

Critical Thinking in Endocrine Science: Are You a Bayesian or a Frequentist?

Akbar Soltani. MD.MSc
Tehran University of Medical Sciences
Evidence Based Medicine Research Center
Shariati Hospital
ebm_ct@yahoo.com

What is under the cover?!

Critical Thinking in Endocrine Science: Frequentists or Bayesians?

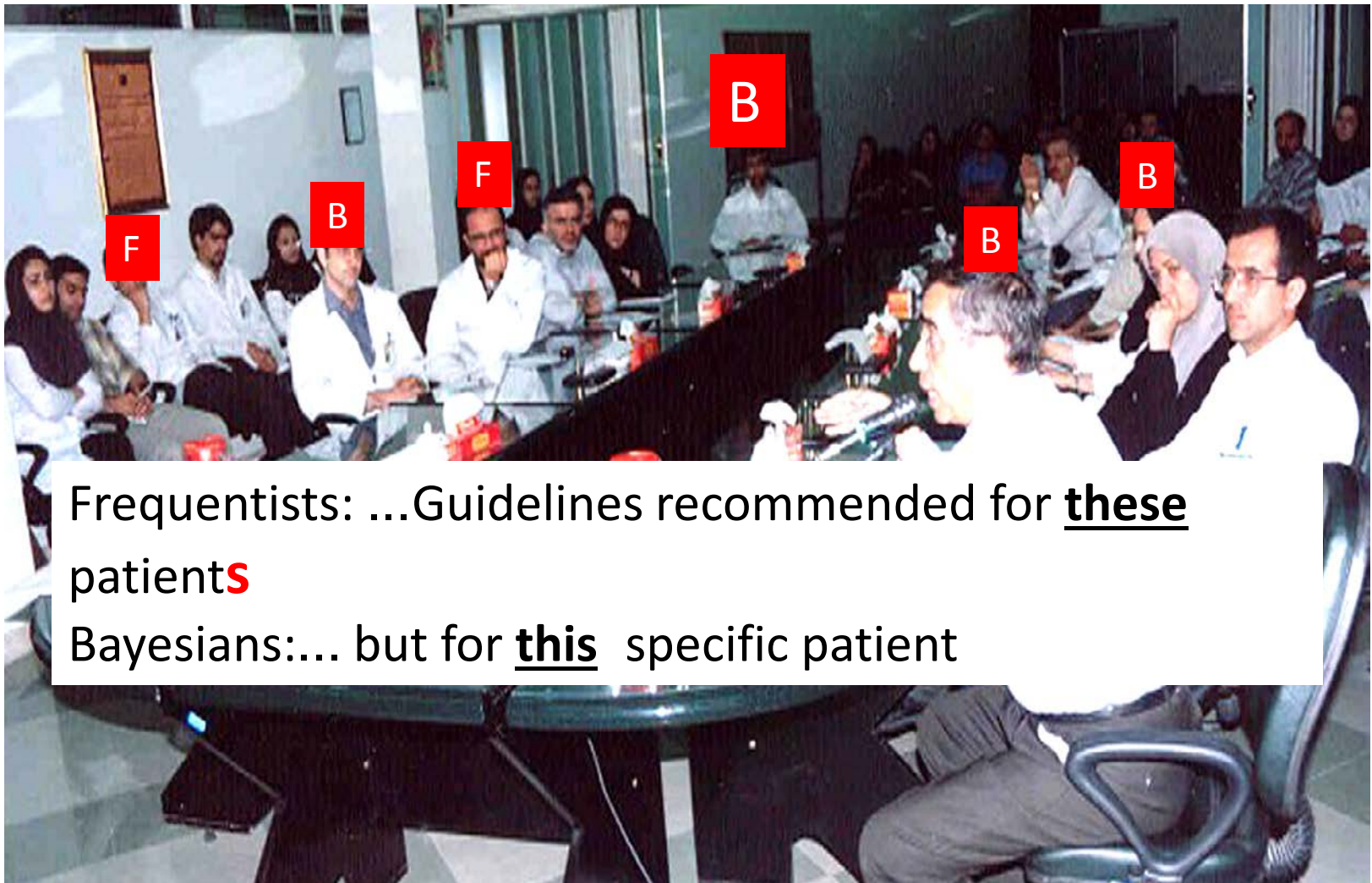
Akbar Soltani. MD.MSc
Tehran University of Medical Sciences
Evidence Based Medicine Research Center
Shariati Hospital
@drakbarsoltani

A statistician
feet in refr

en and his
at on the

average he feels fine!

Why is it important to focus on Bayesian and Frequentist method?



