# load libraries

library(DescTools) # to get the Zodiac

library(lubridate)

library(survminer)

library(readxl)

library(brms)

library(rstan)

library(tidybayes)

library(ggplot2)

library(rms)

library(numbers)

# load dataset

zodiac\_data <- read\_excel("C:/Users/Alberto/Desktop/zodiac pavlos/zodiac\_data.xlsx")

# reconfigure date variables

zodiac\_data$date\_birth<-as.Date(zodiac\_data$date\_birth, format="%Y-%m%-%d")

zodiac\_data$zodiac<-Zodiac(zodiac\_data$date\_birth, lang = c("engl"), stringsAsFactors = TRUE) # get the Zodiac (model1)

zodiac\_data$zodiac2<-relevel(zodiac\_data$zodiac, ref="Sagittarius") # Sagittarius as the reference category for model2

zodiac\_data$year\_birth<- as.numeric(strftime(zodiac\_data$date\_birth, format = "%Y") ) # year of birth

zodiac\_data$year\_from1921<- as.numeric(strftime(zodiac\_data$date\_birth, format = "%y") )- 21 # Years from 1921 to birth-date

zodiac\_data$day\_year<-as.numeric(strftime(zodiac\_data$date\_birth, format = "%j")) # day of the year, on which he was born

zodiac\_data$fraction\_year<-ifelse(leap\_year(zodiac\_data$year\_birth), zodiac\_data$day\_year/366, zodiac\_data$day\_year/365) # fraction of the year taking into account whether it was a leap year or not

zodiac\_data$year\_plus\_fraction<- zodiac\_data$year\_birth + zodiac\_data$fraction\_year # year of birth + fraction

zodiac\_data$year\_plus\_fraction1921<- zodiac\_data$year\_birth + zodiac\_data$fraction\_year - 1921 # year of birth + fraction from 1921 (the oldest patient was born at that year)

View(zodiac\_data)

head(zodiac\_data)

# get Zodiac elements

zodiac\_data$elements<-ifelse(zodiac\_data$zodiac=="Cancer"|zodiac\_data$zodiac=="Scorpio"|zodiac\_data$zodiac=="Pisces","Water","Fire")

zodiac\_data$elements<-ifelse(zodiac\_data$zodiac=="Taurus"|zodiac\_data$zodiac=="Virgo"|zodiac\_data$zodiac=="Capricorn","Earth",zodiac\_data$elements)

zodiac\_data$elements<-ifelse(zodiac\_data$zodiac=="Gemini"|zodiac\_data$zodiac=="Libra"|zodiac\_data$zodiac=="Aquarius.","Air",zodiac\_data$elements)

# naive frequentist proportional hazards (Cox) model (model1)

fit1<-coxph(Surv(time, event)~zodiac, data=zodiac\_data)

summary<-summary(fit1)

summary

summary$logtest # likelihood ratio test for the Zodiac

survdiff(Surv(time,event)~zodiac , data=zodiac\_data) # log-rank test

ggforest(fit1) # plot this model

AIC(fit1)

BIC(fit1)

# naive frequentist proportional hazards (Cox) model (model2, Sagittarius is the reference category)

fit2<-coxph(Surv(time, event)~zodiac2 , data=zodiac\_data)

summary<-summary(fit2)

summary

summary$logtest # likelihood ratio test for the Zodiac

survdiff(Surv(time,event)~zodiac2 , data=zodiac\_data) # log-rank test

ggforest(fit2) # plot this model

AIC(fit2)

BIC(fit2)

