Physician Numeracy: Essential Skills for Practicing Evidence-based Medicine

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Teaching evidence-based medicine (EBM) has become common in family medicine residency programs. EBM teaching usually takes the form of journal clubs or encouraging residents to use EBM summaries of original articles. Both have significant limitations. Residents and other physicians recognize that understanding statistics is important for interpreting results. Unfortunately, they report low self confidence in this area reflected by studies that show poor skills. Physician numeracy refers to a broad range of mathematical skills needed for practicing medicine, including the statistical knowledge necessary to interpret original research papers. Numeracy should be given much more emphasis in residency curricula and can form the foundation of EBM teaching. Objectives for a numeracy curriculum based on a recent research article and a curriculum using an EBM framework are described.

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Nearly all medical schools and residency programs incorporate training and experience in evidence-based medicine (EBM). Sackett defines EBM as the "conscientious, explicit, and judicious use of current best evidence in making decisions about the care of individual patients."[1]

The degree to which EBM is part of the curriculum and the specific skills and the manner in which they are taught vary greatly. According to the Accreditation Council on Graduate Medical Education (ACGME), EBM is included in the practice-based learning and improvement core competency requirement for all programs: "Residents must demonstrate the ability to investigate and evaluate their care of patients, to appraise and assimilate scientific evidence, and to continuously improve patient care based on constant self-evaluation and lifelong learning."[2] Specific skills necessary to practice EBM have been defined by Guyatt et al as the: (1) recognition of a patient problem and construction of a structured clinical question, (2) efficient and effective searching for information resources to retrieve the best available evidence to answer the clinical question, (3) critical appraisal of the evidence, (4) gaining a full understanding of the study results, and (5) integration of the evidence into patient care.[3]

Failure to adequately address skill number 4 (gaining a full understanding of study results) is the focus of this paper. It is my belief that facility with numbers, especially statistics, is necessary to fully understand study results and that understanding study results should be the focus of an EBM curriculum. This view is in marked contrast to that of the original developers of EBM. In fact, when teaching EBM, Sackett et al recommend using what they call "the statistics aren't important" technique.[4]

Current EBM Teaching

Journal club is the predominant format for teaching EBM in residency programs. According to Alguire, journal clubs have become popular because they are easy to implement, require little preparation, are comfortable for faculty, involve provision of food, and emphasize resident-centered learning.[5]

Journal clubs have a number of important limitations. First, though a considerable amount of time is devoted to journal club on a regular basis in most family medicine programs, the objective of each individual session is often poorly defined. Repeating the exercise of presenting a new article in a structured format using simple critical appraisal tools over and over again is unlikely to advance residents' skills. Second, popular critical appraisal tools have serious shortcomings. Katrak et al point out that there is no "gold standard" critical appraisal tool and that the empirical basis for the construction of many tools and their validity is

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often unclear.[6] Indeed, the emphasis of most tools is simply the identification of key terms in research papers such as "intention to treat," "concealed allocation," and "double blinding." It is possible to successfully complete a critical appraisal worksheet neither having a clear understanding of these terms nor even thoroughly reading the paper. The statistical methods used for the design and analysis of the results are often ignored or glossed over. Finally, Hatala et al point out that journal clubs encourage residents to see EBM as a separate exercise that is not integrated into patient care.[7] It is not surprising, therefore, that despite the widespread incorporation of journal clubs in postgraduate programs, residents report limited self-perceived EBM skills.[8]

Another common way of incorporating EBM into residency programs is teaching about and encouraging the use of evidence-based summaries of original research articles, either in paper or electronic format. Summaries are designed both to keep residents up to date and to be used at the point of care. They can be useful sources of information, but they address a limited number of common conditions and questions that arise in practice.[9] Further, EBM summaries are prepared by individuals with varying levels of expertise and experience in clinical epidemiology and biostatistics. The quality of such summaries is thus highly variable. The quality of such summaries is thus highly variable. Further, though summaries are widely available to family medicine residents, there is little evidence that they are used often. McCord et al have shown that family medicine residents most frequently find answers by consulting attending physicians and that the most common electronic sources used were *Up to Date* (an updated electronic textbook) and electronic drug reference programs. Indeed, *Up to Date*, rather than EBM summaries, was rated as the most useful information source.[10]

Defining Physician Numeracy

Numeracy in general can be defined as "the ability to use mathematical ideas efficiently to make sense of the world."[11] Physician numeracy is more specific and can be defined as the ability to understand the quantitative aspects of clinical medicine, original research, quality improvement, and financial matters. Physicians must also, when necessary, be able to convey their quantitative understanding to patients in the simplest and clearest way. This is a broad definition that includes such relatively simple tasks as calculating the dosage of a medication based on body weight or interpreting a clinic's financial statement. With respect to EBM, physician numeracy refers specifically to understanding the statistical aspects of and terminology associated with the design, analysis, and results of original research papers.