Frequentists: ...Guidelines recommended for these patients

Bayesians:... but for this specific patient

Bayesian method

- Before the launch of the first spacecraft, a critic on television said that there was only a 95 percent chance the spacecraft would return safely from its first voyage.
 - Why isn't it a Frequentist?
-
- A politician once told his friend that the probability of his winning the election was fifty-fifty.
 - Why isn't it a Frequentist?

Frequentist or Bayesians method

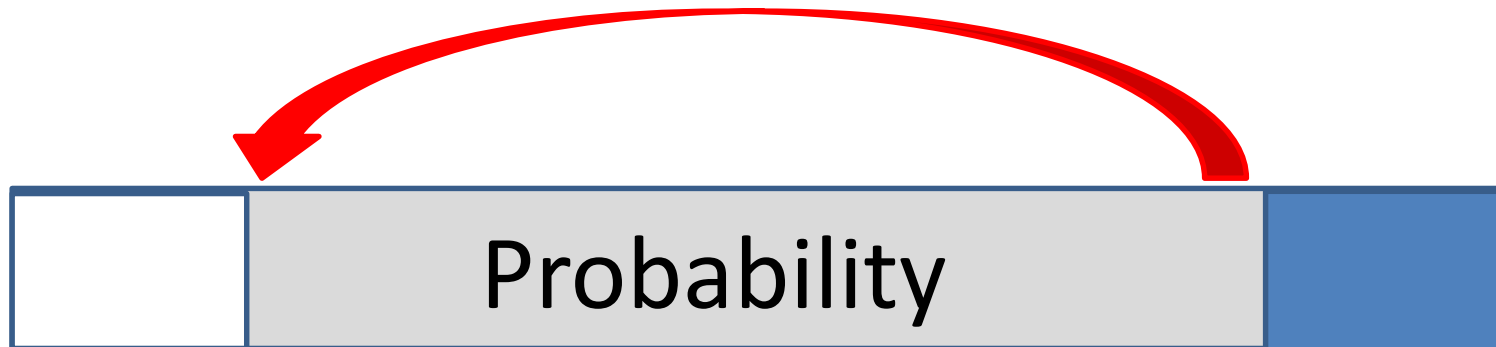
- F: The essence of the frequentist technique is to apply probability to data.
- B: In common language, probability is an estimate of our personal belief in the occurrence of an event or the correctness and truth of a hypothesis.
- B: These probabilities may be expressed in the form of quantitative statements, in which case they resemble frequency probabilities and are read as subjective probabilities.



Conditional probability in Clinical practice

- Thomas Bayes (1702-1761) was a mathematician from England. His famous theorem was published posthumously in 1763, The simple rule has vast ramifications for statistical inference.

$P(A B)$	Sensitivity	$P(A)$
$P(\sim A B)$	1-Specificity	$P(\sim A)$





Philosophy

Modernism: Atomistic-Hard science
Low context

Postmodernism: Holistic-Fuzzy science
High context

Data

Mean/CI 95%/Normal
Uncertainty: Random variability

Outlier/Unique
Uncertainty: + Imperfect knowledge

Clinical Guidelines

Systematic reviews/RCTs
(highest level of evidence)

Expert opinion
(low level of evidence)



Frequentist vs. Bayesian



Proverb in Farsi: *One flower doesn't make a spring*

English version: *One swallow doesn't make a summer*

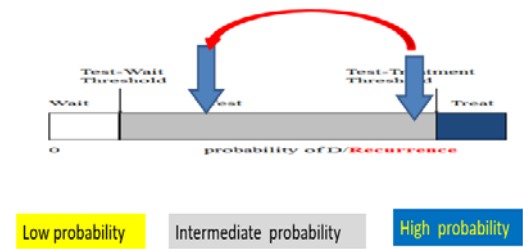
Q: does one flower make spring?

Frequentist

- I don't know but I know the average number of flowers in spring with 95% CI is $X \pm 2SD$!

