Data, models and science

DAIDD 2020

1 Introduction

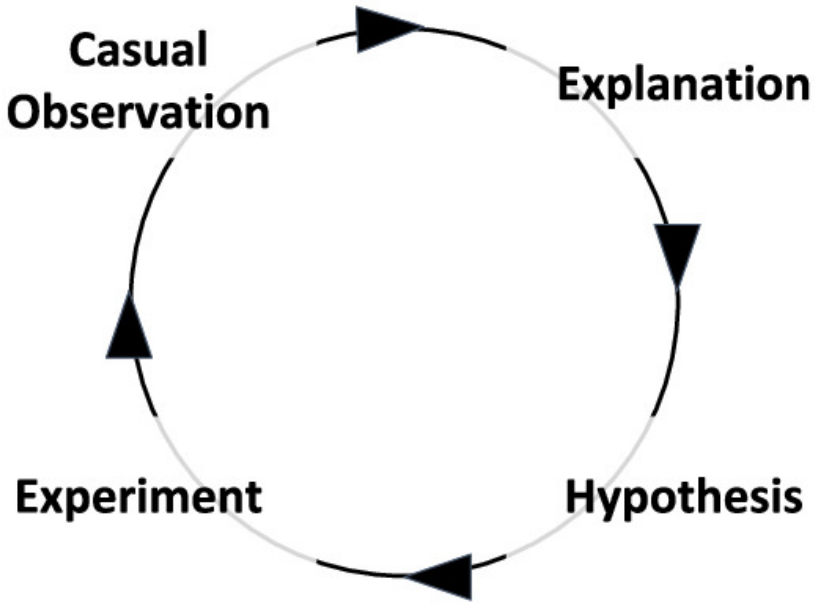
Goals

- Process of science
- How science informs public health
  - Specific examples
- Approaches to epidemiology

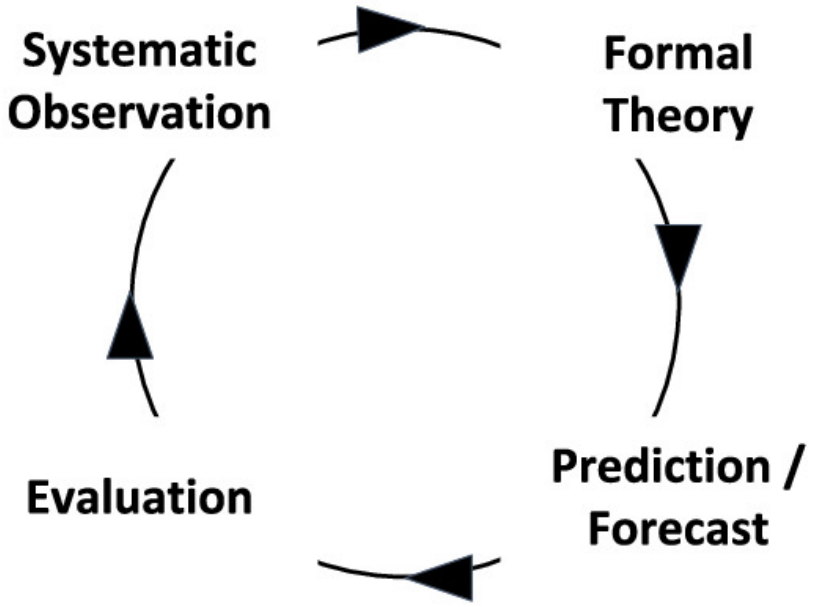
Science is a *process*

- Observe and experiment with reality to *discover* and *challenge* ideas about how it works
- A key to science is that everything is open to question
  - Science is the belief in the ignorance of experts – *Feynman*

