Diabetes is a unique chronic disease in which the decisions most affecting the health and well-being of patients are made by the patients themselves. This is the crucial reason that technologies that target patient/consumer engagement and behavior change are making a large impact on diabetes-related health outcomes. Numerous studies have confirmed the difficulty patients have with adherence to diabetes regimens. Thankfully, new technologies have been created to improve a variety of the specific difficulties that have been noted in relation to nonadherence to diabetes regimens. These technologies are often called “consumer-facing technologies,” in that they are hardware or software products that a business’ customers deal with directly.

This article highlights a variety of consumer-facing technologies that encourage glucose pattern management, motivate patients to perform self-monitoring of blood glucose (SMBG), organize SMBG data, and motivate patients to lose weight—all behaviors that have been shown to have significant effects on health outcomes for people with type 2 diabetes. Theories of patient engagement and health behavior change involving consumer-facing technologies will also be discussed in terms of their effects on type 2 diabetes–related health outcomes.
diabetes education at all.\textsuperscript{7,8} Many patients, and indeed their providers, are not aware that these services are available.

Nonetheless, physician-extender technologies have been recently developed to address this need. A recent study\textsuperscript{9} showed how related health outcomes in adults with insulin-dependent type 2 diabetes can be affected by the growing use of glucose monitoring within a system of communication technologies (e.g., Internet, telephone, mobile phone, and Bluetooth) that track and transmit blood glucose results for assistance with pattern management. This randomized, controlled trial showed a 1.9\% decrease in A1C in the intervention group who used a mobile phone–based remote monitoring and insulin-dosing coaching system called Diabetes Manager (WellDoc, Wilmington, Del.).

The Diabetes Manager system is an example of successful telemonitoring. Telemonitoring systems have been developed with the goals of improving outcomes and reducing the high costs associated with chronic diseases such as heart disease and chronic obstructive pulmonary disease. However, the results of previous trials were inconsistent, largely because of the diverse interventions under investigation and varying study designs.\textsuperscript{10–12} There remains a lack of insight into the features required for successful telemonitoring solutions. Yet, a systematic review of 17 studies of telemonitoring interventions in adults with diabetes showed that telemonitoring was consistently found to have a positive effect on clinical outcomes and a positive impact on patient and clinician behavior.\textsuperscript{13}

Technologies that Motivate Patients to Perform SMBG

In a study of insulin-using patients with type 2 diabetes, SMBG alone (without using its results to adjust therapy) was shown to lead to better health outcomes.\textsuperscript{14} However, sustained engagement is difficult.

Fogg's Behavior Model (FBM),\textsuperscript{15} used frequently by consumer technology designers to sustain engagement with their online or mobile platforms, is now being applied to health technologies to sustain engagement with positive health behaviors such as performing SMBG. Within this model, three elements (motivation, ability, and trigger) must converge at the same moment when patients use a technology for a health behavior or outcome to occur. The model includes three core health behavior motivators (pleasure, hope, and acceptance); six health behavior ability factors that make the behavior simple to execute (time, money, physical effort, brain cycles, social deviance, and non-routine); and three health behavior triggers that remind users to perform the health behavior (spark, facilitator, and signal).

The EndoGoal application (or “app”), developed by the author, is one example of a consumer-facing mobile app (Figure 1). Its goal is to create sustained positive health behaviors for people with type 1 and insulin-requiring type 2 diabetes by incorporating the three elements of the FBM. The main behavior focus of the EndoGoal app is self-entry glucose journaling, which can lead to financial rewards upon achievement of the designated goal of performing SMBG four times daily.

A motivating gaming feature that is a vital part of the EndoGoal app is a virtual pet dog named Cooper who is fed each time users check their glucose but remains hungry when they do not. This feature is similar to the well-known Japanese Tamagotchi digital pet toy that needed to be fed every 3 hours and involved user engagement based on appointment dynamic game mechanics theory. The ability feature of the EndoGoal app, as well as an additional motivating feature now under development, is the rewards points program that drives daily SMBG behavior and engagement and translates directly into prepaid Visa cards and purchasing power with several leading retailers. The trigger features in the app include individualized alarm reminders set by users, as well as barking reminders from the virtual dog, who will be hungry if an SMBG result has not been entered.

Enrollment in a clinical trial with 250 users, funded through crowdfunding, is ongoing. The study hypothesizes that engagement with the app will directly correlate with improved health outcomes for people with type 1 or insulin-requiring type 2 diabetes.\textsuperscript{16}

Bant is another diabetes-related mobile app for iPhones that similarly adheres to the FBM and uses an iTunes rewards system to which teens have been receptive. In a pilot study involving adolescents with type 1 diabetes, Bant use resulted in a 50\% improvement in daily average frequency of blood glucose engagement. However, A1C did not change significantly.\textsuperscript{17} Future studies are planned for adults with type 2 diabetes.

