```
library(mvtnorm)

expit<-function(t) {
  exp(t)/(1+exp(t))
}



#draw samples from the posterior using probab bias analysis
#differential misclassification
#includes correlation, p...corr is same for sens and spec
#get variance using woolf estimate of uncorrected data

#y0,y1,n0,n1 is observed data
#a0,a1 are logit(prior mean) of sensitivities
#b0,b1 are logit(prior mean) of specificity
#v0 is variance of logit sens
#v1 is varaince of logit spec
samp.pba.diff.c<-function(y0,y1,n0,n1,a0,a1,va,b0,b1,vb,Gsim=20000){
res=matrix(0,Gsim,5)
t0=y0/n0;
t1=y1/n1;
for (i in 1:Gsim){
 f=0;
 while (f==0) {
  lta<-rmvnorm(1,c(a0,a1),va)
```

```
  ltb<-rmvnorm(1,c(b0,b1),vb)
  p0=expit(lta[1])
  p1=expit(lta[2])
  q0=expit(ltb[1])
  q1=expit(ltb[2])
  or=((t1+q1-1)/(p1-t1))/((t0+q0-1)/(p0-t0))
  tf0=(0<p0 & p0<t0 & 0<q0 & q0<(1-t0))|(t0<p0 & p0<1 & (1-t0)<q0 & q0<1)
  tf1=(0<p1 & p1<t1 & 0<q1 & q1<(1-t1))|(t1<p1 & p1<1 & (1-t1)<q1 & q1<1)
  if (tf0=="TRUE"&tf1=="TRUE") {
   f=1
  }
 }
 z=rnorm(1,0,1)
 v=1/y0+1/(n0-y0)+1/y1+1/(n1-y1)
 or.r=exp(log(or)-z*sqrt(v))
 res[i,]=c(or.r,p0,q0,p1,q1)
}
res
}
```

```
# draw samples from the posterior using MCMC - gustafson's approach
# differential misclass
# correlated sens/spec drawn from MVN
```

```
samp.unc.diff.c<-function(y0,y1,n0,n1,a0,a1,va,b0,b1,vb,Gsim=20000){

t0.old=y0/n0

t1.old=y1/n1

lta<-rmvnorm(1,c(a0,a1),va)

ltb<-rmvnorm(1,c(b0,b1),vb)

p0.old=expit(lta[1])

p1.old=expit(lta[2])

q0.old=expit(ltb[1])

q1.old=expit(ltb[2])

tf0=(0<p0.old & p0.old<t0.old & 0<q0.old & q0.old<(1-t0.old))|(t0.old<p0.old & p0.old<1 & (1-
t0.old)<q0.old & q0.old<1)

tf1=(0<p1.old & p1.old<t1.old & 0<q1.old & q1.old<(1-t1.old))|(t1.old<p1.old & p1.old<1 & (1-
t1.old)<q1.old & q1.old<1)

while (tf0=="FALSE" | tf1=="FALSE") {

   lta<-rmvnorm(1,c(a0,a1),va)

   ltb<-rmvnorm(1,c(b0,b1),vb)

   p0.old=expit(lta[1])

   p1.old=expit(lta[2])

   q0.old=expit(ltb[1])

   q1.old=expit(ltb[2])

   tf0=(0<p0.old & p0.old<t0.old & 0<q0.old & q0.old<(1-t0.old))|(t0.old<p0.old & p0.old<1 & (1-
t0.old)<q0.old & q0.old<1)

   tf1=(0<p1.old & p1.old<t1.old & 0<q1.old & q1.old<(1-t1.old))|(t1.old<p1.old & p1.old<1 & (1-
t1.old)<q1.old & q1.old<1)

   }

res<-matrix(0,Gsim,8)

for (i in 1:Gsim) {

t0.st=rbeta(1,y0+1,n0-y0+1)
```

```
t1.st=rbeta(1,y1+1,n1-y1+1)

lta<-rmvnorm(1,c(a0,a1),va)

ltb<-rmvnorm(1,c(b0,b1),vb)

p0.st=expit(lta[1])

p1.st=expit(lta[2])

q0.st=expit(ltb[1])

q1.st=expit(ltb[2])

tf0=(0<p0.st & p0.st<t0.st & 0<q0.st & q0.st<(1-t0.st))|(t0.st<p0.st & p0.st<1 & (1-t0.st)<q0.st & q0.st<1)

tf1=(0<p1.st & p1.st<t1.st & 0<q1.st & q1.st<(1-t1.st))|(t1.st<p1.st & p1.st<1 & (1-t1.st)<q1.st & q1.st<1)