The process of science



Science without experiments

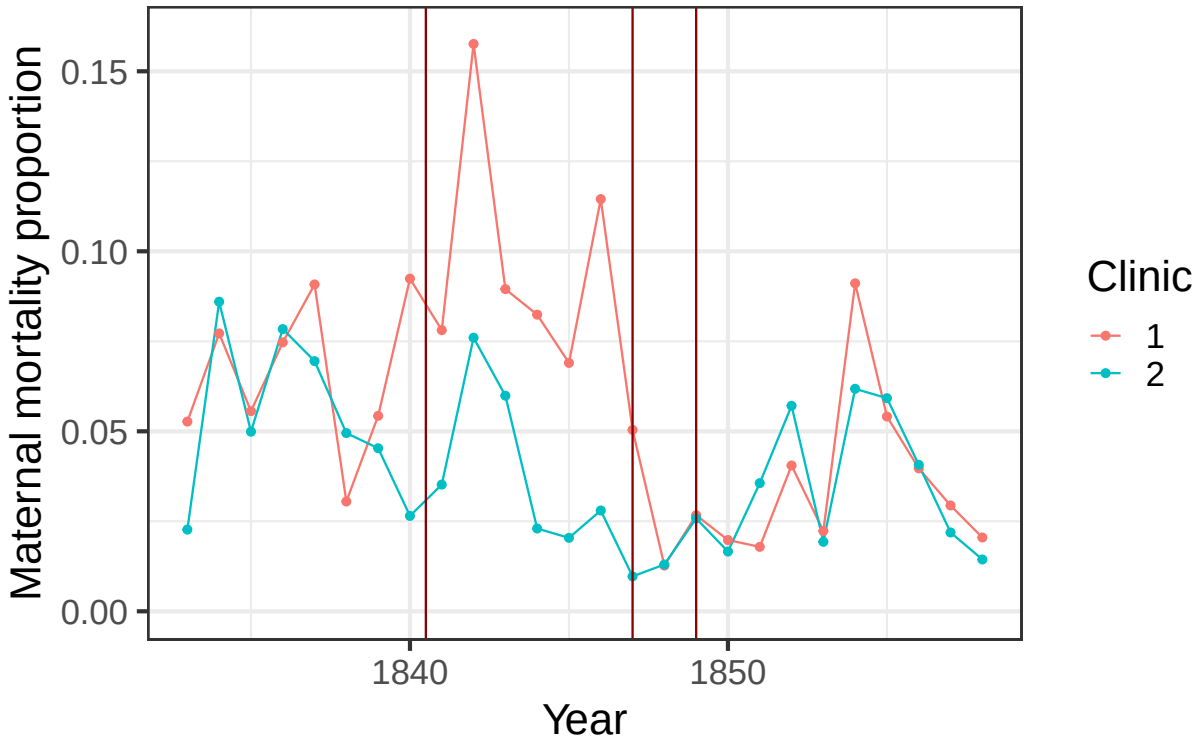


2 Public health

2.1 Maternal mortality

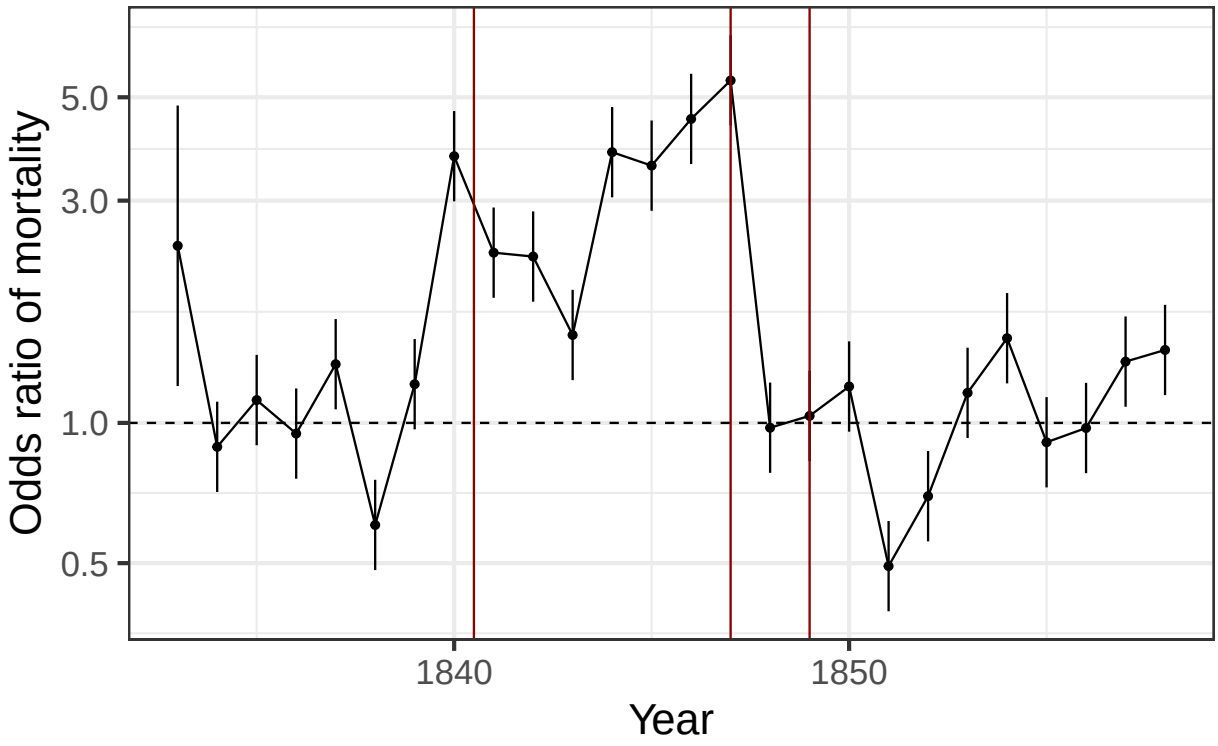
Observation and action

- In 1840, medical students stopped visiting Clinic 1
- In 1847, a surgeon died from infection following a scalpel injury
  - Igor Semmelweiss made medical students wash their hands



