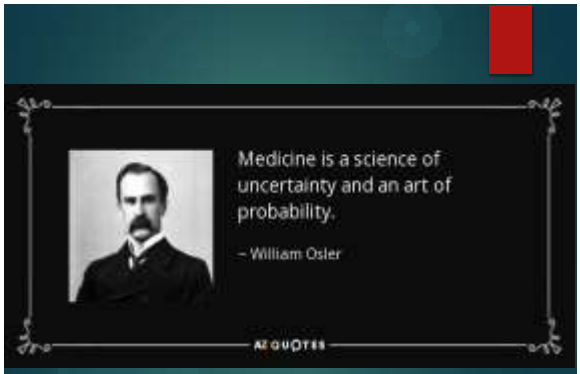
Reducing Diagnostic Error

By Use of Pretest Probabilities

David B. Pitts MD FACP



Diagnostic Error in Medicine Definition:

- *Missed, wrong, or delayed*, as detected by some subsequent definitive test or finding. [1]
- Any *mistake or failure in the diagnostic process* leading to a misdiagnosis, a missed diagnosis, or a delayed diagnosis. [2]
- *Missed opportunities* in diagnosis. [3]

[1] Grader, M. (2005). Diagnostic errors in medicine: a case of neglect. Joint Commission Journal on Quality and Patient Safety / Joint Commission Resources, 31(2). 106-13
[2] Schiff, G.D., et al. (2009). Diagnostic error in medicine: analysis of 583 physician-reported errors. Archives of Internal Medicine, 169(20), 1881-7.
[3] Singh, H. (2014). Editorial: Helping health care organizations to define diagnostic errors as missed opportunities in diagnosis. Joint Commission Journal on Quality and Patient Safety / Joint Commission Resources, 40(3). 99-101.

Incidence of Diagnostic Error

- Body of literature points to an incidence of 10-15% of diagnostic encounters [1].
- Rates may be higher since harm does not invariably occur.
- 40,500 adult patients die annually with ICU misdiagnosis [2].
- 5% of US adults experience diagnostic error annually in outpatient settings [3].

[1]Berner, E.S., & Graber, M.L. (2008). Overconfidence as a cause of diagnostic error in medicine. American Journal of Medicine, 121 (5), S2-S23.
[2]Winters, B. et al. (2012). Diagnostic errors in the intensive care unit: a systematic review of autopsy studies. BMJ Quality & Safety, 21(11), 894-902.
[3]Singh, H., Meyer, A.N.D., & Thomas, E.J. (2014). The frequency of diagnostic errors in outpatient care: estimations from three large observational studies involving US adult populations. BMJ Quality & Safety, 1-5.

Table 1. Most Frequently Missed Diagnoses Among 583 Physician-Reported Cases of Diagnostic Error

Diagnosis	No. (%)
Pulmonary embolism	26 (4.5)
Drug reaction or overdose	26 (4.5)
Lung cancer	23 (3.9)
Colorectal cancer	19 (3.3)
Acute coronary syndrome	18 (3.1)
Breast cancer	18 (3.1)
Stroke, including hemorrhage	15 (2.6)
Congestive heart failure	13 (2.2)
Fracture, various types	13 (2.2)
Abscess, various locations	11 (1.9)
Pneumonia, including type	10 (1.7)
Aortic aneurysm/dissection	9 (1.5)
Appendicitis	9 (1.5)
Depression	9 (1.5)
Diabetes mellitus	8 (1.4)
Tuberculosis	8 (1.4)
Anemia	8 (1.4)
Bacteremia	8 (1.4)
Metastatic cancer	8 (1.4)
Spinal cord compression	8 (1.4)

Schiff GD, et al. Diagnostic error in medicine. Arch Intern Med 2009;169:1881-7

ORIGINAL INVESTIGATION

HEALTH CARE REFORM

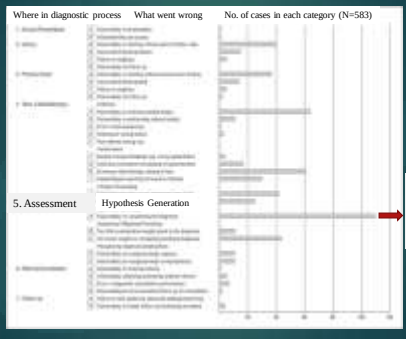
Diagnostic Error in Medicine

Analysis of 583 Physician-Reported Errors

Gordon D. Schiff, MD; Omar Hasan, MD; Seijeong Kim, BS; Richard Abrams, MD; Karen Cosby, MD; Bruce L. Lambert, PhD; Arthur S. Elstein, PhD; Scott Hasler, MD; Martin L. Kabongo, MD; Nela Krosnjar; Richard Odwazny, MD; Mary F. Wisniewski, RN; Robert A. McNutt, MD

