PERSPECTIVES

Numeracy and Communication with Patients: They Are Counting on Us

Andrea J. Apter, MD, MA, MSc[1], *Michael K. Paasche-Orlow, MD, MA, MPH*[2], *Janine T. Remillard, PhD*[3], *Ian M. Bennett, MD, PhD*[4], *Elana Pearl Ben-Joseph, MD*[5], *Rosanna M. Batista, MPH*[6], *James Hyde, MA, SM*[7], *and Rima E. Rudd, ScD*[8]

[1]Division of Pulmonary, Allergy, Critical Care Medicine, Department of Medicine, University of Pennsylvania, Philadelphia, PA, USA; [2]Section of General Internal Medicine, Department of Medicine, Boston University School of Medicine, Boston, MA, USA; [3]Graduate School of Education, University of Pennsylvania, Philadelphia, PA, USA; [4]Department of Family Medicine and Community Health, University of Pennsylvania, Philadelphia, PA, USA; [5]Nemours Center for Children's Health Media, Alfred I. DuPont Hospital for Children, Wilmington, DE, USA; [6]Research Study Coordinator, Children's Hospital, Boston, MA, USA; [7]Department of Public Health and Family Medicine, Tufts University School of Medicine, Boston, MA, USA; [8]Department of Society, Human Development, and Health, Harvard School of Public Health, Boston, MA, USA
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Patient-centered interactive communication between physicians and patients is recommended to improve the quality of medical care. Numerical concepts are important components of such exchanges and include arithmetic and use of percentages, as well as higher level tasks like estimation, probability, problem-solving, and risk assessment - the basis of preventive medicine. Difficulty with numerical concepts may impede communication. The current evidence on prevalence, measurement, and outcomes related to numeracy is presented, along with a summary of best practices for communication of numerical information. This information is integrated into a hierarchical model of mathematical concepts and skills, which can guide clinicians toward numerical communication that is easier to use with patients.

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INTRODUCTION

Inadequate health literacy is associated with poorer communication and health outcomes, higher health costs, and likely contributes to health disparities.[1–11] This research has focused on a narrow set of literacy skills relating primarily to reading comprehension; however, limited numeracy, a component of literacy, is frequently unrecognized and limits patients' ability to communicate with health professionals. Limited numeracy skills will also hamper a patient's ability to understand health information, to make decisions related to health and health care, and may be linked to worse health outcomes.[12–15] Numeracy is increasingly relevant as the promotion of shared decision-making and the use of electronic information have increased the amount of quantitative information patients must comprehend.[16]

WHAT IS NUMERACY?

As an element of health literacy, numeracy comprises basic math skills needed for health-related activities such as timing, scheduling, and dosing of medications as well as numeric concepts needed to understand and act upon directions and recommendations given by health-care providers.[6,12,17] Numeric concepts include higher level tasks like estimation, probability, problem-solving (the ability to decipher when and how to apply numerical skills), understanding variability and error in measurement, and risk assessment. As illustrated through vignettes in Text Box 1, these skills are central to many elements of the clinical encounter.[18,19]

Text Box 1. Vignettes illustrating challenges to patient-clinician communication surrounding numerical concepts.

Vignette	Scenario	Mathematics concept
#1	A 22-year-old woman with unstable asthma is asked to record peak flow readings in the grid provided with the device. She is afraid to tell her doctors that she does not understand how to graph the numbers	Reading numbers, counting
#2	A 55-year-old man, hospitalized for a COPD exacerbation, is discharged with a bottle containing 5-mg prednisone tablets. He is told to take 30 mg in the morning for 5 days. When asked how many pills he should take tomorrow morning, he is unsure	Arithmetic operations*
#3	A mother examines the growth chart of her 6 month old. She sees the line of growth rising consistently along the 10th percentile and feels anxious that her child is too small or underweight. She (erroneously) suspects that she lacks sufficient breast milk and decides to stop nursing, despite the doctor's reassurance that her baby's growth is normal	Estimates, trends, graph reading
#4	A 50-year-old man weighs 275 lbs. His cardiologist advises him that even a 5% weight loss will greatly improve his health. The man has no idea how to determine how many pounds he should lose	Percentage, relative versus absolute values
#5	A physician prescribes alendronate for osteoporosis. The patient asks how likely it is that she will avoid a hip fracture by taking this medication. Her physician responds "the number needed to treat is 15: if 15 patients are treated, 1 will benefit."[90] The woman is confused	Probability, risk

