Journal of Diabetes Science and Technology
Volume 4, Issue 4, July 2010

ORIGINAL ARTICLES

An Analysis of Data Management Tools for Diabetes Self-Management: Can Smart Phone Technology Keep Up?

Elizabeth Ciemins, Ph.D., M.P.H., M.A.,[1] Patricia Coon, M.D.,[1] and Christopher Sorli, M.D.[2]

Abstract

In this issue of *Journal of Diabetes Science and Technology*, Rao and colleagues present a comparison of three iPhone diabetes data management applications: the Diamedic Diabetes Logbook, Blood Sugar Diabetes Control, and WaveSense Diabetes Manager. These applications provide patients the ability to enter blood glucose readings manually, view graphs and simple statistics, and email data to health care providers. While these applications show promise, they are limited in their current forms. All require manual data entry and none convert insulin-to-carbohydrate ratios to insulin dose. Future development of these types of technology should consider integration with blood glucose meters and expanded calculation capabilities, as well as monitoring of other risk factors, e.g., blood pressure and lipids, and tracking of preventive examinations, e.g., eye, foot, and renal.

J Diabetes Sci Technol 2010;4(4):958-960

Diabetes is a leading cause of mortality and morbidity in the United States and a major contributor to deaths due to heart disease and stroke.[1] In 2007, nearly 8% of the population had diabetes. Adding those individuals with prediabetes, the number increases to more than a quarter of the population. In 2007, medical costs and reduced work productivity associated with diabetes were estimated at $218 billion.[2] In their 2010 article in *Health Affairs*, Dall and colleagues noted, "[t]his diabetes burden represents a hidden 'tax' in the form of higher health insurance premiums and reduced disposable income."[2]

While there is no cure for diabetes, extensive research has resulted in approaches for clinical management and prevention.[3–8] The American Diabetes Association[9] and American Association of Clinical Endocrinologists[10] have developed rigorous guidelines and recommendations for diabetes treatment and management. Effective patient blood glucose self-monitoring remains a crucial component of diabetes management. Patient monitoring, particularly among patients on insulin,[11,12] is important in limiting disease progression, but can be labor-intensive, costly, and cumbersome to share with health care providers (HCPs).[9,10]

Over the past several decades, health technologies have successfully aided patients in diabetes self-management, e.g., blood glucose monitoring. The first blood glucose meter was released in 1970, and several portable,

Author Affiliations: [1]Billings Clinic Center for Clinical Translational Research, Billings, Montana; and [2]Billings Clinic Diabetes Center, Billings, Montana

Abbreviations: (HCPs) health care providers, (WDM) WaveSense Diabetes Manager

Keywords: blood glucose self-monitoring, diabetes self-management, health information technology, iPhone

Corresponding Author: Elizabeth Ciemins, Ph.D., M.P.H., M.A., Research Director, Billings Clinic Center for Clinical Translational Research, 2800 Tenth Avenue, Billings, MT 59107; email address eciemins@billingsclinic.org

economical meters followed. Meters were initially designed for the physician's office, but quickly became available for in-home monitoring by patients. Patients initially recorded their blood glucose readings in paper logbooks, but improved meter technology resulted in the ability to upload data onto personal computers via a cable or wireless connection. With the Internet came the ability to share results with HCPs electronically, often automatically.

New technology continues to create opportunities for consumers to be involved in their diabetes management and their health care in general. Personal health accounts are now available on Google™ and other Internet sites, electronic health records can be accessed by patients through Web portals, cell phone and text messaging interventions have demonstrated success,[13,14] and health maintenance programs can be downloaded for use on smart phones and other handheld data devices.

One such popular device is an iPhone or iPod Touch on which it is possible to download various health-related applications. In this issue of *Journal of Diabetes Science and Technology*, Rao and colleagues[15] evaluated three top user-rated applications: the Diamedic Diabetes Logbook, Blood Sugar Diabetes Control, and WaveSense Diabetes Manager (WDM). They examined self-reported ease of use, including time to enter data, requests for help, self-reported feature preferences, desired future features, data sharing, and application trustworthiness. They did not examine clinical outcomes. Their survey sample consisted of 23 individuals. The authors do not indicate how participants were recruited. The authors reported that patients found the WDM to be easiest to use, fastest, most trustworthy, and requiring the fewest requests for help. This study, however, lacked scientific rigor and results should be considered preliminary. In addition, even in a pilot study, clinically meaningful end points, e.g., increased testing compliance, behavior change, and medication adherence, should be included.