# Chronobiological model (model5)

fit5 <- coxph(Surv(time, event) ~ zodiac+sin(2\*pi\*fraction\_year)+cos(2\*pi\*fraction\_year)+rcs(year\_plus\_fraction1921,3),data=zodiac\_data)

vif(fit5) # to test multicollinearity

# Chronobiological model with Zodiac elements (model6)

fit6 <- coxph(Surv(time, event) ~ elements+sin(2\*pi\*fraction\_year)+cos(2\*pi\*fraction\_year)+rcs(year\_plus\_fraction1921,3),data=zodiac\_data)

vif(fit6) # to test multicollinearity

ggforest(fit6) # plot this model

ggcoxdiagnostics(fit6, type = , linear.predictions = TRUE) # test model diagostics

ggcoxdiagnostics(fit6, type = "dfbeta",

 linear.predictions = FALSE, ggtheme = theme\_bw())

ggcoxdiagnostics(fit6, type = "deviance",

 linear.predictions = FALSE, ggtheme = theme\_bw())

# Bayesian Cox model with moderately skeptical priors (model 3)

prior <- c(set\_prior("normal(0,0.1)", class = "b", coef = "zodiacAquarius"),

 set\_prior("normal(0,0.1)", class = "b", coef = "zodiacAries"),

 set\_prior("normal(0,0.1)", class = "b", coef = "zodiacCancer"),

 set\_prior("normal(0,0.1)", class = "b", coef = "zodiacGemini"),

 set\_prior("normal(0,0.1)", class = "b", coef = "zodiacLeo"),

 set\_prior("normal(0,0.1)", class = "b", coef = "zodiacLibra"),

 set\_prior("normal(0,0.1)", class = "b", coef = "zodiacPisces"),

 set\_prior("normal(0,0.1)", class = "b", coef = "zodiacSagittarius"),

 set\_prior("normal(0,0.1)", class = "b", coef = "zodiacScorpio"),

 set\_prior("normal(0,0.1)", class = "b", coef = "zodiacTaurus"),

 set\_prior("normal(0,0.1)", class = "b", coef = "zodiacVirgo")

)

rstan\_options (auto\_write=TRUE)

options (mc.cores=parallel::detectCores ())

fit3 <- brm(time | cens(1-event) ~ 1 + zodiac, data = zodiac\_data, prior=prior, family = brmsfamily("cox"),chains=4, iter=2000, save\_all\_pars = TRUE)

# some posterior probabilities as examples

hypothesis(fit3, "zodiacSagittarius < 0")

hypothesis(fit3, "zodiacLeo > 0")

# half eye plots

fit3 %>% gather\_draws(b\_zodiacAquarius,b\_zodiacPisces,b\_zodiacAries,b\_zodiacTaurus,b\_zodiacGemini,b\_zodiacCancer,b\_zodiacLeo,

 b\_zodiacVirgo,b\_zodiacLibra,b\_zodiacScorpio,b\_zodiacSagittarius) %>%

 ggplot(aes(y=.variable, x=exp(.value))) +

 geom\_halfeyeh(fill ="gray") +

 geom\_vline(xintercept = 1, linetype = "dashed")

#Calculate Bell numbers for zodiac sign

sapply(12, bell)-1

# Bayesian Chronobiological model with neutral priors

zodiac\_data$rcs\_year<-rcs(zodiac\_data$year\_plus\_fraction1921,3)

zodiac\_data$rcs\_year1<-as.numeric(rcs\_year[,1])

zodiac\_data$rcs\_year2<-as.numeric(rcs\_year[,2])

fit\_bayes\_chr <- brm(time | cens(1-event) ~ 1 + elements + sin(2\*3.141593\*fraction\_year)+cos(2\*3.141593\*fraction\_year)+rcs\_year1+rcs\_year2, data = zodiac\_data, family = brmsfamily("cox"),chains=4, iter=2000, save\_all\_pars = TRUE)

# Bayesian model comparison

waic\_weights <- model\_weights(fit3, fit\_bayes\_chr, weights = 'waic')

loo\_weights <- model\_weights(fit3, fit\_bayes\_chr, weights = 'loo')

loo2\_weights <- model\_weights(fit3, fit\_bayes\_chr, weights = 'loo2')

m1 <- add\_criterion(fit3, "waic")

m2 <- add\_criterion(fit\_bayes\_chr, "waic")

loo\_compare(m1,m2, criterion = "waic")