Bayesian

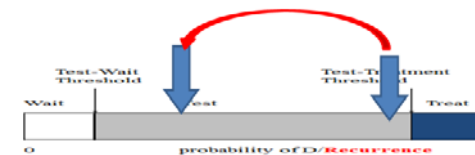
- It depends on the pretest probability of spring!
- Because I see (experience) that almost all of leaves are yellow here (context) so pretest probability of spring is very low and the answer is NO!



definition and
diagnosis



Frequentist vs. Bayesian



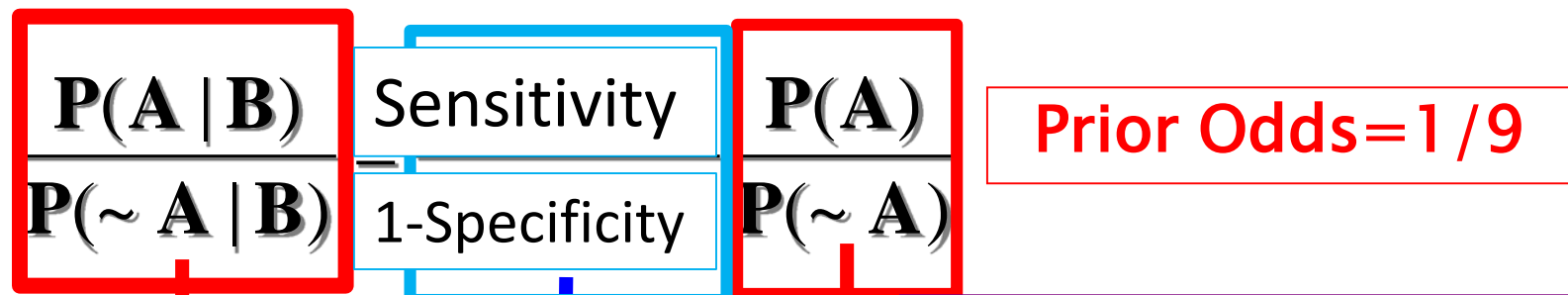
Low probability Intermediate probability High probability

Definition

Frequentist	Bayesian
FBS \geq 126, twice	And Symptoms?
PRL $>$ 40, twice	And Galactorrhea?
T4 = 5 mic/dl is normal	And Hypopituitarism?
UFC $>$ N, twice	And full blown Cushing?

1) Bayesian method provide more natural and useful inferences

- Assuming the probability of Cushing's syndrome is 10% subjectively
- The frequency of **B** (symptom) in Cushing's =80%
- The frequency of **B** (symptom) in population without Cushing's=30%



Prior Odds = 1 / 9

Likelihood Ratio = 80% / 100 - 70% = 2.6

Posterior Odds

Prior Odds

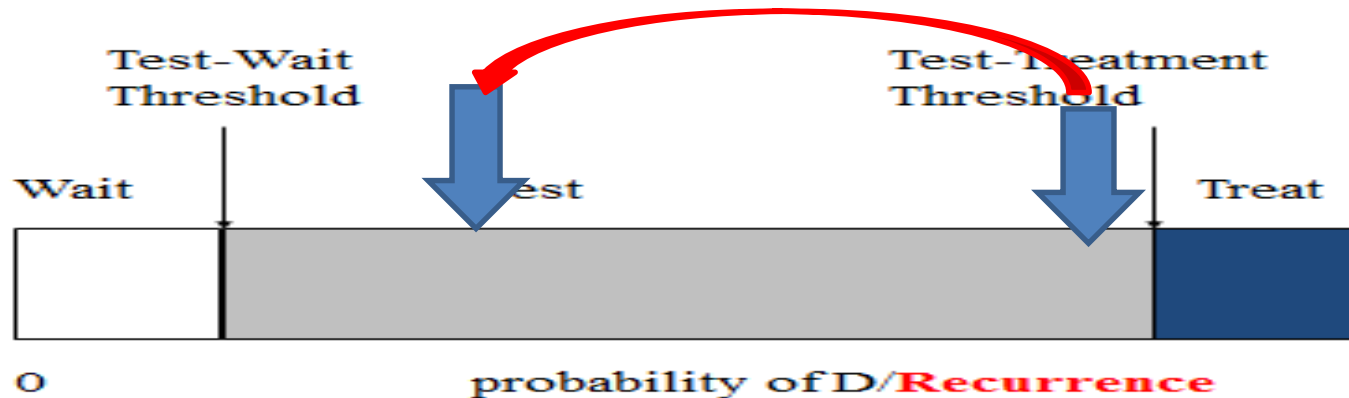
Posterior Odds = 0.3

Likelihood Ratio

Posterior probability = 0.23

2) Bayesian method can make use of more available information and update itself

- The probability of Cushing's syndrome in a middle-aged woman with symptoms including central obesity and easy bruising for the past two years is 80%. If the MRI is negative and $LR=1/9$, what is the probability?

