Journal of Diabetes Science and Technology
Volume 4, Issue 6, November 2010

EDITORIAL

Poor Numeracy: The Elephant in the Diabetes Technology Room

David Kerr, M.D.

Introduction

For people living with type 1 diabetes, the Holy Grail of a closed-loop artificial system, combining glucose measurement and insulin delivery without requiring input from the individual with the condition, remains elusive.[1] At present, the optimum approach appears to be a combination of insulin pump therapy and real-time continuous glucose monitoring.[2] However, despite patient acceptance of this technological approach to glucose control,[3] the majority of people still continue to use multiple daily injections (MDIs) of insulin. Whatever the method of insulin delivery, a fundamental component of training in intensive insulin therapy requires participants to be adept at handling numbers in order for them to understand the nuances of glucose monitoring and to calculate appropriate and safe insulin doses (**Table 1**).

Table 1.
Factors to be Taken into Consideration When Calculating a Mealtime Insulin Bolus

• Carbohydrate content of food
• Insulin-to-carbohydrate ratio
• Prevailing glucose level
• Target glucose level
• Correction factor for the prevailing level of glucose
• Effect of any remaining insulin from a previous bolus
• Less well-defined factors such as contribution from basal insulin, impact of meal content on gastric emptying, and variations in insulin absorption

In practical terms, "numeracy" is "the ability to understand and use numbers in daily life."[4] For individuals with type 1 diabetes using intensive insulin therapies, this skill requires them to be able to:

- Count
- Perform basic math functions (calculations)
- Use fractions, decimals, and percentages
- Understand graphs, tables, and measurements
- Decide when to use these skills (functional numeracy)

Therefore, difficulty in handling numbers is very likely to impact negatively on a patient's attempts to achieve optimum control of blood glucose levels. Difficulties in reading, writing, and listening will also have an influence on the ability of individuals to learn about diabetes and understand and manage the monitoring and treatment required of them on a daily basis. Unfortunately, educational material provided for patients with diabetes often has suboptimal readability, requiring literacy skills well above the average ability of many adults.[5] In addition, although many patients may have adequate literacy ability, they still may lack skills in numeracy necessary for many health-related tasks. Inability to apply effective numeracy skills can also lead to considerable anxiety in the individuals and their families.[6]

Author Affiliation: Centre of Postgraduate Medical Research and Education, Bournemouth University, and Bournemouth Diabetes and Endocrine Centre, Royal Bournemouth Hospital, Dorset, United Kingdom

Abbreviations: (HbA1c) hemoglobin A1c, (MDI) multiple daily injection

Keywords: literacy, numeracy, social networking

Corresponding Author: David Kerr, M.D., Centre of Postgraduate Medical Research and Education, School of Health and Social Care, Bournemouth University, Dorset, UK; email address: dkerrmd@gmail.com

J Diabetes Sci Technol 2010;4(6):1284-1287

In 2008 the U.K. House of Commons Public Accounts Committee reported, "that large numbers of the adult population of England are functionally illiterate and innumerate."[7] Similarly, in the United States, almost two in three adults cannot perform the most rudimentary of quantitative skills, and difficulties with numeracy may be an overlooked factor contributing to racial disparities in achieved glycemic control for people with diabetes.[8] There is also an inverse association between numeracy (but not literacy) and body mass index, which has important implications for weight management programs that require participants to monitor calorie intake and energy expenditure.[9] Poor numeracy has also been shown to have economic, social, and psychological impacts including higher rates of depression, low self-esteem, and the feeling of a lack of personal control.[10] In employment, numeracy, even more than literacy, has a powerful effect on earnings. People with poor numeracy also tend to leave full-time education at the earliest opportunity and usually without establishing qualifications.[11]

Measuring Numeracy and Literacy and the Impact of Low Levels of Numeracy

There are a number of tools available to measure numeracy and literacy, each with advantages and disadvantages, and these have been reviewed.[12,13] Using a specific test of diabetes-related numeracy (*www.mc.vanderbilt.edu/diabetes/drtc/preventionandcontrol/tools.php*), Cavanagh and colleagues[14] reported that low numeracy is common and associated with suboptimal diabetes knowledge, self-efficacy, and worse glycemic control compared to individuals with higher levels of numeracy. Of concern, in that study, almost one in four patients could not even determine what values for blood glucose were within a normal range.[14]

