Session 5

How to interpret the latent class

Matt Denwood

2021-06-30

Recap

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

- Adding more populations and more tests to a Hui-Walter model is technically easy
  - Particualrly if using template_huiwalter
- Verifying that the assumptions you are making are correct is harder
  - The sensitivity and specificity must be consistent
  - Pairwise correlation between tests should be accounted for
    - With >2 tests

How to interpret the latent class

What exactly is our latent class?

Think about what exactly the latent class is in these situations:

1. An antigen plus antibody test

What exactly is our latent class?

Think about what exactly the latent class is in these situations:

1. An antigen plus antibody test

- The latent status is probably close to the true disease status

What exactly is our latent class?

Think about what exactly the latent class is in these situations:

1. An antigen plus antibody test
   - The latent status is probably close to the true disease status
2. Two antibody tests

What exactly is our latent class?

Think about what exactly the latent class is in these situations:

1. An antigen plus antibody test

- The latent status is probably close to the true disease status

2. Two antibody tests

- The latent status is actually ‘producing antibodies’
  - And not ‘diseased’ !!!

What exactly is our latent class?

Think about what exactly the latent class is in these situations:

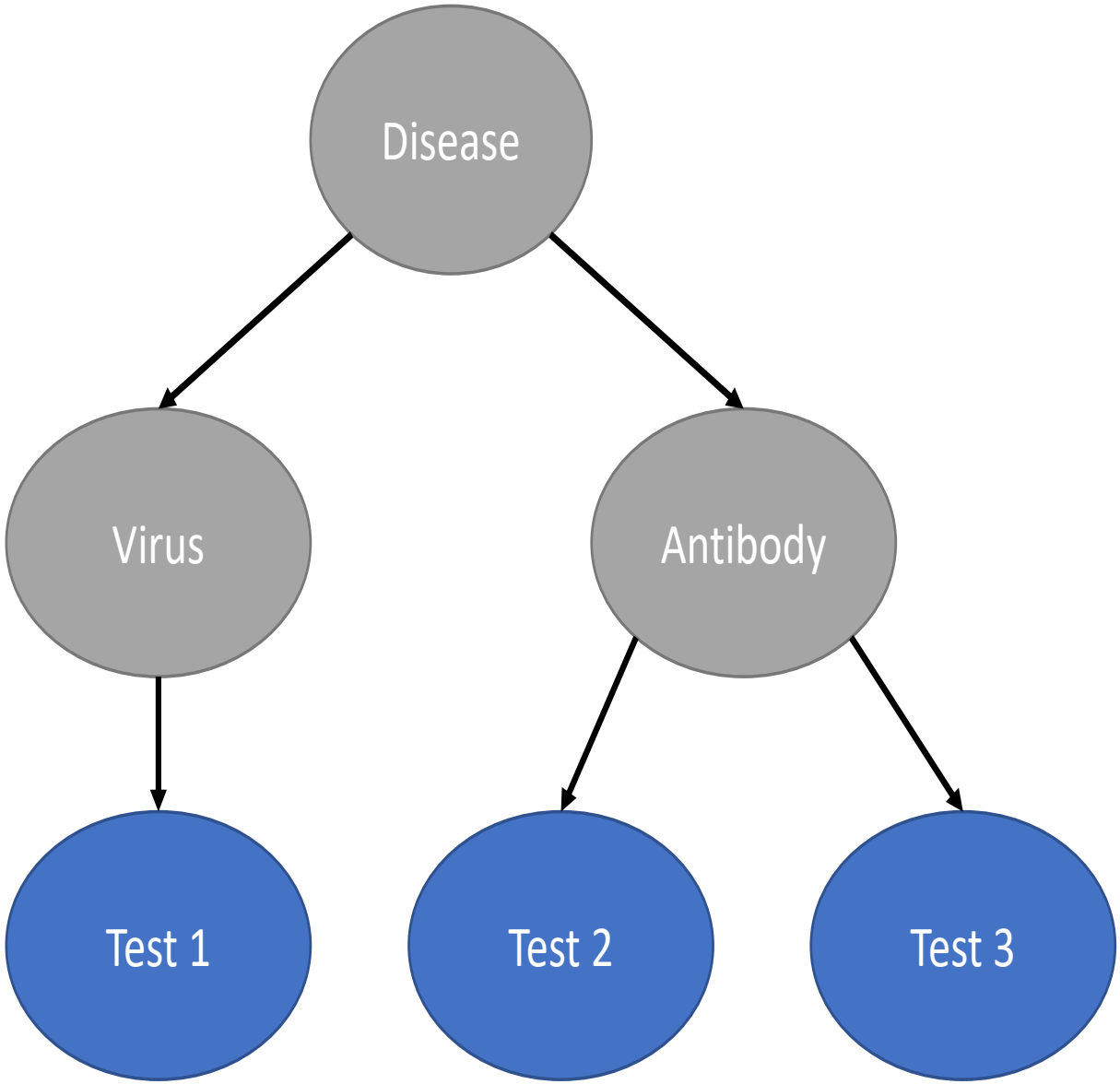
1. An antigen plus antibody test

- The latent status is probably close to the true disease status

2. Two antibody tests

- The latent status is actually 'producing antibodies'
  - And not 'diseased' !!!
- What do we mean by "conditionally independent"?
  - Independent of each other conditional on the latent state
  - But the latent state is NOT always *disease*

A hierarchy of latent states



Branching of processes leading to test results

- Sometimes we have multiple tests detecting similar things
  - For example: two antibody tests and one antigen test
    - The antibody tests will be correlated

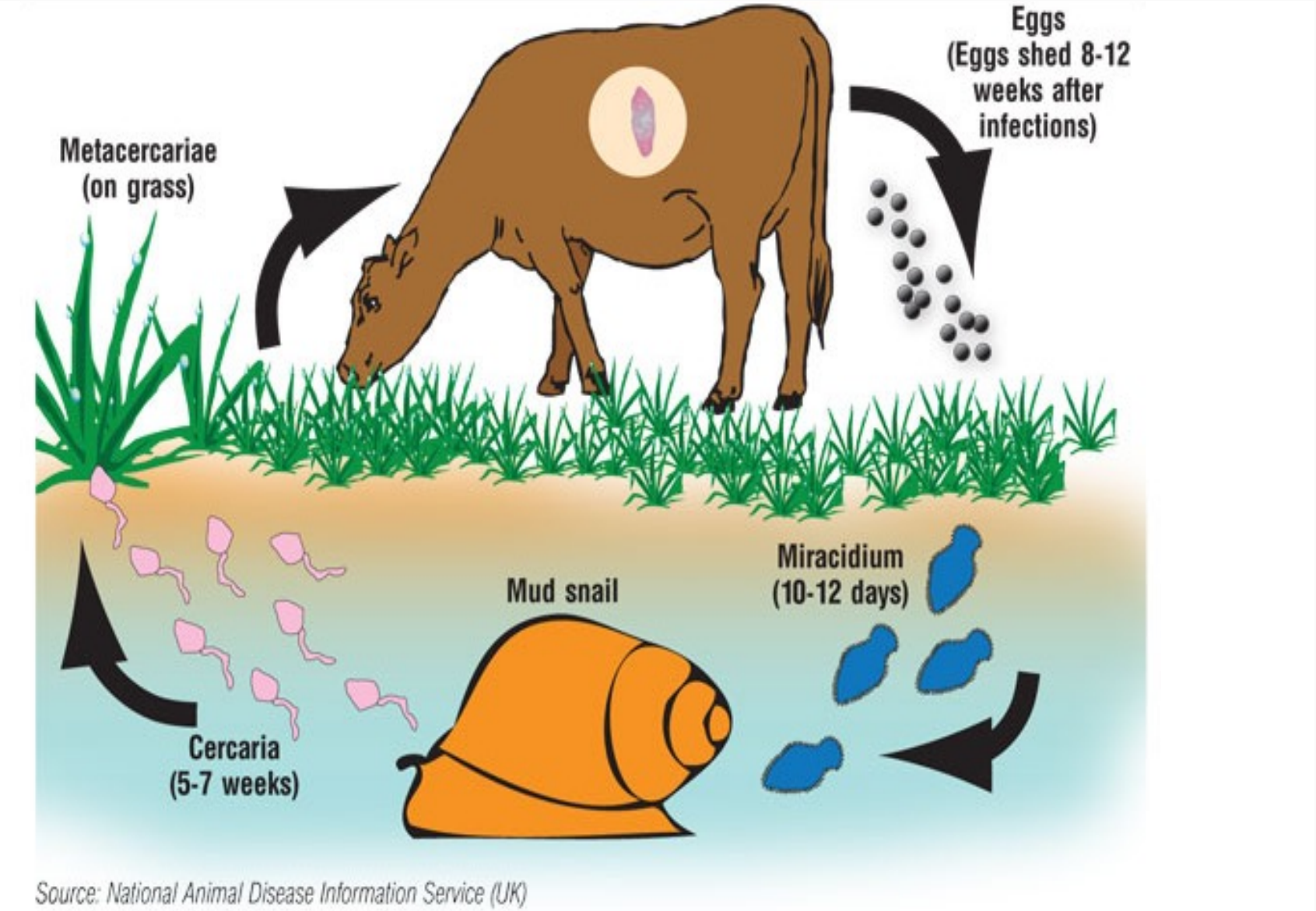
Branching of processes leading to test results

