

Which methods for bedside Bayes?

Understanding how and why Bayes theorem translates pretest into post-test probabilities is the *pons asinorum* (Euclid's 5th proposition is known as the "bridge of asses" because many folk got stuck crossing it) of evidence-based medicine (EBM). Because different minds are sparked by different methods, we teach the theorem by using several presentations: 2×2 tables, trees, geometric figures, and formulas. A good teacher will have several of these in his or her armamentarium (1). However, having crossed the bridge of understanding, we still must cross the bridge to practice. The basic understanding is essential, but the time pressures of clinical practice require that we abandon the training wheels and move to tools of rapid calculation. No single tool will suit all people and circumstances, so a well-stocked tool box is advisable. In this editorial, I describe 3 methods aimed primarily at everyday practice rather than enhancing understanding: precalculated tables or graphs, programmed Bayes calculators, and the Bayes nomogram.

PRECALCULATED TABLES AND GRAPHS

Applying Bayes theorem in clinical practice will be quicker if the calculations are already done. For specific common tests, this precalculation can be achieved by either tabulating or graphing the post-test probabilities for all plausible pretest probability values (2). The calculation becomes a simple look-up (provided you have properly organized your information about the test). Ideally, software for critically appraised topics (CATs) should include the ability to produce such graphs or tables. Figure 1 shows a graphic version of conjunctival pallor for the diagnosis of anemia (3).

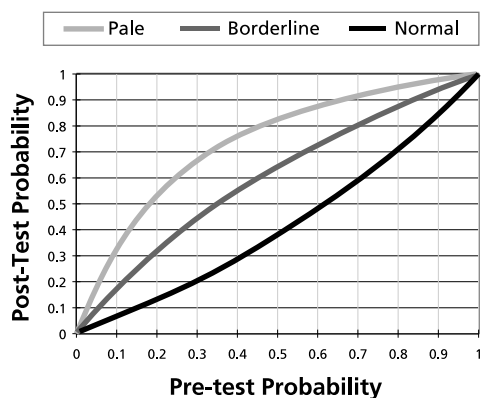


Figure 1. Pre- and post-test probabilities of anemia for 3 categories of conjunctival appearance: pale (little or no red color), borderline (neither clearly red nor clearly pale), and normal (3).

The method is possible for both dichotomous and multicategory tests. Spreadsheets that do such calculations are readily available (4). The results can be kept on a computer or a handheld or printed on paper. Another advantage is that common pretest probabilities can be marked and kept directly on the graph, acting as a guide and anchor for the individual patient being assessed. Given their simplicity, we recommend having such graphs or tables available for your most frequently used tests. However, you will still need another method when applying a test not in your current collection.

PROGRAMMED BAYES CALCULATORS

The presence of computers or handhelds at the point of care has simplified doing exact Bayes calculations. Many programs are available: spreadsheets (4) that require you to have the appropriate spreadsheet software, Internet versions that require you to have a Java-enabled Web browser and an Internet connection (4, 5), and purpose-built Bayes calculators for PCs and handhelds (4). Figure 2 shows an Excel spreadsheet that allows entry of the 3 required probabilities, then calculates the post-test probabilities and provides a graphic presentation of the results.

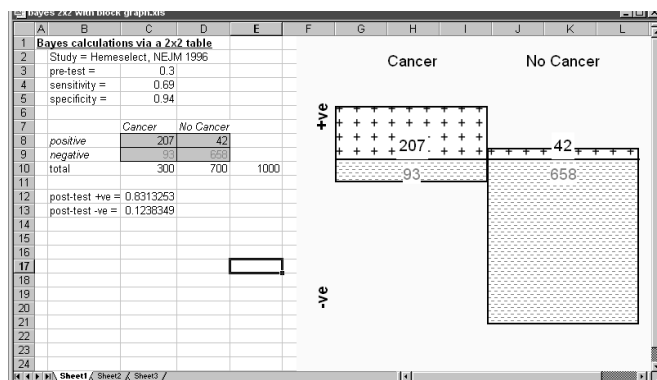


Figure 2. An Excel spreadsheet for calculating post-test probabilities for dichotomous tests.

Such programs simply require the entry of the necessary test characteristics and pretest probability. This method is faster than a calculator, but the requirement to look up the test characteristics and enter the numbers is still more tedious than the precalculation described above. However, every self-respecting EBMer should carry one such program (if for no other purpose than being able to confidently check the calculations of students).

