Rules of thumb for positive and negative test results

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It is well known that tests are not 100% accurate at classifying individuals.

The actual condition of an individual (e.g. diseased, or not diseased) does not coincide with her test result (positive, or negative).

Nevertheless, it is often presupposed, **as a rule of thumb,** that individuals with negative results are not diseased, i.e. can be “ruled out” (if screening test is highly sensitive), and that individuals with positive results are diseased, i.e. can be “ruled in” (if screening test is highly specific). This has led to the mnemonic:

SNNOUT (sensitive negative out)

SPPIN (specific positive in).

Sensitivity is probability of being positive if diseased and

specificity is probability of being negative if not diseased.

But we are interested in positive and negative predictive values:

probability of being diseased if positive and

probability of not being diseased if negative.

(Note “A if B” vs. “B if A”)

Sensitivity and specificity do not depend on the prevalence of the disease.

Predicted values depend on the prevalence.

This is still not sufficiently understood (even in the published articles):

Akobeng AK. *Understanding diagnostic tests 1: sensitivity, specificity and predictive value.* Acta Paediatr. 2006;96:338-341.

Trevethan R. *Sensitivity, specificity, and predictive values: foundations, pliabilities, and pitfalls in research and practice.* Front Public Health. 2017;5:1-7.

Predictive values for a given prevalence in a test with 95% sensitivity and 95% specificity:

Prevalence	Pr(diseased/positive)	Pr(diseased/negative)
0.1%	2%	99.99%
1%	16%	99.9%
5%	50%	99%
10%	67%	99%
30%	89%	97%
50%	95%	95%
70%	98%	89%
90%	99%	67%
95%	99%	50%

The predictive values in the table were calculated using Bayesian inference, but doctors and patients have problems understanding and using these calculations (even the existing apps).

They are simply not able to estimate the predictive values from the relevant health statistics.

They are using incorrect SPPIN and SNNOUT or, **even worse**, they use sensitivity and specificity as predictive values, as attested in:

Gigerenzer G, Gaissmaier W, Kurz-Milcke E, Schwartz LM, Woloshin SW. *Helping doctors and patients make sense of health statistics.* Psychol Sci Public Interest. 2007;8:53-96.

This is not only incorrect, it is dangerous.

Months after receiving a false-positive mammogram, women report anxiety that affect their daily mood and functioning.

Lerman C, Trock B, Rimer BK, Jepson C, Brody D, Boyce A. *Psychological side effects of breast cancer screening.* Health Psychol. 1991;10(4):259-267.

People with false-positive HIV-test commit suicide or engage in unprotected sex with other HIV-positive people, believing that it would not matter anymore.

Gigerenzer G. *HIV screening: helping clinicians make sense of test results to patients.* Br Med J. 2013;347:f5151.

So, these rules of thumb are wrong and dangerous.

But they are simple and people often stick to simple rules, whether they were correct or not.

Hence, it would be really helpful to doctors and patients to have the simple rules of thumb that correctly interpret test results.

I devised such rules.

Of course, they include prevalence, showing clearly that prevalence is necessary for interpreting test results.

Positive rule - PASSAP (Positive: Add Sensitivity/Specificity And Prevalence)

If a patient is positive you need to calculate two sums: *sensitivity* + *prevalence* and *specificity* + *prevalence*. If both sums are less than 100% then the probability of the patient being diseased is less than 50%.

For example, if prevalence of disease is 5%, test specificity is 90% and test sensitivity is 94%, your chances of being diseased if positive are still less than 50%, because 90% + 5% < 100% and 94% + 5% < 100%.

The positive rule warns that testing does not make sense if prevalence is low and that it only makes sense if we limit ourselves to testing populations in which the prevalence will be higher (determined by clinical indications and the like).

Negative rule - NUFSS (Negative: Upward From Sensitivity/Specificity)

If a patient is negative and the prevalence is less than 50% (which is almost always the case) then the probability of the patient not being diseased is greater than the smaller of the two values of sensitivity and specificity.

For example, if prevalence of disease is less than 50%, test specificity is 90% and test sensitivity is 95% your chances of not being diseased if negative are greater than 90%.

I hope that these rules of thumb could be of great help to doctors and patients.