### Algorithm estimation

1. **Programming Code for Parametric Survival Curve NMA**

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######### Bayesian network meta-analysis ###########

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### PREPARING INPUT DATA AND INITIAL VALUES FOR WINBUGS

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library(R2WinBUGS)

library(ggplot2)

*### Computing inputs via Guyot-Ouwens algorithm*

ns\_convert <- function(input, t, b, s) {

 input$time <- c(input[-1,"V1"], 1000)

 input$dt <- input$time - c(0, input[-nrow(input),"time"])

 input$n <- input$V2 # number of patients at risk in the interval

 input$r <- input$V3 # number of deaths in the interval

 input$t <- t # treatment

 input$b <- b # baseline treatment

 input$s <- s # study

 return(input[-nrow(input),c("time", "dt", "n", "r", "t", "b", "s")])

}

winbugsi\_new <- rbind(ns\_convert(read.table("METEOR\_OS\_cabozantinib\_KMdata.txt", header=T), 2, 1, 1), ns\_convert(read.table("METEOR\_OS\_everolimus\_KMdata.txt", header=T), 1, 1, 1), ns\_convert(read.table("checkmate\_OS\_nivolumab\_KMdata.txt", header=T), 3, 1, 2), ns\_convert(read.table("checkmate\_OS\_everolimus\_KMdata.txt", header=T), 1, 1, 2), ns\_convert(read.table("NCT\_OS\_lenvatinib\_everolimus\_KMdata.txt", header=T), 4, 1, 3), ns\_convert(read.table("NCT\_OS\_everolimus\_KMdata.txt", header=T), 1, 1, 3), ns\_convert(read.table("RECORD2\_OS\_placebo\_KMdata.txt", header=T), 5, 1, 4), ns\_convert(read.table("RECORD2\_OS\_everolimus\_KMdata.txt", header=T), 1, 1, 4), ns\_convert(read.table("TARGET\_OS\_sorafenib\_KMdata.txt", header=T), 6, 5, 5), ns\_convert(read.table("TARGET\_OS\_placebo\_KMdata.txt", header=T), 5, 5, 5), ns\_convert(read.table("AXIS\_OS\_Sunitinib\_based\_axitinib\_KMdata.txt", header=T),7, 6, 6), ns\_convert(read.table("AXIS\_OS\_Sunitinib\_based\_sorafenib\_KMdata.txt", header=T), 6, 6, 6))

winbugsi <- winbugsi\_new[winbugsi\_new$n > 0,]

*### Input data:*

bugs\_input <- list("N"=nrow(winbugsi), "NS"=6, "NT"=7, "mean"=c(0,0), "prec2"=matrix(c(.0001,0,0,.0001),2,2), "R"=matrix(c(.01,0,0,.01),2,2), "time"=winbugsi[,1], "dt"=winbugsi[,2], "n"=winbugsi[,3], "r"=winbugsi[,4], "t"=winbugsi[,5], "b"=winbugsi[,6], "s"=winbugsi[,7], "ts"=c(2,3,4,5,6,7), "bs"=c(1,1,1,1,5,6))

bugs\_input\_fixed <- bugs\_input

bugs\_input\_fixed$R <- NULL

### *Initial values:*

bugs\_inits <- list(

 list("mu"=matrix(-c(1,1,1,1,1,1,.1,.1,.1,.1,.1,.1),6,2), "d"=matrix(c(NA, 2, 2,-2, -2,-2,-2,NA,.1,.1, -.1, -.1, -.1, -.1),7,2)),

 list("mu"=matrix(-c(1,1,1,1,1,1,.1,.1,.1,.1,.1,.1),6,2), "d"=matrix(c(NA,-2, 2,2,2,-2,2,NA, -.1,.1, .1, -.1, -.1, -.1),7,2)),

 list("mu"=matrix( c(-1,-1,-1,-1,-1,-1,-.1,-.1,-.1,-.1,-.1,-.1),6,2), "d"=matrix(c(NA, 2, 2,2,2,2,2,NA,.1, .1, .1, -.1, -.1, -.1),7,2)),

 list("mu"=matrix(-c(-1,-1,-1,-1,-1,-1,-.1,-.1,-.1,-.1,-.1,-.1),6,2), "d"=matrix(c(NA,-2,-2,-2,-2,-2,-2,NA,-.1,-.1,-.1, -.1, -.1, -.1),7,2))

