Challenges in Diabetes Care: Can Digital Health Help Address Them?

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IN BRIEF There is great enthusiasm for the potential of digital health solutions in medicine and diabetes to address key care challenges: patient and provider burden, lack of data to inform therapeutic decision-making, poor access to care, and costs. However, the field is still in its nascent days; many patients and providers do not currently engage with digital health tools, and for those who do, the burden is still often high. Over time, digital health has excellent potential to collect data more seamlessly, make collected data more useful, and drive better outcomes at lower costs in less time. But there is still much to prove. This review offers key background information on the current state of digital health in diabetes, six of the most promising digital health technologies and services, and the challenges that remain.

"Digital health" refers to the convergence of health care and technology. In diabetes, it is defined specifically by connected devices gathering data, by software and apps making those data useful, and by the emergence of new care models that use technology to improve the outcomes of a chronic disease. Digital health per se is not new, but driven by the ubiquity of mobile devices and data, it can equip providers with better information, make patients' lives simpler, and offer payers lower costs and better results. The possibilities are significant, but the results are far from guaranteed.

The digital health field has seen tremendous growth in recent years. According to Rock Health, a seed and early-stage venture fund, digital health financing surpassed $4.5 billion in 2015, up from $4.3 billion in 2014 and more than doubling from $1.8 billion in 2013 (1). Projections for 2017 estimate funding to total >$6 billion (2). In 2015 alone, five digital health companies have gone public (Fitbit, Teladoc, Invitae, MindBody, and Evolent Health), generating a total valuation of >$11 billion.

This growth speaks to the potential of digital health, which has, perhaps prematurely, been characterized as the next "elixir" for health care. Yet, there is some basis to these high expectations. After all, digital solutions can help with many large and complex problems in diabetes: too many patients, too few providers, infrequent contact with health care providers (HCPs), inconsistent data, increased spending, and outcomes that are not improving at a satisfactory rate.

The purpose of this article is to explore how digital health could affect the future of diabetes care. This report is organized into two sections. Part 1 analyzes some of the most pertinent challenges in diabetes care today. The section is wide-ranging and touches on a number of health care gaps that require solutions. Part 2 provides a review of six of the most promising digital health technologies and services in diabetes. Our assessment discusses how each

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digital health solution is positioned to address the challenges outlined in Part 1. We also provide specific examples of the solutions currently available and the key questions and challenges ahead.

Ultimately, we believe it is still relatively early for digital health in diabetes. There is much to prove. For example, few patients own diabetes devices that connect to the Cloud, and for those who do, the data often overwhelm both them and their HCPs. Better analytics could make the data more useful, but the technology is not there yet for diabetes. Most current digital applications ("apps") add burdens for patients and offer little in return.

Still, we are cautious optimists about the potential for digital health to make a difference in diabetes. Although these products will not be a solution for everyone, we think the confluence of connectivity, software, and new care delivery models has tremendous potential to improve outcomes at lower costs.

Part 1. Current Challenges in Diabetes Care

Worsening Patient-to-Provider Ratios

In 2012, 29.1 million people in the United States, or ~9% of the population, had diagnosed or undiagnosed diabetes. The Centers for Disease Control and Prevention estimates that, by 2050, this figure could double to 21–33% of the U.S. population (3). The diabetes incidence rate is expected to nearly double in the same time period, from 8 cases per 1,000 people in 2008 to 15 cases per 1,000 in 2050 (3). We have a crisis on our hands.

Unfortunately, the number of U.S. HCPs cannot sustain this growth in patients. In 2011, 4,841 U.S. board-certified adult endocrinologists were in clinical practice, representing an estimated shortage of 1,500 endocrinologists based on patient demand (4).

The situation is even worse for nonendocrinologists (particularly primary care providers), who supply 85% of diabetes care (4). For this group, an estimated shortage of up to 45,000 primary care providers is expected by 2020 (5). If the prevalence of diabetes continues to increase, the supply and demand gap for HCPs is expected to widen considerably.

Geographical Barriers to Accessing Care

Provider shortages disproportionately affect people with diabetes in rural areas. In the United States, those living outside of cities have, on average, less access to specialists (e.g., endocrinologists and ophthalmologists), must travel farther to the nearest health care facility, and have worse self-reported health status. Although 25% of the U.S. population lives in rural areas, only 10% of practicing U.S. providers reside in these areas, and the disparity is even greater for specialists such as endocrinologists (6). Some patients must drive several hours to the nearest city to see an endocrinologist or primary care provider.

