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RESEARCH METHODOLOGY

Decisions on diagnosis in family practice: Use of sensitivity, specificity, predictive values and likelihood ratios

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Case scenario

A 51-year-old male presented for treatment with a high-grade fever which had persisted for 7 days and was associated with abdominal discomfort. He self-medicated with paracetamol, which temporarily relieved the fever, but it recurred a few hours later. He also noted vague abdominal pain associated with a soft bowel movement. There was no cough or any sign of respiratory infection. On physical examination the patient had normal vital signs with a temperature of 39°C. Typhoid fever was considered as a diagnosis because there had been reports of a recent outbreak. In order to make a correct diagnosis and give appropriate treatment the physician must choose between a Widal test or a dot-blot enzyme-linked immunosorbent assay (ELISA) test.

Clinical dilemma

Although the Widal test was introduced over 100 years ago it continues to be plagued with controversies involving the quality of the antigens used and the interpretation of the result, particularly in endemic areas.[1] A recently developed monoclonal antibody test, the dot-blot ELISA was compared with the Widal test and was found to be accurate using blood culture as the reference standard.[2] Between these two available tests, which should a family physician request? The answer to this question depends on several factors:

- accuracy
- availability
- difficulty in performance
- and cost of the test.

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Another important consideration in making a diagnostic decision is to weigh up how much additional information the test will add to what is already known.

Measures and application of diagnostic accuracies

The accuracy of tests is reported in terms of their sensitivity, specificity, predictive values and likelihood ratios. However, in primary care settings (which may have a low disease prevalence) some doctors grossly overestimate the disease probability from a screening test, when the patient has a positive result.[3] They also seem to confuse the sensitivity of the test with its positive predictive value, that is, if the test is very sensitive; a positive result means the presence of the disease.[4] The correct definitions for sensitivity and predictive values are known to most doctors but only a few know how to apply it correctly to their patients.[5] These terms and their use need to be clarified in family practice.

Sensitivity and specificity

Sensitivity is the proportion of patients who were positive for the test among all patients with the disease. Specificity is the proportion of patients who were negative for the test among all the patients without the disease.[6] The definition and practical value of these measures are shown in Table 1.

Generally the sensitivity and specificity depend on the cut-off values and may have some trade-off. A more sensitive test may be less specific and a more specific test may be less sensitive, so the decision on what test to request is often not easy. The answer depends on the purpose of doing the test. A family physician often has to decide to rule out the possibility of a treatable disease because the outcome is dangerous, that is, early detection of cervical cancer so that surgical intervention can be done immediately.

Table 1 Application of the different measures of diagnostic tests

Measures	Definition	Practical value
Sensitivity	Property of test to detect patients with the disease	Ruling out disease for screening
Specificity	Property of the test to exclude patient with the disease	Ruling in a disease for giving difficult treatment
Positive predictive value	Probability that the patient has the disease if test is positive	Patient education Starting treatment
Negative predictive value	Probability that the patient does not have the disease if the test is negative	Patient education Discontinue or no treatment
Likelihood ratio of positive result	Likelihood of the test to be positive among patients with disease than among patients without the disease	Medical decision making for requesting further tests or treatment
Likelihood ratio of negative result	Likelihood of the test to be negative among patients with disease than among patients without the disease	Medical decision making for requesting further tests or treatment

Table 2 How disease prevalence affects the predictive values

	High prevalence				Low prevalence		
	Disease	**No disease**	**Total**		**Disease**	**No disease**	**Total**
Positive	27	14	41	Positive	9	18	27
Negative	3	56	59	Negative	1	72	73
Total	30	70	100	Total	10	90	100

Thus, if the purpose is for 'ruling-out' a disease (making sure the patient does not have cervical neoplasm), a more sensitive test will be the right choice. In this case, a physician may request a regular Pap smear, which is more sensitive but not specific to cervical neoplasm. In some situations a physician has to decide to only recommend treatment for those who really have the disease because the effect of treatment for a non-diseased patient can harm the patient physically, emotionally or financially. Therefore, when recommending hysterectomy for patients with possible cervical neoplasm, a physician must be guided by a more specific test like a cervical biopsy. So if the purpose is for 'ruling-in' a disease, a more specific test will be the right choice because a very specific test is rarely positive in the absence of the disease.[6]

Predictive values

Measures that give the probability that the patient has, or does not have the disease are the predictive values (Table 1):

- A *positive predictive value* is the proportion of patients with the disease among all patients who were positive for the test.
- A *negative predictive value* is the proportion of patients who do not have the disease among those patients who were negative for the test.

It gives us the probability of the presence or absence of the disease if the test is positive or negative, respectively.

The predictive values are affected by the prevalence of the disease. A test with 90% sensitivity and 80% specificity in a population that has 30% prevalence of the disease (Table 2) will have a positive predictive value of 66% and a negative predictive value 95%. If the same test is applied to an area where the prevalence of a disease is 10%, the positive predictive value becomes 33% and the negative predictive value becomes 99%. Thus a diagnostic test that was validated in high prevalence area, for example a hospital setting, will have different predictive values when applied to a family practice setting. The probability of the disease may be wrong if we use the predictive values of the test obtained from hospital-based validity studies for our patients in family practice.

Likelihood ratios

Likelihood ratios are alternative ways of describing the usefulness of a diagnostic test. They summarize the same information as sensitivity and specificity and can also be used to calculate the probability of disease.[6,7] The likelihood ratio of a positive test result will tell us how likely the test will be positive in a patient with the disease compared with a patient without the disease. The likelihood ratio of a negative test result will tell us how likely the test will be negative in a patient with the disease compared with a patient without the disease. The main advantage of the likelihood ratio is that it can be computed even if the result is interpreted in different ways instead of just positive or negative.

