Lab Values in Research: an Introduction

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Lab Values in Research: an Introduction

Steven Hatch, MD
Goals

- This is from a *clinical* (ie not primarily *statistical*) research perspective
- Discuss sensitivity and specificity
- Discuss predictive value
- Review Type I & Type II error
- Consider reliability, validity
Case presentation

- 24 yo F presents with fever, cough x 3d (whitish/yellow sputum), dyspnea
- Exam: Temp 39.1, HR 122, BP 106/78, O2 88%
- Crackles diffusely, no dullness
- You order a CBC & chemistries
- WBC 6.8
- Cr 1.2
Chest X-Ray
Question: what to make of the WBC (6.8)?

- *Maybe* it’s “normal” (range ~4-11)?
- *Maybe* it’s low (wouldn’t we expect it to be high)?
- ..or *maybe* it’s high?

- How could it be *high*?!
Well, what if the CXR was like *this*: 

![CXR Image]

*Note: The image is not clearly visible.*
This is a story about a test’s accuracy

- The *sensitivity* of the WBC can be thought of as: “how many pneumonias will be picked up by a high white count?”

- The *specificity* of the WBC can be thought of as: “how many high white counts indicate pneumonia?”

- We normally treat a high white count as fairly sensitive (pneumonias are typically associated with high WBC) but not very specific (lots of things cause high WBC besides pneumonia)
Mathematical expression of sens/spec

- Sensitivity:
  - true positive tests/# of people with disease

- Specificity:
  - true negative tests/# of people who don’t have the disease (this is counter-intuitive!)
<table>
<thead>
<tr>
<th>Predicted condition</th>
<th>True positive</th>
<th>False positive,</th>
<th>False negative,</th>
<th>True negative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Predicted condition negative</td>
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<td>Total population</td>
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<td>Condition positive</td>
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<td>Condition negative</td>
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<tr>
<td>True condition</td>
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</table>
Sensitivity & Specificity are not predictive value

- Predictive value tells you whether the test is *actually telling you what you want to know*
- Meaning: is a positive test *really* positive? Does this mean they *really* have the disease?
- This is not the same thing as sens & spec...
- Because it’s affected by *prevalence*
- Let’s take mammograms as an example
Screening Mammography in US women age 40-50 with (theoretical) 99% Sensitivity & Specificity (21.5 million women in this age range)

• 1% of 21.5 million women = 215,000 **false positives**
• 35,000 cases invasive breast cancer = 360 false negatives (basically, zero)
• Total positive mammograms: 250,000 (215K + 35K)
• Positive predictive value: 35,000 / 250,000
• Equals **14 percent**
Population without disease

Population with disease

False Positive →

Total number of positive tests:

False Positive

True positive
How probability affects predictive value: Urine Culture

- 55 yo F with urgency but no dysuria, hematuria, fever, pelvic or bladder pain
- Urine culture grows 100K *E coli*
- Does this mean she has a UTI?
- The symptoms (or lack thereof) and signs (or lack thereof) affect the *pre-test probability*, which works a bit like how prevalence affects predictive value as well
- Low pre-test prob increases false positives!
Reliability & Validity

- **Reliability** refers to how many times you can *reliably* produce the same (or almost the same) outcomes doing a test the exact same way.

- **Example**: CBC, chemistries, other serum labs.

- Less reliable tests might include chest x-rays (dependent on movement, inhalation, rotation).

- **Validity** refers to whether the test you are using is measuring the thing you want to measure.
Reliability & Validity con’t

- **Validity** refers to whether the test you are using is measuring the thing you want to measure.
- A scale that gives you the same weight each time you step on it is **reliable**.
- A scale that is calibrated accurately is **valid**.

Not my feet or weight!
What a test aims for in terms of reliability and validity
Questions?
Type I & II errors in continuous variables

- Type I error: $\alpha$
- Type II error: $\beta$