Patient Burden

In no other disease are patients required to give themselves a potentially fatal drug, yet >30% of all diabetes patients, including all who have type 1 diabetes, must do that every day with insulin. Although data vary on the number of hospitalizations for severe hypoglycemia, all such estimates are alarmingly high. Studies estimate that there were 20,839 hospitalizations in 2009 for hypoglycemia in patients with type 1 diabetes, and another 248,422 hypoglycemia hospitalizations in type 2 diabetes patients (7,8). Diabetic ketoacidosis is also a life-threatening risk, leading to >140,000 hospitalizations in the United States each year.

Diabetes also places other significant daily demands on patients, from glucose monitoring to carbohydrate counting. One study (9) showed that people with diabetes spend an average of 58 min/day on self-care. Assuming that patients live for 50 years with diabetes, 58 min/day translates to a full 2 years devoted exclusively to their disease. Another study (10) found that, if type 2 diabetes patients followed every self-care recommendation made by the American Diabetes Association (ADA), they would have >2 hours of extra work per day. According to data from diabetes market research company dQ&A (11), in a panel of 5,410 patients, 21% called diabetes "job #1" in their life.

Provider Burden

The chronic nature of diabetes also adds burdens on HCPs, who are often flying blind when it comes to understanding what is happening with patients' blood glucose levels. A1C, the most commonly used metric to assess glucose control, only provides an average blood glucose measurement for the previous 3 months, with no indication of the actual high and low glucose levels or their frequency—in short, no indication of how high a patient's risk actually is—during that period. At best, HCPs can get A1C measurements from patients four times per year.

Time is also of the essence. According to the 2010 National Ambulatory Medical Care Survey (12), the average general and family practice visit was 19.3 minutes, leaving little time for providers to analyze reams of data and review patients' various needs.

Economic Burden

The ADA estimates that the United States spent >$322 billion on diabetes (diagnosed and undiagnosed), gestational diabetes, and prediabetes in 2012, a 48% increase since 2007, including $244 billion in medical costs and $78 billion from reduced productivity (13). In particular, the cost of prediabetes rose 74% during this 5-year period, whereas the cost of undiagnosed diabetes increased 82%. At the individual level, the annual cost of diabetes in 2012 was $10,970 per diagnosed patient, translating to ~$1,000 for each American (14). The ADA estimates that people with diagnosed diabetes, on average,

have medical expenditures ~2.3 times higher than patients without diabetes (15). Moreover, in 2008, the Agency for Healthcare Research and Quality reported that diabetes hospital fees amounted to $83 billion, representing 23% of total hospital spending (16).

No Improvement in A1C Outcomes

Health outcomes for patients are not improving. Recent data for adults with self-reported diabetes from the government-funded National Health and Nutrition Examination Survey show that only ~50% of diabetes patients achieve an A1C <7.0%, whereas one in seven has out-of-control blood glucose with an A1C >9.0% (17). These results compare to 58% of patients with an A1C <7% from 2003 to 2006, and 52% from 2007 to 2010. Of course, A1C does not capture the full extent of patient outcomes; other outcomes, such as the incidences of major complications (17), have significantly improved in the past two decades. Ultimately, though, these A1C data show that improvements in patient outcomes do not necessarily mirror increases in funding or major advances the field has made on the science and technology fronts.

Part 2. Can Digital Health Solutions Help to Address Some of These Challenges?

The remainder of this article explores how digital health could affect the future of diabetes care. In the following discussion, we have broken down digital health products and services into six categories: *1*) Cloud-connected glucose monitoring systems, *2*) data management platforms, *3*) telehealth services, *4*) type 2 diabetes digital prevention programs, *5*) mobile apps, and *6*) social media. These categories do not constitute an exhaustive list, but we do believe they have potential to address the previously described challenges.

Cloud-Connected Glucose Monitoring Systems

Overview

Cloud-connected glucose meters and continuous glucose monitoring (CGM) devices can automatically transmit glucose readings from devices to smartphone apps or Web-based platforms ("the Cloud"). Such devices enable data to be distributed and viewed on multiple devices (e.g., smartphones, smartwatches, and tablets) via mobile and Web-based apps. They also reduce the hassle of using cables and software to download data by allowing wireless or cellular data transfer. A handful of connected glucose monitoring products have been launched in the past few years, and many more are expected. Currently, very few patients use such devices, but they are expected to become more widely adopted as their prices fall and their utility increases.