**Arithmetic operations = addition, subtraction, multiplication, division*

MEASURING NUMERACY

The 1992 National Adult Literacy Survey (NALS)[20] and the 2003 National Assessment of Adult Literacy (NAAL)[21,22] included assessment of quantitative skills, the application of basic math. Findings indicate that 22% of American adults possess no more than the most simple and concrete quantitative skills. Another 33% of adults have only basic quantitative skills. These surveys evaluate numeracy in a written format that requires reading comprehension, thereby intermeshing reading and numerical activities and complicating independent assessments of numeracy. The Adult Literacy and Lifeskills Survey, the most recent international assessment of adult literacy skills, included measures of numeracy, defined as 'the ability to interpret, apply, and communicate mathematical information in commonly encountered situations."[23,24] Of the six countries participating, the US ranked fifth, below Switzerland, Norway, Bermuda, and Canada.[25]

Relatively few health-related assessment tools are dedicated to or contain quantitative items.[1,11,13,26–34] They vary in number of items, administration, and mathematical content.[35] Topics range from items assessing arithmetic skills like counting to more complicated skills like calculations of probability and risk. One unique measure tests subjective self-assessment of numeracy skills, which has been shown to correlate with actual mathematical skills.[32]

Results of numeracy tests in health settings are discouraging.[13,33,34,36] For example, only 16% of women participating in a study of basic percentage and probability concepts related to the benefits of screening for breast cancer answered all items correctly.[13] Similarly, 16% of study participants answered all items correctly in a test of common asthma self-management concepts requiring simple arithmetic and percentage computations.[1]

Most numeracy measures are self-administered, requiring reading comprehension.[13,26–34] Researchers testing understanding of food labels found that even patients with higher prose literacy had difficulty interpreting numerical information on labels.[37] Similarly, even though scores on the Asthma Numeracy Questionnaire (ANQ) generally correlated with scores of the Short Test of Functional Health Literacy in Adults (STOFLHA) ($r=0.34$, $p=0.004$), individuals who scored well on the reading test did not necessarily score well on the ANQ.[1] Researchers, using tests containing probability, positive predictive value, and other complex concepts, found that better numeracy was associated with more education, being male, and being white.[7,11,34] At the same time, a study of women's capacity to estimate the chance of breast cancer survival and benefit of screening mammography found that black compared with white women were more likely to make an accurate assessment of cancer survival and women who did not graduate from high school were more accurate in assessing mammography benefit.[38]

Even well-educated patients may have trouble converting proportions to percent or understanding simple probability and risk.[13,19,32,39–43] Among medical students attending a seminar on risk-communication, 23% got at least one item wrong on a numeracy test assessing risk.[13] Although 90% were able to determine which of two drugs offered greater benefit when information was presented in terms of relative risk reduction, absolute risk reduction, number-needed-to-treat or a combination of these concepts, only 61% could calculate how much one of the drugs reduced disease risk.[43] In another study, almost half of the doctors surveyed made different treatment recommendations when identical data were presented in a relative versus an absolute risk format.[44]

NUMERACY AND HEALTH OUTCOMES

The literature in health literacy research offers substantial evidence of links between literacy skills and health outcomes.[16] However, research on the relationship between numeracy and health is scant. Limited numeracy has been associated with poorer anti-coagulation control[45] and poorer diabetes self-management.[11] Additionally, limited numeracy was associated with a history of more hospitalizations and ED visits for adults with asthma.[1] However, one study found that correct scores on probability questions were not associated with being up-to-date with colorectal screening or mammography,[46] and another reported that understanding numerical concepts in nutrition labels was not associated with blood pressure or cholesterol levels.[47]