Schiff GD, et al. Diagnostic error in medicine. Arch Intern Med 2009;169:1881-7

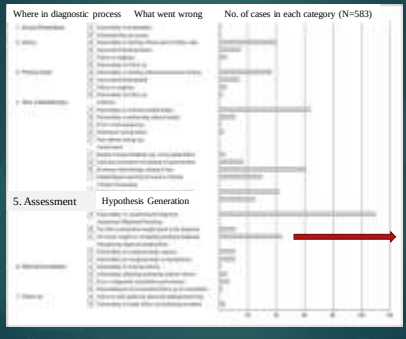
Classification of diagnostic errors in 583 physician-reported cases using *D*iagnostic *E*rror *E*valuation and *R*esearch project tool to localize where in the diagnostic process error occurred.



Failure / delay in considering the diagnosis

Schiff GD, et al. Diagnostic error in medicine. Arch Intern Med 2009;169:1881-7

Classification of diagnostic errors in 583 physician-reported cases using *D*iagnostic *E*rror *E*valuation and *R*esearch project tool to localize where in the diagnostic process error occurred.



Too much weight on competing / coexisting diagnosis

Schiff GD, et al. Diagnostic error in medicine. Arch Intern Med 2009;169:1881-7

Information Overload

T. S. Eliot (1888-1965): The Rock 1934

Where is the Life we have lost in living?

Where is the Wisdom we have lost in knowledge?

Where is the knowledge we have lost in information?

Bad Test Habits

Fear ⟷ Guilt

Conflicted

- We are supposed to be efficient yet thorough
- Throughput now has priority over thoroughness
- Easier to order lots of tests than spend time with patient
- No time to effectively deal with the uncertainties in medicine

Indications for Head CT

- Abnormal neurologic exam.
- Normal neurologic exam.

Before ordering a test ask:

What will you do if the test is positive?

What will you do if the test is negative?

If the answers are the same, then *don't do the test*.

Poster in an Emergency Department

Don't want to miss something

Cannot rule out remote possibility

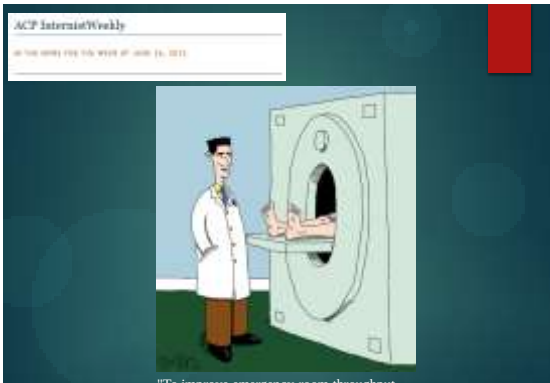
Then we'd know for sure

Do everything you can doctor

Read on the Internet

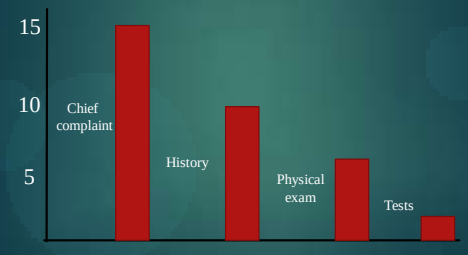
Are you a specialist

My brother in law is a retired psychiatrist in San Francisco



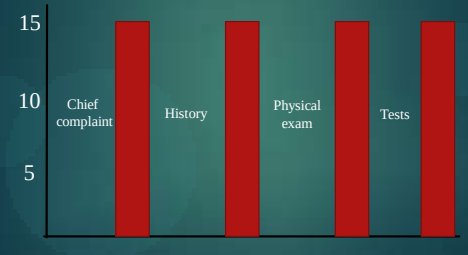
"To improve emergency room throughput we've replaced the front door with a CT scanner."