Bayesian decision making

The probability of a diagnosis can be calculated using the likelihood ratio when the Bayesian concept is applied (Table 3). The likelihood ratios used to compute the probabilities were from the study of Nguyen *et al*.[2] Going back to our case scenario, the physician decided he will not treat the patient for typhoid fever if the probability is 5% or lower and he will start treating if the probability is 60% or higher (decision threshold).

In applying the Bayesian concept, the first step is to establish the probability of a disease before the test. An accurate estimate of the pretest probability of the disease can come from:

- personal experience
- prevalence statistics
- practice databases, and
- medical published reports.[8]

The probability of typhoid fever in our case is approximately 35%, the latest reported prevalence rate in the area where the patient lives. If the physician requested the Widal test the probabilities of the disease will only be 41% and 12% if the test result is positive or negative, respectively. Based on the threshold initially set, the physician will still request another test. However, if the physician requested the typhi-dot test, the probabilities will be 63% and 5% if the result of the test will be positive or negative, respectively. These values are enough to decide on treatment based on the initially set decision threshold.

Conclusion

Reporting test accuracy in terms of sensitivity, specificity, predictive values and likelihood ratios has been done for many years now, however, only a minority of family physicians could correctly apply it. The difficulty in carrying out the required calculations when using the Bayesian model probably explains there under use in general practice.[9] Rather than blaming doctors for this lack of aptitude, authors of diagnostic test data should reconsider the way they communicate

Table 3 Steps in applying likelihood ratio in clinical decision making

Step	**Formula/source**	**Widal test**		**Typhi-dot test**	
		LR(+) = 1.6	**LR(–) = 0.3**	**LR(+) = 3.2**	**LR(–) = 0.1**
1. Determine baseline probability	Prevalence data	0.35 (35%)	0.35 (35%)	0.35 (35%)	0.35 (35%)
2. Convert baseline probability to pre-test odds	Pre-test odds = prevalence/1-prevalence	Pre odds 0.35/1–0.35 = 0.54	Pre odds 0.35/1–0.35 = 0.54	Pre odds 0.35/1– 0.35 = 0.54	Pre odds 0.35/1– 0.35 = 0.54
3. Compute for post-test odds by applying Baye's theorem	Post-test odds = pre-test odds × likelihood ratio	Post odds = 0.54 × 1.6 = 0.86	Post odds = 0.54 × 0.3 = 0.16	Post odds = 0.54 × 3.2 = 1.73	Post odds = 0.54 × 0.1 = 0.05
4. Convert post-test odds to post-test probability	Post-test probability = post-test odds/1 post-test odds	Post prob = 0.69/1 + 0.69 = 0.41 (41%)	Post prob = 0.13/1.13 = 0.12 (12%)	Post prob =1.73/1 + 1.73 = 0.63 (63%)	Post prob = 0.05/1 + 0.05 = 0.05 (5%)

their research data.[5] This can be done by giving examples on how to apply their computed likelihood ratio to the population with known pretest probabilities and showing the post-test probabilities based on the test result.

The use of simple presentation of likelihood ratios is not without problems. Some general practitioners tend to use likelihood ratios directly with pretest probabilities instead of first converting them to pretest odds, resulting in an overestimation of disease probabilities.[10] The problem however, is inadequate knowledge of family physicians in applying the Bayesian concept rather than inherent problems with likelihood ratios.

References

1 Olopoenia L, King A. Widal agglutination test – 100 years later: still plague by controversy. *Postgrad. Med. J.* 2000; **76**: 80–4.
2 Nguyen N, Tapchaisri P, Chongsa-nguan M *et al.* Diagnosis of enteric fever caused by Salmonella spp. in Vietnam by monoclonal antibody-based dot-blot ELISA. *Asian Pac. J. Allerg. Immunol.* 1997; **15**: 205–12.
3 Eddy DM. Judgement Under Uncertainty - Heuristics and Biases. In: *Probabilistic Reasoning in Clinical Medicine: Problems and Opportunities*. Cambridge: Cambridge University Press, 1982; 249–67.
4 Hoffrage U, Lindsey S, Hertwig R, Gigerenzer G. Medicine. Communicating statistical information. *Science* 2000; **290**: 2261–2.
5 Steurer J, Fischer JE, Bachmann LM, Koller M, ter Riet G. Communicating accuracy of tests to general practitioners: a controlled study. *BMJ* 2002; **324**: 824–6.
6 Fletcher RH, Fletcher SW, Wagner EH. *Clinical Epidemiology: The Essentials*, 2nd edn. Baltimore: Williams & Wilkins, 1988.
7 Sackett DL, Straus SE, Richardson WS, Rosenberg W, Haynes RB. Is this evidence about a diagnostic test valid? In: *Evidence-Based Medicine; How to Practice and Teach EBM*, 2nd edn. Edinburgh: Churchill Livingstone, 2000; 82–4.
8 Sackett DL, Haynes RB, Guyatt GH, Tugwell P. *Clinical Epidemiology: A Basic Science for Clinical Medicine*, 2nd edn. Boston: Little and Brown, 1991.
9 Reid MC, Lane DA, Feinstein AR. Academic calculations versus clinical judgments: practicing physicians' use of quantitative measures of test accuracy. *Am. J. Med.* 1998; **104**: 374–80.
10 Bachmann LM, Steurer J, Gerben R. Simple presentation of testaccuracy may lead to inflated disease probabilities (letter). *BMJ* 2003; **326**: 393.