10.3 - Sensitivity, Specificity, Positive Predictive Value, and Negative Predictive Value

In this example, two columns indicate the actual condition of the subjects, diseased or non-diseased. The rows indicate the results of the test, positive or negative.

Cell A contains true positives, subjects with the disease and positive test results. Cell D subjects do not have the disease and the test agrees.

A good test will have minimal numbers in cells B and C. Cell B identifies individuals without disease but for whom the test indicates 'disease'. These are false positives. Cell C has the false negatives.

Truth

Test Result	Disease (number)	Non Disease (number)	Total (number)
Positive (number)	A (True Positive)	B (False Positive)	$T_{Test\ Positive}$
Negative (number)	C (False Negative)	D (True Negative)	$T_{Test\ Negative}$
	$T_{Disease}$	$T_{Non\ Disease}$	Total

If these results are from a population-based study, prevalence can be calculated as follows:

- **Prevalence of Disease= $T_{disease}$/ Total × 100**

The population used for the study influences the prevalence calculation.

Sensitivity is the probability that a test will indicate 'disease' among those with the disease:

- **Sensitivity: A/(A+C) × 100**

Specificity is the fraction of those without disease who will have a negative test result:

- **Specificity: D/(D+B) × 100**

Sensitivity and specificity are *characteristics of the test*. The population does not affect the results.

A clinician and a patient have a different question: what is the chance that a person with a positive test truly has the disease? If the subject is in the first row in the table above, what is the probability of being in cell A as compared to cell B? A clinician calculates across the row as follows:

- **Positive Predictive Value: A/(A+B) × 100**
- **Negative Predictive Value: D/(D+C) × 100**

Positive and negative predictive values are influenced by the prevalence of disease in the population that is being tested. If we test in a high prevalence setting, it is more likely that persons who test positive truly have disease than if the test is performed in a population with low prevalence..

Let's see how this works out with some numbers...

Hypothetical Example 1 - Screening Test A

100 people are tested for disease. 15 people have the disease; 85 people are not diseased. So, prevalence is 15%:

- Prevalence of Disease:
  $T_{disease}$/ Total × 100,
  15/100 × 100 = 15%

Sensitivity is two-thirds, so the test is able to detect two-thirds of the people with disease. The test misses one-third of the people who have disease.

- Sensitivity:
  A/(A + C) × 100
  10/15 × 100 = 67%

Truth

Test Result	Disease (number)	Non Disease (number)	Total (number)
Positive (number)	10 A (True Positive)	40 B (False Positive)	50 $T_{Test Positive}$
Negative (number)	5 C (False Negative)	45 D (True Negative)	50 $T_{Test Negative}$
	15 $T_{Disease}$	85 $T_{Non Disease}$	100 Total

The test has 53% specificity. In other words, 45 persons out of 85 persons with negative results are truly negative and 40 individuals test positive for a disease which they do not have.

- Specificity:
  D/(D + B) × 100
  45/85 × 100 = 53%

The sensivity and specificity are characteristics of this test. For a clinician, however, the important fact is among the people who test positive, only 20% actually have the disease.

- Positive Predictive Value:
  A/(A + B) × 100
  10/50 × 100 = 20%

For those that test negative, 90% do not have the disease.

- Negative Predictive Value:
  D/(D + C) × 100
  45/50 × 100 = 90%

Now, let's change the prevalence..

Hypothetical Example 2 - Increased Prevalence, Same Test

This time we use the same test, but in a different population, a disease prevalence of 30%.

- Prevalence of Disease:
  $T_{disease}$/ Total × 10
  30/100 × 100 = 30%

We maintain the same sensitivity and specificity because these are characteristic of this test.

- Sensitivity:
  A/(A + C) × 100

20/30 × 100 = 67%

- Specificity:
  D/(D + B) × 100
  37/70 × 100 = 53%

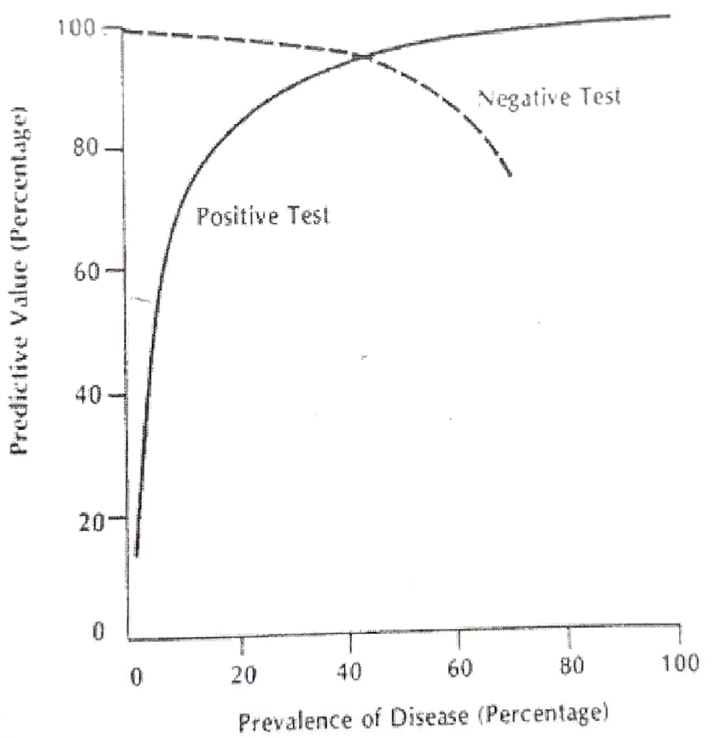
Now let's calculate the predictive values:

- Positive Predictive Value:
  A/(A + B) × 100
  20/53 × 100 = 38%

- Negative Predictive Value:
  D/(D + C) × 100
  37/47 × 100 = 79%

Test Result	Truth: Disease (number)	Truth: Non Disease (number)	Total (number)
Positive (number)	20 A (True Positive)	33 B (False Positive)	53 $T_{Test\ Positive}$
Negative (number)	10 C (False Negative)	37 D (True Negative)	47 $T_{Test\ Negative}$
	30 $T_{Disease}$	70 $T_{Non\ Disease}$	100 Total

Using the same test in a population with higher prevalence increases positive predictive value. Conversely, increased prevalence results in decreased negative predictive value. *When considering predictive values of diagnostic or screening tests, recognize the influence of the prevalence of disease.* The figure below depicts the relationship between disease prevalence and predictive value in a test with 95% sensitivity and 95% specificity:



Relationship between disease prevalence and predictive value in a test with 95% sensitivity and 85% specificity. (From Mausner JS, Kramer S: Mausner and Bahn Epidemiology: An Introductory Text. Philadelphia, WB Saunders, 1985, p. 221.)

Think About It!

Come up with an answer to this question and then click on the icon to the left to reveal the answer.

Under what circumstance would you really want to minimize the false positives?