 )

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### WINBUGS MODELLING

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*# weibull*

weib.fixed <- bugs(data = bugs\_input\_fixed, inits=bugs\_inits, "BUGS run", model.file="bugs\_model\_Weibull.txt", bugs.directory="C:/Users/janedoe/Documents/WinBUGS14", parameters=c("mu", "d"), n.chains=4, n.iter=50000, n.burnin=25000, n.thin=10)

*# gompertz*

gompertz.fixed <- bugs(data = bugs\_input\_fixed, inits=bugs\_inits, "BUGS run", model.file="bugs\_model\_Gompertz.txt", bugs.directory="C:/Users/janedoe/Documents/WinBUGS14", parameters=c("mu", "d"), n.chains=4, n.iter=50000, n.burnin=25000, n.thin=10)

*# loglogistic*

log.fixed <- bugs(data = bugs\_input\_fixed, inits=bugs\_inits, "BUGS run", model.file="bugs\_model\_loglogistic.txt", bugs.directory="C:/Users/janedoe/Documents/WinBUGS14", parameters=c("mu", "d"), n.chains=4, n.iter=50000, n.burnin=25000, n.thin=10, debug=FALSE)

 *# lognormal*

lognorm.fixed <- bugs(data = bugs\_input\_fixed, inits=bugs\_inits, "BUGS run", model.file="bugs\_model\_lognormal.txt", bugs.directory="C:/Users/janedoe/Documents/WinBUGS14", parameters=c("mu", "d"), n.chains=4, n.iter=50000, n.burnin=25000, n.thin=10, debug=FALSE)

 *# exponential: needs other initial values as unidimensional*

bugs\_inits\_exp <- list(

 list("mu"=c(1,1,1,1,1,1), "d"=c(NA, .1,.1, -.1, -.1, -.1, -.1)),

 list("mu"=c(1,1,1,1,1,1), "d"=c(NA,.1,.1, -.1, -.1, -.1, -.1)),

 list("mu"=c(-1,-1,-1,-1,-1,-1), "d"=c(NA, .1,.1, -.1, -.1, -.1, -.1)),

 list("mu"=c(-1,-1,-1,-1,-1,-1), "d"=c(NA,.1,.1, -.1, -.1, -.1, -.1))

 )

exp.fixed <- bugs(data = bugs\_input\_fixed, inits=bugs\_inits\_exp, "BUGS run", model.file="bugs\_model\_exponential.txt", bugs.directory="C:/Users/janedoe/Documents/WinBUGS14", parameters=c("mu", "d"), n.chains=4, n.iter=50000, n.burnin=25000, n.thin=10)

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### COMPUTING RESULTS

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*### Sample from posterior*

xsim <- seq(0,24, length=500) # 24 months

sm.weib <- weib.fixed$sims.matrix

sm.gomp <- gompertz.fixed$sims.matrix

sm.log <- log.fixed$sims.matrix

sm.exp <- exp.fixed$sims.matrix

sm.lognorm <- lognorm.fixed$sims.matrix

 *### Estimated survival function with help of estimated parameters*

gomp.surv <- function(xsim, sm) {

 mean.para <- apply(sm[,1:2],2,mean)

 para <- rep(0, 2)

 para[1] <- exp(mean.para[1])

 para[2] <- mean.para[2]

 res <- exp(-para[1]/para[2]\*(exp(xsim\*para[2]) - 1))

 return(res)

 }

weib.surv <- function(xsim, sm) {

 mean.para <- apply(sm[,1:2],2,mean)

 para <- rep(0, 2)

 para[1] <- exp(mean.para[1])/(mean.para[2]+1)

 para[2] <- mean.para[2] + 1

 res <- exp(-((xsim^para[2])\*para[1]))

 return(res)

 }

log.surv <- function(xsim, sm) {

 mean.para <- apply(sm[,1:2],2,mean)

 para <- rep(0, 2)

 para[1] <- exp(-exp(mean.para[2])\*mean.para[1])

 para[2] <- exp(mean.para[2])

 res <- 1/(1+para[1]\*xsim^para[2])

 return(res)

 }

exp.surv <- function(xsim, sm) {

 para <- exp(mean(sm))

 res <- exp(-xsim\*para)

 return(res)

