The Nomogram Epidemic: Resurgence of a Medical Relic

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The obsolete calculators known as nomograms have become epidemic in recent medical literature. The frequency of articles in PubMed retrieved with this search term nearly doubled between 1990 to 1999 and 2000 to 2007. Popular in medicine from about 1925 to 1975, a nomogram is a crude graphical means for solving an equation by placing a straightedge across several scales. Today, most reported nomograms are inconsistent with both established definitions and half a century of clinical use. The need for nomograms disappeared with the advent of personal computing. Instead of constructing nomograms, authors should develop software, such as prediction models, that can either be downloaded to personal digital assistants or be used on the Internet. Modern computing features both accuracy and speed; nomograms offer only the latter.

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Nomograms have become epidemic in the medical literature, a problem that stems from a lack of understanding of both the term and its history. Current definitions of *nomogram* are usually aberrant and, even if correct, the need for medical nomograms disappeared 3 decades ago. Hence, the resurgence of this relic is inappropriate. This article defines nomograms, reviews their history as crude calculators, documents the current epidemic, gives examples of good and bad medical nomograms, and recommends a better approach to contemporary medical calculations.

Definition

A nomogram (or nomograph) is a simple calculator, akin to a slide rule. It is "a form of line chart showing scales for the variables involved in a particular formula in such a way that corresponding values for each variable lie in a straight line intersecting all the scales" (1). An alternative definition is "a figure consisting of three or more straight or curved lines, each graduated for a different variable and aligned in such a way that a straightedge crossing all of the scales cuts the scales at values of the variable that have a specified mathematical or empirical relationship" (2). A nomogram's distinguishing feature is that placing a straightedge across its several scales immediately solves a formula (3).

Although a slide rule has general use, each nomogram is designed to solve a specific equation. The simplest nomograms consist of 3 scales: a straightedge that connects known (independent) values on 2 of the scales provides the unknown (dependent) value from the third scale (4–6). In the **Figure**, if one knows the pretest probability of illness (left scale; here, 0.80) and the likelihood ratio from a test (middle scale; here, 0.10), a straightedge connecting those 2 values gives the posttest probability of illness on the right scale (here, about 0.30). Each value that the straightedge intersects solves the equation. Some complex equations require curved or multiple scales; the common distinguishing feature, however, is that placing a straightedge across the nomogram immediately solves the equation (7)—no arithmetic is needed.

Nomograms may have some didactic value because they allow visual representation of an equation; however, this potential benefit is likely outweighed by the resultant inaccuracy in calculation. Advocating clinical use of nomograms today is analogous to recommending the use of slide rules in college physics courses.

Terminological Troubles

Use of the term *nomogram* has been debased in recent years, with such definitions as "a graphical device which implements a regression model in a friendly manner, enabling the user to map the subject-specific covariates to the probability of an event" (8) and "a mathematical model that employs variables with additive prognostic importance to predict risk for individual patients" (9). These unorthodox definitions share 2 features: They do not cite a dictionary, and the proposed nomograms do not solve an equation with a straightedge. Thus, although these graphs may be crude calculators, they are not traditional nomograms.

Early Calculations

Ancient calculations were done with rudimentary tools. The earliest digital calculators were just that: digits of the hand and foot, with their limited numerical range. Pebbles and sand tables expanded the range of potential calculations that could be done to well beyond 20. The abacus, from China, is a sophisticated form of pebble calculator. After 2 millennia of stagnation in calculating machines, the development of logarithms in 1614 led to the slide rule in 1650. The addition of a moveable, double-sided cursor in 1850 created the slide rule used well into the 20th century (10). It, in turn, was the parent of the nomogram.

Nomograms arose in civil engineering, not medicine. Engineers used tables and then graphs to solve complex

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Key Summary Points

Nomograms, like slide rules, are computational relics.

Nomograms were popular in medicine and engineering from around 1925 to 1975, after which electronic calculators became widely available.

A nomogram solves an equation by placing a straightedge across 2 or more scales and reading the unknown value from another scale.

Nomograms have been rendered obsolete by the advent of personal computing and should be replaced by software that can be downloaded or used on the Internet.

Nomograms offer speed of calculation at the cost of accuracy; personal computing today offers both.

questions about cut and fill of dirt when building railways. In 1899, d'Ocagne published a treatise on nomograms, showing their appeal: A diagram was less cluttered than a chart, 1 diagram could handle all the terms in an equation, and users arrived at the answer more quickly by using a straightedge (11). When speed was more important than precision, nomograms filled the bill. For example, gunners in World War I used nomograms to direct antiaircraft artillery because pencil-and-paper calculations were too slow, even for biplane speeds.

The Nomogram Epidemic

Although nomograms are antiques, use of the term has become epidemic in recent years. The number of PubMed citations from the 1960s identified with the search term *nomograms* is 2.3 per 100 000. This figure has continued to increase each decade, to 4.9 in the 1970s, 6.1 in the 1980s, 6.8 in the 1990s, and 12.8 from 2000 to 2007. Much of this resurgence stems from aberrant use of the term. By comparison, no corresponding epidemic of citations for *slide rule* has occurred; I found only 130 citations in PubMed since 1946 with this search term, fewer than the 156 citations identified with *nomograms* in 2007 alone.