The applications are limited in that they require manual entry of blood glucose data, which requires significant patient effort and time commitment. For the majority of patients who use meters and upload data directly onto personal computers, usually with the help of HCPs, these applications offer few advantages. Uploaded meter data can be graphed, analyzed statistically, and shared with providers via email or hard copies during office visits. Existing meters are enabled to use adapters that allow them to communicate with the iPhone and meters currently in development will be able to send data wirelessly and automatically to HCPs following blood glucose testing, e.g., the bant iPhone app, the University Health Network and SickKids Hospital, Toronto. All medical device connections to smartphones (hard wired and wireless) are pending regulatory approval. Currently, there are wireless cell phone-based monitoring systems that interface with several models of glucose meters,[14,16] offering preferred automated data entry.

In their discussion, the authors note this limitation but do not discuss future plans to allow synchronization of the WDM to blood glucose meters or Web-based servers, nor whether multiple meter types could be used. Several diabetes meters are available on the market and many are provided free to consumers. An application that could synchronize with any brand meter would be ideal, similar to the aforementioned cell phone technologies.

A second major limitation to these applications is that they do not use inputted data to help patients determine daily insulin requirements based on carbohydrate intake at meals or adjust basal insulin by protocol. The patient must rely on hand calculations based on insulin-to-carbohydrate ratios provided by HCPs or diabetes educators. Automated insulin dose calculations, based on inputted insulin-to-carbohydrate ratios and carbohydrate intake data, could improve these applications greatly. Protocol-driven basal insulin adjustment capability would also be desirable. Factoring in individual lifestyle behaviors, e.g., exercise, could further refine calculations.[17] Meter technology currently has the ability to calculate and, in the case of insulin pumps, administer the correct patient-specific insulin dose.

For the minority of patients currently transferring data from meters to paper logbooks, these applications may offer some advantages. By entering data into the handheld device, patients have the capability to identify out-of-range values quickly and easily and to examine blood glucose trends over time, including average readings. However, without a meaningful clinical end point, there is little incentive for patients to enter data dually. Once in the device, data can be emailed to a HCP or certified diabetes educator for review. Ideally, HCPs should be able to respond to patients easily, manually as well as through automated alerts to assist patients with management strategies. For example, a reminder to check fasting blood sugars daily would be useful for patients adjusting their basal insulin dose. Failure to check could trigger a notification to patient and provider, followed by an email from the provider. Automatic hypoglycemia alerts could be used to assist HCP-directed reductions in oral medications, e.g., sulfonylureas.

From a patient's perspective, we found the WDM to be the easiest of the three applications to use in terms of data entry, graphing, and statistical reporting. Compared to viewing paper logs or meters, these applications offer an advantage to providers in terms of ease of viewing data and receipt of emailed reports. However, individuals who use paper logbooks may be doing so because they are averse to using computer technology in general or they enjoy the aesthetic of a tangible paper record.

Currently, type 2 diabetes is a disease of older individuals. As the younger, technology-savvy generation ages and develops chronic conditions such as diabetes and as cell phones are replaced by smart phones, use of such technologies will become increasingly relevant. For diabetes management, efficient use of these devices should include the ability to monitor other cardiovascular risk factors, such as high blood pressure and lipids, as well as to cue patients to complete recommended preventive examinations, e.g., eye, foot, and renal. Health maintenance applications for weight loss, chronic disease management, including hypertension and heart failure, and receipt of necessary preventive examinations, e.g., mammograms and colonoscopies, would further enhance patient health self-management. The diabetes blood glucose monitoring applications reviewed by Rao and colleagues[15] represent an important first step in moving toward integration of diabetes patient self-management with the latest smart phone technology, but need to keep pace with current blood glucose meter technology, which greatly surpasses the current state of these applications.

