Inference

Connecting models to data

The problem with infection data

Often only observe a proportion of reality

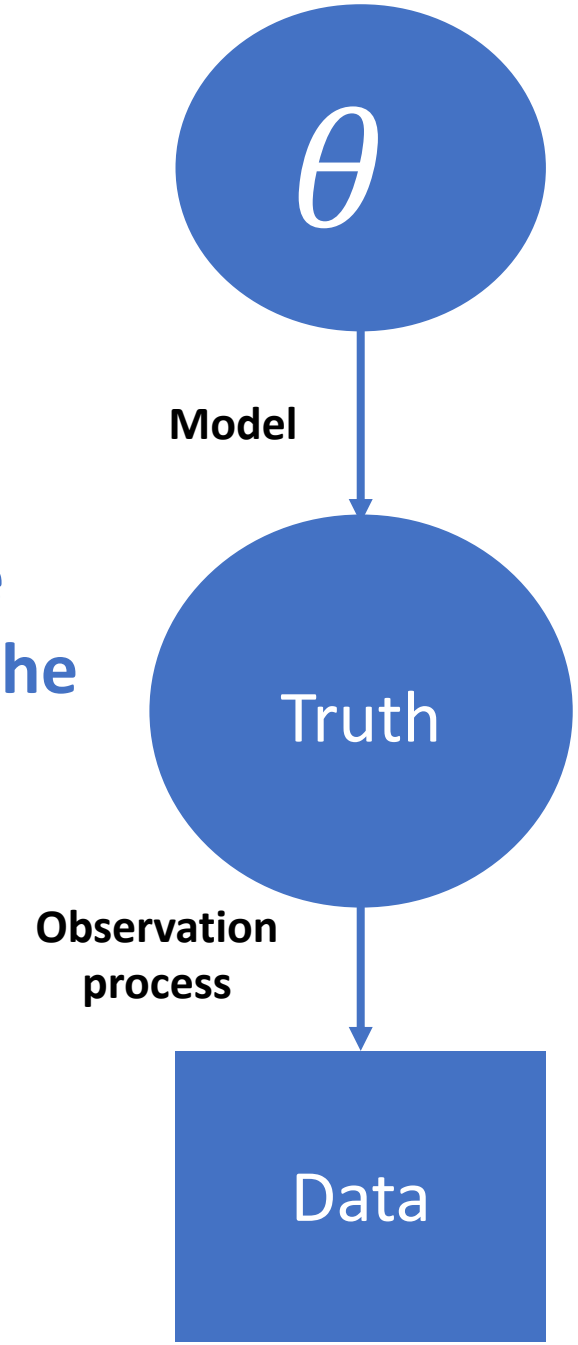
- Hospitalised case data gives you those who had severe infection
- Symptom onsets are observed but infection times are not

Or only observe a measure of infection

- antibody response at one time point
- result of imperfect diagnostic test

We use this data to infer the ‘truth’.

In a perfect world, we would directly observe the 'truth'.