BAYES NOMOGRAM

For the price of a laminated strip of paper, you can obtain the simplest of the Bayes calculators—the Bayes nomogram. First described by Fagan (6) in the days before personal computers and handhelds, the nomogram has had an enduring popularity. A typical nomogram is shown in Figure 3. The only requirements for calculating the post-test probability are the pretest probability, the relevant likelihood ratio (LR), and an implement with a straight edge (although a nonarthritic finger can substitute in a pinch).

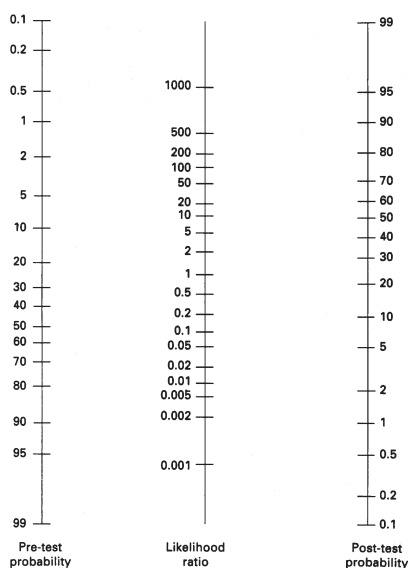


Figure 3. Bayes nomogram (adapted from Fagan [6]).

The construction of the nomogram relies on being able to convert Bayes theorem into a simple linear additive function. A couple of mathematical tricks can achieve this. First, we need the odds version of Bayes theorem:

$$\text{Post-test odds} = \text{Pretest odds} \times \text{LR}$$

or in mathematical notation:

$$O(\text{DIR}) = O(\text{D}) \times P(\text{RID})/P(\text{R|NonD})$$

where $O(\text{D})$ is the odds of the disease, that is $O(\text{D}) = P(\text{D})/(1 - P(\text{D}))$, and R is a specific test result. Taking logarithms converts this to a simple addition, which allows the ruler to do the work:

$$\text{Log}(\text{Post-test odds}) = \text{Log}(\text{Pretest odds}) + \text{Log}(\text{LR})$$

or in mathematical notation:

$$\text{Log}(O[\text{DIR}]) = \text{Log}(O[\text{D}]) + \text{Log}(P[\text{RID}]/P[\text{R|NonD}]).$$

While instructive for students, the nomogram has several limitations. First, it requires knowing the LRs, which often means looking up the sensitivity and specificity and then converting these to LRs. For example, with a dichotomous test, the positive LR is sensitivity/(1 – specificity), and the negative LR is (1 – sensitivity)/ specificity. Second, the nomogram has limited accuracy, although it is generally sufficient for bedside calculations. Finally, the pre- and post-test ranges of the nomogram are limited (generally from 0.001 to 0.99), which may be inadequate for some screening test problems.

CONCLUSIONS

The 3 methods described in this editorial are for bedside calculation. For teaching, other methods, such as 2×2 tables or box diagrams, are more helpful for gaining insight into the need for and mechanism of Bayes theorem. Having gained that insight, students should then be able to rapidly experiment with calculations to learn the consequences of changing test characteristics and pretest probabilities. With the advent of handheld computers, we believe that precalculation and software will largely take over from the nomogram; hence, we have dropped it from our glossary.* Readers are invited to use the methods described above (4) and send us comments on how the presentation of test probabilities may be made more useful at the bedside.

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References

1. Sackett DL, Straus SE, Richardson WS, Rosenberg W, Haynes RB. Evidence-Based Medicine: How to Practice and Teach EBM. 2d ed. Edinburgh: Churchill Livingstone; 2000.
2. Glasziou PP. Probability revision. *Prim Care*. 1995;22:235-45.
3. Sheth TN, Choudhry NK, Bowes M, Detsky AS. The relation of conjunctival pallor to the presence of anaemia. *J Gen Intern Med*. 1997;12:102-6. <http://www.cebm.utoronto.ca/practise/ca/statscal/>
4. <http://www.health.usyd.edu.au/ebm/bayes.htm> and <http://www.intmed.mcw.edu/clinical/bayes.html> can be used online or offline (click on “Make available offline”).
5. Fagan TJ. Nomogram for Bayes theorem [Letter]. *N Engl J Med*. 1975; 293:275.

*The Bayes nomogram that appeared in the glossary of ACP Journal Club in the September/October and November/December 1999 issues should not be used because the likelihood ratio is imperfectly drawn, giving inaccurate readings in parts of the nomogram; and the lower 500 on the likelihood ratio scale should be 200.