A few examples of available Cloud-connected CGM devices at the time of publication include the Dexcom Share, Dexcom Gen 5, Medtronic MiniMed Connect, and Nightscout (an open-source system). Cloud-connected glucose meters include the Roche Accu-Chek Connect, LifeScan VerioSync and Verio Flex, iHealth Align, LabStyle Dario, Sanofi iBGStar, Livongo for Diabetes, and Telcare.

How Cloud-Connected Systems Can Help

Reducing provider burden. These devices can lead to more efficient and effective clinic visits. With automated transfer to apps and online software, glucose data will be more easily accessible during appointments—not lost or forgotten at home or siloed in the meter. Diabetes is a data-driven disease, and Cloud-connected devices can equip providers with information to make decisions.

The focus of these devices is on uploading the device data and providing automated statistics and graphic displays. Over the next few years, automated algorithms will increasingly help providers identify trends that may otherwise go unnoticed or be hard to find (e.g., "the patient is consistently low in the afternoon"). Such decision-support algorithms have the potential to reduce the burden of deciphering glucose data and titrating insulin; they may also help make appointments more efficient and inform therapeutic recommendations.

Improving clinical outcomes. There are few rigorous data tying Cloud-connected devices to improved clinical outcomes. The hope is that such devices can bring better data to HCPs, informing more targeted and accurate therapeutic changes. Such devices may also tighten feedback loops between data collection and action—a historical challenge in diabetes—leading to improved outcomes.

Reducing economic burden. Cloud-connected systems can enable remote population management (e.g., systems that allow providers to monitor patients remotely) that can avoid costly hospitalizations or unnecessary trips to the clinic. Although clinical trials have not yet been conducted to document real-world savings in diabetes, the potential of proactive management is already garnering interest. Glooko has launched the Population Tracker, a Web-based software program that alerts providers when patients are experiencing risky high and low blood glucose trends. Patients remotely upload their blood glucose information to the Cloud-based platform using the company's mobile app, and the Population Tracker aggregates the data in a single dashboard. This system can help payers and health systems identify patients who are in trouble before a severe event occurs, which would lead to obvious cost savings. Such remote population management rests on patients actually uploading their glucose data and care managers looking at the dashboard, both of which are made easier with Cloud-connected glucose monitoring devices.

Challenges and Unanswered Questions

- Will Cloud-connected technology actually make providers' lives easier? Will the data be more overwhelming than useful?
- How will Cloud-connected systems integrate with electronic medical record systems and clinical workflow?
- Will Cloud-connected devices improve clinical outcomes? Can companies prove that they will?
- Will Cloud-connected diabetes devices be more expensive than traditional devices? Will patients, providers, and payers be willing to pay more for them?
- How long will it take for better algorithms to become available to make data easier to understand and interpret?

Telehealth Services

Overview

"Telehealth" refers to services in which patients and providers exchange health information through electronic communication (e.g., via video calls or text messaging). Often, the patients are located at their local (often rural) health center or home, and the HCPs are based at a more distant (often urban) health center. After such visits, which can be as short as 15 minutes, providers can prescribe medication remotely.

To date, telehealth services target acute care (e.g., cold and flu or skin issues), with the exception of some psychology visits. Whether companies will expand to treat chronic conditions remotely remains an open question.

Telehealth is a rapidly expanding health care industry; it is expected to expand tenfold by 2018 (18), generating up to $4.5 billion compared to $440 million in telehealth revenue in 2013. Given that 58% of U.S. adults now use a smartphone and 87% use the Internet, telehealth can provide several benefits particularly related to chronic illnesses such as diabetes (19).

A few examples of telehealth services at the time of publication include Doctor on Demand, Teladoc, Health Tap, MDlive, American Well Corporation, and Livongo Health.

How Telehealth Services Can Help

Lowering costs. Telehealth services can reduce the costs of transportation and lost productivity because patients who use them do not need to take time off or travel long distances to visit a health care center. These services can reduce equipment and hospitality costs for inpatient services, as well as costs associated with readmissions. In one matched control study, chronic illness patients placed on the telehealth-based Health Buddy Program were compared to those on standard treatment (20). Those in the intervention group had average health care spending reductions of 7.7–13.3% per person per quarter. Another study estimated that adding telehealth equipment to all national nursing homes specifically could save $479 million annually in reduced transportation costs (21). Indeed, as much as 33% of all ambulatory care visits in the United States could potentially be treated via telehealth (22). This research is relatively nascent, and some studies have found negative cost-benefit effectiveness of telehealth interventions, but, if optimized, telehealth certainly has potential for bringing about significant cost reductions.