square=observed,
circle=unobserved

Imperfect reporting of incidence data

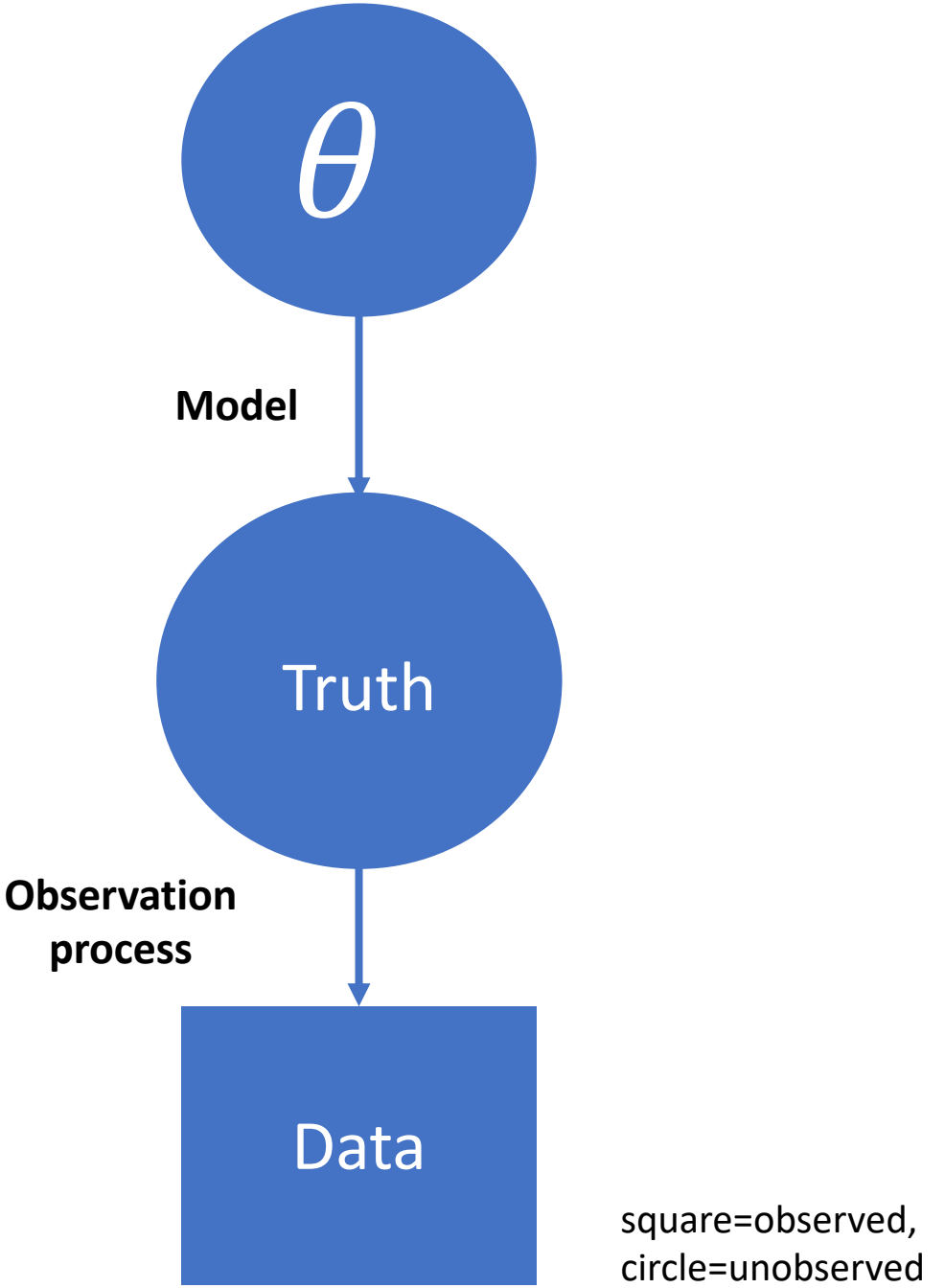
- $\theta = R_0, D_{lat}, D_{inf}, D_{imm}, \alpha, \rho$

- Deterministic/Stochastic model SEITL model

- Predicted incidence Inc

- We assumed data were recorded according to a Poisson process : Poisson(ρInc) with reporting rate ρ and predicted incidence Inc

