Visualizing Uncertainty

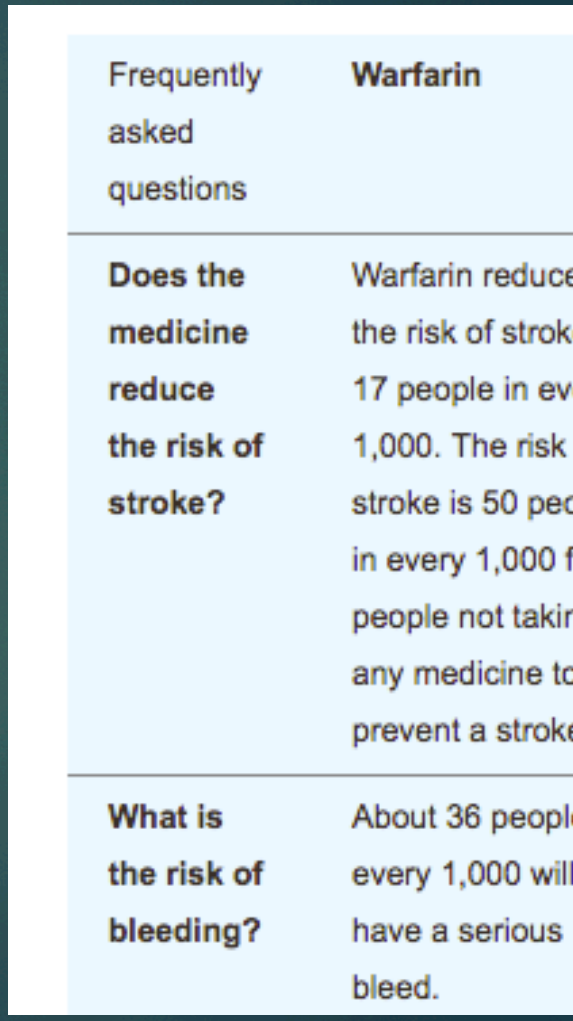
Helping Atrial Fibrillation Patients Understand That Risk Estimates Are Imprecise

JAMES HICKLIN

http://understandinguncertainty.jameshicklin.com
https://github.com/hicklin-james/547_project

Uncertainty in Health Risk Estimates

- Conceptually difficult to understand without visual aids
- Shared decision-making becoming prevalent
  - Patients should be fully informed
  - Only 53% of health decision support tools convey a basic textual representation that there is uncertainty around the risk estimates (Bansback, 2016)



Frequently asked questions	**Warfarin**
Does the medicine reduce the risk of stroke?	Warfarin reduce the risk of strok 17 people in ev 1,000. The risk stroke is 50 pe in every 1,000 f people not takir any medicine to prevent a stroke
What is the risk of bleeding?	About 36 peopl every 1,000 will have a serious bleed.

Why Atrial Fibrillation?

- Treated with warfarin
  - Decreases risk of stroke
  - Possibility of side effects
    - Potentially serious – e.g. internal bleed
  - Diverging data
    - All uncertainty is derived
- Risks & benefits given as point estimates
  - Values are uncertain
  - Averages not always helpful

Project Goals

- Design a tool for developers of decision support tools to compare various methods of visualizing uncertainty
- Allow interaction with the tool such that the parameters of uncertainty can be changed
  - Degree of confidence (95% vs. 99%)
  - Point estimate (mean vs. median)
  - Sampling characteristics (entire sample vs. random sample)
  - Best & worst case scenarios given a sample

Demo

certainty
9%

e
Median

compare

Hemorrhage Risk
Pain Risk

Show another 100 people

Show Best Case Scenario

Show Worst Case Scenario

Reset distributions

isualizing a **random selection of 100 people** from the tion.

Stroke Risk

25 out of 100 people (25%) saved from having a stroke
75 out of 100 people (75%) don't have a stroke

Bleed Risk

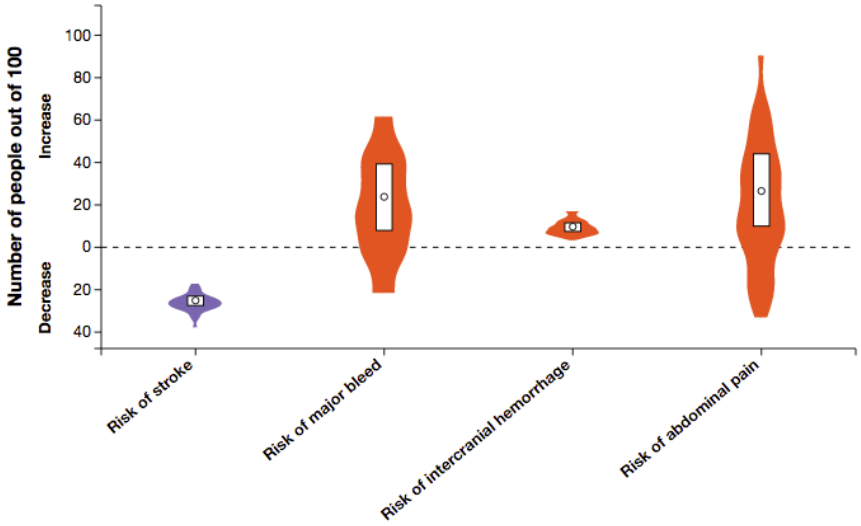
24 out of 100 people (24%) have a major bleed caused by warfarin
76 out of 100 people (76%) don't have a major bleed