Improving patient-to-provider ratios. Traditionally, patients have been limited to the medical care available within their personal provider network (e.g., a personal primary care provider or endocrinologist and local urgent care clinics). This, of course, limits the supply of available providers. Research shows that the average wait time for an initial non-urgent consultation in endocrinology is 37 days, compared to 15 days for cardiologist consultations (4). Telehealth expands the number of available providers at any given time, regardless of location, allowing patients to get immediate access to an HCP outside of their personal provider network. Although there are concerns that telehealth visits may provide worse patient experiences, multiple studies demonstrate significant patient satisfaction with telehealth delivery services, and a recent online Harris poll of 2,019 adults found that 64% of patients are willing to have video visits with their provider (23).

Expanding geographical access. As noted above, access to endocrinologists and quality health care can be a problem, particularly for patients in rural areas. Telehealth provider visits can enable patients to gain immediate access to needed specialty care. Moreover, such services provide patients more choice for their HCPs, which can be especially relevant for patients of minority backgrounds with specific needs (i.e., those who may need a bilingual provider).

Reducing provider burden. Telehealth services have strong potential to reduce providers' administrative workload. Telehealth companies can handle the paperwork and reimbursement procedures associated with medical visits, allowing providers to focus on patients. Teledoc, for example, reports that it handles provider reimbursement electronically twice per month, and its providers make 50% more than the average full-time provider based on hourly salaries (22). Telehealth services allow providers to take patient visits outside of normal office hours (i.e., on weekends or while on vacation), allowing them to increase the time spent with patients (and likewise their own income) at times that are most convenient for them.

Improving clinical outcomes. The clinical benefits of telehealth interventions need further study, particularly with regard to specific diseases such as diabetes. A meta-analysis (24) of 29 peer-reviewed articles on telehealth interventions found that these interventions led to "moderate, positive, and significant" effects on clinical

outcomes, but noted that these benefits were not realized in diabetes care specifically. A 2013 study of youth with poorly controlled type 1 diabetes (25) found no significant difference in A1C reduction between a Skype-based intervention and face-to-face intervention, suggesting equivalent outcomes through this more accessible care delivery format.

Challenges and Unanswered Questions

- Will telehealth work for diabetes and other chronic conditions? Will companies expand in this direction, or will they limit efforts to acute health issues?
- Can telehealth tools gain widespread patient and provider adoption? If so, how long will it take?
- How will telehealth services be reimbursed?
- Will the ease and convenience of telehealth lead to overuse?
- Will telehealth services become a primary source of health care, or will they complement in-person visits?
- How important is continuity of care (i.e., seeing the same provider over time rather than seeing a new provider at any given moment)?
- How will telehealth handle diabetes medications? When is it safe to prescribe medication without physically examining a patient?

Data Management Platforms

Overview

Data management platforms are electronic systems that download and consolidate data from blood glucose meters, CGM devices, insulin pumps, and even fitness trackers into a single, standardized report. Data from these devices have historically resided in proprietary, company-specific software, whereby data from one device can only be downloaded to one type of software. These information silos can serve as barriers to providers and patients who want to download, aggregate, and interpret relevant health data (26). The ultimate vision is for disparate devices to all have the ability to transmit data automatically to a single unified platform, in which information can be combined, displayed intuitively, analyzed, and interpreted by patients and providers.

A few examples of data management platforms at the time of publication include Diasend, Glooko, and Tidepool.

How Data Management Platforms Can Help

Reducing patient burden. The vast majority of patients with diabetes do not upload their diabetes devices, losing the benefit of highly valuable data that could improve care (27). Tidepool CEO Howard Look has described the uploading process as "crawling through broken glass blindfolded," given the time it takes, the proprietary cables and software needed, and the overall frustration level (28). Recent data have shown that only a tiny minority of patients with type 1 diabetes routinely download and review their device data (27); indeed, only 31% of adults report *ever* downloading data from one or more devices, and only 12% of those patients actually review their data regularly (27). Clinical trials have not rigorously examined whether better data management platforms will increase this percentage, but intuitively, making it easier to upload and display together data from various sources should reduce the burden on patients.

Reducing provider burden. Uploading data from diabetes devices is also a struggle for providers. Although estimates vary, multiple studies and key opinion leaders have suggested that a majority of providers do not regularly download or review diabetes data (29). This is concerning because it is impossible to make fully informed therapeutic decisions without such data. Platforms that make downloading and reviewing data easier and faster can help providers and reduce the burden of managing such data.