while (tf0=="FALSE" | tf1=="FALSE") {

   lta<-rmvnorm(1,c(a0,a1),va)

   ltb<-rmvnorm(1,c(b0,b1),vb)

   p0.st=expit(lta[1])

   p1.st=expit(lta[2])

   q0.st=expit(ltb[1])

   q1.st=expit(ltb[2])

   tf0=(0<p0.st & p0.st<t0.st & 0<q0.st & q0.st<(1-t0.st))|(t0.st<p0.st & p0.st<1 & (1-t0.st)<q0.st &
q0.st<1)

   tf1=(0<p1.st & p1.st<t1.st & 0<q1.st & q1.st<(1-t1.st))|(t1.st<p1.st & p1.st<1 & (1-t1.st)<q1.st &
q1.st<1)

   }



k.old.1.s.all=pmvnorm(lower=c(-Inf,-Inf),upper=c(logit(t0.old),logit(t1.old)),c(a0,a1),va)

k.old.1.t.all=pmvnorm(lower=c(-Inf,-Inf),upper=c(logit(1-t0.old),logit(1-t1.old)),c(b0,b1),vb)

k.old.1=k.old.1.s.all[1]*k.old.1.t.all[1]


k.old.2.s.all=pmvnorm(lower=c(-Inf,logit(t1.old)),upper=c(logit(t0.old),Inf),c(a0,a1),va)
```

```
k.old.2.t.all=pmvnorm(lower=c(-Inf,logit(1-t1.old)),upper=c(logit(1-t0.old),Inf),c(b0,b1),vb)
k.old.2=k.old.2.s.all[1]*k.old.2.t.all[1]

k.old.3.s.all=pmvnorm(lower=c(logit(t0.old),-Inf),upper=c(Inf,logit(t1.old)),c(a0,a1),va)
k.old.3.t.all=pmvnorm(lower=c(logit(1-t0.old),-Inf),upper=c(Inf,logit(1-t1.old)),c(b0,b1),vb)
k.old.3=k.old.3.s.all[1]*k.old.3.t.all[1]

k.old.4.s.all=pmvnorm(lower=c(logit(t0.old),logit(t1.old)),upper=c(Inf,Inf),c(a0,a1),va)
k.old.4.t.all=pmvnorm(lower=c(logit(1-t0.old),logit(1-t1.old)),upper=c(Inf,Inf),c(b0,b1),vb)
k.old.4=k.old.4.s.all[1]*k.old.4.t.all[1]
k.old=k.old.1+k.old.2+k.old.3+k.old.4

k.st.1.s.all=pmvnorm(lower=c(-Inf,-Inf),upper=c(logit(t0.st),logit(t1.st)),c(a0,a1),va)
k.st.1.t.all=pmvnorm(lower=c(-Inf,-Inf),upper=c(logit(1-t0.st),logit(1-t1.st)),c(b0,b1),vb)
k.st.1=k.st.1.s.all[1]*k.st.1.t.all[1]

k.st.2.s.all=pmvnorm(lower=c(-Inf,logit(t1.st)),upper=c(logit(t0.st),Inf),c(a0,a1),va)
k.st.2.t.all=pmvnorm(lower=c(-Inf,logit(1-t1.st)),upper=c(logit(1-t0.st),Inf),c(b0,b1),vb)
k.st.2=k.st.2.s.all[1]*k.st.2.t.all[1]

k.st.3.s.all=pmvnorm(lower=c(logit(t0.st),-Inf),upper=c(Inf,logit(t1.st)),c(a0,a1),va)
k.st.3.t.all=pmvnorm(lower=c(logit(1-t0.st),-Inf),upper=c(Inf,logit(1-t1.st)),c(b0,b1),vb)
k.st.3=k.st.3.s.all[1]*k.st.3.t.all[1]

k.st.4.s.all=pmvnorm(lower=c(logit(t0.st),logit(t1.st)),upper=c(Inf,Inf),c(a0,a1),va)
k.st.4.t.all=pmvnorm(lower=c(logit(1-t0.st),logit(1-t1.st)),upper=c(Inf,Inf),c(b0,b1),vb)
k.st.4=k.st.4.s.all[1]*k.st.4.t.all[1]
k.st=k.st.1+k.st.2+k.st.3+k.st.4
```

```
f.old=y0*log(t0.old)+(n0-y0)*log(1-t0.old)+y1*log(t1.old)+(n1-y1)*log(1-
t1.old)+log(1/abs(p0.old+q0.old-1))+log(1/abs(p1.old+q1.old-
1))+log(dmvnorm(c(logit(p0.old),logit(p1.old)),c(a0,a1),va))+log(dmvnorm(c(logit(q0.old),logit(q1.old)),c(
b0,b1),vb))+log(1/abs(p0.old*(1-p0.old)*p1.old*(1-p1.old)))+log(1/abs(q0.old*(1-q0.old)*q1.old*(1-