CONCEPTUAL MODEL FOR COMMUNICATION OF NUMERICAL INFORMATION

Knowing that the average numeracy skills of US adults are limited, clinicians may likely struggle with the communication of critical health information. In Table 1 we introduce a conceptual model of elements necessary for communication of health information with numeric concepts. The model is based on Golbeck's four overlapping categories of numerical information: basic (e.g., ability to identify and read numbers), computational (e.g., counting and arithmetic), analytical (e.g., inference, estimation, proportion, percentage, frequencies, basic graphs), and statistical (e.g., basic probability, statistics, and risk assessment).[48] It presents numerical concepts arranged by difficulty as assessed and taught by educators.[49] We selected those concepts frequently appearing in health communication.[19] Related concepts are adjacent and similarly colored.[48–50] Relatively easy tasks like reading or locating numbers, such as those on a peak flow meter, fall within the

Table 1. Numeracy and Patient-Physician Communication: A Hierarchy of Numerical Complexity and Comprehension

Numeracy element*	Level of Patient Mastery Required (demand on patient)		
	Describe	Interpret	Decision-Making
Reading numbers, counting, telling time	V1[¶]		
Arithmetic operations			V2
Estimation of size, trend	V1	V3	
Frequency	V5		
Percentage		V3, V4	V4
Problem-solving[†] & inferring the mathematical concepts to be applied			V1, V4
Logic[‡]			
Reading tables	V1		
Reading graphs	V1	V3	
Reading maps			
Estimation of error, uncertainty, variability[§]		V3	
Relative versus absolute[‖]			
Risk (cumulative, relative, conditional)			V5

We propose this matrix as a conceptual model that offers a theoretical guide for communicating numerical information. It is also a framework for formulating research to improve communication of numerical information. The left column displays numerical concepts frequently used in health care, grouped by approximate level of difficulty. From left to right, the columns represent the level of comprehension patients need to perform health-related tasks. We hypothesize that patient autonomy and shared decision-making can be improved by, whenever possible, replacing a communication in one cell by one that is higher and to the left. We link this matrix to the vignettes to show where in this matrix common self-care activities and patient-clinician communication are situated.

**Numerical tasks are displayed vertically in order of difficulty with colors indicating related numerical tasks of approximately similar level of difficulty. We emphasize that the ordering of difficulty is only approximate. The categories are roughly as taught sequentially in schools and as described by educators.[49]*

†Problem-solving is the ability to decide which numerical or logical concepts to employ in order to find a solution.

‡Logic: the understanding of logical operators such as and, or, not.

§Estimation of error/uncertainty, variability: e.g. understanding measurement differences, such as glucose of 101, 99, 102 do not indicate significant clinical differences in blood sugar; or that with a weight of 220 lbs one day and 230 lbs the next day, such large variability indicates a probable error in measurement.

‖ Relative versus absolute indicates the need to be able to understand and compare absolute and relative changes, particularly when absolute values are small. In V4, the patient must comprehend relative compared with absolute weight.

¶V1 = Vignette #1

top left cells. More complicated tasks like estimating size and problem-solving (determining the appropriate mathematical concept to employ) are further down.

Low on Text Box 1 and Table 1 is the numerical concept most frequently studied in health communication: risk, the probability of a bad outcome.[39,48,51,52] Indeed, all preventive care revolves around risk reduction.[40,50,52] Concepts like the standard gamble, time trade-off, and number-needed-to-treat were developed to facilitate understanding of risk, but are themselves difficult to understand.[39,40,42,43,53–55] Changes in risk are sometimes presented as relative values without absolute quantities. This may be particularly hard to understand when the absolute quantities are small. For example, a patient advised to take a medication to reduce the chance of a bad outcome by 50% may not understand that the absolute risk is only 0.4% per lifetime.

In Table 1, the hierarchy of numerical concepts is depicted vertically, and the depth of comprehension needed by patients to apply these skills to describe, interpret, or make decisions is depicted horizontally. It is similar to a model of assimilation and synthesis of medical information used in medical student education.[56] We hypothesize that patient autonomy and shared decision-making can be improved by replacing a communication in one cell by one that is higher and to the left.

TECHNIQUES TO IMPROVE COMPREHENSION OF QUANTITATIVE INFORMATION

Recommended techniques fall into six groupings and include: simplification, clear formatting, omission of distracting information, appropriate framing, use of visuals, and confirmation.