Improving clinical outcomes. Few studies have examined whether data management solutions are correlated with improved clinical outcomes. However, it makes intuitive sense that such platforms should increase awareness of blood glucose trends and motivate patients to make timely adjustments in their diabetes care regimen instead of waiting for typically infrequent provider appointments. Although this benefit is theoretical for now, we are hopeful that research will emerge to support it.

Challenges and Unanswered Questions

- Even with more convenient software, will data management platforms be widely adopted by patients and providers?
- How important is data downloading to the average patient?
- Will data management platforms improve clinical outcomes in practice? If so, what is needed to achieve this?
- How will providers be reimbursed for time spent reviewing patients' data?
- What is the best business model for data management companies?

Digital Type 2 Diabetes Prevention Programs

Overview

There are several digital type 2 diabetes prevention programs targeted at people with prediabetes. These use the curriculum from the landmark Diabetes Prevention Program (DPP), which focused on lifestyle coaching and education regarding weight loss, healthy eating, exercise, and other healthy lifestyle behaviors to reduce the risk of developing type 2 diabetes (30). These products take the DPP to the digital setting, either in individualized or community-based approaches. The goal is to take a successful in-person clinical trial and scale it more cost-effectively via digital tools, allowing coaches to serve many more patients than costly in-person programs.

A few examples of digital prevention programs at the time of publication are Omada Health's Prevent, Canary Health's Virtual Lifestyle Management, and Noom Health's Coach.

How Digital Prevention Programs Can Help

Improving clinical outcomes. Omada Health's Prevent program has the longest follow-up data today; it reported 2-year data in April 2015 (31). The results demonstrated that participants who completed Prevent lost an average of 4.9% of their initial body weight after 1 year and largely maintained that weight loss (4.3%) after 2 years. On average, participants completing Prevent reduced A1C by 0.40% at 1 year and by 0.46% after 2 years. Although these results show promise, it is not yet clear whether such programs can reduce the incidence of type 2 diabetes on a population level, particularly in the long term.

Reducing economic burden. Previous research has shown that diabetes prevention programs, particularly when conducted in group settings, may lead to a decrease in overall health care costs compared to the absence of such intervention. According to Anderson et al. (32), the intensive individual counseling model of the DPP costs roughly $1,400 per participant. In community-based settings, these costs are significantly reduced to $275–$325 per participant. Digital interventions can further reduce costs by eliminating incremental spending associated with in-person programs and expanding access to those who are not in close proximity to an in-person program.

Challenges and Unanswered Questions

- Will digital prevention programs demonstrate long-term, sustained, clinically meaningful improvements?
- How will these programs scale to help the 86 million Americans with prediabetes?
- Will maintaining patient adherence and engagement be problematic for online programs?
- What about those without access to a smartphone or computer?
- Is the potential for a weight loss of ~5% enough to encourage patients to participate?
- How can these programs affect childhood obesity and type 2 diabetes in youth?
- Who will pay for patients to participate in such programs?

Clinically Validated Mobile Apps

Overview

Mobile phones, and particularly smartphones, are ubiquitous. Recent studies have estimated a current mobile cellular penetration rate of 95% worldwide, including 128% in developed countries (i.e., more phones than people) and 89% in developing countries. The worldwide penetration rate for smartphones is estimated to be 25% (33).

In health care, mobile apps that generate, aggregate, and disseminate information via wireless devices are still in the very early stages of proliferation. Recent reports have suggested that only the top 5% of health-related apps reach >500,000 patients, whereas 82% of apps generate <50,000 downloads. In diabetes, only 1.6 million patients with smartphones and tablets (1.2% of the population) are estimated to use a diabetes app, and probably just a fraction of those do so enthusiastically (34).

For the most part, diabetes apps offer the ability to log glucose, food, and insulin data manually and have not been clinically validated. Such apps can be cumbersome for patients to use and typically offer little value in return.

WellDoc's BlueStar is a notable exception. This prescription-only software program has been approved by the U.S. Food and Drug Administration (FDA) and provides real-time coaching, educational content, and motivational support to people with type 2 diabetes. We believe the most useful diabetes apps will be those that are similarly clinically validated and approved. Accordingly, the discussion below focuses largely on WellDoc's BlueStar and draws conclusions from reported data. Other examples of such apps at the time of publication include the Accu-Chek Connect, Dexcom Share, and Glooko Mobile App.

