U.S. FOOD & DRUG ADMINISTRATION

INTRO TO BAYESIAN & FREQUENTIST STATISTICS

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DISCLAIMER

This presentation is an informal communication and represents my own best judgement. My comments do not bind or obligate FDA.

STATISTICS

- Focused on drawing evidence or conclusions from data: information subject to uncertainty
- Much of statistics is underpinned by mathematics: probability, decision theory, etc.
- Bayesian and frequentist statistics are built on two different mathematical paradigms:
  - Different assumptions lead to different statistical methods for drawing conclusions from data

BAYESIAN & FREQUENTIST

- Frequentist
  - Probability: the long-run *frequency* at which an event occurs
  - Population parameters are fixed (i.e., take only a single value)
  - Frequentist methods designed to have specific properties in the long-run
    - Can be hard to design new methods, as no obvious way to design them
- Bayesian
  - Probability: the belief that an event will occur
  - Population parameters have distributions
  - Bayesian methods use Bayes' rule and shown to have specific properties
    - Easy to design new methods, but computationally intensive

BAYES' RULE (OR THEOREM)

$$p(A|B) = \frac{p(B|A)\, p(A)}{p(B)}$$

BAYESIAN STATS

$$p(\text{parameter} \mid \text{data}) = \frac{p(\text{data} \mid \text{parameter})\, p(\text{param.})}{p(\text{data})}$$

BAYESIAN STATS

posterior distribution
best guess after observed data

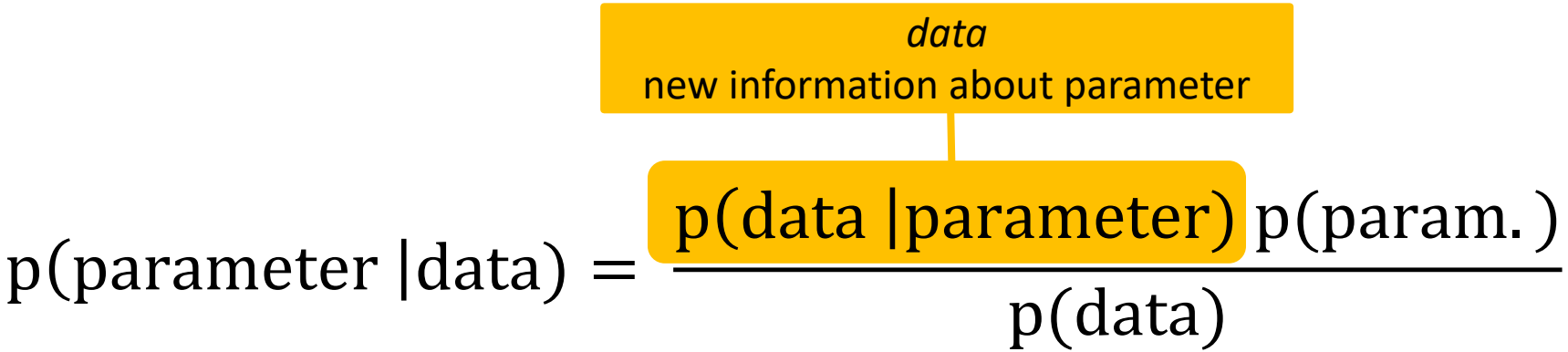
$$p(\text{parameter} \mid \text{data}) = \frac{p(\text{data} \mid \text{parameter})\, p(\text{param.})}{p(\text{data})}$$

BAYESIAN STATS

prior distribution
best guess before we see data

$$p(\text{parameter}\,|\text{data}) = \frac{p(\text{data}\,|\text{parameter})\,p(\text{param.})}{p(\text{data})}$$

BAYESIAN STATS



BAYESIAN & FREQUENTIST: Practically

- Both are valid statistical methods
- Both make *unverifiable* assumptions
  - Therefore, need to justify *specific* choice of methods
  - Are your assumptions reasonable, given scientific/stat knowledge?
- In simple cases, can define "equivalent" analyses
  - Simple linear model fit with either method will give similar slope est.
- In complex cases, with adequate data, usually consistent results
  - If not, you have a bigger problem than Bayesian or Frequentist: probably not enough data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