For patients with low levels of numeracy, there are additional difficulties with their perceptions of risk and the potential benefits of screening, medication compliance, and treatment assessment.[15] Low levels of numeracy may also increase an individual's risk of severe hypoglycemic episodes.[16] Within the diabetic population, the risk of premature death is also inversely related to educational achievement; this is mostly due to an excess of vascular disease.[17] Although clinicians approve of receiving notification of a patient's level of health literacy prior to a consultation, in practice they often do not test their patient's levels of recall and understanding when discussing new diabetes-related topics.[18,19] Providing numeracy- and literacy-focused education programs for adults with diabetes does improve self-efficacy and glycemic control, although the benefit attenuates with time.[20]

In a 2010 study,[21] we assessed numeracy and literacy skills in 112 randomly selected adults with type 1 diabetes using questions that focused on everyday subjects rather than diabetes *per se*. Literacy assessment focused on listening for details from texts, using correct grammar and spelling, identifying main points, and obtaining specific information from text. To evaluate numeracy, questions involved understanding measures; performing calculations; extracting and interpreting information from lists, bar charts, and diagrams; and handling data. In this study,[21] 75% of adults with diabetes had low literacy skills and 47% also had poor numeracy skills. Although literacy skill level was not associated with the prevailing level of glycemia, participants with poor numeracy had an average hemoglobin A1C (HbA1c) of 0.63% higher (confidence interval: -1.18 to -0.07) than those with better numeracy skills.[21]

The numeracy assessment identified problems with using decimals, recognizing and understanding fractions and percentages, selecting relevant information from charts, and converting units of measure as well as handling and comparing data. The literacy assessment also revealed that participants had difficulties in using correct grammar, spelling, and punctuation; listening and responding to spoken information; and inferring meaning from text.

These findings are relevant to existing programs providing structured education for individuals with diabetes and their families. The current emphasis on core subjects, such as teaching effective carbohydrate counting, may be of limited value if assessments of numeracy and literacy are not taken into account (**Table 2**).

A potential solution to overcome numeracy (and literacy) barriers would be for manufacturers of new devices to consider the following during device development and when creating the training materials associated with the product.[22] Computer-based algorithms and interactive multimedia programs, telephone and cell phone interventions, and medical records for learning and applying new technologies that take into account an individual's achieved level of numeracy and literacy in addition to native language, culture, and age. Other potentially useful technologies could include bolus calculators for patients using MDI therapy, systems for supporting behavior modification for overweight or obese subjects, and devices for supporting home

monitoring and care for those who live a distance from specialist centers (telemonitoring and Telehealth). However, for a message to be conveyed successfully, the words and meaning of what is said need to be understood in the context of the discussion.[23] When it comes to understanding diabetes technologies, it is unclear if the outcomes for patients would be different if the individuals using a device understood the nuances of the calculations embedded within a device or whether they need simply to accept the result provided by the machine.

Changes in consumer electronics have markedly altered the methods of communication and facilitated engagement between vast numbers of people that cross national, cultural, and political borders. The question is whether this type of communication can be applied effectively in diabetes care.

Social Networking

It is now very common for individuals to participate regularly in social networking, sharing information with the key elements of immediacy and peer support.[24] For example, in 2010, Facebook has 500 million active users, with 50% of them logging on every day. More than 150 million Facebook users access the site through mobile telephones.[25] On average, each user has 130 friends; is connected to 80 community pages, groups, and events; and creates 90 pieces of content each month (web links, news stories, blog posts, notes, and photo albums). Microblog systems, such as Twitter, also provide a vehicle for sharing of information and advice, with the potential for influencing patient concordance and affecting behaviour change.[26] Patients and health care professionals are already using social networking to share their experiences of investigation and treatment and for research networking and fundraising. Those living with any chronic disease are very likely to use blogging and online health discussions as a source of information.[27]