- Reported incidence over time



square=observed,
circle=unobserved

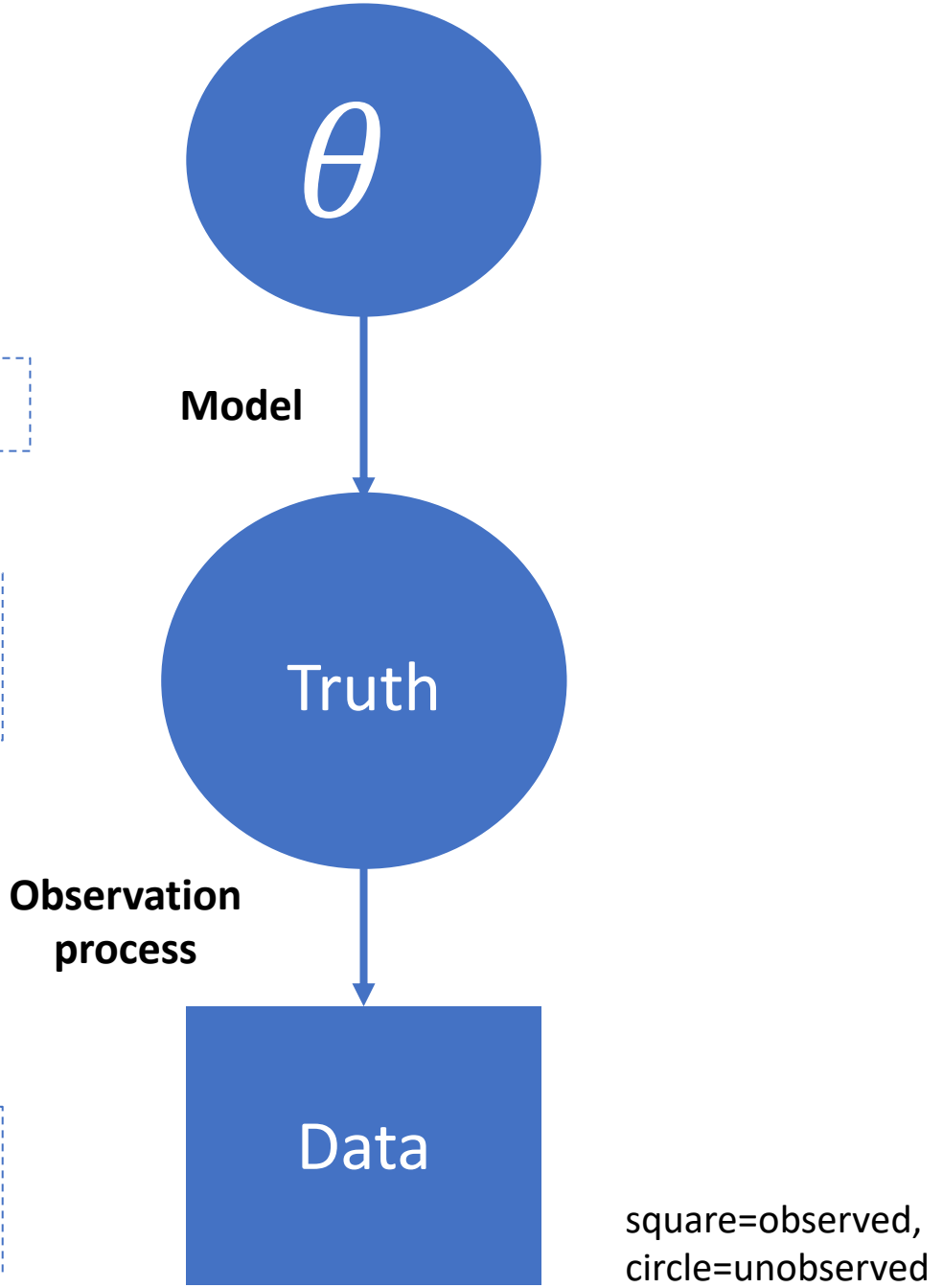
Diagnostic testing results

- Susceptible-Infected model

- Predicted number of susceptible (S) and infected (I) animals

- Binomial(I, sensitivity).Binomial(S, specificity)

- Diagnostic test results : test positives () and test negatives ()