Simplify the Numerical Concept

Simplifying means explaining the concept by moving as far as possible upward and to the left in the model presented in Table 1. For example, in Vignette 4, recommending that the patient lose 14 lbs rather than 5% of his weight replaces a numeracy task of deriving a percentage with the easier task of reading/telling numbers. In addition, a statement that “even a 5% weight loss will improve health” leaves the patient in the second column of interpreting rather than in the first column of describing. Such simplification does not negate the obligation to provide more detailed and complete information for those who want it.

Format for Clarity

Use of white space and simple prose captions to accompany the numerical message is recommended for all documents to ease reading. Studies indicate that employing larger rather than the smaller numbers to represent more desirable scores facilitates understanding. Thus, for a scale of 1 to 5, 5 should represent the desirable score rather than 1.[7,57] Furthermore, tables and graphs should present the most important information first and the least important last to highlight key information and to improve understanding.[7]

Remove Nonessential Information

The presence of distracting information makes any text more difficult to use.[7,58] The key is to understand what information is critical and what is extraneous.

Frame Effectively

Framing describes the packaging or presentation of information and influences its interpretation.[6,52] Patients tend to underestimate common risks and overestimate rare risks.[52] The depiction of risk as 1 in 10 may be understood differently from a risk of 10 in 100.[51] Furthermore, patients’ interpretation of risk tends to be biased toward an outcome presented in a positive versus negative light, i.e., risk of chemotherapy posed as the probability of living rather than of dying.[6,59–62] A patient may not understand the significance of a cholesterol level of 160 mg/dl, until told that 160 is within the normal range of 112–200 mg/dl. Even well-educated clinicians may be influenced by framing.[52] Forensic psychologists and psychiatrists were less likely to discharge a patient when told *20 out of every 100* similar patients were estimated to commit an act of violence, compared with being told that such patients have a *20% chance* of committing an act of violence.[63] When numerical information, such as risk, is unfamiliar, reliance on framing increases and will increasingly determine which information is used in making decisions.

For communicating risk and probability, numbers rather than words are associated with a more accurate perception. Words without numbers like the words few, some, and many do not have precise meaning.[62,64] However, interpretive framing that uses explanatory phrases along with numbers can enhance communication and increase trust in the physician and belief in the health information.[65–67]

Another consideration relates to the value of framing issues within a time period. The time frame used influences risk perception.[51,68] For example, one study found that older women preferred a 10-year time frame and younger women resonating more with a 1-year time frame.[51] Framing, if used wisely, provides context and supports recipients in finding meaning in the numerical message.[52,62,67]

Use Visuals

Visuals, including tables, graphs, formatted boxes in essays, and pictures, enhance understanding.[69,70] The choice of image influences interpretation of numerical concepts and, thus, must be tailored to the patient, the numerical concept, and the health message.[69,70] For example, in Figure 1 the identical lifetime risk of breast cancer for a 50-year-old woman was displayed in different formats and presented to focus groups of women.[51,89] Figure 1a, a frequency graph with a clear numerator and denominator, was considered more understandable than the bar graph of Figure 1b, which does not provide a denominator. Denominators of 10 or 100 were easiest for focus group participants to understand, compared with larger denominators. Additionally, women tended to perceive larger risk for identical proportions if a smaller denominator was used, i.e., a 1/10 frequency graph was estimated to depict greater risk than 10 out of 100 or 100 out of 1,000. In Figure 1a human figures, an icon array,[69] were used to personalize information for women, although the focus

