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EDUCATIONAL

Part 1: Simple Definition and Calculation of Accuracy, Sensitivity and Specificity

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Introduction:

Emergency physicians, like other specialists, are faced with different patients and various situations every day. They have to use ancillary diagnostic tools like laboratory tests and imaging studies to be able to manage them (1-8). In most cases, numerous tests are available. Tests with the least error and the most accuracy are more desirable. The power of a test to separate patients from healthy people determines its accuracy and diagnostic value (9). Therefore, a test with 100% accuracy should be the first choice. This does not happen in reality as the accuracy of a test varies for different diseases and in different situations. For example, the value of D-dimer for diagnosing pulmonary embolism varies based on pre-test probability. It shows high accuracy in low risk patient and low accuracy in high risk ones. The characteristics of a test that reflects the aforementioned abilities are accuracy, sensitivity, specificity, positive and negative predictive values and positive and negative likelihood ratios (9-11). In this educational review, we will simply define and calculate the accuracy, sensitivity, and specificity of a hypothetical test.

Definitions:

Patient: positive for disease

Healthy: negative for disease

True positive (TP) = the number of cases correctly identified as patient

False positive (FP) = the number of cases incorrectly identified as patient

True negative (TN) = the number of cases correctly identified as healthy

False negative (FN) = the number of cases incorrectly identified as healthy

Accuracy: The accuracy of a test is its ability to differentiate the patient and healthy cases correctly. To estimate the accuracy of a test, we should calculate the proportion of true positive and true negative in all evaluated cases. Mathematically, this can be stated as:

$$\text{Accuracy} = \frac{TP + TN}{TP + TN + FP + FN}$$

Sensitivity: The sensitivity of a test is its ability to determine the patient cases correctly. To estimate it, we should calculate the proportion of true positive in patient cases. Mathematically, this can be stated as:

$$\text{Sensitivity} = \frac{TP}{TP + FN}$$

Specificity: The specificity of a test is its ability to determine the healthy cases correctly. To estimate it, we should calculate the proportion of true negative in healthy cases. Mathematically, this can be stated as:

$$\text{Specificity} = \frac{TN}{TN + FP}$$

Examples:

Scenario 1

Imagine we have a sample of 100 cases, 50 healthy and the others patient. If a test can be positive for all patients and be negative for all the healthy ones, it is 100% accurate. In figure 1, arrow shows the test and it has been able to differentiate the healthy and patient exactly. In this example, the sensitivity of the test is 50 divided by 50 or 100% and its specificity in determining the healthy people is 50 divided by 50 or 100%.

Taking into account the mentioned statistical characteristics, this test is appropriate for both screening and final verification of a disease.

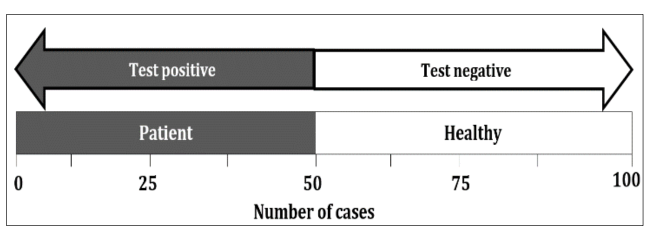

Figure 1: A schematic presentation of an example test with 100% accuracy, sensitivity, and specificity.

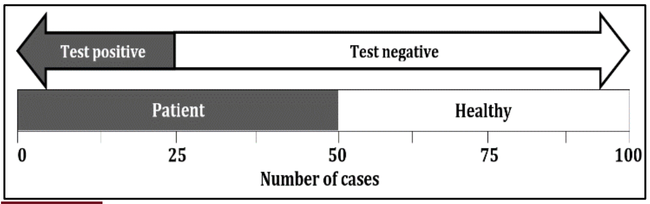

Figure 2: A schematic presentation of an example test with 75% accuracy, 50% sensitivity, and 100% specificity.

Scenario 2

If the test can only diagnose 25 out of the 50 patients and has reported the others as healthy (Figure 2); accuracy, sensitivity, and specificity will be as follows:

Accuracy: Of the 100 cases that have been tested, the test could determine 25 patients and 50 healthy cases correctly. Therefore, the accuracy of the test is equal to 75 divided by 100 or 75%.

Sensitivity: From the 50 patients, the test has only diagnosed 25. Therefore, its sensitivity is 25 divided by 50 or 50%.

Specificity: From the 50 healthy people, the test has correctly pointed out all 50. Therefore, its specificity is 50 divided by 50 or 100%.

According to these statistical characteristics, this test is not suitable for screening purposes; but it is suited for the final confirmation of a disease.

Scenario 3

This time we will assume that the test has been able to identify 25 of the 50 healthy cases and has reported the others as patients (Figure 3). In this scenario accuracy, sensitivity and specificity will be as follows:

Accuracy: Of the 100 cases that have been tested, the test could identify 25 healthy cases and 50 patients correctly. Therefore, the accuracy of the test is equal to 75 divided by 100 or 75%.

Sensitivity: From the 50 patients, the test has diagnosed all 50. Therefore, its sensitivity is 50 divided by 50 or 100%.

Specificity: From the 50 healthy cases, the test has correctly pointed out only 25. Therefore, its specificity is 25 divided by 50 or 50%.

According to these statistical characteristics, this test is suited for screening purposes but it is not suitable for the final confirmation of a disease.

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Conflict of interest:

None

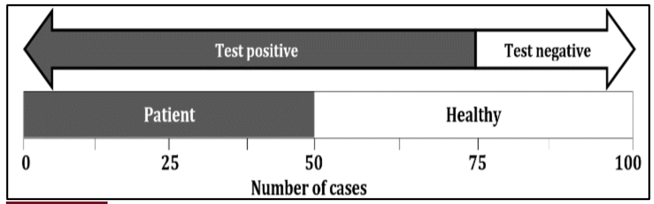

Figure 3: A schematic presentation of an example test with 75% accuracy, 100% sensitivity, and 50% specificity.

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