This is only a draft!

User-friendly software for Bayesian analysis of medical data

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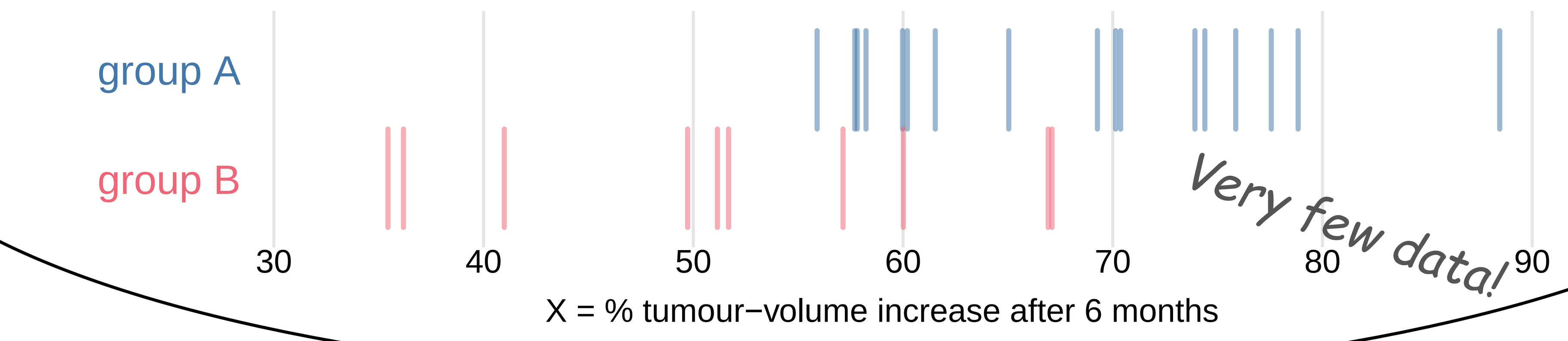
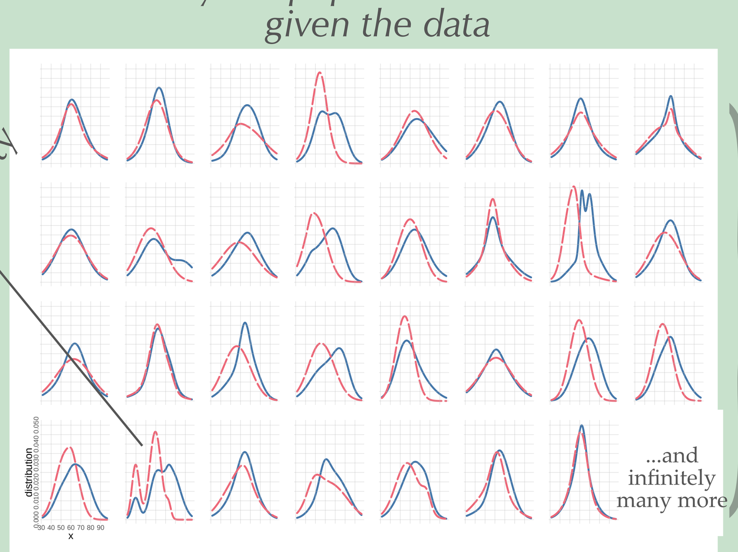
Simple example question:
do treatment A and treatment B
have different effects on tumour increase X?



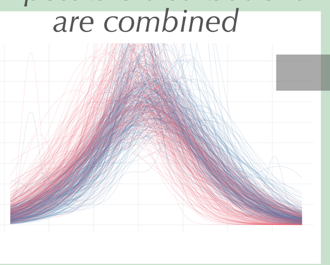
Bayesian theory

Bayesian probability theory considers **all** likely full-population distributions given the data

