In order to arrive at a diagnosis, one must consider a myriad of information, often in the form of the history (which describes the symptoms the patient is experiencing) and a clinical examination (which elicits the signs related to the disease process). This usually provides a sensible list of differential diagnoses, which can be confirmed or reputed with the use of diagnostic testing. This may be in the form of a blood sampling, radiological imaging, urine testing and more.

Here is the crux; tests are never 100% accurate. We must consider the statistics around testing to determine what makes a good test and what makes a not-so-good test.

Consider the following example:

A company creates a blood test for Disease X.

	Has Disease X	**Doesn't have Disease X**
Blood test POSITIVE	True Positives (TP)	False Positives (FP)
Blood test NEGATIVE	False Negatives (FN)	True Negatives (TN)

Now let's look at the same table, inserting some values to work with.

	Has Disease X	Doesn't have Disease X
Blood test POSITIVE	134	7
Blood test NEGATIVE	11	245

Sensitivity

Sensitivity is the proportion of people WITH Disease X that have a POSITIVE blood test. A test that is 100% sensitive means all diseased individuals are correctly identified as diseased i.e. there are no false negatives. Importantly, as the calculation involves all patients with the disease, it is not affected by the prevalence of the disease.

"If I have Disease X, what is the likelihood I will test positive for it?"

Mathematically, this is expressed as:

Sensitivity = True Positives / (True Positives + False Negatives)

= TP / (TP + FN)
= 134 / (134 + 11)
= 134 / 145
= 0.924 x 100
Sensitivity = 92.4%

In other words, the company's blood test identified 92.4% of those WITH Disease X.

A sensitive test is used for excluding a disease, as it rarely misclassifies those WITH a disease as being healthy. An example of a highly sensitive test is D-dimer (measured using a blood test). In patients with a low pre-test probability, a negative D-dimer test can accurately exclude a thrombus (blood clot).

Specificity

Specificity is the proportion of people WITHOUT Disease X that have a NEGATIVE blood test. A test that is 100% specific means all healthy individuals are correctly identified as healthy, i.e. there are no false positives.

"If I do not have disease X, what is the likelihood I will test negative for it?"

Mathematically, this is expressed as:

Specificity = True Negatives / (True Negatives + False Positives)

= TN / (TN + FP)
= 245 / (245 + 7)
= 245 / 252
= 0.972 x 100
Specificity = 97.2%

In other words, the company's blood test identified 97.2% of those WITHOUT Disease X.

A specific test is used for ruling in a disease, as it rarely misclassifies those WITHOUT a disease as being sick. A perfectly specific test therefore means no healthy individuals are identified as diseased.

Additional measures

We can take this a step further. The predictive value of tests can be calculated with similar statistical concepts. For the sake of simplicity, we will continue to use the example above regarding a blood test for Disease X.

Positive Predictive Value

Positive Predictive Value (PPV) is the proportion of those with a POSITIVE blood test that have Disease X.

"If I have a positive test, what is the likelihood I have disease X?"

PPV = True Positives / (True Positives + False Positives)

= TP / (TP + FP)
= 134 / (134 + 7)
= 134 / 141
= 0.950 x 100
PPV = 95%

In other words, the blood test identified 95% of those with a POSITIVE blood test, as having Disease X.

As the calculation for PPV and NPV includes individuals with and without the disease, it is affected by the prevalence of the disease in question. Therefore you must ensure that the same population is used (or the incidence of the disease is the same between the populations) when comparing PPV and NPV for different tests.

Negative Predictive Value

Negative Predictive Value (NPV) is the proportion of those with a NEGATIVE blood test that do not have Disease X.

“If I have a negative test, what is the likelihood I do not have Disease X”

NPV = True Negatives / (True Negatives + False Negatives)

= TN / (TN + FN)
= 245 / (245 + 11)
= 245 / 256
= 0.957
NPV = 95.7%

In other words, the blood test identified 95.7% of those with a NEGATIVE blood test, as not having Disease X.

Note

The example used in this article depicts a fictitious test with a very high sensitivity, specificity, positive and negative predictive values. In real scenarios, it is often challenging to create a test with maximal precision in all four areas and often improvements in one area are subject to sacrificing accuracy in other areas.