Looking at the data

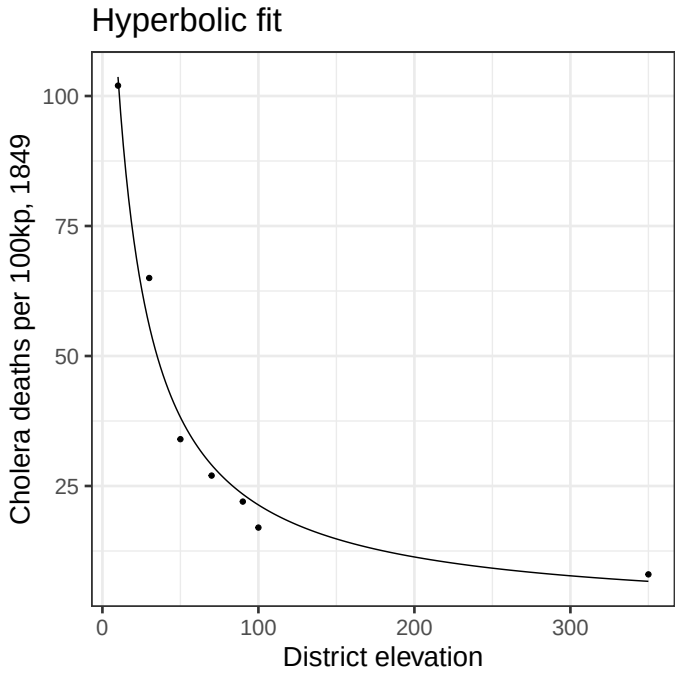
-
-
-
-



2.2 Cholera

- Is it caused by bad air, or bad water?
- What's bad about it?

Cholera and air



2.3 Yellow fever and malaria

- Ross determined the cause of malaria primarily by experiments on mosquitoes
- Reed determined the cause of yellow fever primarily by experiments on human volunteers

3 Approaches to epidemiology

Data, models and science

- We're never finished, we compare models to data over and over again
- Data is what we use to develop and understand models
- Models are what we use to interpret data
  - and they can suggest what data we need to collect
- Complicated or hard-to-test theories may require *dynamical* models

Classical epidemiology

- Avoid mechanism
- Control for non-independence of "units"

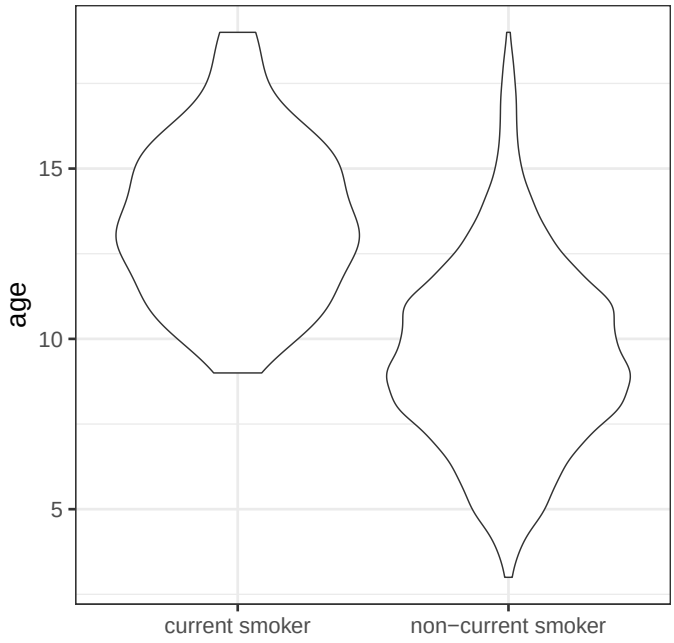
Dynamical epidemiology

- Embrace mechanism
- Explicitly incorporate dependence between units
  - X is infected because Y infected them

