Accuracy and Apparent Accuracy in Medical Testing

Content for a Quantitative Reasoning Course

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A Component of QR

- Simple Mathematics in a complex setting

Simple Mathematics: proportional reasoning, likelihood, multiplication, addition, and subtraction

Complex Setting: Medical Screening Tools

Student Activity

- Part 1: (screening tool: ELISA; medical condition: HIV)
  - Definitions: true/false positive/negative, sensitivity, & specificity
  - Using two way tables to categorize results of screening tools
  - Investigate the likelihood (probability) of receiving a false positive or false negative and how this depends on the prevalence of the medical condition in the population

Example:

- ELISA:

  sensitivity = 99.9%

  specificity = 99.9%
- Population 1: Blood Donor Pool (0.1% infected with HIV)

BLOOD DONOR POOL	HIV-positive	HIV-negative	**TOTAL**
ELISA-positive	999 (TP)	999 (FP)	1,998
ELISA-negative	1 (FN)	998,001 (TN)	998,002
TOTAL	1,000	999,000	1,000,000

Prob of false positive = 999/1998 = 50%
Prob of false negative = 1/998002 = 0.0001%

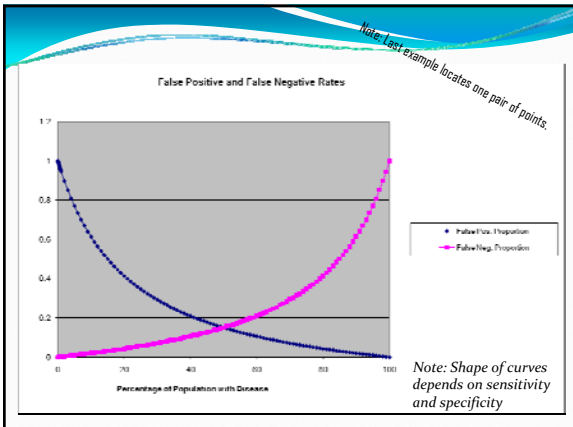
- ELISA:

  sensitivity = 99.9%

  specificity = 99.9%
- Population 2: "At Risk" Pool (10% infected with HIV)

I.V. DRUG USERS	HIV-positive	HIV-negative	**TOTAL**
ELISA-positive	99,900 (TP)	900 (FP)	100,800
ELISA-negative	100 (FN)	899,100 (TN)	899,200
TOTAL	100,000	900,000	1,000,000

Prob of false positive = 900/100800 = 0.89% (compared w/ 50% before)
Prob of false negative = 100/899200 = 0.01% (compared w/ .0001% before)



Note: Shape of curves depends on sensitivity and specificity

Student Activity (cont)

- Part 2: (screening tool: exercise stress test, medical condition: CAD)
  - Investigate the questions
    - "How does one know which positives are false positives?"
    - "Why aren't all patients given a definitive test?"
    - "What happens when only a percentage of patients undergo the definitive test?"
  - Referral rates ➔ notion of referral/verification bias

Sensitivity = 75%, specificity = 85%

	CAD +	CAD -
Stress-Positive	1,875 (TP)	1,125 (FP)
Stress-negative	625 (FN)	6,375 (TN)

Referral rates

32%

3.5%

	CAD +	CAD -
Positive Referrals	600 (TP)	360 (FP)
Negative Referrals	22 (FN)	223 (TN)

Apparent Sensitivity = 600/622 = 96%

Apparent Specificity = 223/583 = 38%

Given the right hand table, fill in the left hand table (i.e. correct for referral bias)

	CAD +	CAD -
Stress-Positive	625 (TP)	141 (FP)
Stress-negative	1,886 (FN)	7,371 (TN)

32%

→

3.5%

	CAD +	CAD -
Positive Referrals	200 (TP)	45 (FP)
Negative Referrals	66 (FN)	258 (TN)

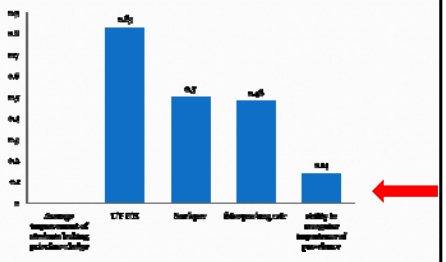
True Sensitivity = 25%
True Specificity = 98%

Apparent Sensitivity = 75%
Apparent Specificity = 85%

Effects of Referral Bias

- When the two referral rates are equal, the true sensitivity and specificity values will equal the apparent values. There is no *referral bias* in this case.
- When the positive referral rate is higher than the negative referral rate, the true sensitivity will be lower than the apparent sensitivity, while the true specificity will be greater than the apparent specificity.
- When the positive referral rate is lower than the negative referral rate these relationships are reversed: true sensitivity higher and true specificity lower.
- Changing the referral rates has no effect on the false positive and false negative rates.

Assessment Results



Student Activity

- Time: 3-4 class days (50 minutes)
- Use: Mixture of class discussion, small group collaboration, and turn in assignment
- Available: www.cwu.edu/~boersmas
  - Student activity
  - Instructor notes/solutions
  - Excel Tool
- Also, see paper in *Numeracy* (http://services.bepress.com/numeracy/)

References

- Danias, P.G. and J. A. Parker. 2002. Novel Internet-based Tool for Correcting Apparent Sensitivity and Specificity of Diagnostic Tests to Adjust for Referral (Verification) Bias. *Radiographics*. 22: e4-e4. http://radiographics.rsnajnls.org/cgi/content/abstract/22/2/e4
- Medical University of South Carolina Doctoring Curriculum (MUSCDC). 2007. Practical examples using sensitivity, specificity, gold (reference) standard, positive predictive value, and negative predictive value. MUSCDC., Medical University of South Carolina Doctoring Curriculum. [http://www.musc.edu/dc/icrebm/sensitivity.html]
- Punglia, R.S, A.V. D'Amico, W.J. Catalona, K.A. Roehl, and K.M. Kuntz. 2003. Effect of verification bias on screening for prostate cancer by measurement of prostate-specific antigen. *The New England Journal of Medicine,* 349 (4): 335-342.

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