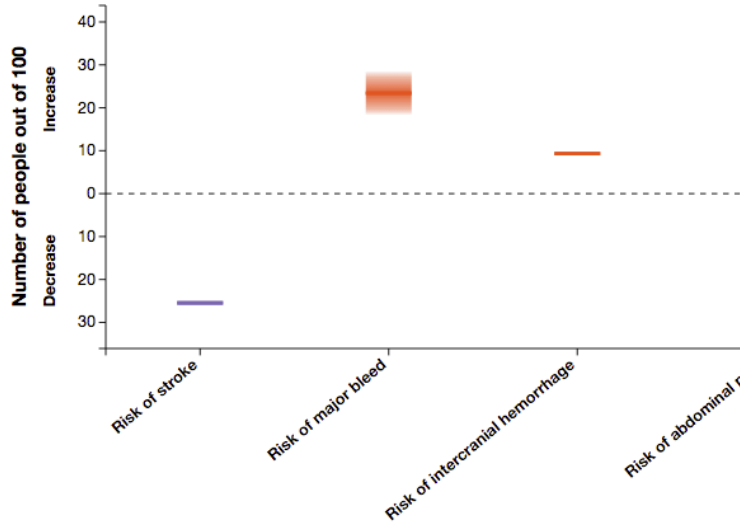
Intercranial Hemorrhage Risk

10 out of 100 people (10%) have an intercranial hemmorhage caused by warfarin
90 out of 100 people (90%) don't have an intercranial hemmorhage

Abdominal Pain Risk

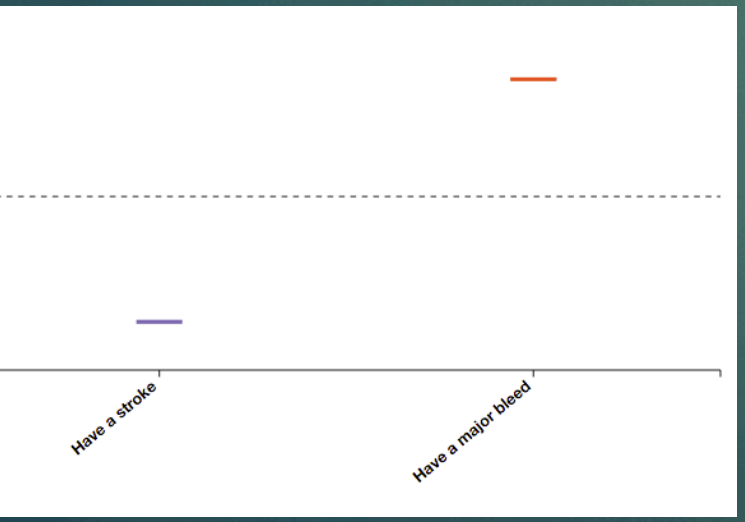
27 out of 100 people (27%) develop abdominal pain from taking warfarin
73 out of 100 people (73%) don't have any abdominal pain





Importance of Interactivity

- Confidence intervals in gradient charts can be misleading
  - Random sample interaction with isotypes allows users to see rough estimates of probability distribution, but still in an easy to understand way, compared to violins



Limitations, Critique and Lessons

- Data is simulated
  - Clinical prediction models can't output enough information
  - May be difficult to get sufficient data for other diseases
  - Hard to generalize because of this
- Focus is on second-order uncertainty
  - Relatively easy to include first-order uncertainty in isotypes by randomly choosing people who are affected – but may make interpretation difficult
- Difficult to build a visualization that satisfies the lay-person
  - Randomized control trials needed to determine "best"

References

- Bansback, Nick, et al. "Communicating Uncertainty in Benefits and Harms: A Review of Patient Decision Support Interventions." *Patient-Centered Outcomes Research*. 2016.

Thank you!

Questions?

Which is best?

- Isotypes (icon arrays) preferred in health
  - But they have no built-in channel to convey uncertainty
- Violin plots good representation of underlying probability distribution
  - But unfamiliar to most people and can be complex
- Gradient plots
  - Better than plain confidence intervals
  - Can be misleading