Reducing Diagnostic Error

By Use of Pretest Probabilities

David B. Pitts MD FACP

Medicine is a science of uncertainty and an art of probability.

– William Osler

The toll of Dx Error

US
40,000 – 80,000
deaths/yr

1 in 20 primary care patients will be involved in a diagnostic error every year; half are potentially preventable

Error-related Harm

1 patient harmed every other day in your clinics or ER

Diagnostic Error

Your Hospital
10 deaths every year
Diagnostic Error in Medicine

Definition:

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


Incidence of Diagnostic Error

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

Classification of diagnostic errors in 583 physician-reported cases using Diagnostic Error Evaluation and Research project tool to localize where in the diagnostic process error occurred.

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.
Don’t want to miss something
Then we’d know for sure
Read on the Internet

Cannot rule out remote possibility
Do everything you can doctor
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:

- Chief complaint: 15
- History: 10
- Physical exam: 5
- Tests: 5

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


Pre-Test Probability

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
Pretest Probability:

Patient factors
- Is contextual and situational
- Varies by setting and location

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

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.
“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

Diagnostic Accuracy

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

Approximate change in disease probability

<table>
<thead>
<tr>
<th>Likelihood Ratio</th>
<th>No change</th>
<th>-15%</th>
<th>-20%</th>
<th>-25%</th>
<th>-30%</th>
<th>-45%</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>+45%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>+40%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>+35%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>+30%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>+25%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>+20%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>+15%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.5</td>
<td>-15%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.4</td>
<td>-20%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.3</td>
<td>-25%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.2</td>
<td>-30%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.1</td>
<td>-45%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

Bayes: Pre x LR = Post

- Test too weak
- Test Strong Enough
- Positive Test Result
- Negative Test Result
- 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

Undergraduate Mathematics and Its Applications 33 (4) 2011 279–298
Pretest Probability Below TT

Only a **Positive** Test Result Helps

- Test too weak
- Treatment Threshold
- Test Strong Enough

<table>
<thead>
<tr>
<th>Pretest</th>
<th>Test</th>
<th>Posttest</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 %</td>
<td>100%</td>
<td>0 %</td>
</tr>
</tbody>
</table>

Pretest Probability Above TT

Only a **Negative** Test Result Helps

- Test too weak
- Treatment Threshold
- Test Strong Enough

<table>
<thead>
<tr>
<th>Pretest</th>
<th>Test</th>
<th>Posttest</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 %</td>
<td>100%</td>
<td>0 %</td>
</tr>
</tbody>
</table>
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.

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

Aldous Huxley (1894-1963)
Likelihood Ratios

STEMI

Low Risk Patient w/ Atypical Symptoms

NSTEMI

Unstable angina

High Risk Patient w/ Atypical Symptoms

Low/Int Risk Patient w/ Worrisome Symptoms

Low Risk Patient w/ Atypical Symptoms
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