Number of diagnostic hypotheses remaining during the steps of evaluating a symptom:



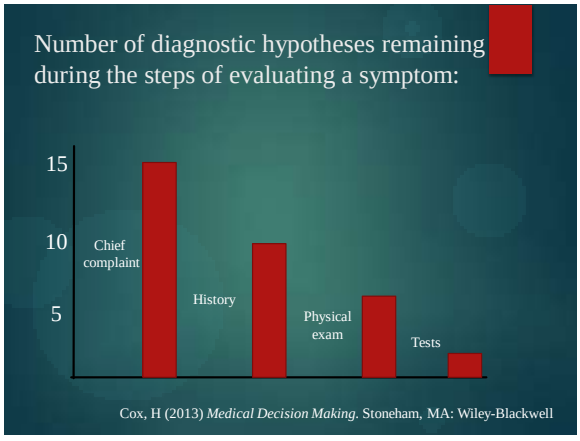
Cox, H (2013) *Medical Decision Making.* Stoneham, MA: Wiley-Blackwell

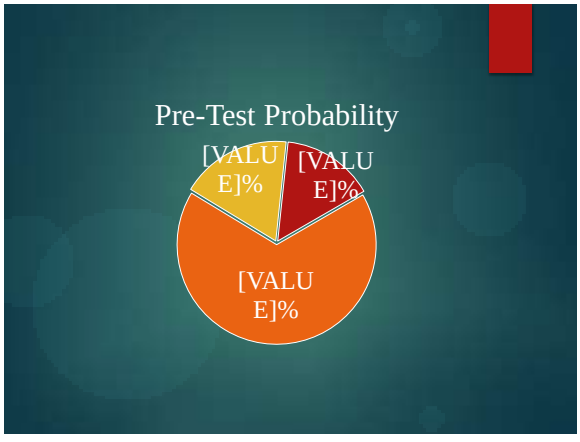
Number of diagnostic hypotheses remaining during the steps of evaluating a symptom:



Cox, H (2013) *Medical Decision Making.* Stoneham, MA: Wiley-Blackwell


APM Perspectives
The Lost Art of Clinical Skills
The American Journal of Medicine, Vol 120, No 4, April 2007


Number of diagnostic hypotheses remaining during the steps of evaluating a symptom:
15
10
5
Chief complaint
History
Physical exam
Tests
Cox, H (2013) *Medical Decision Making.* Stoneham, MA: Wiley-Blackwell


Pre-Test Probability
[VALUE]%
[VALUE]%
[VALUE]%

Pretest Probability

- First impressions
- Should be starting point for all subsequent clinical decisions.
- Should be in mind before physical exam or testing.
- Based on knowledge of disease probability.

Pre-test probability should

- A. Not be based on physician's clinical judgment.
- B. Be the basis for making clinical decisions.
- C. Combine both science and the art of medicine.
- D. Not influence laboratory testing and diagnostic imaging.
- E. Both B. and C.
- F. All the above.

From Where Diagnostic Probabilities?

- Personal experience
  - Judgement
- Published experience
  - Similar patients
  - Prevalence of disease
- Attributes of the patient
  - Adjust probability according to risk factors
- Risk stratification tools and clinical prediction rules

Clinical Prediction Rules

Wells' Score Curb-65 Apache CHADS-VASC

Pretest Probability:

Patient factors

- Is contextual and situational
- Varies by setting and location

Acute illness

Acute on chronic illness

Frequent flyer with well established medical records

Pretest Probability:

Physician factors

- Clinician's experience.
- Knowledge structure.
- Data collection.
- Gestalt.
- Capability as a diagnostician.
- Skill in clinical judgements.
- Flexibility in thinking.


MEDICAL DISPATCHES JANUARY 29, 2007 ISSUE

WHAT'S THE TROUBLE?

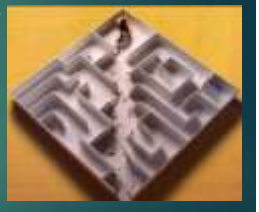
How doctors think.

By Jerome Groopman

Most physicians already have in mind two or three possible diagnoses within minutes of meeting a patient.

