Session 7

Incorporating imperfect sensitivity and specificity into more complex models

Matt Denwood

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Recap

NOTE: THIS MATERIAL IS NOT YET FINALISED, PLEASE CHECK BACK SOON!

TODO: redo so it is covariates

- covariates on Se/Sp
- covariates on prevalence (random effects)
- categorical predictors on prevalence (population/group becomes predictor) - example where we modify the code to add a fixed effect across e.g. 3 populations
- categorical predictors on se/sp: group by population and allow to vary - example with age group and covid paper
- continuous covariates and/or random effects on prevalence

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Incorporating imperfect sensitivity and specificity into more complex models

Logistic regression in JAGS

```
model{

  for(i in 1:N){
    Observation[i] ~ dbern(prob[i])
    logit(prob[i]) <- intercept + beta1[Category[i]] +
    ↪  beta2*Covariate[i]
  }

  intercept ~ dnorm(0, 0.01)
  beta1[1] <- 0
  for(c in 2:NC){
    beta1[c] ~ dnorm(0, 0.01)
  }
  beta2 ~ dnorm(0, 0.01)

  #data# N, Observation, NC, Category, Covariate
  #monitor# intercept, beta1, beta2
  #inits# intercept, beta1, beta2
}
```

```
model{

  for(i in 1:N){
    Observation[i] ~ dbern(obs_prob[i])
    obs_prob[i] <- prob[i]*se + (1-prob[i])*(1-sp)
    logit(prob[i]) <- intercept + beta1[Category[i]] +
    ↪  beta2*Covariate[i]
  }

  se ~ dbeta(1,1)T(1-sp, )
  sp ~ dbeta(1,1)

  intercept ~ dnorm(0, 0.01)
  beta1[1] <- 0
  for(c in 2:NC){
    beta1[c] ~ dnorm(0, 0.01)
  }
  beta2 ~ dnorm(0, 0.01)

  #data# N, Observation, NC, Category, Covariate
  #monitor# intercept, beta1, beta2, se, sp
  #inits# intercept, beta1, beta2, se, sp
}
```

```
model{

  for(i in 1:N){
    Observation[i] ~ dbern(obs_prob[i])
    obs_prob[i] <- prob[i]*se + (1-prob[i])*(1-sp)
    logit(prob[i]) <- intercept + beta1[Category[i]] +
    ↪  beta2*Covariate[i]
  }

  se ~ dbeta(148.43, 16.49)T(1-sp, )
  sp ~ dbeta(240.03, 12.63)

  intercept ~ dnorm(0, 0.01)
  beta1[1] <- 0
  for(c in 2:NC){
    beta1[c] ~ dnorm(0, 0.01)
  }
  beta2 ~ dnorm(0, 0.01)

  #data# N, Observation, NC, Category, Covariate
  #monitor# intercept, beta1, beta2, se, sp
  #inits# intercept, beta1, beta2, se, sp
}
```

```
model{

  for(i in 1:N){
    Observation[i] ~ dbern(obs_prob[i])
    obs_prob[i] <- prob[i]*se + (1-prob[i])*(1-sp)
    logit(prob[i]) <- intercept + beta1[Category[i]] +
    ↪  beta2*Covariate[i]
  }

  se <- 0.9
  sp <- 0.95

  intercept ~ dnorm(0, 0.01)
  beta1[1] <- 0
  for(c in 2:NC){
    beta1[c] ~ dnorm(0, 0.01)
  }
  beta2 ~ dnorm(0, 0.01)

  #data# N, Observation, NC, Category, Covariate
  #monitor# intercept, beta1, beta2
  #inits# intercept, beta1, beta2
}
```

```
model{

  for(i in 1:N){
    Observation[i] ~ dbern(obs_prob[i])
    obs_prob[i] <- prob[i]*se + (1-prob[i])*(1-sp)
    logit(prob[i]) <- intercept + beta1[Category[i]] +
    ↪  beta2*Covariate[i]
  }

  #data# se, sp

  intercept ~ dnorm(0, 0.01)
  beta1[1] <- 0
  for(c in 2:NC){
    beta1[c] ~ dnorm(0, 0.01)
  }
  beta2 ~ dnorm(0, 0.01)

  #data# N, Observation, NC, Category, Covariate
  #monitor# intercept, beta1, beta2
  #inits# intercept, beta1, beta2
}
```

```
model{

  for(i in 1:N){
    Observation[i] ~ dbern(obs_prob[i])
    obs_prob[i] <- prob[i]*se[Test[i]] + (1-prob[i])*(1-sp[Test[i]])
    logit(prob[i]) <- intercept + beta1[Category[i]] +
    ↪  beta2*Covariate[i]
  }

  #data# se, sp

  intercept ~ dnorm(0, 0.01)
  beta1[1] <- 0
  for(c in 2:NC){
    beta1[c] ~ dnorm(0, 0.01)
  }
  beta2 ~ dnorm(0, 0.01)

  #data# N, Observation, NC, Category, Covariate, Test
  #monitor# intercept, beta1, beta2
  #inits# intercept, beta1, beta2
}
```