Physician numeracy has been widely acknowledged for many years to be essential for the accurate interpretation of original research.[12,13] Unfortunately, for more than 25 years, the skills of physicians in this area have been shown to be poor.[14-16] A survey of Massachusetts family physicians, for example, recently showed that 87% felt comfortable communicating risk to patients in qualitative terms, compared with just 36% who felt comfortable communicating risk in quantitative terms such as probability.[17] Moreover, poor numeracy is not a function of a negative attitude toward biostatistics and other types of mathematics because in the same survey of Massachusetts physicians, 76% perceived numerical risk communication to be important. In another survey, 95% of residents believed it was important to understand key biostatistics concepts used in original research papers, but 75% of the same residents reported low confidence in understanding biostatistics and answered a mean of just 41% of questions on a biostatistics knowledge test correctly.[18] These results should not be surprising, given the focus of EBM teaching in residency programs that I described earlier. Failure to teach key aspects of physician numeracy to residents is common to residency programs across all specialties.[19]

EBM Numeracy Curricula and Implementation

Faculty physicians are likely to be uncomfortable teaching key biostatistical concepts. Successful implementation of a numeracy curriculum will therefore require a significant faculty development effort, which is not discussed in this paper but for which valuable resources are available.[20,21] Potential objectives, content, and strategies for a numeracy curricula are discussed below.

In evaluating medical residents' understanding of biostatistics, Windish et al reviewed 239 original research articles published over a 3-month period in six general medical journals and identified the most commonly used statistical methods and concepts. They developed a knowledge test based on this extensive journal survey.[20] Proposed objectives for a numeracy curriculum, based on this knowledge test, are described in Table 1. Some common statistical concepts, however, (eg, predictive values, likelihood ratios) are not included. Unfortunately, Windish et al do not describe strategies for meeting these objectives. Jacobsen describes teaching numeracy to residents, but the range of recommended statistical concepts was limited.[22]

One way to teach physician numeracy is to divide concepts into key categories, discuss each category of concepts in one or two didactic sessions led by faculty, and then spend a session discussing an original article that both illustrates the concepts and is clinically relevant. The standard EBM framework described by Sackett et al can be used to categorize concepts. Numeracy and interpretation of

Table 1

Objectives Based on Paper by Windish et al[18]

1. Distinguish among continuous, ordinal, and nominal variables.
2. Identify studies that use a cross sectional, cohort, or randomized trial design.
3. Describe the purpose of double-blind studies.
4. Describe the correct use of ANOVA.
5. Describe the correct use of a t test.
6. Describe the correct use of a χ^2 test.
7. Describe the correct use of logistic regression.
8. Recognize the purpose of double-blind studies.
9. Define the terms confounding, bias, interaction, and stratification.
10. Correctly interpret P values.
11. Correctly interpret confidence intervals.
12. Correctly interpret standard deviation.
13. Describe the correct use and interpretation of Kaplan Meier analysis.
14. Describe the correct use and interpretation of Cox proportional hazard regression.
15. Describe power, sample size, significance level, and their interrelationships.
16. Interpret an unadjusted odds ratio.
17. Interpret odds ratio in multivariate regression analysis including strength of evidence for risk factors.
18. Interpret relative risk.
19. Define and interpret sensitivity.
20. Define and interpret specificity.

articles, rather than article selection and critical appraisal (ie, most journal clubs), thus becomes the basis of the curriculum. Instead of asking, "Is this paper useful or not?" residents should ask themselves, "How can I best understand what is useful about this paper?" The advantage of this approach includes that it uses the traditional EBM framework for classifying research with which many educators are familiar. Labeling the curriculum "physician numeracy" also makes it possible to discuss a broad range of mathematical skills useful for the practice of medicine. There is nothing wrong with discussing the calculation and interpretation of odds ratios, together with using a paper on type 2 diabetes to illustrate use of odds ratios, and even together with spending time calculating outpatient insulin requirements for patients discharged from the hospital. A numeracy curriculum that uses the EBM framework is outlined in Table 2.

Conclusions

Because of the importance of mathematical skills to clinical care in general and EBM in particular, numeracy should be given more emphasis in residency curricula by forming the foundation for EBM teaching. The curriculum recommended in this paper provides an approach for introducing numeracy into residency teaching.