The value of social networking in overcoming numeracy and literacy barriers could involve:[28]

- Creation of specific groups of individuals with a common interest, using language specific for a peer group
- Immediate feedback after participation in training in the use of new devices
- Engagement with industries and individuals able to make important contributions outside of the normal circle involved in diabetes care

Table 2.
Numeracy Skills Involved in Carbohydrate Counting and Insulin Dose Adjustment

Measuring	Includes weighing foods in metric units, converting between metric units, and converting imperial units to metric units.
Multiplying and dividing	Using multiples of 10 with a carbohydrate portion system or dividing whole numbers by 100, such as using reference values for carbohydrates per 100 grams.
Using decimals	Multiplying and dividing decimals by 10 and 100. Rounding decimals to make estimates and knowing when to round the answer to give a more accurate total. Often a formula is presented in patient information packs to calculate the amount of carbohydrates in a food. This formula combines several concepts—multiplying and dividing, measuring using metric units, and rounding decimals—all in one step.
Recognizing and understanding fractions	Working out a fraction of a whole number (a share of a pizza or the squares from a bar of chocolate). In practice, understanding food labels requires the ability to understand and use fractions.
Working with ratios, proportions, and percentages	These are required for dose adjustment and recipe adaptation, interpreting HbA1c levels, and calculating percentage increase and decrease in insulin dosage.

- Providing practical and emotional support
- Accessing hard-to-reach communities

Problematic areas relate to confidentiality and urgency of the expected response to a message or Tweet and also the potential for professional members to post material that can have a negative impact on their patients' perceptions of them.[29] Worryingly, social networking is already being used as a vehicle for marketing tobacco products by companies that join and administer special-interest groups, join pages as fans, post photographs of their products, and sponsor events that circumvent existing advertising bans.[30] Device manufacturers may have concern about the unregulated nature of social networking and the potential for perpetuating "bad" advice in relation to their product.

The challenge for the diabetes health care community is to come up with an effective strategy to deliver better health care using the vast power of social networking. This may be another vehicle for providing information that overcomes the barrier of limited skills in numeracy and literacy, which until now means that a large tranche of the diabetic population are not receiving the benefit that technology has to offer.

Acknowledgments:

The author thanks Sarah Marden from the Royal Bournemouth Hospital for providing information on numeracy needs for carbohydrate counting.

References:

1. Harvey RA, Wang Y, Grosman B, Percival MW, Bevier W, Finan DA, Zisser H, Seborg DE, Jovanovic L, Doyle FJ, Dassau E. Quest for the artificial pancreas: combining technology with treatment. IEEE Eng Med Biol Mag. 2010;29(2):53–62.
2. Rubin R, Peyrot M. Treatment satisfaction and quality of life for an integrated continuous glucose monitoring/insulin pump system compared to self-monitoring plus an insulin pump. J Diabetes Sci Technol. 2009;3(6):1402–10.
3. Van Bon A, Kohinor M, Hoekstra B, von Basum G, DeVries J. Patients' perception and future acceptance of an artificial pancreas. J Diabetes Sci Technol. 2010;4(3):596–602.
4. Rothman R, Housam R, Weiss H, Davis D, Gregory R, Gebretsadik T, Shintani A, Elasy TA. Patient understanding of food labels: the role of literacy and numeracy. Am J Prev Med. 2006;31(5):391–8.
5. Kerr D. Information in diabetes care: is there a need to dumb down even more? Diabetic Med. 2007;24(5):561–3.
6. Rothman R, Montori V, Cherrington A, Pignone M. Perspective: the role of numeracy in health care. J Health Commun. 2008;13(6):583–95.
7. House of Commons Public Accounts Committee - Third Report. Skills for Life: Progress in Improving Adult Literacy and Numeracy. Available from: http://www.publications.parliament.uk/pa/cm200809/cmselect/cmpubacc/154/15402.htm. Accessed September 24, 2010.
8. Osborn C, Cavanaugh K, Wallston K, White R, Rothman R. Diabetes numeracy. An overlooked factor in understanding racial disparities in glycemic control. Diabetes Care. 2009;32(9):1614–9.
9. Huizinga M, Beech B, Cavanaugh K, Elasy T, Rothman R. Low numeracy skills are associated with higher BMI. Obesity. 2008;16(8):1966–8.
10. Parsons S, Bynner J. Does numeracy matter more? National Research and Development Centre for adult literacy and numeracy, Institute of Education, London; 2005.
11. Department of Education and Employment. A Fresh Start – Improving Literacy and Numeracy. CMBS 1 (The Moser Report). London; 1999.
12. Boren S. A review of health literacy and diabetes: opportunities for technology. J Diabetes Sci Technol. 2009;3(1):202–9.
13. Powers B, Trinh J, Bosworth H. Can this patient read and understand written health information? JAMA. 2010;304(1):76–84.
14. Cavanaugh K, Huizinga M, Wallston K, Gebretsadik T, Shintani A, Davis D, Gregory R, Fuchs L, Malone R, Cherrington A, Pignone M, DeWalt D, Elasy T, Rothman R. Association of numeracy and diabetes control. Annals Intern Med. 2008;148(10):737–46.
15. Reyna V, Nelson W, Han P, Dieckmann N. How numeracy influences risk comprehension and medical decision making. Psychol Bull. 2009;1359(issue):943–73.
16. Sarkar U, Schillinger D. Does lower diabetes-related numeracy lead to increased risk for hypoglycemic events? Annals Intern Med. 2008;149(8):594.
17. Dray-Spira R, Gary-Webb T, Brancati F. Educational disparities in mortality among adults with diabetes in the US. Diabetes Care. 2010;33(6):1200–5.
18. Schillinger D, Piette J, Grumbach K, Wand F, Wilson C, Daher C, Leobg-Grotz K, Castro C, Bindman A. Closing the loop. Physician communication with diabetic patients who have low health literacy. Arch Intern Med. 2003;163(1):83–90.
19. Seligman H, Wang F, Palacios J, Wilson C, Daher C, Piette J, Schillinger D. Physician notification of their diabetes patients' limited health literacy. A randomized controlled trial. J Gen Intern Med. 2005;20(11):1001–7.
20. Cavanaugh K, Wallston K, Gebretsadik T, Shintani A, Huizinga M, Davis D, Gregory R, Malone R, Pignone M, DeWalt D, Elasy T, Rothman R. Addressing literacy and numeracy to improve diabetes care. Two randomized controlled trials. Diabetes Care. 2009;32(12):149–55.
21. Marden S, Knott J, Thomas P, Kerr D. Impact of numeracy and literacy on achieved glycaemic control in type 1 diabetes. Diabetic Med. 2010. (Forthcoming).
22. Marden S, Kerr D. Numeracy and insulin pump therapy. Diabetic Med. 2010:27(6):730–1.
23. Reach G. Linguistic barriers in diabetes care. Diabetologia. 2009;52(8):1461–3.
24. Chou W, Hunt Y, Beckford E, Moser R, Hesse B. Social media use in the United States: Implications for health communication. J Med Internet Res. 2009;11(4):e48.
25. Available from: http://www.facebook.com/press/info.php?statistics. Accessed September 14, 2010.
26. Scanfeld D, Scanfeld V, Larson E. Dissemination of health information through social networks: Twitter and antibiotics. Am J Infect Control. 2010;38(3):182–8.
27. Farmer A, Brucker-Holt C, Cook M and Hearing S. Social networking sites: a novel portal for communication. Postgrad Med J. 2009;85(1007):455–9.
28. King J, Davis L, Guntzviller L. Utilization of internet technology by low-income adults: the role of health literacy, health numeracy and computer assistance. J Aging Health. 2010;22(7):804–26.
29. MacDonald J, John S, Ellis P. Privacy, professionalism and Facebook: a dilemma for young doctors. Med Educ. 2010;44(8):805–13.
30. Freeman B, Chapman S. British American Tobacco on Facebook: undermining article 13 of the global World Health Organization Framework Convention of Tobacco Control. Tobacco Control. 2010;19(5):e1–9.