Diabetes management has evolved with the presence of smartphones, offering a plethora of applications, or “apps,” to assist technologically savvy users. This rapidly growing field of mobile apps has hosted a multifarious selection ranging from novice startup software to programs designed for professional use. This article reviews some crucial factors for consideration when seeking to optimize diabetes management via smartphone.

Evaluation and Evolution of Diabetes Mobile Applications: Key Factors for Health Care Professionals Seeking to Guide Patients

According to statistics from 2011, the American Diabetes Association (ADA) estimates that 25.8 million children and adults in the United States have type 1 or type 2 diabetes.\textsuperscript{1} Diabetes poses a heavy economic burden on the U.S. health care system, with estimated associated costs in 2007 of $174 billion.\textsuperscript{1} Proper patient education and management are pivotal because diabetes is a progressive disease that leads to macro- and microvascular complications, including heart disease, stroke, hypertension, nephropathy, and neuropathy.

With the advent of smartphones, patients are increasingly using mobile technology through automated text messages and various applications, or “apps,” to monitor their disease states. Myriad mobile apps with various features for diabetes management are now available, and the growing number of technologically savvy patients with diabetes has ratcheted up the use of these programs.

Several randomized studies have reported on the effectiveness of diabetes management using mobile app interventions.\textsuperscript{2} One such study\textsuperscript{3} revealed that using a smartphone app for diabetes management resulted in a statistically significant improvement in A1C in adults with type 2 diabetes.

To encourage the efficient management of diabetes and maximize the benefits of mobile apps, it is crucial for health care professionals (HCPs) to recognize and assess the needs of each patient. Patients’ age, app cost, and app-specific features are key factors for HCPs to consider when recommending apps for diabetes self-management.

Factors for Consideration

Patient demographics

In 2010, an estimated 10.9 million people > 65 years of age and 215,000 people < 20 years of age in the United States had diabetes.\textsuperscript{1} The diversity among people with diabetes imposes a challenge for HCPs to identify and address the needs of each patient, including those related to patients’ age.

In the fast-paced and evolving world of technology, younger populations are often highly proficient with and adaptable to smartphones. As a result, mobile apps for Apple iOS (used in the iPhone, iPad, and iPod Touch) and Android operating systems have overwhelming popularity. More than 500 million Apple iOS and Android devices have been activated since 2007.\textsuperscript{4}

Many software development agencies have identified the growing market in mobile apps and are developing apps to target individual disease states. A recent study\textsuperscript{5} showed that a smartphone glucose monitoring system had significant potential for improving glucose management for adolescents with type 1 diabetes.

However, people with diabetes who are > 55 years of age and did not grow up immersed in advanced technological systems may face challenges in adopting app-based mobile technologies for diabetes management.
Although mobile apps typically are not designed to appeal to older populations, some easy-to-use apps may still be worth considering for older patients.

Technology costs
The initial cost of obtaining and activating a smartphone may be a significant barrier for patients considering mobile apps to aid in managing their diabetes. The latest version of popular smartphones using the Android or Apple iOS operating system, without a wireless service contract, can cost $500–700 per device.6

Wireless networks subsidize the cost of smartphones by setting up contracts, alleviating much of the initial burden by offering previous-generation models of popular phones (i.e., phones that are one model earlier than the latest version) for a fraction of their original price. A study by a mobile tracking service7 reported that the average selling price for smartphones fell to a relatively affordable $135 in 2011. Decreasing phone prices may be one factor contributing to the estimation that nearly one in seven people worldwide are now using a smartphone.

Smartphone owners have access to an extensive selection of mobile apps. Depending on the apps’ specific features, app prices vary from free to $50.

Initial fees associated with smartphone devices, service contracts, and apps may seem costly, but such investments could benefit patients by providing daily reminders and motivation for self-managing their health. Managing diabetes via mobile apps can be a practical means of improving patient adherence to glucose targets and health care goals.

Platform varieties
It has been estimated that > 322 million people in the United States owned a smartphone in 2012.8 Platforms currently available include Apple iOS, Android, RIM BlackBerry, Symbian, and Windows.9 As of February 2013, Android and Apple iOS are the dominant platforms in the U.S. market. A keyword search for “diabetes” conducted in April 2013 identified > 650 available apps for Apple iOS and > 1,600 for Android.

According to the market research firm Manhattan Research, > 75% of physicians use Apple iOS devices, which had the highest number of available health-related apps in 2012.10 Although a majority of physicians prefer Apple iOS apps, it is important to recognize that many of those apps are not available for other platforms. HCPs must explore popular apps for different operating platforms to provide recommendations appropriate for patients’ specific smartphones.