Heuristics

- Mental shortcut to an answer.
- A rule of thumb that generally, but not always, can be used to make a judgment to solve a problem.
- Not a guarantee of accuracy.
- Fast, but prone to errors.



Heuristics: Mental Shortcuts to Answers

- *Availability Heuristic (bias)*
  - Dx based upon what is most easily available in the physician's mind.
- *Anchoring Heuristic*
- *Representativeness Heuristic*
  - Application of pattern recognition.

Other Cognitive Bias

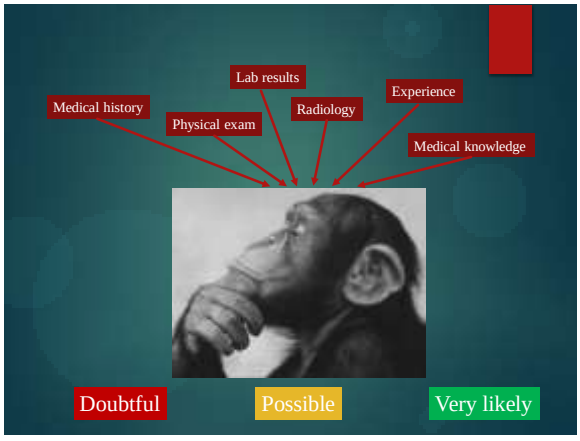
Momentum bias

Premature closure

Confirmation bias

Momentum bias

Overconfidence



When to Estimate Probability

Course of action must be chosen

When to Estimate Probability

0% Test Threshold 100%

Do Nothing

When to Estimate Probability

0% Treat Threshold 100%

Treat patient

SPECIAL ARTICLE

THE THRESHOLD APPROACH TO CLINICAL DECISION MAKING

History (symptoms)
Past studies
Physical (findings)
Family Hx
Physician knowledge and experience

0 .5 1.0

History (symptoms)
Physical (findings)
Family History

0 .5 1.0

When to Estimate Probability

0% Test Threshold Treat Threshold 100%

Not worth to test

More tests needed to make Diagnosis and Treat

Dx complete start treatment

Application of Pretest Probability

- Interpreting the results of a diagnostic test
- Selecting one or more diagnostic tests
- Choosing whether to start therapy:
  * a) without further testing (treatment threshold);
  * b) while awaiting further testing;
- Deciding whether it's worth testing at all (test threshold)

"The interpretation of new information depends on what you believed beforehand."

Harold Sox M.D.

Bayes' Theorem

1702-1761

Post test probability of having a disease is determined by

1) the disease probability before the test and
2) the probability that the test will provide a true result.

Mathematical way to calculate the post test probability of disease from three parameters:

1) Pretest probability
2) Sensitivity (SNOUT)
3) Specificity (SPIN)

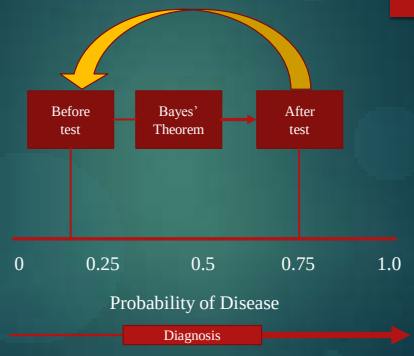
Bayes' Theorem

Basically a mathematical recognition of *context* as an important factor in decision making

Post test probability of having a disease is determined by

1) the *disease probability before the test* and
2) the *probability that the test will provide a true result.*

Bayes' Theorem



Diagnostic Testing: Measures of Accuracy

- Purpose of testing:
  - Reduce uncertainty.
  - Aid in making management decisions.
- Any technology that changes a physician's understanding of a patient's problem qualifies as a diagnostic test.

Diagnostic Accuracy

"Clinicians' judgment and experience are important "tests" in diagnostic evaluations that should not be ignored when evaluating other candidate tests."

J.M. Mrus: Clinical Infectious Disease 2004;38:1391-3

How helpful is the test?

Likelihood ratios are used for assessing the value of performing a diagnostic test.

- LRs are basically a ratio of the probability that a test result is correct to the probability that the test result is incorrect.
- Express how many times more (or less) likely a test result is likely in a patient with vs without the condition.