 }

lognorm.surv <- function(xsim, sm) {

 mean.para <- apply(sm[,1:2],2,mean)

 para <- rep(0, 2)

 para[1] <- mean.para[1]

 para[2] <- exp(mean.para[2])

 res <- pnorm(-(log(xsim)-para[1])/para[2])

 return(res)

 }

*###By choosing columns of sm matrix we change baseline / effect definitions, to adjust treatment to different studies*

 *### weibull, survival with estimated parameter*

 grweib1.esti <- weib.surv(xsim, sm.weib[,1:2]) #using parameters for everolimus in study 1

 grweib7.esti <- weib.surv(xsim, sm.weib[,1:2]+sm.weib[,c(13,14)]) #using parameters for cabo in study 1

grweib8.adjusted.esti <- weib.surv(xsim, sm.weib[,1:2]+sm.weib[,c(15,16)]) #using parameters for nivo adjusted to study 1

 grweib9.adjusted.esti <- weib.surv(xsim, sm.weib[,1:2]+sm.weib[,c(17,18)]) #using parameters for lenv+ever adjusted to study 1

 grweib10.adjusted.esti <- weib.surv(xsim, sm.weib[,1:2]+sm.weib[,c(19,20)]) #using parameters for placebo adjusted to study 1

 grweib11.adjusted.esti <- weib.surv(xsim, sm.weib[,1:2]+sm.weib[,c(21,22)]) #using parameters for sora adjusted to study 1

 grweib12.adjusted.esti <- weib.surv(xsim, sm.weib[,1:2]+sm.weib[,c(23,24)]) #using parameters for axit adjusted to study 1

*### gompertz, survival with estimated parameter*

grgomp1.esti <- gomp.surv(xsim, sm.gomp[,1:2]) #using parameters for everolimus in study 1

grgomp7.esti <- gomp.surv(xsim, sm.gomp[,1:2]+sm.gomp[,c(13,14)]) #using parameters for cabo in study 1

grgomp8.adjusted.esti <- gomp.surv(xsim, sm.gomp[,1:2]+sm.gomp[,c(15,16)]) #using parameters for nivo adjusted to study 1

 grgomp9.adjusted.esti <- gomp.surv(xsim, sm.gomp[,1:2]+sm.gomp[,c(17,18)]) #using parameters for lenv+ever adjusted to study 1

 grgomp10.adjusted.esti <- gomp.surv(xsim, sm.gomp[,1:2]+sm.gomp[,c(19,20)]) #using parameters for placebo adjusted to study 1

 grgomp11.adjusted.esti <- gomp.surv(xsim, sm.gomp[,1:2]+sm.gomp[,c(21,22)]) #using parameters for sora adjusted to study 1

 grgomp12.adjusted.esti <- gomp.surv(xsim, sm.gomp[,1:2]+sm.gomp[,c(23,24)]) #using parameters for axit adjusted to study 1

 *### log-logistic, survival with estimated parameter:*

 grlog1.esti <- log.surv(xsim, sm.log[,1:2]) #using parameters for everolimus in study 1

grlog7.esti <- log.surv(xsim, sm.log[,1:2]+sm.log[,c(13,14)]) #using parameters for cabo in study 1

grlog8.adjusted.esti <- log.surv(xsim, sm.log[,1:2]+sm.log[,c(15,16)]) #using parameters for nivo adjusted to study 1

 grlog9.adjusted.esti <- log.surv(xsim, sm.log[,1:2]+sm.log[,c(17,18)]) #using parameters for lenv+ever adjusted to study 1

 grlog10.adjusted.esti <- log.surv(xsim, sm.log[,1:2]+sm.log[,c(19,20)]) #using parameters for placebo adjusted to study 1

 grlog11.adjusted.esti <- log.surv(xsim, sm.log[,1:2]+sm.log[,c(21,22)]) #using parameters for sora adjusted to study 1

 grlog12.adjusted.esti <- log.surv(xsim, sm.log[,1:2]+sm.log[,c(23,24)]) #using parameters for axit adjusted to study 1