The benefits of SMBG for patients with insulin-requiring type 2 diabetes are clear.\textsuperscript{18} However, there is no consensus regarding the optimal frequency and timing of SMBG for patients with type 2 diabetes who do not take insulin. A meta-analysis of daily SMBG testing in noninsulin-treated patients with type 2 diabetes concluded that some SMBG regimens were associated with an A1C reduction of 0.4\%.\textsuperscript{19} However, many of the studies in this analysis were confounded by interventions that also included patient education with diet and exercise counseling and, in some cases, pharmacological intervention, thereby making it difficult to assess the specific contribution of SMBG to improved control. The cost-effectiveness and clinical
utility of daily blood glucose testing for patients with non-insulin regimens has also been questioned in several randomized trials. Therefore, it is unclear whether the above-mentioned technologies would affect health outcomes in patients with type 2 diabetes who are not on insulin therapy.

Technologies That Organize SMBG Data
Polonsky et al. showed that people who use organized glucose data, or “structured data,” gained more confidence in their diabetes care, used fewer test strips, and achieved lower A1C levels. With structured blood glucose monitoring, research subjects were taught to write down events that could affect their blood glucose control, such as exercise and changes in diet, along with blood glucose results from seven significant points—before and 2 hours after eating and at bedtime. The subjects and their health care providers were then taught how to interpret the SMBG data and identify patterns to best address any issues with their diabetes control.

The concept of structured monitoring is closely related to pattern management. Structured monitoring puts patients in charge of their diabetes, whereas mindless monitoring is just another job they must perform on top of all the other work diabetes requires of them. Following are a few examples of Food and Drug Administration–approved technologies that provide platforms for structured organization of blood glucose testing results to be presented to health care providers.

- **iBGStar** (Sanofi-Aventis, Bridgewater, N.J.) is an iPhone-specific glucose meter that provides structured data by connecting the meter to the iPhone to better organize the data through the accompanying iBGStar app.
- **Glooko** (Glooko, Palo Alto, Calif.) is a cable cord product that provides structured data by connecting a variety of different glucose meters directly to smartphones with an accompanying Glooko app.
- **Diabetes Pal** (Telcare, Bethesda, Md.) is a glucose meter that provides structured data via wireless transmission to the Diabetes Pal smartphone app, which provides space for recording food, medication, or other comments to be used for pattern management.

Technologies That Motivate Patients to Lose Weight
Traditional standard-of-care counseling methods for type 2 diabetes prevention and weight loss are primarily based on providing health knowledge only, without a theoretical base and in a fairly non-engaging manner. However, engaging interactive media technologies are now being used to complement the delivery of health care and education. These technologies have been shown to be beneficial in permanently changing over-nutrition–related behavior, which is strongly correlated with type 2 diabetes development, compared to delivery of health knowledge only through standard-of-care nutrition education programs in an obesity clinic.

One example is the ongoing Project Not Me study, which is assessing 300 adults with prediabetes in Pennsylvania and Tennessee. Project Not Me is a public-private collaboration among UnitedHealth Group, YMCA, Comcast, and the Centers for Disease Control and Prevention–led National Diabetes Prevention Program (NDPP). Its aim is to show that sustained health behavior change can occur through an intervention that engages patients by providing ongoing access to health information and weekly coaching via a reality-style TV show. Its hypothesis is that participants’ similar experiences will help them to achieve outcome goals similar to those demonstrated in the Diabetes Prevention Program: a nearly 60% reduction in risk for type 2 diabetes brought about by participants’ loss of 5–7% of their body weight and achievement of 150 minutes per week of moderate physical activity.

For 16 weeks, weekly episodes of the reality TV show can be viewed through Comcast TV’s On Demand service. The show follows six people who are at high risk for developing type 2 diabetes and who are following a diabetes prevention intervention designed by the NDPP. The show documents the subjects’ emotional ups and downs, physician visits, family tensions, and efforts to lose weight.

In addition to viewing the TV show, Project Not Me provides online tools that correspond to the show to help viewers follow the same healthy steps undertaken by the six people followed in the show. Participation in the 12-month study is free and includes 16 weeks of TV show episodes, as well as weekly evaluations and coaching by the research team for the first 5 months. Participants also receive at the time of enrollment an electronic scale and information about mobile tracking or journaling apps, as well as mobile-integrated pedometers to track their physical activity. Participants are reassessed after 12 months. However, the TV show is available to anyone who wants to view it through Comcast On Demand.

Project Not Me hopes to demonstrate that people who are more engaged in daily decisions that affect their health and wellness can work to achieve a better health outcome and live a healthier life. More information about the study is available online at projectnotmedp.com.

When compared to face-to-face interaction and knowledge-based methods alone, interactive media technologies that incorporate a specific theoretical base in their design are a more comprehensive and influential method of influencing behavior. Project Not Me, for example, applies both social cognitive theory and technology to lifestyle-based diabetes prevention.

Social cognitive theory defines human behavior as a triadic, dynamic, and reciprocal interaction of personal factors, behavior, and the environment. According to this theory, individuals’ overall behavior is uniquely determined by the interplay among these three factors and is largely regulated through cognitive processes. Social cognitive theory also proposes that individuals’ knowledge acquisition, and thus behavior regulation, can be directly related to observing others within the context of relatable social interactions, experiences, and outside media influences. Thus, this theory can be easily applied in informative, interactive media platforms to influence overall health behavior.

Conclusion
Consumer-facing technologies that encourage individualized patient engagement specific to type 2 diabetes therapies and prevention are clearly in keeping with the recent American Diabetes Association/
References

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