How likely is the disease present?

$$(LR+) = \frac{\text{Sensitivity}}{(1\text{-Specificity})}$$

$$(LR-) = \frac{(1\text{-Sensitivity})}{\text{Specificity}}$$

Using Likelihood Ratios

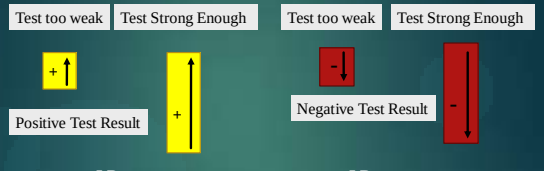
- LHRs are based on a ratio of sensitivity and specificity.
- Do not vary in different settings or populations.
- Independent of disease prevalence.
- Sensitivity and specificity are inherent properties of the test.
- Can be used directly at the individual patient level.
- Allows clinician to quantitate the probability of disease for an individual patient.

Aust Prescr 2003;26:111-3

Likelihood Ratio	Approximate change in disease probability
10	+ 45%
8	+ 40%
6	+ 35%
5	+ 30%
4	+ 25%
3	+ 20%
2	+ 15%
1	No change
0.5	-15%
0.4	-20%
0.3	-25%
0.2	-30%
0.1	-45%

McGee SJ. Gen Internal Med 2002; 17: 646-649

Bayes: Pre x LR = Post

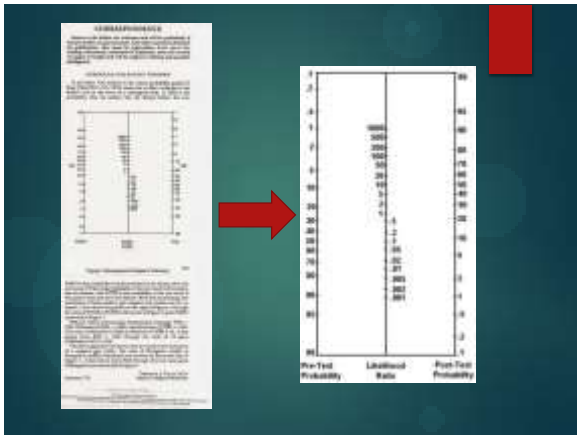


LR +
- Length of "up arrow"
- Odds multiplier
- Always greater than or equal to 1

LR +
- Length of "down arrow"
- Odds multiplier
- Always less than or equal to 1

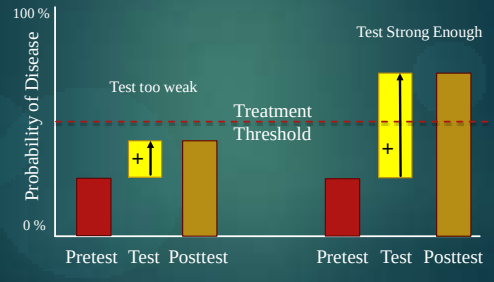
These two numbers, called Likelihood Ratios (LR), completely characterize the test.

Undergraduate Mathematics and Its Applications 32 (4) 2011 279-298



Pretest Probability Below TT

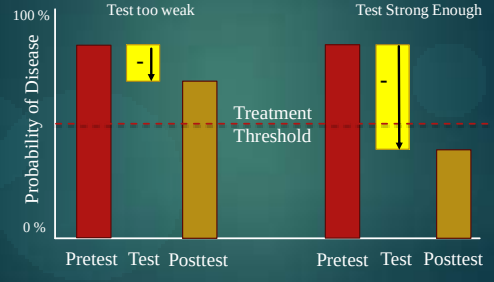
Only a *Positive* Test Result Helps



Undergraduate Mathematics and Its Applications 32 (4) 2011 279-298

Pretest Probability Above TT

Only a ***Negative*** Test Result Helps



Undergraduate Mathematics and Its Applications 32 (4) 2011 279-298

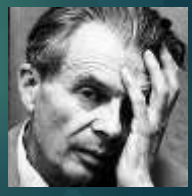
The Role of Education in Diagnostic Error

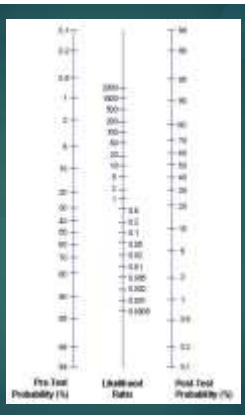
- Cognitive error plays a role in the majority of diagnostic errors, yet
  - Few medical schools or residences have explicit curricula in clinical reasoning
  - Few faculty are equipped to teach about cognitive psychology, informatics and clinical reasoning
  - Few physicians receive feedback on their diagnostic performance.
- In addition to clinical reasoning, reduction in skill development is reported
  - History and physical
  - Test ordering – radiology, laboratory
  - Test result interpretation.