Ease of use
Diabetes self-management requires patients to self-monitor medication adherence, carbohydrate intake, exercise, and blood glucose levels. HCPs want to encourage patients to self-manage their health and provide them with tools to help achieve optimal control of their diabetes. For patients to maximize apps as resources, it is crucial that the apps are easy to use.11

HCPs should recommend apps that are commensurate with patients’ comfort level with technology and tailored to patient-specific needs. Some apps are designed with simple, easy-to-use features, whereas others offer a multitude of features for technologically savvy populations. Ease of navigation, logging, data modification, note-taking, and time-tracking should be considered based on each patient’s knowledge of technology. Patients should be encouraged to continue using a new app for at least a couple of weeks before deciding whether it will work for them. Navigating through an app may become easier in time, as proficiency improves with repetition.

App Features

Blood glucose logging
Self-monitoring of blood glucose (SMBG) is recognized as an important tool for guiding management strategies and decision-making for both patients and HCPs.12 Historically, patients have used paper log books to document their blood glucose values and report their findings to HCPs at their next scheduled appointment. Advances in blood glucose meters and mobile technology have empowered patients to record blood glucose values electronically on the go.

The ADA recommends that patients whose medication regimen includes multiple daily insulin injections or who use insulin pumps test and record their blood glucose ≥ 3 times daily.13 Recording blood glucose values using an app that logs results may alleviate some of the burden of carrying a hard copy recording system. Some apps offer additional advantages, such as graphic displays of SMBG trends to help identify and correct hypoglycemic events linked to medications, food, diet, and exercise (Figure 1).

Nutrition databases and carbohydrate tracking
Monitoring carbohydrate and caloric intake is imperative to maintain optimal glycemic control because food directly affects blood glucose levels and the amount of insulin a person needs.14 Unhealthy food choices and large portions may lead to out-of-range blood glucose levels. Patients may benefit from using apps to help them improve their nutritional choices and monitor their carbohydrate intake.

Many apps include a feature that allows users to search food databases by typing or scanning bar codes for specific nutritional data that can be saved to the smartphone. For example, apps such as Diabetes Buddy, Diabetes Log, and Track3 offer extensive databases, allowing users to quickly look up nutritional information, including carbohydrate content and calories. Calorie Counter by MyNetDiary offers target-planning and goal-setting to help users manage their weight and caloric intake with advice from a registered dietitian.15 A comprehensive database is also available specifically to guide people with diabetes.
recent study found that patients ing to achieve their fitness goals. One be useful as a constant reminder to weight loss using a smartphone may new ideas for fitness may aid weight Apps that allow users to track their weight loss has been shown to improve self-management through chronicity is an important feature transfer out of the device. Data syn- collocated often do not automatically data into a file that can be shared with HCPs. Obvious benefits of this technology are that it can make data-sharing more frequent and is paperless. Apps such as iBGStar Diabetes Manager App & Glucose Meter (Apple iOS) and OnTrack (Android) allow users to e-mail data to HCPs and family members. Additionally, use of a device such as iBGStar may allow for effective blood glucose measurement and logging with a single multi-use device, reducing the inconvenience associated with using multiple devices. Monitoring changes in blood glucose using a smartphone may be convenient for patients, but the data collected often do not automatically transfer out of the device. Data synchroization is an important feature because it allows HCPs to have an accurate snapshot of their patients’ glycemic control. A 2010 study found that diabetes management apps capable of seamlessly sharing SMBG data with HCPs are likely to benefit patients. HCPs in the study were able to rapidly visualize trends and make adjustments to medication therapy regimens, thereby improving health outcomes. Telcare, the first U.S. Food and Drug Administration (FDA)-approved, wireless-capable glucose meter, transfers data to a private online database that patients, family members, and HCPs can access. Family members may also receive text messages each time users check their blood glucose levels. Apps such as Diabetes Guardian (Apple iOS) allow parents to closely monitor their child’s blood glucose levels from a distance, alleviating the stress of not knowing the state of their child’s condition. Maintaining close communication with HCPs, friends, and family is likely to result in better monitoring and management of diabetes. Likewise, the ability to share data and communicate with friends or other people with diabetes is another feature that may entice patients to use smartphone apps. Apps that offer such features can foster a sense of connection and serve as a virtual social support system, which may further improve diabetes self-management. It has been documented that acquiring new knowledge and information through mutual exchange of experiences occurs more effectively when such exchanges involve peers with whom individuals identify and share common experiences. Through interaction with other app users, patients may become more aware of the importance of diabetes management and learn more pragmatic and efficient ways to control their diabetes. Short message service and reminders Short message service (SMS), also known as text messaging, has become an integral form of communication and can be useful in promoting adherence because it does not require a high level of technological expertise. Apps with incorporated SMS are widely used to remind patients when to administer insulin and to encourage regular blood glucose logging. A meta-analysis identified common design elements of text messaging for diabetes data collection, including blood glucose levels, diabetes facts, and tailored messages based on individual characteristics and goals. For effective diabetes management, apps should also provide the ability to remind users to take medications at appropriate times throughout the day. More than $300 billion are spent annually for complications associated with patients failing to take their medications properly. SMS alerts could potentially reduce such costs. Guidelines and Regulations The market for health care–related apps nearly doubled in 1 year, from $718 million in 2011 to $1.3 billion in 2012. This rapid growth of the mobile app industry has raised some concerns regarding the lack of regulation for health monitoring apps. In some cases, apps may not comply with evidence-based guidelines or may contain outdated information. In 2011, the FDA issued draft guidelines for mobile medical apps, including those used as an accessory to a regulated device, those that transform mobile devices into medical devices, and those intended for use with a medical device connected to a smartphone. In the past few years, the FDA has approved multiple diabetes management apps, including WellDoc, Glooko, and Telcare. Unfortunately, most apps on the market are not approved by the FDA because they are exempt from regulation as outlined in the draft guidelines. Even so, the FDA has published its intention to monitor the performance of all apps to protect public health. HCPs should review smartphone apps that their patients intend to use because it is likely that the market of new health care apps will be too saturated for close FDA monitoring. Precautions for Patients Patients should be advised that smartphone apps may be used as helpful tools but should not be a substitute for regular check-ups or follow-ups with HCPs. Because many apps are developed by programmers who may not be in the health care field, apps sometimes contain outdated or inaccurate information. In addition, patients who use virtual social support features on mobile apps should be warned not to rely heavily on comments or advice from other users. HCPs may also encourage patients to notify them if they notice any sig-
significant fluctuations in weight, blood glucose, or medication tolerance. Patients whose medical care is covered by the Centers for Medicare and Medicaid Services should be advised to continue recording their blood glucose readings on a physical paper copy because electronic copies from beneficiaries are not currently recognized by this payer.