- Sometimes we have multiple tests detecting similar things
  - For example: two antibody tests and one antigen test
    - The antibody tests will be correlated
- Sometimes we have multiple tests on the same site / sample:
  - For example: two throat swab tests vs a nasal swab test
    - The throat swab tests will be correlated

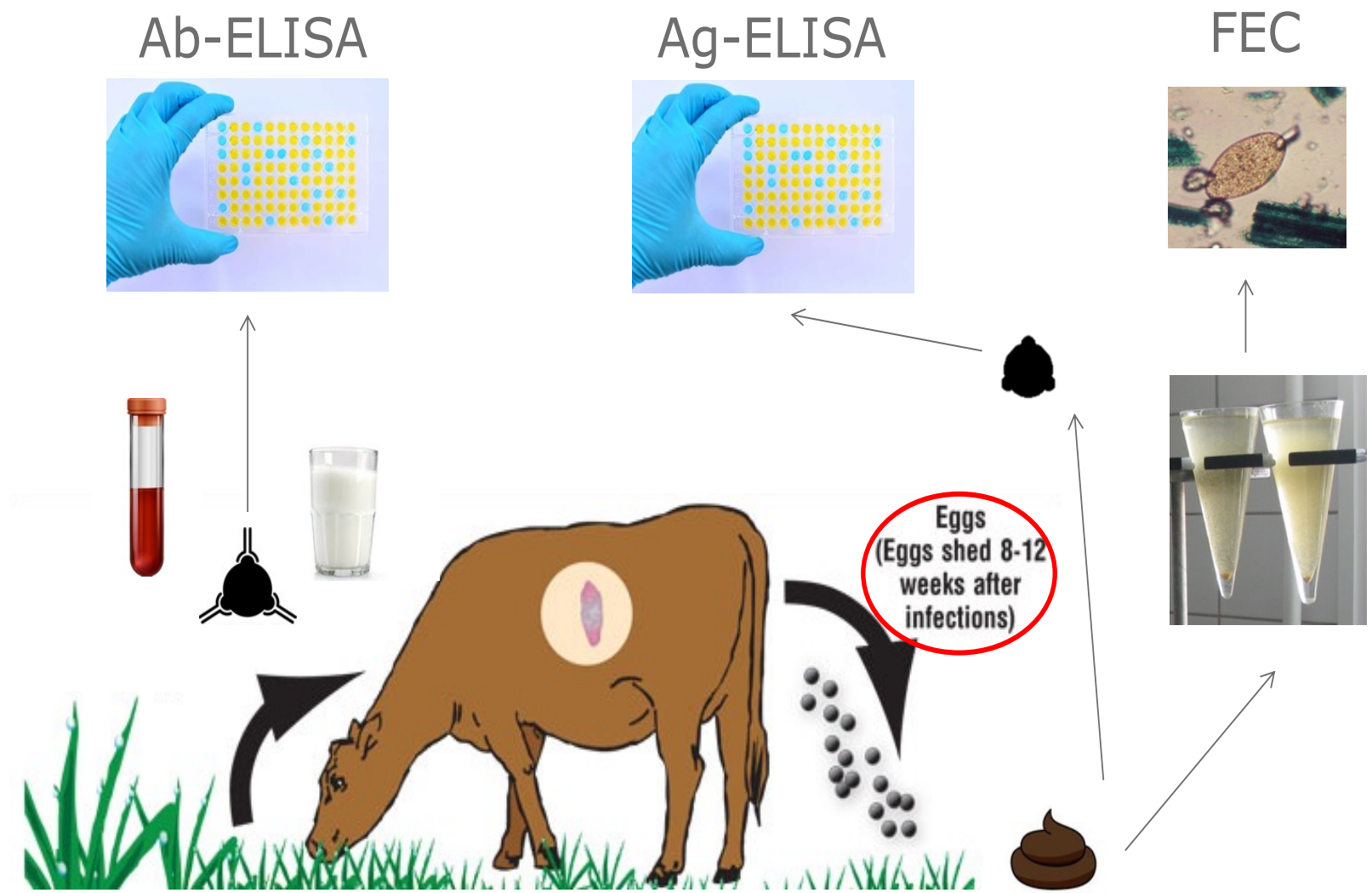
Branching of processes leading to test results

- Sometimes we have multiple tests detecting similar things
  - For example: two antibody tests and one antigen test
    - The antibody tests will be correlated
- Sometimes we have multiple tests on the same site / sample:
  - For example: two throat swab tests vs a nasal swab test
    - The throat swab tests will be correlated
- Or even three antibody tests where two are primed to detect the same thing, and one has a different target!
  - In this case all three tests are correlated
  - But two are more strongly correlated

Parasites generally have more complex life cycles



So diagnostic tests are more difficult to interpret!