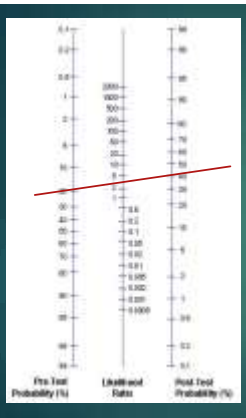
Feddock,C. A.(2007). The lost art of clinical skills. AJM, 120(4), 374-8

"Medical science has made such tremendous progress that there is hardly a healthy human left."

Aldous Huxley (1894-1963)

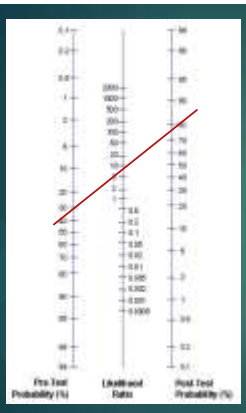






$$LR(+) = \frac{\text{Sensitivity}}{1 - \text{Specificity}}$$

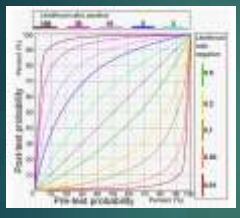
$$LR(-) = \frac{1 - \text{Sensitivity}}{\text{Specificity}}$$



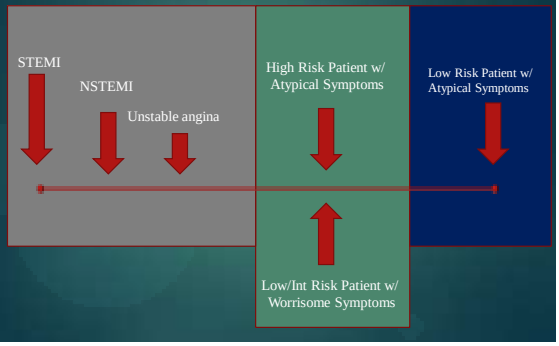
$$LR(+) = \frac{Sensitivity}{1 - Specificity}$$

$$LR(-) = \frac{1 - Sensitivity}{Specificity}$$

Likelihood Ratios



The Chest Pain Spectrum



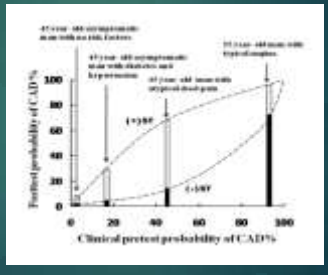
Pretest probability of coronary heart disease (CHD) in patients with chest pain according to age, gender, and symptoms

Age	Nonanginal pain		Atypical angina		Typical angina	
	Men	Women	Men	Women	Men	Women
30 to 39	4	2	34	12	78	28
40 to 49	13	3	51	22	87	55
50 to 59	28	7	65	31	93	73
60 to 69	27	14	72	51	94	88

The probability values are expressed as the percent of patients with significant coronary artery disease on angiography. Combined data from Diamond GA, Forrester JS. N Engl J Med 1979; 300:1350; and from Weiner DA, Ryan TJ, McCabe CH, et al. N Engl J Med 1979; 301:230.

UpToDate

Bayes' Theorem to Calculate the Probability of Coronary Artery Disease



More Origins and Definitions

- Law of conditional probability or *Bayes' Theorem*
  - Original essay published 1763
  - Formal diagnostic application by Ledley & Lusted 1959
- *Sensitivity* and *specificity* first used in describing diagnostic accuracy by Jacob Yerushalmy (1947 biostatistics, Berkley).
- *Likelihood ratios*:
  - Decision rules 1954
  - Medical applications 1975-1980