element_text()` is not officially supported.
## Results may be unexpected or may change in future versions of ggplot2.

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## Results may be unexpected or may change in future versions of ggplot2.
```

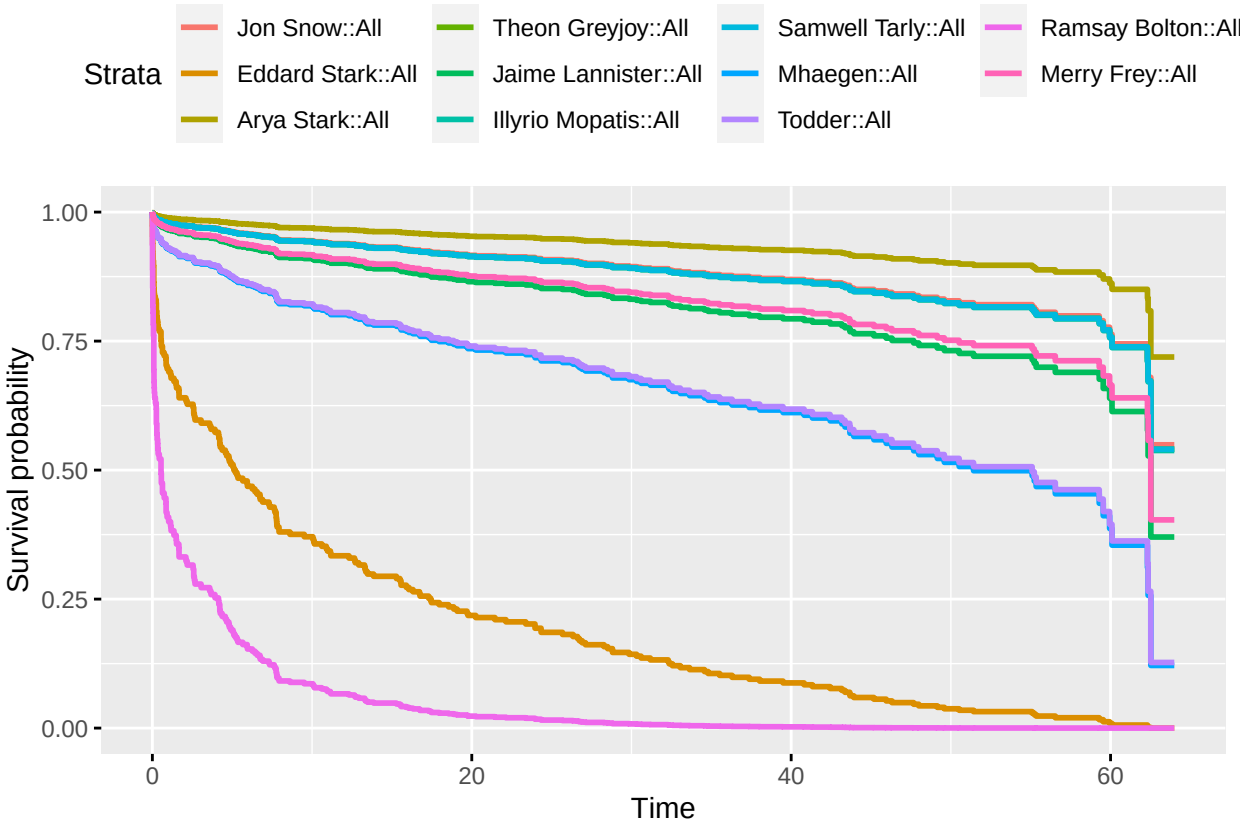
Strata
Jon Snow::All
Eddard Stark::All
Arya Stark::All
Theon Greyjoy::All
Jaime Lannister::All
Illyrio Mopatis::All
Samwell Tarly::All
Mhaegen::All
Todder::All
Ramsay Bolton::All
Merry Frey::All
Survival probability
1.00
0.75
0.50
0.25
0.00
0
20
40
60
Time