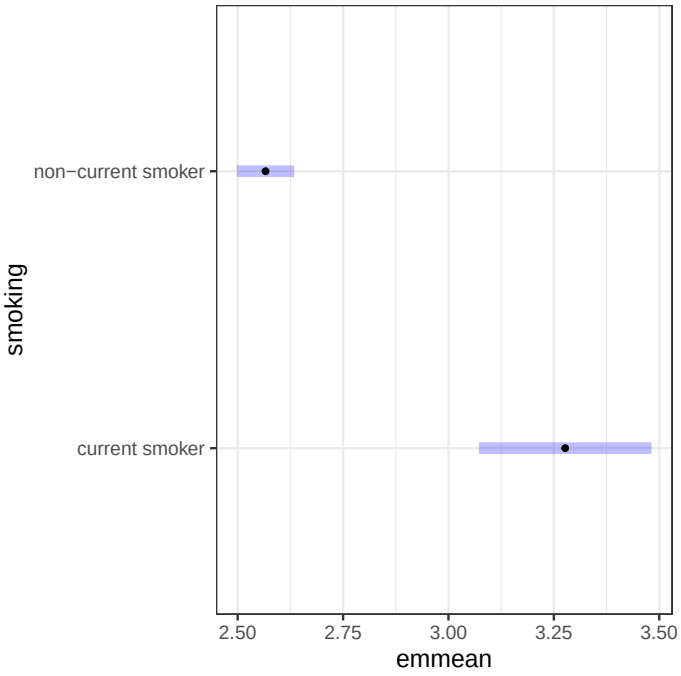
3.1 Classical epidemiology

Classical example

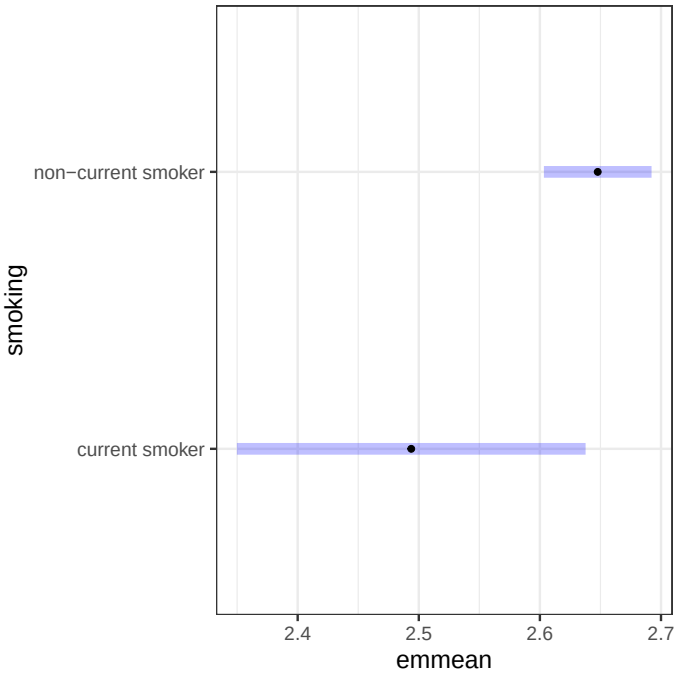
Classical example



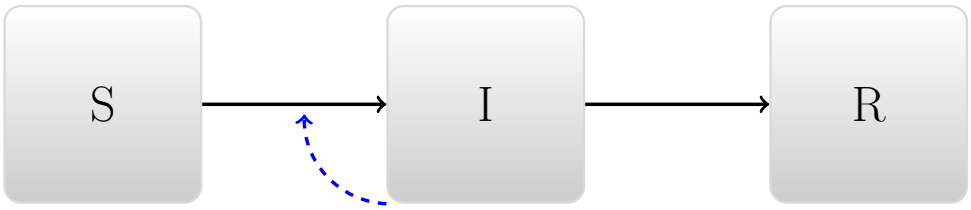
Univariate means



Multivariate means



3.2 Dynamical epidemiology



Other viruses

Pictures from CDC Pink book `https://www.cdc.gov/vaccines/pubs/pinkbook/index.html`

- Rubella
- Measles
- Polio
- Influenza

Bridging

- Classical epidemiology relies on statistics, avoids mechanism
- Mathematical epidemiology (the traditional approach to dynamical epidemiology) explores mechanism, avoids statistics
- Much modern dynamical epidemiology seeks ways to put dynamical mechanisms into a statistical framework
  - This is hard

4 Summary

- Science is an ongoing process
- Models are the way that we bridge between theory and reality
- Dynamical models have a key role
  - When we can't do experiments
  - When mechanisms are complex
- We should work to combine dynamics with statistical approaches