Statistics of Diagnostic Tests

Predictive Values

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Introduction

The section on basic principles showed that we can begin to evaluate diagnostic tests by calculating sensitivity and specificity.

However, these are defined in terms of probabilities of test results, given disease status. We don't know this in practice:

Wish to go Test → Diagnosis…

		Coronary Artery Disease Present (D+)	Coronary Artery Disease Absent (D-)	Total
Exercise Tolerance Test	Positive (T+)	815	115	930
	Negative (T-)	208	327	535
Total		1023	442	1465

Main interest may be in Probabilities "other way round"

Positive Predictive Value $P(D+ \mid T+) = 815 / 930 = 0.88$

Negative Predictive Value $P(D- \mid T-) = 327 / 535 = 0.61$

NB PPV and NPV affected by prevalence

Original Table

		Coronary Artery Disease		Total
		Present (D+)	Absent (D-)	
Exercise Tolerance Test	Positive (T+)	815	115	930
	Negative (T-)	208	327	535
	Total	1023	442	1465

Sensitivity = 815/1023 = 0.80
Specificity = 327/442 = 0.74

PPV = 815/930 = 0.88
NPV = 327/535 = 0.61

Table with Prevalence = 0.3

		Coronary Artery Disease		Total
		Present (D+)	Absent (D-)	
Exercise Tolerance Test	Positive (T+)	350	267	617
	Negative (T-)	90	758	848
	Total	440	1025	1465

Sensitivity = 350/440 = 0.80
Specificity = 758/1025 = 0.74

PPV = 350/617 = **0.57**
NPV = 758/848 = **0.89**

Since disease ***less*** prevalent, +ve test less likely to be real disease & -ve test more likely to indicate absence.

Predictive Values

$$PPV = \frac{sens \times prev}{(sens \times prev + (1 - spec)(1 - prev))}$$

$$NPV = \frac{spec \times (1 - prev)}{(spec \times (1 - prev) + (1 - sens) \times prev)}$$

sens - sensitivity; spec - specificity; prev – prevalence

Therefore, PPV and NPV can't be compared between populations – apply only to current population/ prevalence.

Estimating Precision

Sensitivity & specificity are just proportions

Standard methods allow Confidence Intervals to be calculated.

e.g. CAD example above:

Sensitivity = 0.80 (95% CI: 0.77, 0.82)
Specificity = 0.74 (95% CI: 0.70, 0.78)

Similar considerations for predictive values.

Alternative Approach

Assess test by e.g. comparing probabilities of positive test if disease present to those when disease absent…

$$\text{Positive Likelihood Ratio} = \frac{\Pr(T+|D+)}{\Pr(T+|D-)} = \frac{Sensitivity}{1-Specificity}$$

LR gives information on value of test when a + diagnosis.

If Pre-test odds of disease = $\frac{Prevalence}{1-Prevalence}$, then post-test odds (+ result) are

$$\text{Post-test Odds} = \text{LR} \times \text{Pre-test odds}$$

Can also define Negative Likelihood Ratio for T-

Negative Likelihood Ratio $= \frac{\Pr(T-|D+)}{\Pr(T-|D-)} = \frac{1-Sensitivity}{Specificity}$

So can then also evaluate Post-test odds (for a – result), as before

Good tests will tend to have **large Positive LR** (>>1) and **small Negative LR** (<< 1)

Example – Screening for Cervical Cancer

- Carrying out testing in large "healthy" population
- Disease is (relatively) rare (i.e. low prevalence)
- Initially, want high sensitivity & NPV – mainly wish to avoid false negatives
- False positives can be identified at 2^{nd} stage – high specificity & PPV test