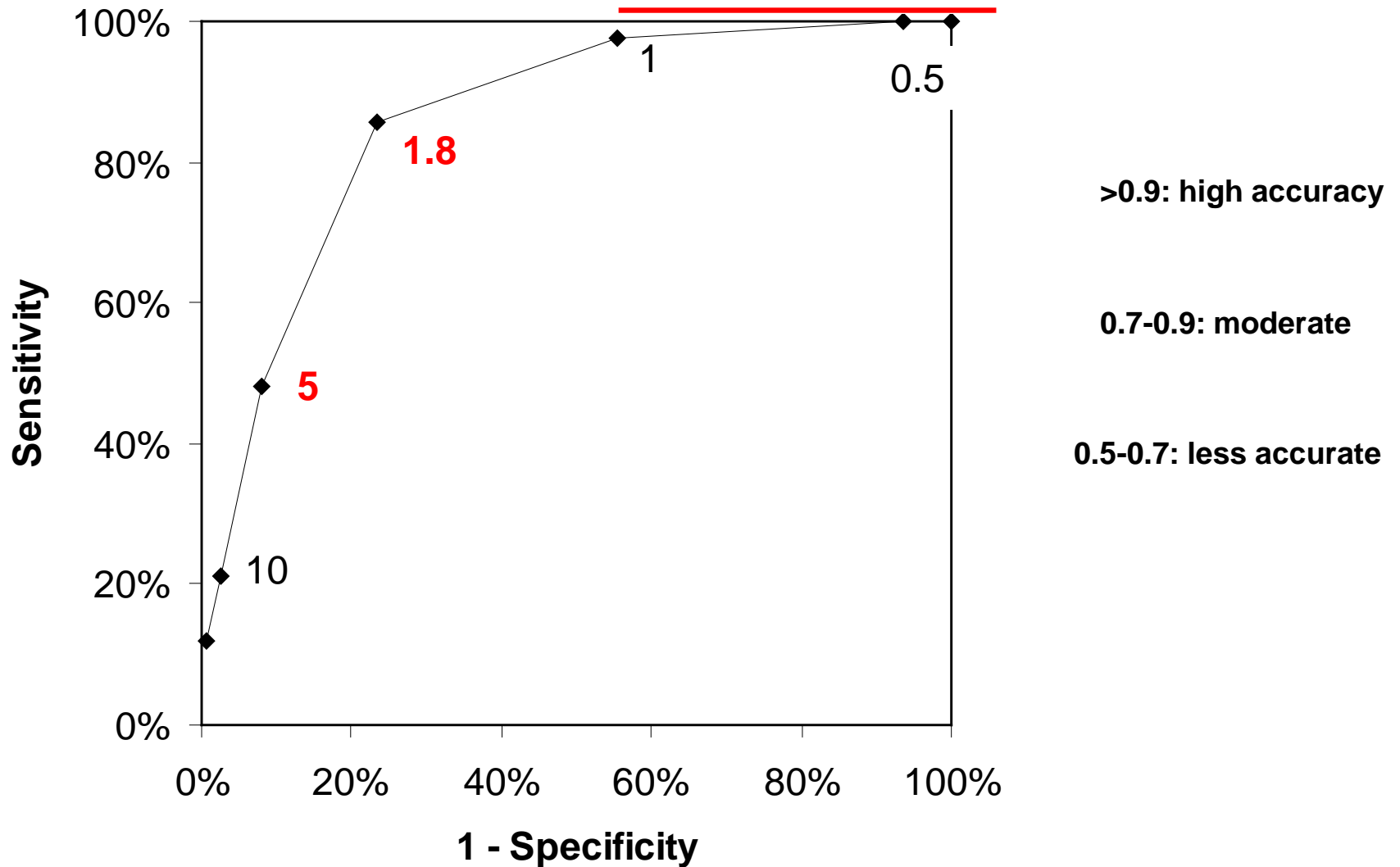


Low probability

Intermediate probability

High probability

Bayesian method can make use of more available information



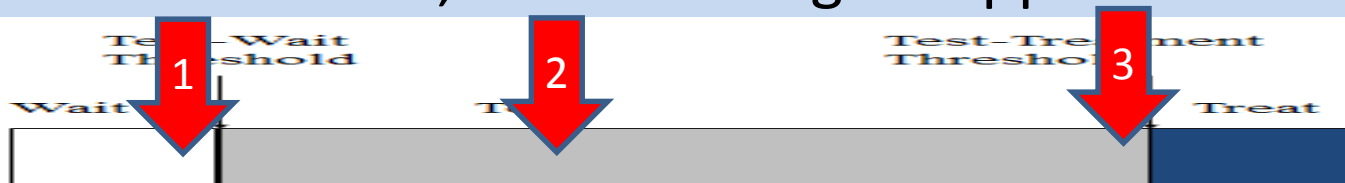
AUC = $P(x)$ for random D+ individual > $P(x)$ for random D- individual