q1.old)))

f.st=y0*log(t0.st)+(n0-y0)*log(1-t0.st)+y1*log(t1.st)+(n1-y1)*log(1-t1.st)+log(1/abs(p0.st+q0.st-
1))+log(1/abs(p1.st+q1.st-
1))+log(dmvnorm(c(logit(p0.st),logit(p1.st)),c(a0,a1),va))+log(dmvnorm(c(logit(q0.st),logit(q1.st)),c(b0,b1
),vb))+log(1/abs(p0.st*(1-p0.st)*p1.st*(1-p1.st)))+log(1/abs(q0.st*(1-q0.st)*q1.st*(1-q1.st)))

g.old=log(dbeta(t0.old,y0+1,n0-y0+1))+log(dbeta(t1.old,y1+1,n1-
y1+1))+log(1/k.old)+log(dmvnorm(c(logit(p0.old),logit(p1.old)),c(a0,a1),va))+log(dmvnorm(c(logit(q0.old
),logit(q1.old)),c(b0,b1),vb))+log(1/abs(p0.old*(1-p0.old)*p1.old*(1-p1.old)))+log(1/abs(q0.old*(1-
q0.old)*q1.old*(1-q1.old)))

g.st=log(dbeta(t0.st,y0+1,n0-y0+1))+log(dbeta(t1.st,y1+1,n1-
y1+1))+log(1/k.st)+log(dmvnorm(c(logit(p0.st),logit(p1.st)),c(a0,a1),va))+log(dmvnorm(c(logit(q0.st),logit
(q1.st)),c(b0,b1),vb))+log(1/abs(p0.st*(1-p0.st)*p1.st*(1-p1.st)))+log(1/abs(q0.st*(1-q0.st)*q1.st*(1-
q1.st)))


accp=min(exp(f.st+g.old-f.old-g.st),1)

acc=rbinom(1,1,accp)

t0.old=acc*t0.st+(1-acc)*t0.old

p0.old=acc*p0.st+(1-acc)*p0.old

q0.old=acc*q0.st+(1-acc)*q0.old

t1.old=acc*t1.st+(1-acc)*t1.old

p1.old=acc*p1.st+(1-acc)*p1.old

q1.old=acc*q1.st+(1-acc)*q1.old



res[i,]<-c(((t1.old+q1.old-1)/(p1.old-t1.old))/((t0.old+q0.old-1)/(p0.old-
t0.old)),acc,p0.old,q0.old,p1.old,q1.old,t0.old,t1.old)

}
```

```
res
}


####
#
#Simulations for paper
#
#
G=10000
Sims=100
sp0.true=.95; sn0.true=.9;
sp1.true=.7; sn1.true=.6;
r0.true=.45; r1.true=.5;
n0=1000;n1=1000;
theta0.true=r0.true*sn0.true+(1-r0.true)*(1-sp0.true)
theta1.true=r1.true*sn1.true+(1-r1.true)*(1-sp1.true)
psi.true=((r1.true/(1-r1.true))/(r0.true/(1-r0.true)))


###############
#
# simulation 1
#
mb<-c(logit(0.95),logit(0.70));
```

```
vb<-matrix(0,2,2)
vb[1,1]=.02;vb[2,2]=.02;vb[1,2]=vb[2,1]=.8*sqrt(vb[1,1])*sqrt(vb[2,2])

ma<-c(logit(0.9),logit(0.6));
va<-matrix(0,2,2)
va[1,1]=.02;va[2,2]=3;va[1,2]=va[2,1]=.8*sqrt(va[1,1])*sqrt(va[2,2])


data1.out<-matrix(0,Sims,2)
sim1.out.u1<-matrix(0,Sims,3)
sim1.out.p1<-matrix(0,Sims,3)


for (iter in 1:Sims) {
y0=rbinom(1,n0,theta0.true)
y1=rbinom(1,n1,theta1.true)


out1.p1<-samp.pba.diff.c(y0,y1,n0,n1,ma[1],ma[2],va,mb[1],mb[2],vb,Gsim=G)
out1.u1<-samp.unc.diff.c(y0,y1,n0,n1,ma[1],ma[2],va,mb[1],mb[2],vb,Gsim=G+1000)

hpd.u1<-HPDinterval(as.mcmc(out1.u1[,1]))
hpd.p1<-HPDinterval(as.mcmc(out1.p1[,1]))

cov.u1<-as.numeric(hpd.u1[1]<psi.true & psi.true<hpd.u1[2])
cov.p1<-as.numeric(hpd.p1[1]<psi.true & psi.true<hpd.p1[2])

sim1.out.u1[iter,]<-c(median(out1.u1[1000:11000,1]),cov.u1,hpd.u1[2]-hpd.u1[1])
```

```
