March 2003: In screening, ruling out disease requires high sensitivity, ruling in disease requires high specificity (New Rule, 4.13).

Introduction

At times I encounter information that suggests a useful new rule--evidence that not all the rules have been covered in the book. I will number such new rules according to the chapter in which the rule fits best. So far I have not found rules for which I would create a new chapter, but that possibility is not excluded either, of course.
In the context of screening situations, two scenarios can arise: a test can be used to rule out disease or to confirm, or rule in, disease. These are two distinct scenarios which place different demands on the test. I'm indebted to Paul Crane (see Preface in text) for referring this idea to me.

Rule of Thumb

A test has to have high sensitivity in order to rule out disease; the test needs high specificity to rule in disease.

Illustration

Consider the following two scenarios for sensitivity for a population of, say, 1000 people.
Scenario 1

	Disease	No Disease
Test (+)	50	450
Test (-)	50	450
Total	100	900

Scenario 2

	Disease	No Disease
Test (+)	99	450
Test (-)	1	450
Total	100	900

In Scenario 2, if the test is negative it's almost certain that the subject does not have the disease, the probability of disease given a negative test is 1/451=0.002. In Scenario 1, this probability is50/500=0.10.

Now consider two more scenarios,
Scenario 3

	Disease	No Disease
Test (+)	50	450
Test (-)	50	450
Total	100	900

Scenario 4

	Disease	No Disease
Test (+)	50	10
Test (-)	50	690
Total	100	900

In Scenario 4, if the test is positive then the probability is 50/60=0.83 that the subject has the disease. In Scenario 3 this probability is 50/500=0.10. Thus high sensitivity rules out disease and high specificity rules in disease.

Basis of the Rule

The basis of the rule follows from a 2x3 table of probabilities.

	Disease	No Disease
Test (+)	p_{11}	p_{12}
Test (-)	p_{21}	p_{22}
Total	$p_{\cdot 1}$	$p_{\cdot 2}$

High sensitivity implies that the value for p_{21} is very small; high specificity implies that p_{12} is small, and the conclusion follows.

Discussion and Extensions

It is clear that we have been describing tests with high Positive Predictive Value and high Negative Predictive Value (see page 96 of *Statistical Rules of Thumb*). What this rule does is relate these values to sensitivity and specificity.
Sackett et al (1991) have coined the mnemonics SPin=Specificity rules in, and SNout=Sensitivity rules out (actually, they use the notation, SpPin,

and SnOut; this seems slightly less elegant to me). This is very useful. This rule also provides a rationale for choosing between two tests. If the objective is to rule out disease, choose the test with the higher sensitivity. If the objective is to confirm or rule in disease, choose the test with the higher specificity.

This rule can also be used when trying to find a point on an ROC curve that basically provides a trade-off between sensitivity and specificity.

Paul Crane also pointed out that the correct phrase for ROC (Receiver Operating Characteristic) is sometimes mislabeled as Receiving Operator Characteristic).

The unmentioned fly in this ointment is the prevalence. The effectiveness of all these strategies depends on the prevalence: you can play with the above scenarios. For example, multiply the entries in the No Disease column by 10, changing the prevalence of the disease from 0.1 to 0.01. The rule still holds but the predictive values become much worse.

There is an analogy with hypothesis testing. Lack of sensitivity could be considered equivalent to a Type I error, and lack of specificity equivalent to a Type II error (or perhaps the other way around). As I discuss in the context of drug testing, organizations may have different goals with respect to testing. Drug approval agencies want to minimize approving an ineffective drug, pharmaceutical firms want to maximize the probability that an effective drug is approved. This can lead to conflicting strategies (see further discussion pages 149-151 in *Statistical Rules of Thumb).*

References

Sackett, D.L., Hayes, R.B., Guyatt, G.H. and Tugwell, P. (1991). *Clinical Epidemiology: A Basic Science for Clinical Medicine.* Second Edition. Little, Brown and Company, Boston, MA. (page 77).