References:

1. Centers for Disease Control and Prevention Department of Health and Human Resources. National diabetes fact sheet; 2007.
2. Dall TM, Zhang Y, Chen YJ, Quick WW, Yang WG, Fogli J. The economic burden of diabetes. Health Aff (Millwood). 2010;29(2):297-303.
3. The Diabetes Control and Complications Trial Research Group. The effect of intensive treatment of diabetes on the development and progression of long-term complications in insulin-dependent diabetes mellitus. N Engl J Med. 1993;329(14):977-86.
4. UK Prospective Diabetes Study (UKPDS) Group. Intensive blood-glucose control with sulphonylureas or insulin compared with conventional treatment and risk of complications in patients with type 2 diabetes (UKPDS 33). Lancet. 1998;352(9131):837-53.
5. Knowler WC, Barrett-Connor E, Fowler SE, Hamman RF, Lachin JM, Walker EA, Nathan DM; Diabetes Prevention Program Research Group. Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. N Engl J Med. 2002;346(6):393-403.
6. Ohkubo Y, Kishikawa H, Araki E, Miyata T, Isami S, Motoyoshi S, Kojima Y, Furuyoshi N, Shichiri M. Intensive insulin therapy prevents the progression of diabetic microvascular complications in Japanese patients with non-insulin-dependent diabetes mellitus: a randomized prospective 6-year study. Diabetes Res Clin Pract. 1995;28(2):103-17.
7. ADVANCE Collaborative Group, Patel A, MacMahon S, Chalmers J, Neal B, Billot L, Woodward M, Marre M, Cooper M, Glasziou P, Grobbee D, Hamet P, Harrap S, Heller S, Liu L, Mancia G, Mogensen CE, Pan C, Poulter N, Rodgers A, Williams B, Bompoint S, de Galan BE, Joshi R, Travert F. Intensive blood glucose control and vascular outcomes in patients with type 2 diabetes. N Engl J Med. 2008;358(24):2560-72.
8. Tuomilehto J, Lindström J, Eriksson JG, Valle TT, Hämäläinen H, Ilanne-Parikka P, Keinänen-Kiukaanniemi S, Laakso M, Louheranta A, Rastas M, Salminen V, Uusitupa M; Finnish Diabetes Prevention Study Group. Prevention of type 2 diabetes mellitus by changes in lifestyle among subjects with impaired glucose tolerance. N Engl J Med. 2001;344(18):1343-50.
9. American Diabetes Association. Standards of medical care in diabetes--2009. Diabetes Care. 2009;32 Suppl 1:S13-61.
10. The American Association of Clinical Endocrinologists Medical Guidelines for the Management of Diabetes Mellitus: the AACE system of intensive diabetes self-management--2002 update. Endocr Pract. 2002;8:40-82.
11. Bergenstal RM, Johnson M, Powers MA, Wynne A, Vlajnic A, Hollander P, Rendell M. Adjust to target in type 2 diabetes: comparison of a simple algorithm with carbohydrate counting for adjustment of mealtime insulin glulisine. Diabetes Care. 2008;31(7):1305-10.
12. Jovanovic L. Using meal-based self-monitoring blood glucose (SMBG) data to guide dietary recommendations in patients with diabetes. Diabetes Educ. 2009;35(6):1023-30.
13. Krishna S, Boren SA. Diabetes self-management care via cell phone: a systematic review. J Diabetes Sci Technol. 2008;2(3):509-17.
14. Katz D, Nordwall B. Novel interactive cell-phone technology for health enhancement. J Diabetes Sci Technol. 2008;2(1):147-53.
15. Rao A, Hou P, Golnik T, Flaherty J, Vu S. Evolution of data management tools for managing self-monitoring of blood glucose results: a survey of iPhone applications. J Diabetes Sci Technol. 2010;4(4):949-57.
16. Carroll AE, Marrero DG, Downs SM. The HealthPia GlucoPack Diabetes phone: a usability study. Diabetes Technol Ther. 2007;9(2):158-64.
17. Curran K, Nichols E, Xie E, Harper R. An intensive insulinotherapy mobile phone application built on artificial intelligence techniques. J Diabetes Sci Technol. 2010;4(1):209-20.