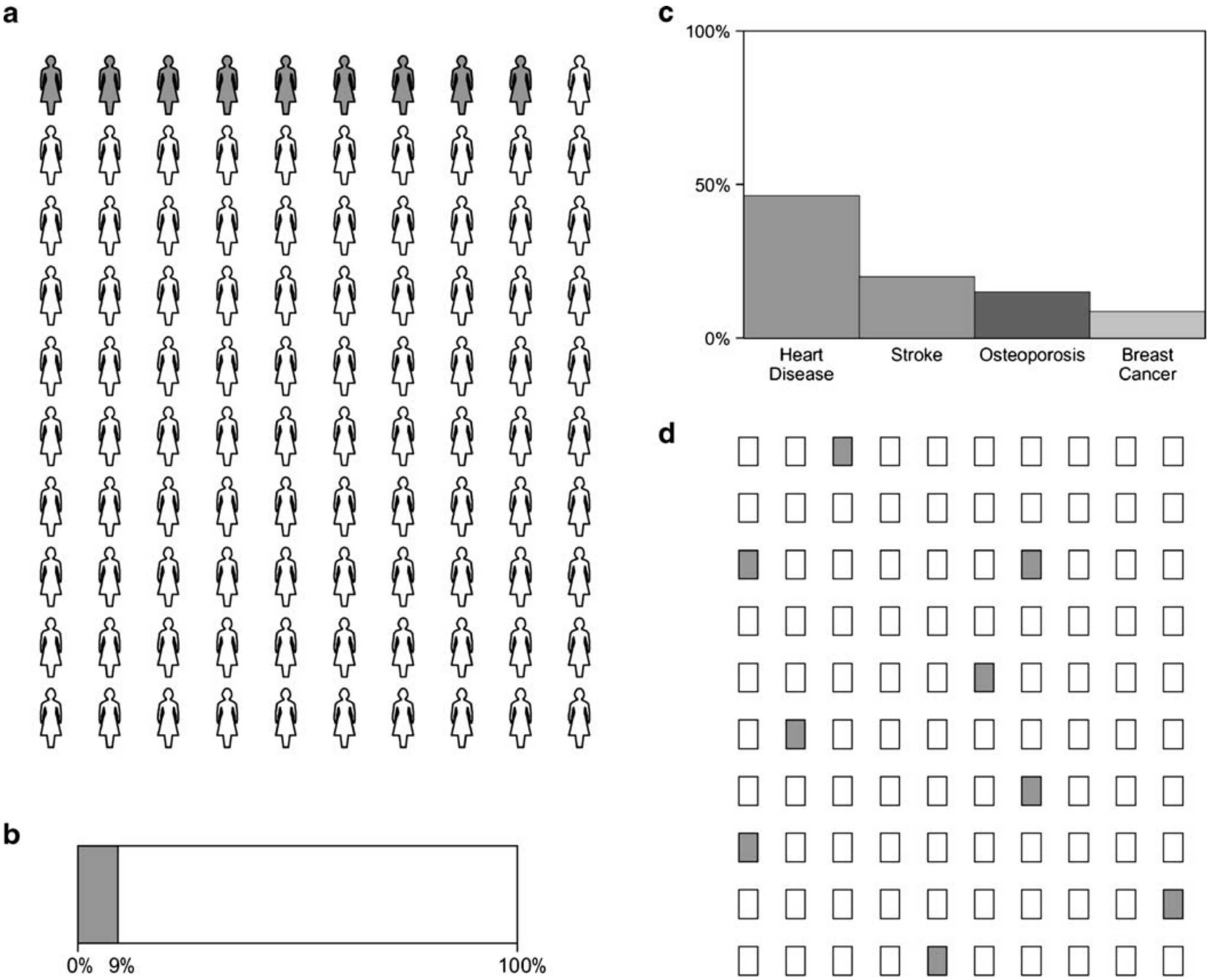

Figure 1. Examples of use of figures to convey the lifetime risk of breast cancer for a 50-year-old woman. (a) Risk is displayed as a frequency with a clear numerator and denominator. (b) This bar graph has no definite denominator; risk is displayed as a proportion rather than a frequency. (c) Multiple bar graphs depicting other comorbidities illustrates that bar graphs are an excellent format for making comparisons. (d) The random highlighting of the matrix makes it difficult to appreciate the numerator, but displays the idea of chance well. From Schapira MM, Nattinger AB, McAuliffe TL, The Influence of Graphic Format on Breast Cancer Risk Communication, *Journal of Health Communication* 2006;11:569–582, reprinted by permission of the publisher (Taylor & Francis, http://www.informaworld.com).[89]

group participants did not find the icon enhanced personal applicability.[51] The multiple bar graphs of Figure 1c depicting other comorbidities illustrates that bar graphs are an excellent format for making comparisons and depicting relative risk.[57] In Figure 1d the random highlighting was considered difficult to understand compared with consecutive highlighting (Figure 1a).[51] However, random arrays (Figure 1d) were useful in understanding chance in genetic counseling.[69]