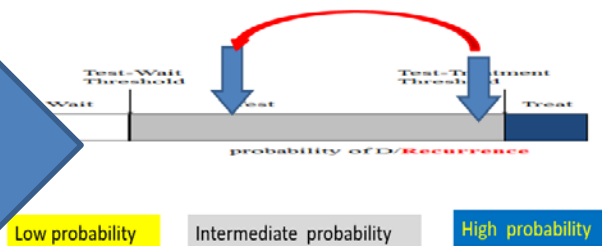
3) Bayesian method can address more complex problems

1) The likelihood of Cushing's syndrome in a middle-aged individual who is asymptomatic and slightly overweight with a history of surgery for an approximately 9mm ACTH producing pituitary adenoma, and overnight suppression test is 4 ?

2) Suppose the probability of Cushing's syndrome in an asymptomatic individual with incidental adrenal mass is about 10%. If the overnight cortisol test is 4, what is the probability?

3) The likelihood of Cushing's syndrome in a middle-aged individual who is asymptomatic and slightly overweight with a history of surgery for a pituitary adenoma invading the cavernous sinus, if the overnight suppression test is 4?

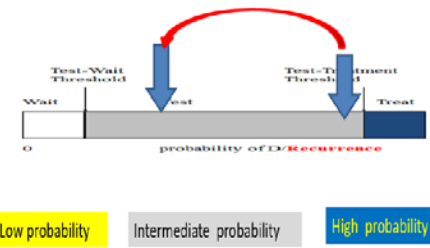




Prognosis and treatment



1) The extra information that Bayesian method utilizes is difficult to specify reliably