 *### exponential, survival with estimated parameter:*

grexp1.esti <- exp.surv(xsim, sm.exp[,1]) #using parameters for everolimus in study 1

 grexp7.esti <- exp.surv(xsim, sm.exp[,1]+sm.exp[,c(7)]) #using parameters for cabo in study 1

grexp8.adjusted.esti <- exp.surv(xsim, sm.exp[,1]+sm.exp[,c(8)]) #using parameters for nivo adjusted to study 1

 grexp9.adjusted.esti <- exp.surv(xsim, sm.exp[,1]+sm.exp[,c(9)]) #using parameters for lenv+ever adjusted to study 1

 grexp10.adjusted.esti <- exp.surv(xsim, sm.exp[,1]+sm.exp[,c(10)]) #using parameters for placebo adjusted to study 1

 grexp11.adjusted.esti <- exp.surv(xsim, sm.exp[,1]+sm.exp[,c(11)]) #using parameters for sora adjusted to study 1

 grexp12.adjusted.esti <- exp.surv(xsim, sm.exp[,1]+sm.exp[,c(12)])#using parameters for axit adjusted to study 1

 *### lognormal, survival with estimated parameter*

grlognorm1.esti <- lognorm.surv(xsim, sm.lognorm[,1:2]) #using parameters for everolimus in study 1

grlognorm7.esti <- lognorm.surv(xsim, sm.lognorm[,1:2]+sm.lognorm[,c(13,14)]) #using parameters for cabo in study 1

grlognorm8.adjusted.esti <- lognorm.surv(xsim, sm.lognorm[,1:2]+sm.lognorm[,c(15,16)]) #using parameters for nivo adjusted to study 1

grlognorm9.adjusted.esti <- lognorm.surv(xsim, sm.lognorm[,1:2]+sm.lognorm[,c(17,18)]) #using parameters for lenv+ever adjusted to study 1

grlognorm10.adjusted.esti <- lognorm.surv(xsim, sm.lognorm[,1:2]+sm.lognorm[,c(19,20)]) #using parameters for placebo adjusted to study 1

grlognorm11.adjusted.esti <- lognorm.surv(xsim, sm.lognorm[,1:2]+sm.lognorm[,c(21,22)]) #using parameters for sora adjusted to study 1

grlognorm12.adjusted.esti <- lognorm.surv(xsim, sm.lognorm[,1:2]+sm.lognorm[,c(23,24)]) #using parameters for axit adjusted to study 1

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### WINBUGS MODELS

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*### Weibull*

Model{

for (i in 1:N){ # N=number of data points in dataset

#likelihood

r[i]~ dbin(p[i],n[i])

p[i]<-1-exp(-h[i]\*dt[i])

log(h[i])<-nu[i] + log(time[i])\*theta[i]

nu[i]<-mu[s[i],1]+delta[s[i],1]\*(1-equals(t[i],b[i]))

theta[i]<-mu[s[i],2]+ delta[s[i],2]\*(1-equals(t[i],b[i]))

}

for(k in 1 :NS){ # NS=number of studies in dataset

delta[k,1] <- md[k,1]

delta[k,2] <- md[k,2]

md[k,1]<-d[ts[k],1]-d[bs[k],1]

md[k,2]<-d[ts[k],2]-d[bs[k],2]

}

# priors

d[1,1]<-0

d[1,2]<-0

for(j in 2 :NT){ # NT=number of treatments

d[j,1:2] ~ dmnorm(mean[1:2],prec2[,])

}

for(k in 1 :NS){

mu[k,1:2] ~ dmnorm(mean[1:2],prec2[,])

}

}

*### Gompertz*

Model{

for (i in 1:N){ # N=number of data points in dataset

#likelihood

r[i]~ dbin(p[i],n[i])

p[i]<-1-exp(-h[i]\*dt[i])

log(h[i])<-nu[i] + (time[i]\*theta[i])

nu[i]<-mu[s[i],1]+delta[s[i],1]\*(1-equals(t[i],b[i]))

theta[i]<-mu[s[i],2]+ delta[s[i],2]\*(1-equals(t[i],b[i]))

}

for(k in 1 :NS){ # NS=number of studies in dataset

delta[k,1] <- md[k,1]

delta[k,2] <- md[k,2]

md[k,1]<-d[ts[k],1]-d[bs[k],1]

md[k,2]<-d[ts[k],2]-d[bs[k],2]

}

# priors

d[1,1]<-0

d[1,2]<-0

for(j in 2 :NT){ # NT=number of treatments

d[j,1:2] ~ dmnorm(mean[1:2],prec2[,])