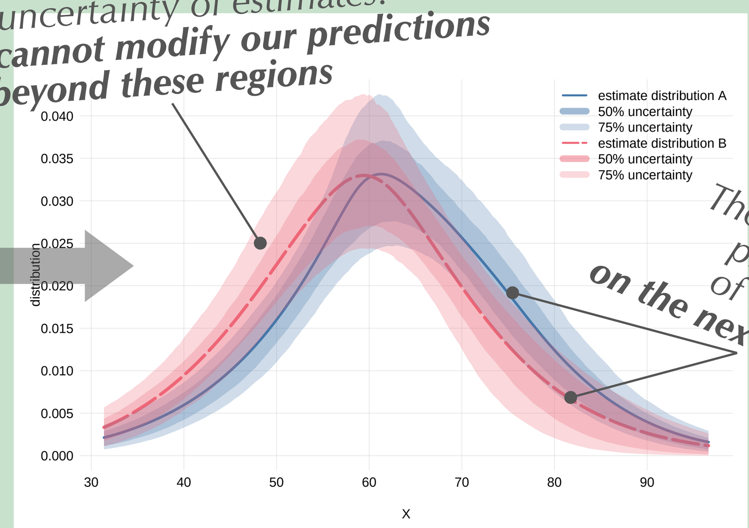
No assumptions of gaussianity



all possible distributions are combined

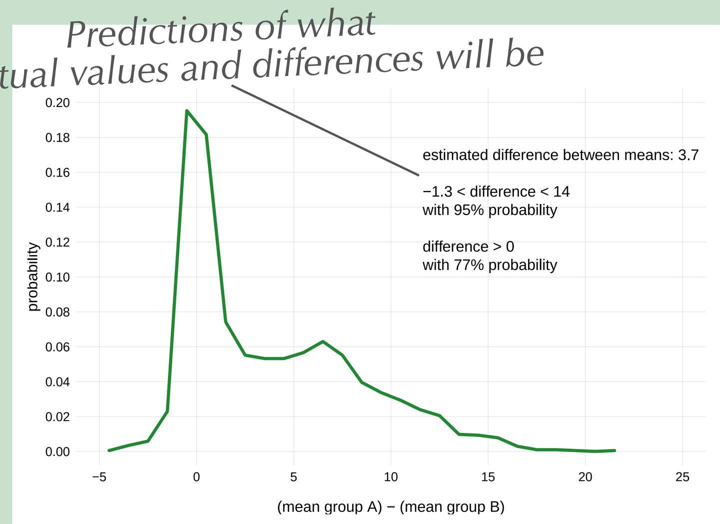


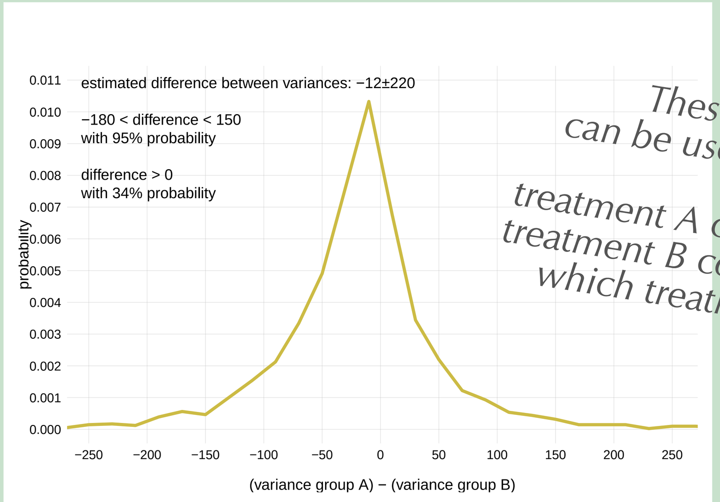
Estimates of full distributions and uncertainty of estimates.
New data cannot modify our predictions beyond these regions