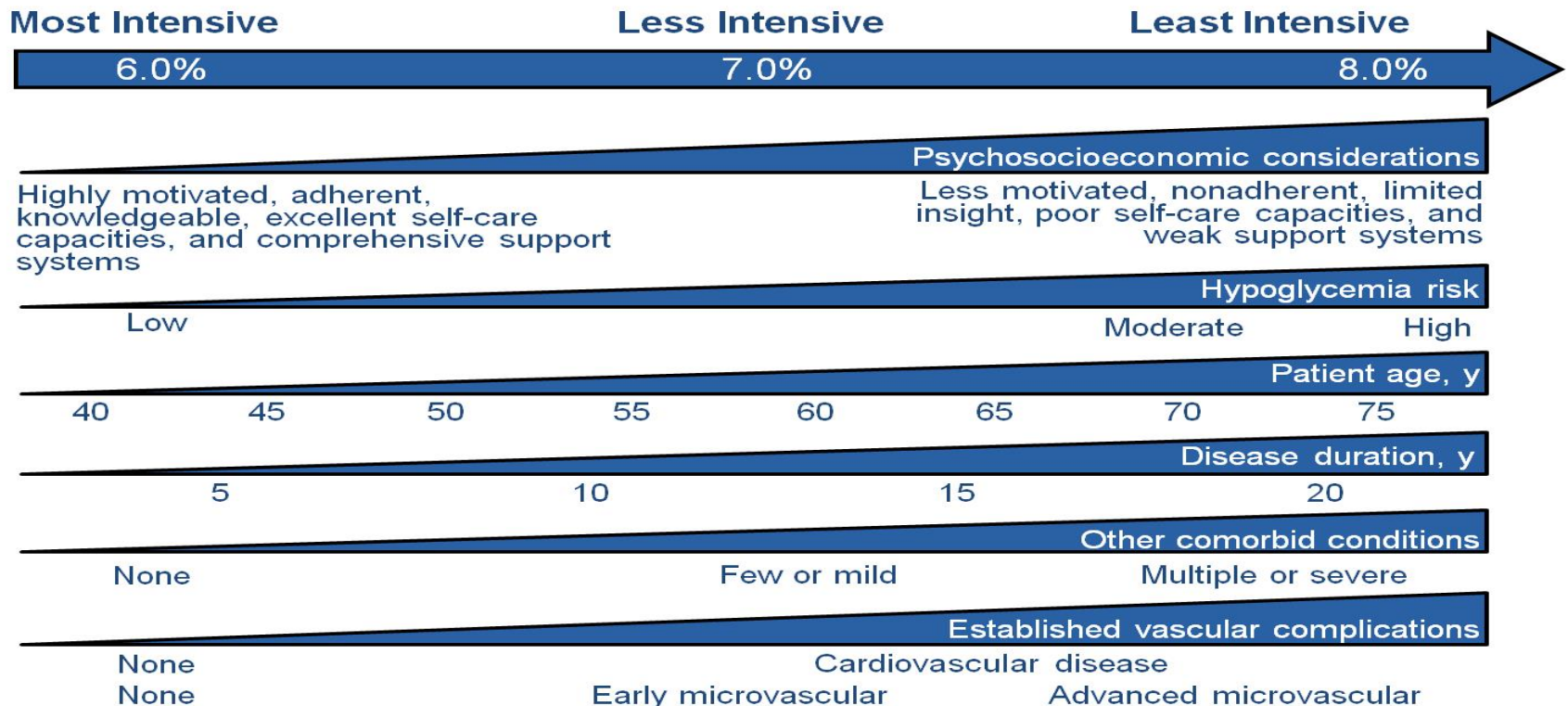


Prognosis

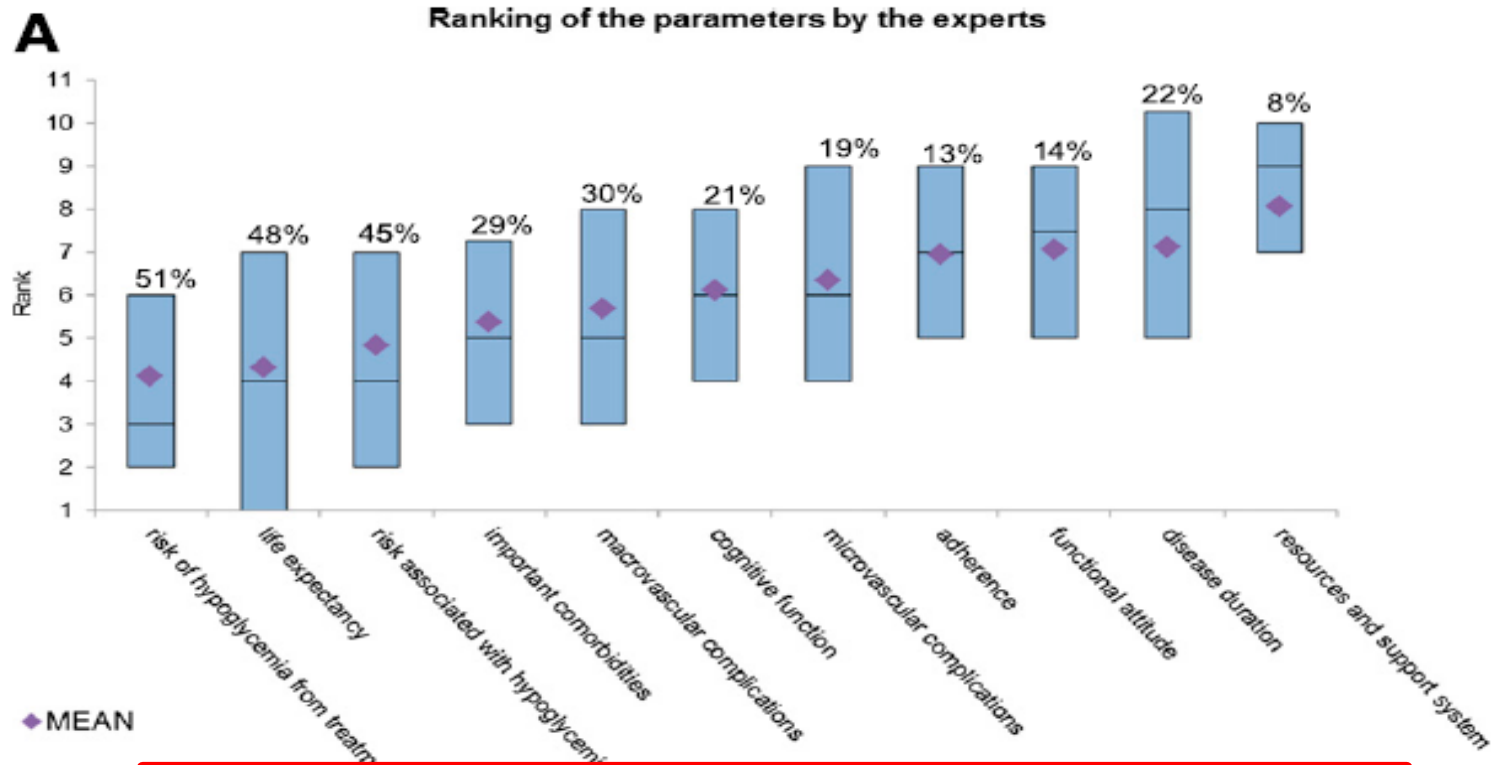
Frequentist	Bayesian
<p>The current Guidelines of the ATA suggest: FDG-PET -CT scan should be considered when serum Tg is >10 ng/ml and the usual iodine-131 scan is negative.</p> <p><i>FDG-PET/ CT:</i> <i>sensitivity=83 %</i> <i>specificity =84 %.</i></p>	<ul style="list-style-type: none"> We have different approach to differentiated vs. <u>undifferentiated</u> cancer Sensitivity depends on severity of disease