How Mobile Apps Can Help

Improving clinical outcomes. A recent, randomized, controlled trial (n = 167) assessed whether coaching via WellDoc's mobile app could reduce A1C in patients with type 2 diabetes compared to standard diabetes management (35). One-year findings demonstrated that individuals using BlueStar achieved a 1.9–percentage point reduction in A1C compared to a 0.7–percentage point decline in the control group. These results suggest that the combination of behavioral coaching with blood glucose data individually analyzed and presented to providers can substantially improve glycemic control over 12 months.

Reducing provider burden. Given the shortage of clinic time, WellDoc has sought to minimize the time providers need to spend on BlueStar. There is no setup required by HCPs, and the technology can be prescribed like a drug. Providers can also use WellDoc's clinical decision-support system, which is intended to make workflow more efficient by providing a consolidated report of patients' health that enables better informed and more rapid treatment decisions (35).

BlueStar is also powered by proprietary software that analyzes trends in users' entered data (i.e., blood glucose, A1C, blood pressure, and lipid levels; dietary intake; exercise; and foot exam results) and makes recommendations based on behavioral patterns. The system is personalized from the initial setup, with feedback and messaging adapting over time. The analytics educate patients about

their medications and can suggest treatment changes to providers, making the process of therapeutic change more efficient. WellDoc has found that putting analyzed data in doctors' hands makes them twice as likely to make changes to patients' therapeutic regimens (35).

Reducing economic burden. WellDoc has demonstrated that the use of BlueStar is associated with a 58% reduction in emergency department visits and hospitalizations in Medicaid patients with type 2 diabetes. Over a 12-month follow-up period, 32 patients using WellDoc reduced their total average number of hospital visits from five to zero and their emergency department visits from 21 to 11. Although this was a small study, its results are notable given their implications for potential improvement in patient health and reduction in health care costs (36).

Challenges and Unanswered Questions

- Will patients stay engaged and motivated to use apps if they require logging data manually?
- Will providers embrace these apps? Can they save providers time?
- Will providers be comfortable relying on mobile apps for therapy recommendations?
- Is it possible to build a sustainable business by providing free or very inexpensive diabetes apps?
- Will the most useful diabetes apps require regulatory approval? Are developers sufficiently knowledgeable about how to pursue such approval?
- Can an app product be scaled to serve a population while maintaining the necessary level of personalization?
- What is the most appropriate business model for mobile app companies such as WellDoc?

Social Media

Overview

Social media enable peer-to-peer communication through a multitude of platforms. These platforms primarily include *1*) patient blogs or podcasts, through which patients document their own experiences with diabetes; *2*) online diabetes forums, through which patients can pose questions and comments in a public setting for peer feedback; *3*) general social media platforms such as Facebook or Twitter; and *4*) information-sharing sites that post diabetes news and advice.

Examples at the time of publication include the patient blogs/podcasts SixUntilMe and Scott's Diabetes Blog; online diabetes forums such as TuDiabetes, EstuDiabetes, Children with Diabetes, and Diabetes Daily; general social media platforms and mobile apps such as Facebook, Twitter, and Instagram; and information-sharing sites such as diaTribe and Diabetes Mine.

How Social Media Can Help

Reducing patient burden. Social media allow for communication among patients, providing a source of information on daily experiences of living with diabetes. One analysis of top diabetes Facebook groups (36) found that two-thirds of posts involved the unsolicited sharing of management strategies, and 13% of posts included specific feedback to comments or information requested by other users. Patients can also use social media to learn about sides of diabetes management that may not be discussed in a typical health care setting, including how to safely consume alcohol with diabetes, where on the body to wear an insulin pump with a bathing suit, and other more colloquial components of diabetes management. According to a limited study of 57 participants with diabetes (37), 19% of participants used an online patient portal to access health records or medical information, and 65% were willing to discuss health information online in chat rooms, discussion groups, or virtual support groups.

Improving patient-to-provider ratios. Although HCPs remain the most common source of technical medical information, patients are increasingly relying on peers and others with their disease for medical guidance. The Pew Research Center reports that 60% of adults get health information from friends and family, and 24% get such information from other people with their disease (19). For emotional support in dealing with a health issue and for quick remedies to everyday health issues, 59% and 51% of adults, respectively, view nonmedical professionals as more helpful than medical professionals (19). Although, in the general population, many of these peer interactions are thought to occur offline, for people with chronic diseases such as diabetes, online resources are particularly pertinent. Indeed, 23% of patients with a chronic disease seek medical peer support online, compared to 15% of those without a chronic condition (38).