Proper Nomograms

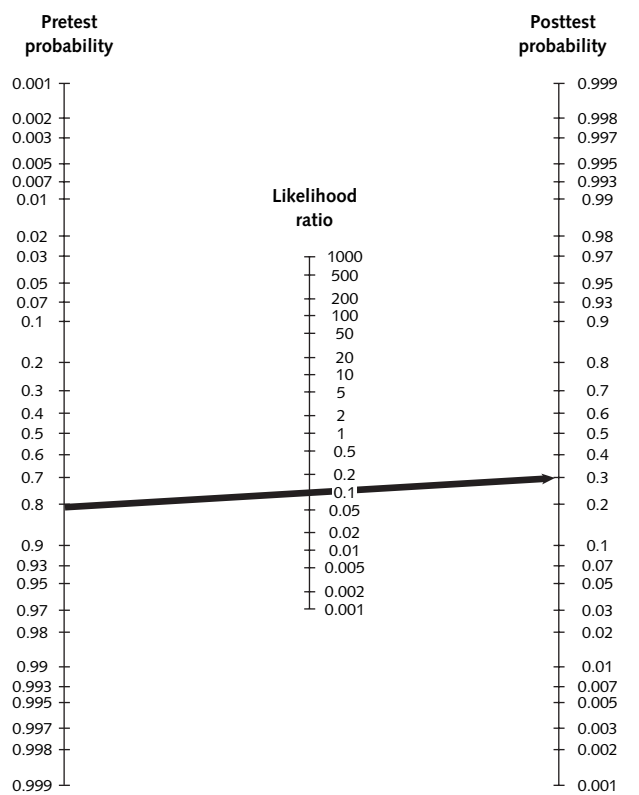
Although obsolete, nomograms consistent with accepted definitions are still available. For example, an early medical nomogram (available at www.bioscience.org/atlases/clinical/nomogram/nomoadul.htm) calculates body surface area if height and weight are known. Placing a straightedge on height in the left column and weight in the right column yields the surface area from the middle column. Before the era of personal computers and free statistical software (12), Altman (13) developed a clever nomogram for calculating sample size and power. Although it includes power, total study size, the standardized difference, and significance level, the equation is still solved by placing a straightedge across the nomogram. A recent nomogram (14) calculates the nasogastric tube–insertion distance on the basis of patient weight and distance from nose to umbilicus.

Aberrant Nomograms

All sorts of figures and tables, ranging from line charts of penile length (15) to scatter plots of glutathione peroxidase levels in endometriosis (16), have been mislabeled as nomograms. Indeed, use of the term has become so corrupted that even tables of numbers are called nomograms (17).

Graphical portrayals of the results of logistic regression have fueled the current epidemic of aberrant nomograms. This use has extended from the probability of cancer survival (18) to the probability of hyperlipidemia (19), hip fracture (20), and vaginal birth after cesarean delivery (21). The common feature in these graphical representations of logistic regression is that they require adding points or scores from several scales and then extrapolating from 1 scale to a final probability scale. This cumbersome process is the antithesis of a nomogram.

Figure. **Nomogram for posttest probability.**



Adapted from reference 4, with permission of the Massachusetts Medical Association.

Control of the Epidemic

Several steps should remedy this epidemic of aberrant terminology. First, investigators should restrict use of the term *nomogram* to the accepted definitions (1–3, 6) that are based on a half-century of clinical use (5). Second, journal editors and reviewers need to provide better oversight of medical terminology. Finally, the National Library of Medicine should play a more normative role in lexicography; its current permissive attitude repeats and thus legitimizes the unorthodox use of medical terms.

Computers and personal digital assistants are widely available in clinical medicine and are fast and accurate. Instead of making graphics that require arithmetic (and thus invite human errors) (22), investigators should develop software that can be used online or downloaded by clinicians. For example, Web-based calculators (such as, the body surface area calculator, available at www-users.med.cornell.edu/~spon/picu/calc/bsacalc.htm) and free software for personal digital assistants and smartphones (such as MedCalc, available at www.med-ia.ch/medcalc/) have supplanted the original nomogram for determining body surface area. Web-based calculators for predicting cancer survival (for example, those available at www.mskcc.org/mskcc/html/5794.cfm) or vaginal birth after cesarean delivery (for example, that available at www.bsc.gwu.edu/mfmu/vagbirth.html) are similarly preferable to nomograms on a printed page (18, 21).

Having outlived their clinical usefulness, nomograms (like slide rules) should be retired. As crude calculators, they were popular in medicine and engineering from about 1925 to 1975, after which electronic computing rendered them obsolete (10). In the previous century, nomograms provided speed in calculation at the cost of precision. Today, personal computing offers both. As Tufte noted (23), ". . . their computational use has passed. Computational power is so cheap now, we don't need look-up tables or nomograms; we can just plug the numbers into the equations and solve." Using a nomogram as a calculator is analogous to estimating hematocrit with clay-plugged microcapillary tubes spun in a centrifuge. We have better tools today, and we should use them.

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