2) Bayesian method involve an element of subjectivity

Approach for Individualizing Glycemic Targets



Clinical Assessment of Individualized Glycemic Goals in Patients With Type 2 Diabetes: Formulation of an Algorithm Based on a Survey Among Leading Worldwide Diabetologists

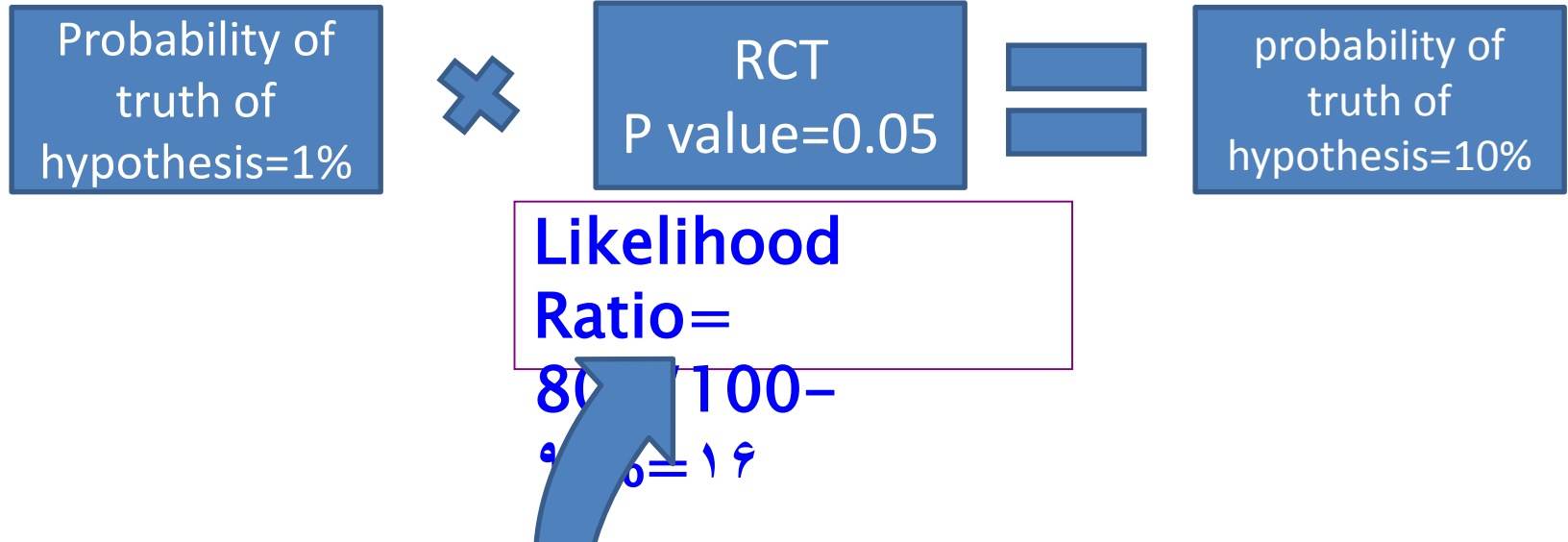


Diabetes Care

۲) Bayesian method involve an element of subjectivity

Bayesian method to RCTs

Treatment



Bayesian and frequentist estimators can be numerically very close, especially when the initial information is vague (uninformative prior) or the data is very huge.

Assumptions:

1. False negative or type two error is 20% so sensitivity is 80%
2. False positive is 5%(=P value) so specificity is 95%

Bayesian methods: Benefits

- Provide more natural and useful inferences
- Can make use of more available information, and update itself
- Can address more complex problems
- Are ideal for problems of decision making, whereas frequentist methods are limited to statistical analyses that inform decisions only indirectly.