Improving clinical outcomes. In theory, greater access to information can encourage behavioral change and better outcomes. Although data supporting this theory in diabetes are scarce, research has shown that social media use supports weight loss and tobacco cessation (39,40).

Challenges and Unanswered Questions

- Can patients distinguish between accurate and inaccurate health information they find online?
- Will HCPs become more involved in social media in the future? What are the barriers to increasing HCP involvement?
- How can specific populations such as elderly people and teens with diabetes be engaged through social media?
- How do the type 1 and type 2 diabetes communities interact online? Do people with type 2 diabetes feel too stigmatized to participate fully online?
- Can social media communities ensure that they are providing a "safe space" for participants? What

policies are needed to meet this goal?

Digital Health: Early Days

Despite the promise outlined above, we are still in the 1.0 days of digital health—an era more comparable to that of early Palm Pilots compared to today's smartphones. New technologies offer the potential to change health care delivery and scale limited resources, with growing recognition that more drugs and devices are not going to solve all the challenges in diabetes. However, future products and services must make life easier for patients and providers (e.g., by offering personalized trend identification and reliable help with insulin dose titration). They must provide valuable solutions that save the health care system money (e.g., by identifying the impending risk of severe hypoglycemia, particularly episodes that may require ambulance calls, emergency department visits, or hospitalizations) and must do so without increasing burdens on patients and providers.

The growth of digital health also will require changing clinical practice and adjusting reimbursement models. Companies will have to create digital tools that patients will want to use, and the FDA will have to determine how best to ensure patient safety without stifling innovation in this new realm of health care delivery.

Excellence in diabetes care requires new thinking, and existing trends seem to be driving us in the direction of more digital solutions. Digital health is not and will never be the only answer, but it could become an integral part of the diabetes toolbox.

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Duality of Interest

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References

1. Rock Health. Digital health funding: 2015 year in review. Available from https://rockhealth.com/reports/digital-health-funding-2015-year-in-review. Accessed 14 June 2016

2. Accenture. US Funding for Digital Healthcare Start-Ups Expected to Reach $6.5 Billion by 2017. Available from https://newsroom.accenture.com/industries. Accessed 12 August 2015

3. Boyle JP, Thompson TJ, Gregg EW, Barker LE, Williamson DF. Projection of the year 2050 burden of diabetes in the US adult population: dynamic modeling of incidence, mortality, and prediabetes prevalence. Popul Health Metr 2010;8:29

4. Vigersky RA, Fish L, Hogan P, et al. The clinical endocrinology workforce: current status and future projections of supply and demand. J Clin Endocrinol Metab 2014;99:3112–3121

5. Gallegos A. Medical experts say physician shortage goes beyond primary care. AAMC Reporter, 2014

6. Gamm LD, Hutchinson LL, Dabney BJ, Dorsey AM. *Rural Healthy People 2010: A Companion Document to Healthy People 2010*. Texas A&M University Health Science Center, School of Rural Public Health, College Station, TX, 2003

7. Singh G, Mithal A, Mannalithara A, Sehgal A, Bron M, Dabbous O, Triadafilopoulos G. Hospitalisations due to severe hypoglycaemia in patients with type 2 diabetes: a US national perspective. Presentation 629-OR at the European Association for the Study of Diabetes, 2012

8. Singh G, Sehgal A, Mannalithara A, Bron M, Dabbous O, Peng X, Mithal A. Hospitalizations due to Severe Hypoglycemia in Patients with Type 1 Diabetes: A U.S. National Perspective. Presentation 279-OR at the American Diabetes Association 73rd Annual Meeting, 2013

9. Safford MM, Russell L, Suh DC, Roman S, Pogach L. How much time do patients with diabetes spend on self-care? J Am Board Fam Pract 2005;18:262–270

10. Russell LB, Suh DC, Safford MA. Time requirements for diabetes self-management: too much for many? J Fam Pract 2005;54:52–56

11. Folias AE, Brown AS, Carvalho J, Wu V, Close KL, Wood R. Investigation of the presence and impact of social stigma on patients with diabetes in the USA. Poster 59-LB presented at the American Diabetes Association 74th Scientific Sessions, San Francisco, CA, 2014

12. National Ambulatory Medical Care Survey: 2010 Summary Tables. Available from http://www.cdc.gov/nchs/data/ahcd/namcs_summary/2010_namcs_web_tables.pdf. Accessed 7 October 2010