square=observed,
circle=unobserved

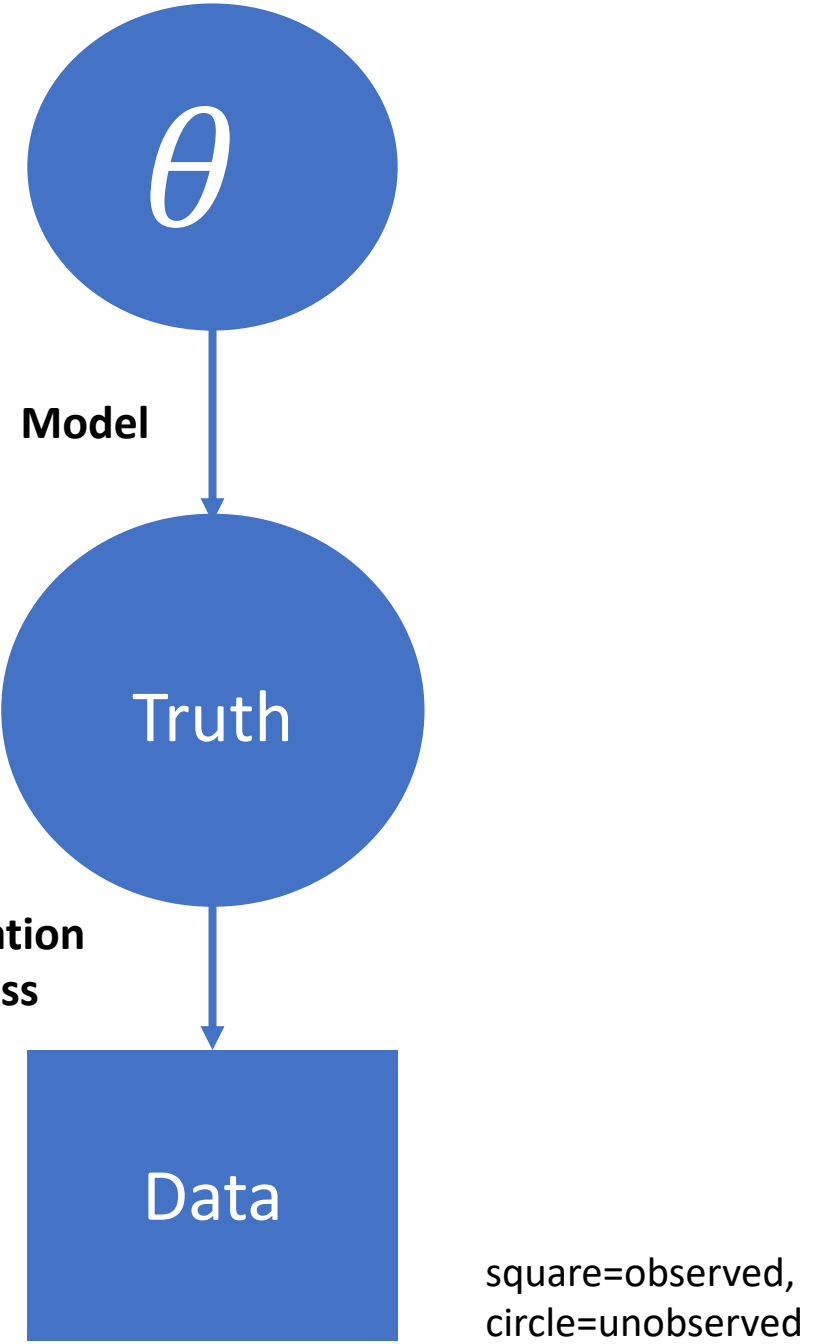
Laboratory error

- Antibody process model

- Predicted log antibody titre

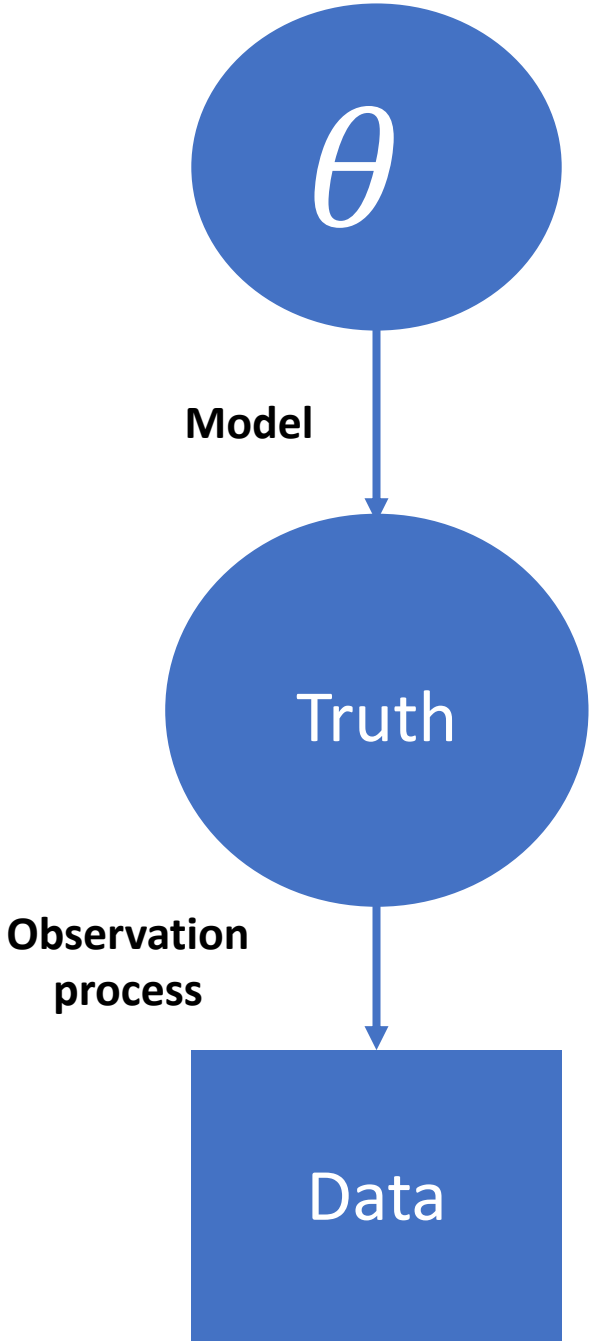
- Normally distributed error around predicted log antibody titre

- Laboratory based assay (measure of log antibody titre)



square=observed,
circle=unobserved

Connecting your models to data relies on distinguishing how you predict the ‘truth’ (model) and how you connect this ‘truth’ to your data (observation process).



Examples

- Kucharski AJ, Lessler J, Cummings DAT, Riley S (2018) Timescales of influenza A/H3N2 antibody dynamics. PLOS Biology 16(8): e2004974.https://doi.org/10.1371/journal.pbio.2004974
- Brooks-Pollock E, Roberts G.O, Keeling, M.J (2014) A dynamic model of bovine tuberculosis spread and control in Great Britain. Nature, 511, pp. 228-231