Other types of GL(M)M

You can use template.jags as inspiration:

```
template.jags(weight ~ group, family="gaussian", data=data,
↪  file="linear_model.txt")
## Your model template was created at "linear_model.txt" - it is highly
↪  advisable to examine the model syntax to be sure it is as intended
## You can then run the model using run.jags("linear_model.txt")
results <- run.jags("linear_model.txt")
## Loading required namespace: rjags
## module glm loaded
## module dic loaded
```

```
results
##
## JAGS model summary statistics from 20000 samples (chains = 2;
↪  adapt+burnin = 5000):
##
##                        Lower95   Median Upper95     Mean
## regression_precision 0.83645   1.9914  3.4315   2.0674
## intercept             4.5874   5.0333   5.503   5.0327
## group_effect[1]            0        0       0        0
## group_effect[2]       -1.021 -0.36962 0.27593 -0.36887
## deviance              40.177     42.7   48.57   43.402
## resid.sum.sq          8.7293   9.4188  12.166   9.8138
##
##                           SD     Mode     MCerr MC%ofSD
## regression_precision 0.68615   1.9382 0.0052908     0.8
## intercept             0.2328   5.0234 0.0016402     0.7
## group_effect[1]            0        0        --      --
## group_effect[2]      0.32804 -0.36575 0.0023196     0.7
## deviance              2.6534   41.646  0.021613     0.8
## resid.sum.sq          1.2395   9.0307 0.0098046     0.8
##
##                      SSeff      AC.10   psrf
## regression_precision 16819  -0.010163      1
## intercept            20147   0.010746 1.0001
## group_effect[1]         --         --     --
## group_effect[2]      20000 -0.0070204 1.0003
## deviance             15072  0.0015453      1
```

Supported features:

- Gaussian, binomial, Poisson, negative binomial, ZIB, ZIP, ZINB
- Random intercepts

We can also add (currently manually):

- Random slopes
- Spline terms
- Interval censoring

What about other models?

MCMC is highly flexible!

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We can have:

- Hidden Markov models
- State Space models
- Other types of latent class model

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We can have:

- Hidden Markov models
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- Other types of latent class model

But does your data match your ambitions?

- All models can be specified
- Relatively few are identifiable

Before you go...

- Feedback on the course would be extremely welcome!
  - https://www.survey-xact.dk/LinkCollector?key=RKMUENCXS11N
  - I will send a reminder email later today with (the same) survey link

Before you go...

- Feedback on the course would be extremely welcome!
  - https://www.survey-xact.dk/LinkCollector?key=RKMUENCXS11N
  - I will send a reminder email later today with (the same) survey link
- Remember to keep an eye on the COST action website:
  - http://harmony-net.eu
  - Physical training schools are being run in September and accepting sign-ups now!

Practical session 7

Points to consider

1. When is there a benefit to adding imperfect test characteristics?
2. When is there no real benefit?