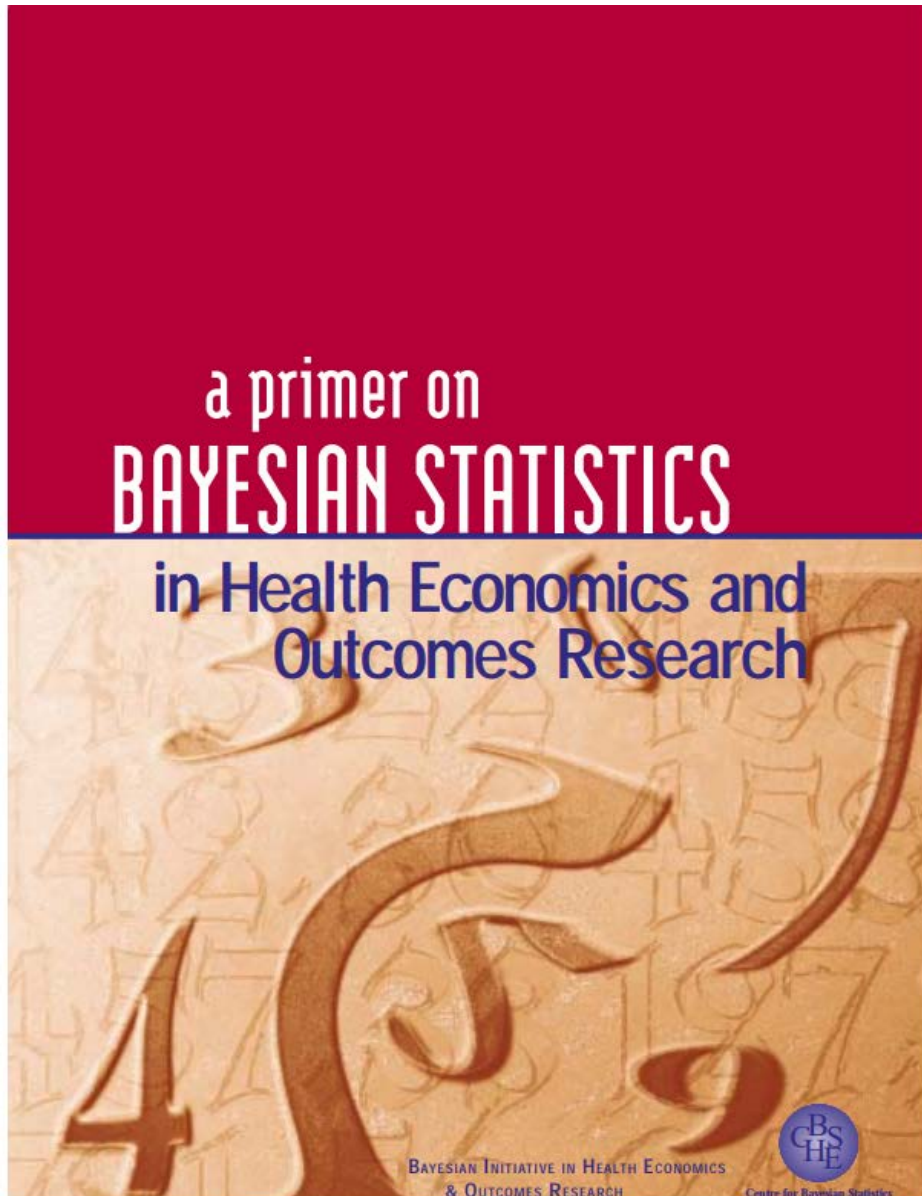
Bayesian methods: Drawbacks

- Involve an element of subjectivity that is not overtly present in frequentist methods.
- In practice, the extra information that Bayesian methods utilize is difficult to specify reliably.
- Are more complex than frequentist methods, and software to implement them is scarce.

Frequentists vs. Bayesians in dialogue!



Suggested sources for busy clinicians

The image shows the cover of a book. The top half has a dark red background with the text 'a primer on BAYESIAN STATISTICS' in white. The bottom half has a light brown background with a pattern of embossed numbers and symbols. The text 'in Health Economics and Outcomes Research' is in blue. At the bottom, there are logos for the Bayesian Initiative in Health Economics & Outcomes Research and the Centre for Bayesian Statistics.

a primer on
BAYESIAN STATISTICS
in Health Economics and
Outcomes Research

- Goodman SN. Introduction to Bayesian methods, I: measuring the strength of evidence. Clin Trial. 2005; 2: 282e90. discussion 301e4, 364e78
- Louis TA. Introduction to Bayesian methods, II: fundamental concepts. Clin Trial. 2005; 2: 291e4. discussion 301e4, 364e78
- Berry DA. Introduction to Bayesian methods, III: use and interpretation of Bayesian tools in design and analysis. Clin Trial. 2005; 2: 295e300. discussion 301e4, 364e78