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Table 2

Proposed EBM Numeracy Curriculum†

Module or Topic Area	*Key Concepts for Sessions*	*Format and Duration of Sessions*
Common Descriptive and Comparative Statistics	Introduction Types of data, normal distribution, mean, median, standard deviation	1. Lecture discussion* of key concepts. (1 hour) 2. Discussion of original article that uses only descriptive statistics (eg, simple cross-sectional survey). (1 hour)
	Comparative Statistics Analysis of variance, *t* tests, Chi-square test, overview of non-parametric tests	1. Lecture discussions of general principles behind comparative statistics. (2 hours) 2. Article discussions of original research that uses common parametric and non-parametric tests. (2 hours)
	Correlation and Regression Introduction to concepts and types of correlation and regression, Pearson's correlation coefficient, how to interpret regression analyses	1. Lecture discussions of general principles of regression and correlation with examples. (2 hours) 2. Article discussions of original research that uses regression and correlation. (2 hours)
Diagnostic Reasoning	How Doctors ThinkAbout Diagnosis Inductive and deductive reasoning, pattern recognition, definition and purpose of screening	1. Lecture discussion about doctors' approach to diagnosis. (1 hour)
	Quantitative Evaluation and Interpretation of Diagnostic Tests 2x2 tables and test characteristics (sensitivity, specificity, predictive values, likelihood ratios)	1. Lecture discussion of quantitative concepts. (1 hour) 2. Article discussions of research that uses different test characteristics. (2 hours)
	Bayes Theorem Origin and applicability of Bayes theorem to use of diagnostic tests, odds versus probability, calculation of posttest odds and probability, errors that influence estimate of pretest probability of disease (eg, "conjunction fallacy").	1. Lecture discussion overview of Bayes theorem and its use in interpretation of diagnostic tests. (1 hour) 2. Article discussions of diagnostic research about common family medicine problems, extraction of likelihood ratios, and application of likelihood ratios and Bayes theorem to common clinical scenarios. (2 hours)
Design of Research to Evaluate Therapies	Key Concepts in Design Types of study design to evaluate new therapies, definitions of confounder, internal validity, external validity, bias, sampling, type 1 error, type 2 error, power, randomization, allocation, allocation concealment, and general principles of sample size estimation	1. Lecture discussions of key concepts in design. (3 hours) 2. Article discussions of clinically relevant research about new therapies with emphasis on design of each study. (3 hours)
Interpretation of Results of Studies of Therapies	Basic Numeracy Concepts Intention to treat, relative risk reduction (RRR), numbers needed to treat/harm (NNT/NNH)	Lecture discussion of basic numeracy concepts. (1 hour) Article discussion in which RRR, NNT, and NNH are calculated from data in an article and their applicability to different clinical scenarios is discussed. (1 hour)
	Advanced Numeracy Concepts Interpretation of *P* values and confidence intervals, *P* value fallacy	1. Lecture of discussion of advanced numeracy concepts. (1 hour) Article discussion with focus on accurate interpretation of *P* values and/or confidence intervals. (1 hour)

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Table 2

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Module or Topic Area	*Key Concepts for Sessions*	*Format and Duration of Sessions*
	Essential Concepts in Interpretation of Studies of Etiology Cohort and case-control studies and advantages of each, relative risk (RR), odds ratios (ORs), why RR cannot be used for case-control studies, 95% confidence intervals for ORs and RR	Lecture discussions of key concepts including design of studies of etiology, ORs, RRs, and their interpretation. (2 hours) Article discussion of research about etiology of a common illness including interpretation of ORs. (1 hour)
Survival	Essential Concepts in Interpretation of Studies of Survival Censoring, Kaplan-Meier estimates, Log rank test, definition of hazard and hazard ratios, overview of Cox proportional hazards model	1. Lecture discussions of key concepts including interpretation of survival curves and comparison of survival curves and Cox proportional hazards analysis. (2 hours) 2. Article discussions of research about survival that uses Kaplan-Meier survival curves and Cox proportional hazards analysis. (2 hours)
Systematic Reviews	Introduction to Systematic Reviews Definitions of systematic review, meta-analysis, narrative review, overview of key steps in development of a systematic review	1. Lecture and article discussion with focus on identifying documentation of key steps in development of systematic review. (1 hour total)
	Results of Systematic Reviews Definitions of heterogeneity, Cochran's Q statistic, inconsistency, fixed and random effects models, interpretation of forest plots, sensitivity analysis, bias in development of systematic reviews, funnel plots	1. Lecture discussions of key concepts described to the left. (2 hours) 2. Article discussions of systematic reviews with an emphasis on interpretation of the results (2 hours).

*A lecture discussion consists of introduction of numeracy concepts by a faculty member followed by a general discussion including questions and answers to make sure numeracy concepts are clear to residents.

†Adapted from: Rao G. Rational Medical Decision Making: A Case-based Approach. New York: McGraw-Hill, 2006.