Summary and Conclusion
Diabetes is a chronic illness that requires vigilant monitoring and management of glycemic fluctuations through medication, diet, and exercise. Patients diagnosed with diabetes are often challenged by the need to incorporate these various monitoring components into their daily lives. The recent emergence of mobile technology in the health care field has made diabetes self-management apps available. These smartphone apps can allow for more accurate and convenient self-monitoring. Evidence of the benefits of smartphone apps in health care is mounting as researchers conduct and publish studies evaluating these new tools.

HCPs must evaluate a wide array of factors before recommending mobile apps for their patients with diabetes (Figure 2). First, they should assess their patients’ comfort level and proficiency with mobile technology. In general, elderly patients may require a longer period of time and more experience to become accustomed to apps and may be reluctant to use mobile technology for diabetes management. In contrast, patients with advanced technological proficiency may prefer apps. The cost associated with smartphones and apps is also an integral factor. Not all diabetes management apps are free, and the costs may pose additional financial burdens for patients. HCPs also must be aware of the different types of platforms available to consumers. Most importantly, they should tailor their recommendations to apps that address each patient’s particular areas of difficulty in managing diabetes.

It is important to discuss overall goals to gain an understanding of what each patient hopes to gain by using a smartphone app. For example, some apps focus on tracking blood glucose, whereas others also include carbohydrate-tracking features. Patients’ expectations should help to guide HCPs in recommending an app that best fits their lifestyle and health condition.

Patients may prefer certain apps to others based on their ease of use. The availability of other important features, such as reminders via text messages, data-sharing with HCPs, and compatibility with medical devices, is also a consideration.

The FDA recently developed draft guidelines for mobile medical apps in three categories: those that are used as an accessory to a regulated device, those that transform a mobile platform into a medical device, and those that are intended to use with a medical device connected to a smartphone. Unfortunately, most diabetes management apps on the market do not fit into these categories and thus remain unregulated. These could potentially provide inaccurate information that is unsupported by clinical evidence.

The smartphone app market is becoming inundated with hundreds of health care apps as technology advancements continue. As smartphones have become more affordable and user-friendly, the number of smartphone owners has continued to grow in all age-groups. It is incumbent on HCPs to appropriately tailor their app recommendations to individual patients and to guide patients in selecting the most useful and reliable apps to meet their needs.

Factors to Consider for Diabetes Management Application

<table>
<thead>
<tr>
<th>Patient</th>
<th>Device and Application</th>
</tr>
</thead>
</table>
| • Familiarity with technology  
  - Older generation less likely to be technologically savvy  
  - Financial burden  
  - Can the patient afford device and applications? | • Platform  
  - Apple iOS, Android, Blackberry, Symbian, Windows  
  - Not all mobile applications are available for all platforms  
  - Ease of use  
  - Easy to navigate, enter, modify, retrieve, and share data?  
  - Application features  
  - Logging and tracking  
  - Blood glucose logging  
  - Nutrition and carbohydrate tracking  
  - Physical activity and weight tracking  
  - Data sharing and social support  
  - SMS and reminders  
  - Guidelines and regulations  
  - Does the application follow established guidelines?  
  - Is the mobile application FDA-approved?  
  - FDA draft guidelines do not apply to all mobile applications |

Figure 2. Factors to consider when recommending a diabetes management app to patients.

References


Ryan A. Ristau, BS, and Jessica Yang, BA, are doctorate in pharmacy candidates, and John R. White, Jr., PA-C, PharmD, is a professor and interim chair of the Department of Pharmacotherapy at Washington State University College of Pharmacy in Spokane.