These curves are predictions of the effect ***on the next future patient***

Predictions of what the actual values and differences will be



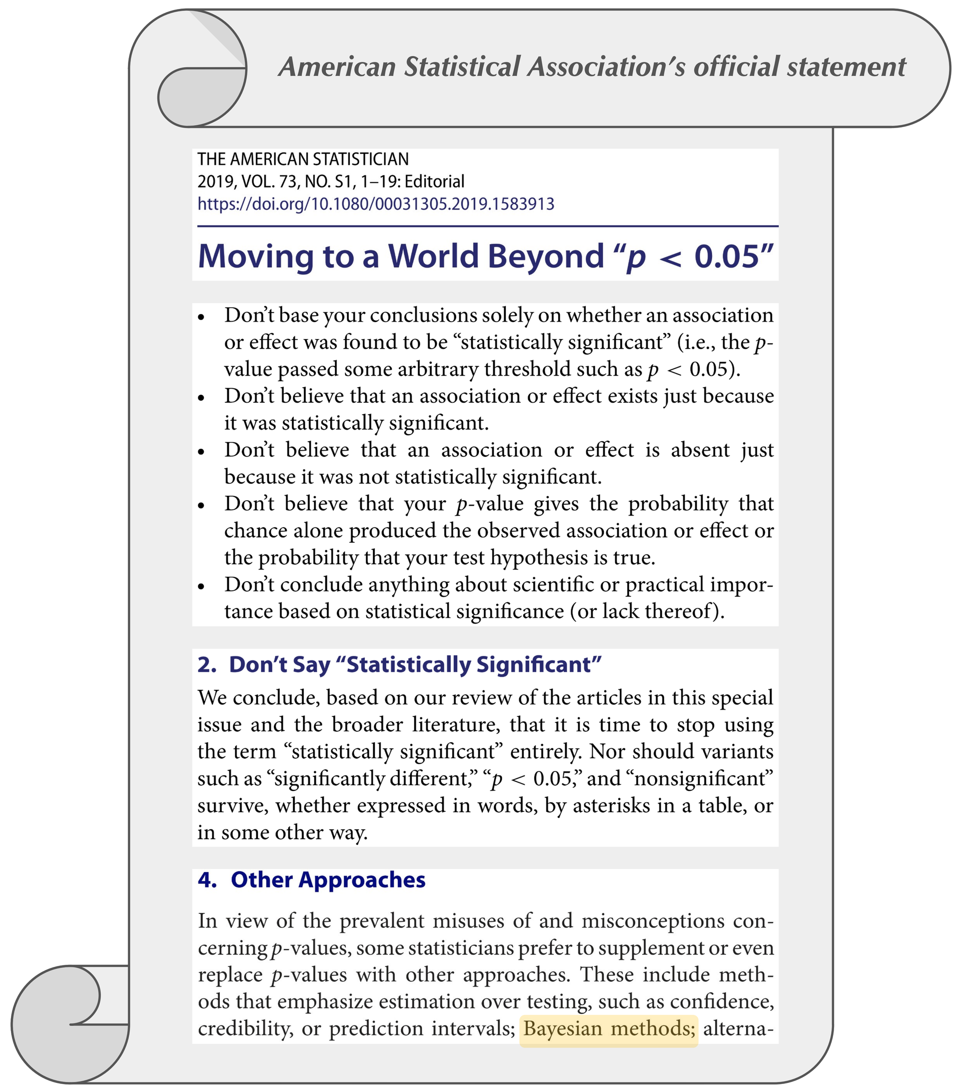


These detailed probabilities can be used in a cost/benefit analysis
("given that:
treatment A costs \$ and gives Y% benefit,
treatment B costs \$\$ and gives Z% benefit,
which treatment should we choose?")

" Assuming that the two full-population distributions are smooth, we predict:

- The distributions of **future treatment outcomes** will be as in the plots, within the uncertainties shown
- Future patients under treatment A will have on average $X=63$, and $59<X<69$ with 95% probability
- Future patients under treatment B will have on average $X=59$, and $52<X<66$ with 95% probability
- The difference between the mean X of the treatments will be within –1.3 and 14 with 95% probability
- Average X under treatment A will be **larger** than under treatment B with 77% probability
- Variance of X under treatment A will be **smaller** than under treatment B with 66% probability "

American Statistical Association's official statement



THE AMERICAN STATISTICIAN
2019, VOL. 73, NO. S1, 1–19: Editorial
https://doi.org/10.1080/00031305.2019.1583913

Moving to a World Beyond "$p < 0.05$"

- Don't base your conclusions solely on whether an association or effect was found to be "statistically significant" (i.e., the p-value passed some arbitrary threshold such as $p < 0.05$).
- Don't believe that an association or effect exists just because it was statistically significant.
- Don't believe that an association or effect is absent just because it was not statistically significant.
- Don't believe that your p-value gives the probability that chance alone produced the observed association or effect or the probability that your test hypothesis is true.
- Don't conclude anything about scientific or practical importance based on statistical significance (or lack thereof).

2. Don't Say "Statistically Significant"

We conclude, based on our review of the articles in this special issue and the broader literature, that it is time to stop using the term "statistically significant" entirely. Nor should variants such as "significantly different," "$p < 0.05$," and "nonsignificant" survive, whether expressed in words, by asterisks in a table, or in some other way.

4. Other Approaches

In view of the prevalent misuses of and misconceptions concerning p-values, some statisticians prefer to supplement or even replace p-values with other approaches. These include methods that emphasize estimation over testing, such as confidence, credibility, or prediction intervals; Bayesian methods; alterna-

old sampling theory

" Assuming that the two full populations:

- are gaussian and independent
- have identical variances (F-test, $p = 0.44$)

It's actually more probable that the variances are different: non-gaussianity leads to an unreliable F-test

The hypothesis that their means are equal has a p-value 0.00043 (two-tail t-test: +4.0).

Does the value "0.00043" have a meaning easy to grasp?

The sample mean difference of X is 17.6
The 95% confidence interval is [8.6, 26.7] "

*This does **not** mean that $8.6 < X < 26.7$ with 95% probability!
It means that this technique to construct the interval contains the true value in 95% of all imaginary datasets.
But we care about the dataset actually observed!*

Compare the two analyses

The predictions of Bayesian analysis are:

- detailed
- quantitative
- easy to understand

(eg, "fraction x% of population will have effect y")

The statements of sampling theory are:

- vague
- obscure or misleading
- heavily dependent on tacit assumptions

This was just a simple example. Bayesian theory deals in the same way with multiple covariates and correlation questions

"Looks great, but there's very little friendly software for doing this!"

True! That's why we are preparing a user-friendly software to do Bayesian analysis on (non-imaging) medical data

The maths will be taken care of under the hood
Works with continuous and categorical variables
- allows predictions about their correlations and relevance
No assumptions of gaussianity or other assumptions typical of sampling theory
No need for corrections of any kind
The software will suggest meaningful questions to be asked (in line with ASA's statement)

We're already using a prototype version for drug-discovery research

Please get in touch if you want to test it and help us making a great sofware!