Credit: Nao Takeuchi-Storm

What are the tests detecting?

- Faecal egg counts
  - Detect eggs from adult parasites
  - These are produced 8-12 weeks after infection
  - Eggs may persist in the gall bladder for some weeks after infection has been cleared
- Antigen ELISA
  - Detects presence of maturing/adult parasites in faeces
  - This occurs from 5-8 weeks after infection
  - Parasites only detectable during active infection
- Antibody ELISA
  - Triggered by migrating juveniles and adults
  - Persists (although declining) for several months after infection has been cleared

What is sensitivity and specificity?

The probability of test status conditional on true disease status?

What is sensitivity and specificity?

The probability of test status conditional on true disease status?

The probability of test status conditional on the latent state?

What is sensitivity and specificity?

The probability of test status conditional on true disease status?

The probability of test status conditional on the latent state?

So is the latent state the same as the true disease state?

What is sensitivity and specificity?

The probability of test status conditional on true disease status?

The probability of test status conditional on the latent state?

So is the latent state the same as the true disease state?

Important quote:

"Latent class models involve pulling **something** out of a hat, and deciding to call it a rabbit"

- Some Danish guy

Publication of your results

STARD-BLCM: A helpful structure to ensure that papers contain all necessary information

- You should follow this and refer to it in your articles!

Publication of your results

STARD-BLCM: A helpful structure to ensure that papers contain all necessary information

- You should follow this and refer to it in your articles!

If you use the software, please cite JAGS:

- Plummer, M. (2003). JAGS : A Program for Analysis of Bayesian Graphical Models Using Gibbs Sampling JAGS : Just Another Gibbs Sampler. Proceedings of the 3rd International Workshop on Distributed Statistical Computing (DSC 2003), March 20–22,Vienna, Austria. ISSN 1609-395X. https://doi.org/10.1.1.13.3406

And R:

```
citation()
##
## To cite R in publications use:
##
##   R Core Team (2022). R: A language and environment
##   for statistical computing. R Foundation for
##   Statistical Computing, Vienna, Austria. URL
##   https://www.R-project.org/.
##
## A BibTeX entry for LaTeX users is
##
##   @Manual{,
##     title = {R: A Language and Environment for Statistical
↪  Computing},
##     author = {{R Core Team}},
##     organization = {R Foundation for Statistical Computing},
##     address = {Vienna, Austria},
##     year = {2022},
##     url = {https://www.R-project.org/},
##   }
##
## We have invested a lot of time and effort in creating
## R, please cite it when using it for data analysis.
## See also 'citation("pkgname")' for citing R packages.
```

And runjags:

```
citation("runjags")
##
## To cite runjags in publications use:
##
##   Matthew J. Denwood (2016). runjags: An R Package
##   Providing Interface Utilities, Model Templates,
##   Parallel Computing Methods and Additional
##   Distributions for MCMC Models in JAGS. Journal of
##   Statistical Software, 71(9), 1-25.
##   doi:10.18637/jss.v071.i09
##
## A BibTeX entry for LaTeX users is
##
##   @Article{,
##     title = {{runjags}: An {R} Package Providing Interface Utilities,
↪  Model Templates, Parallel Computing Methods and Additional
↪  Distributions for {MCMC} Models in {JAGS}},
##     author = {Matthew J. Denwood},
##     journal = {Journal of Statistical Software},
##     year = {2016},
##     volume = {71},
##     number = {9},
##     pages = {1--25},
##     doi = {10.18637/jss.v071.i09},
##   }
```

Between-test correlation structure

We have two antibody tests (with similar targets) plus one antigen test. The two antibody tests give the same result more frequently together than with the antigen test. How might the following two models differ in terms of the estimated sensitivity and specificity of the antigen test:

- Assumed conditional independence between all 3 tests
- Assumed correlation between the two antibody tests

...

Answer: the first model will produced biased estimates for the antigen test (downward) and also the antibody tests (upward).

...

Note: this is only necessary to consider for >=3 tests - and

TODO

Have some scenarios for discussion

Sh

Number of unknown parameters - formula and pD

Discussion session 5 - should we correct for correlation?

Discussion session 5 - should we correct for correlation?

TODO:

Two tests - is there a point?

Multiple antibody tests - latent state is always antibody

What does “conditionally independent mean”?

Session: discussion