The type of graph used can be determined by the data to be presented.[69–73] For example, part-to-whole concepts such as percentages may be emphasized with histograms and pie charts. Such formats display the denominator and may also convey relative versus absolute comparisons.[70] Line graphs are effective for communicating trends. Such trends can be distorted if the vertical scale is not representative of the true scale. Scatter plots effectively display variability.[70,74] The addition of brief captions and reference points enhances a graph's message.[52,62,70] Graphs also can distort, for example, when the numerator is displayed without the denominator.[69,75]

Pictographs have been found to improve attention and recall when they are closely linked to spoken directions or text,[71,72,76–78] and statistics presented as pictographs have been shown to reduce reliance on anecdotes and framing.[79] A study of an educational intervention to improve self-management of heart failure randomized patients to receive picture-based materials, a digital scale, and telephone follow-up. These patients had a lower rate of hospitalization or death than did those randomized to a general heart failure education brochure and usual care, and the effect was larger for patients

Table 2. Summary of Recommendations from the Literature for Presenting Numerical Concepts

Recommendation*
Use the fewest and simplest mathematical constructs[6,7,51,66] (e.g., highest and to the left on Table 1)
Remove nonessential information[7]
Order information from most to least important or along a discernible hierarchy[7]
Use several formats for presentation, e.g., verbal, quantitative, visual[7,52,57,66,67,71,77,79,91]
Consider using constructive framing or anecdotes[6,59–61,65–67,79,92]
Present benefits and risks, loss and gains, negative and positive[6,59–62]
Realize positive is more likely to be chosen[6,61]
Consider the best time frame for presenting risk[51,68]
When using graphs, use most appropriate format and explain it to the patient[52,57,69,70,72,73,79]
When applicable, show full denominator or full range of scale and explain both the numerator and denominator[51,69,70]
Tailor information to the patient[66,84]
Make communication interactive[46,66,77]
Reinforce important messages with repeat instruction[66]
Confirm comprehension[84]

*Superscripts indicate references

with low literacy.[80] Videos, interactive computer interfaces, and use of the internet all hold promise for use in patients with low literacy.[81]

Confirm Comprehension

A brief individualized assessment of numerical skill may be useful for tailoring teaching in the clinical setting, but clinical screening may be threatening to vulnerable patients. Furthermore, national studies such as the NALS and NAAL indicate that a majority of adults have limited quantitative skills. Consequently, we do not recommend clinical numeracy screening until it has been proven to benefit patients.[82] Instead, since all patients will benefit from simple explanations, we recommend that clinicians apply universal precautions (Table 2).[83] Furthermore, we should confirm comprehension of important numeric concepts with techniques such as the teach-back method.[84] This approach, asking a patient to state what will be done or what he or she will tell a family member, can be part of closing the encounter. Teach-back and other techniques noted above are helpful to all patients and particularly for those with limited numeracy.[7]

DISCUSSION

Limited numeracy is prevalent and may likely influence clinical outcomes. Increased awareness and training to help clinicians communicate successfully are important goals. To start, clinicians can use Tables 1 and 2 to guide simplification of their numerical communication.

National studies indicate that the gap in mathematics achievement between whites and blacks and Hispanics is even worse than in reading.[85,86] It is possible that health disparities in chronic disease management and for participation in screening are driven in part by poor education, particularly in mathematics. At the same time, while the concern for numeracy development is intensified for low-income populations, this concern must influence encounters with patients from middle and high income communities as well. Findings indicate that a majority of US adults do not have adequate numeracy and that K-12 mathematical instruction in the US does not prepare students for needed reasoning and problem-solving tasks.[87,88]

Focused clinical research is needed to better define the numerical concepts necessary for communicating health information and to delineate the best ways to measure and improve numeric communication. Conceptual models elucidating the pathways by which numeracy may be linked to health outcomes are needed to motivate further study. Table 1 can be considered a first approximation of such a model. The communication of numerical concepts must be studied in health-care settings, not simply in test-taking venues. It will be especially important to study patients from vulnerable populations to understand how removing unneeded complexity and improving communication around numerical concepts can decrease health disparities.[84]

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Corresponding Author: *Andrea J. Apter, MD, MA, MSc; Division of Pulmonary, Allergy, Critical Care Medicine, Department of Medicine, University of Pennsylvania, 829 Gates Building, 3600 Spruce Street, Philadelphia, PA 19104, USA (e-mail: apter@mail.med.upenn.edu).*

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