sim1.out.p1[iter,]<-c(median(out1.p1[,1]),cov.p1,hpd.p1[2]-hpd.p1[1])

data1.out[iter,]<-c(y0,y1)
print(iter)
}

i=1;c(mean(sim1.out.u1[,i]),mean(sim1.out.p1[,i]))
i=2;c(mean(sim1.out.u1[,i]),mean(sim1.out.p1[,i]))
i=3;c(mean(sim1.out.u1[,i]),mean(sim1.out.p1[,i]))

c(var(sim1.out.u1[,1]),var(sim1.out.p1[,1]))

mse1.u1<-mean((sim1.out.u1[,1]-psi.true)^2)
mse1.p1<-mean((sim1.out.p1[,1]-psi.true)^2)



###############
#
# simulation 2
#
va[1,1]=.02;va[2,2]=1;va[1,2]=va[2,1]=.8*sqrt(va[1,1])*sqrt(va[2,2]);

data2.out<-matrix(0,Sims,2)
```

```
sim2.out.u1<-matrix(0,Sims,3)
sim2.out.p1<-matrix(0,Sims,3)

for (iter in 1:Sims) {
y0=rbinom(1,n0,theta0.true)
y1=rbinom(1,n1,theta1.true)
out1.p1<-samp.pba.diff.c(y0,y1,n0,n1,ma[1],ma[2],va,mb[1],mb[2],vb,Gsim=G)
out1.u1<-samp.unc.diff.c(y0,y1,n0,n1,ma[1],ma[2],va,mb[1],mb[2],vb,Gsim=G+1000)
hpd.u1<-HPDinterval(as.mcmc(out1.u1[,1]))
hpd.p1<-HPDinterval(as.mcmc(out1.p1[,1]))
cov.u1<-as.numeric(hpd.u1[1]<psi.true & psi.true<hpd.u1[2])
cov.p1<-as.numeric(hpd.p1[1]<psi.true & psi.true<hpd.p1[2])
sim2.out.u1[iter,]<-c(median(out1.u1[1000:11000,1]),cov.u1,hpd.u1[2]-hpd.u1[1])
sim2.out.p1[iter,]<-c(median(out1.p1[,1]),cov.p1,hpd.p1[2]-hpd.p1[1])
data2.out[iter,]<-c(y0,y1)
print(iter)
}

i=1;c(mean(sim2.out.u1[,i]),mean(sim2.out.p1[,i]))
i=2;c(mean(sim2.out.u1[,i]),mean(sim2.out.p1[,i]))
i=3;c(mean(sim2.out.u1[,i]),mean(sim2.out.p1[,i]))

c(var(sim2.out.u1[,1]),var(sim2.out.p1[,1]))

mse2.u1<-mean((sim2.out.u1[,1]-psi.true)^2)
mse2.p1<-mean((sim2.out.p1[,1]-psi.true)^2)
```

```
###############
#
# simulation 3
#
va[1,1]=.02;va[2,2]=.1;va[1,2]=va[2,1]=.8*sqrt(va[1,1])*sqrt(va[2,2])




data3.out<-matrix(0,Sims,2)
sim3.out.u1<-matrix(0,Sims,3)
sim3.out.p1<-matrix(0,Sims,3)



for (iter in 1:Sims) {
y0=rbinom(1,n0,theta0.true)
y1=rbinom(1,n1,theta1.true)
out1.p1<-samp.pba.diff.c(y0,y1,n0,n1,ma[1],ma[2],va,mb[1],mb[2],vb,Gsim=G)
out1.u1<-samp.unc.diff.c(y0,y1,n0,n1,ma[1],ma[2],va,mb[1],mb[2],vb,Gsim=G+1000)
hpd.u1<-HPDinterval(as.mcmc(out1.u1[,1]))
hpd.p1<-HPDinterval(as.mcmc(out1.p1[,1]))
cov.u1<-as.numeric(hpd.u1[1]<psi.true & psi.true<hpd.u1[2])
cov.p1<-as.numeric(hpd.p1[1]<psi.true & psi.true<hpd.p1[2])
sim3.out.u1[iter,]<-c(median(out1.u1[1000:11000,1]),cov.u1,hpd.u1[2]-hpd.u1[1])
```

```
sim3.out.p1[iter,]<-c(median(out1.p1[,1]),cov.p1,hpd.p1[2]-hpd.p1[1])
data3.out[iter,]<-c(y0,y1)
print(iter)
}

i=1;c(mean(sim3.out.u1[,i]),mean(sim3.out.p1[,i]))
i=2;c(mean(sim3.out.u1[,i]),mean(sim3.out.p1[,i]))
i=3;c(mean(sim3.out.u1[,i]),mean(sim3.out.p1[,i]))

c(var(sim3.out.u1[,1]),var(sim3.out.p1[,1]))

mse3.u1<-mean((sim3.out.u1[,1]-psi.true)^2)
mse3.p1<-mean((sim3.out.p1[,1]-psi.true)^2)
```