}

for(k in 1 :NS){

mu[k,1:2] ~ dmnorm(mean[1:2],prec2[,])

}

}

*### Log-logistic*

Model{

 for (i in 1:N){ # N=number of data points in dataset

 #likelihood

 r[i]~ dbin(p[i],n[i])

 p[i]<-1-exp(-h[i]\*dt[i])

 h[i]<-(exp(theta[i])/exp(nu[i]))\*pow(time[i]/exp(nu[i]), exp(theta[i])-1)/(1+pow(time[i]/exp(nu[i]), exp(theta[i])))

 nu[i] <- mu[s[i],1] + (delta[s[i],1]\*(1-equals(t[i],b[i])))

 #log(nu[i])<-mu[s[i],1]+delta[s[i],1]\*(1-equals(t[i],b[i]))

 theta[i] <- mu[s[i],2]+ (delta[s[i],2]\*(1-equals(t[i],b[i])))

 #log(theta[i])<-mu[s[i],2]+ delta[s[i],2]\*(1-equals(t[i],b[i]))

 }

 for(k in 1 :NS){ # NS=number of studies in dataset

 delta[k,1] <- md[k,1]

 delta[k,2] <- md[k,2]

 md[k,1]<-d[ts[k],1]-d[bs[k],1]

 md[k,2]<-d[ts[k],2]-d[bs[k],2]

 }

 # priors

 d[1,1]<-0

 d[1,2]<-0

 for(j in 2 :NT){ # NT=number of treatments

 d[j,1:2] ~ dmnorm(mean[1:2],prec2[,])

 }

 for(k in 1 :NS){

 mu[k,1:2] ~ dmnorm(mean[1:2],prec2[,])

 }

}

*### Log-normal*

Model{

 for (i in 1:N){ # N=number of data points in dataset

 #likelihood

 r[i]~ dbin(p[i],n[i])

 p[i]<-1-exp(-h[i]\*dt[i])

 #h[i]<-pow(2\*3.1415926,-0.5)\*exp(-pow(-(log(time[i]-nu[i]))/theta[i],2)\*0.5)/(theta[i]\*time[i]\*phi(-(log(time[i]-nu[i]))/theta[i]))

 h[i]<-pow(2\*3.1415926,-0.5)\*exp(-pow((log(time[i])-nu[i])/exp(theta[i]),2)\*0.5) / (exp(theta[i])\*time[i]\*phi(-(log(time[i])-nu[i])/exp(theta[i])))

 nu[i] <- mu[s[i],1] + (delta[s[i],1]\*(1-equals(t[i],b[i])))

 theta[i] <- mu[s[i],2]+ (delta[s[i],2]\*(1-equals(t[i],b[i])))

 }

 for(k in 1 :NS){ # NS=number of studies in dataset

 delta[k,1] <- md[k,1]

 delta[k,2] <- md[k,2]

 md[k,1]<-d[ts[k],1]-d[bs[k],1]

 md[k,2]<-d[ts[k],2]-d[bs[k],2]

 }

 # priors

 d[1,1]<-0

 d[1,2]<-0

 for(j in 2 :NT){ # NT=number of treatments

 d[j,1:2] ~ dmnorm(mean[1:2],prec2[,])

 }

 for(k in 1 :NS){

 mu[k,1:2] ~ dmnorm(mean[1:2],prec2[,])

 }

}

*### Exponential*

Model{

 for (i in 1:N){ # N=number of data points in dataset

 #likelihood

 r[i]~ dbin(p[i],n[i])

 p[i]<-1-exp(-h[i]\*dt[i])

 log(h[i])<-nu[i] + log(time[i])\*theta[i]

 nu[i]<-mu[s[i]]+delta[s[i]]\*(1-equals(t[i],b[i]))

 theta[i]<-0

 }

 for(k in 1 :NS){ # NS=number of studies in dataset

 delta[k] <- md[k]

 md[k]<-d[ts[k]]-d[bs[k]]

 }

 # priors

 d[1]<-0

 for(j in 2 :NT){ # NT=number of treatments

 d[j] ~ dnorm(mean[1],prec2[1,1])

 }

 for(k in 1 :NS){

 mu[k] ~ dnorm(mean[1],prec2[1,1])

 }

}