13. Cefalu WT, Petersen MP, Ratner RE. The alarming and rising costs of diabetes and prediabetes: a call for action! Diabetes Care 2014;37:3137–3138

14. American Diabetes Association. Economic costs of diabetes in the U.S. in 2012. Diabetes Care 2013;36:1033–1046

15. Huang ES, Basu A, O'Grady M, Capretta J. Projecting the future diabetes population size and related costs for the U.S. Diabetes Care 2009;32:2225–2229

16. Fraze TK, Jiang HJ, Burgess J. Hospital stays for patients with diabetes: HCUP statistical brief. Available from http://www.hcup-us.ahrq.gov/reports/statbriefs/sb93.pdf. Accessed 4 September 2015

17. Kiefer MM, Silverman, JB, Young BA, Nelson KM. National patterns in diabetes screening: data from the National Health and Nutrition Examination Survey (NHANES) 2005–2012. J Gen Intern Med 2015;30:612–618

18. Roashan R. World market for telehealth: 2014 edition. Accessed from http://info.ims-research.com/lz/Instances/lz/documents/InMedica/Brochures/Abstract%20-%20World%20Market%20for%20Telehealth%202014%20Edition.pdf. Accessed 4 September 2015

19. Pew Research Center. Health fact sheet. Available from http://www.pewinternet.org/fact-sheets/health-fact-sheet. Accessed 20 August 2015

20. Baker LC, Johnson SJ, Macaulay D, Birnbaum H. Integrated telehealth and care management program for Medicare beneficiaries with chronic disease linked to savings. Health Aff (Millwood) 2011;30:1689–1697

21. Pan E, Cusack C, Hook J, et al. The value of provider-to-provider telehealth. Telemed J E Health 2008;14:446–453

22. U.S. Securities and Exchange Commission. Teladoc, Inc. form S-1. Available from http://www.sec.gov/Archives. Accessed 4 September 2015

23. American Well. Telehealth index: 2015 consumer survey. Available from http://info.americanwell.com/telehealth-index-2015-consumer-survey. Accessed 19 August 2015

24. Dellifraine JL, Dansky KH. Home-based telehealth: a review and

meta-analysis. J Telemed Telecare 2008;14:62–66

25. Freeman KA, Duke DC, Harris MA. Behavioral health care for adolescents with poorly controlled diabetes via Skype: does working alliance remain intact? J Diabetes Sci Technol 2013;7:727–735

26. Driver M. Transforming patient data into actionable insights. J Mhealth Uhealth 2015;2:34–36

27. Wong JC, Neinstein AB, Spindler M, Adi S. A minority of patients with type 1 diabetes routinely downloads and retrospectively reviews device data. Diabetes Technol Ther 2015;17:555–562

28. Look H. #WeAreNotWaiting: the (not so?) brief story of Tidepool. Available from http://sixuntilme.com/wp/2015/01/19/wearenotwaiting-brief-story-tidepool. Accessed 5 August 2015

29. Hirsch I. Interactive use of downloaded data in adults with type 1. Symposium Presentation at the American Association of Diabetes Educators 41st Annual Meeting, Orlando, Fla., 8 August 2014

30. DPP Research Group. The Diabetes Prevention Program (DPP): description of lifestyle intervention. Diabetes Care 2002;25:2165–2171

31. Sepah SC, Jiang L, Peters AL. Long-term outcomes of a web-based diabetes prevention program: 2-year results of a single-arm longitudinal study. J Med Internet Res 2015;4:e92

32. Anderson J, Riley M, Everette TD. How proven primary prevention can stop diabetes. Clinical Diabetes 2012;30:76–79

33. Gaudry-Perkins F. Are we all connected? Recent data. Symposium presentation at the European Association for the Study of Diabetes 50th Annual Meeting, Vienna, Austria, 12 September 2014

34. Research2Guidance. *mHealth App Developer Economics 2014*. Available from http://mhealtheconomics.com/mhealth-developer-economics-report. Accessed 20 July 2015

35. Quinn CC, Shardell MD, Terrin ML, Barr EA, Ballew SH, Gruber-Baldini AL. Cluster-randomized trial of a mobile phone personalized behavioral intervention for blood glucose control. Diabetes Care 2011;34:1934–1942

36. Greene JA, Choudhry NK, Kilabuk E, Shrank WH. Online social networking by patients with diabetes: a qualitative evaluation of communication with Facebook. J Gen Intern Med 2011;26;287–292

37. Shaw R, Johnson CM. Health information seeking and social media use on the Internet among people with diabetes. Online J Public Health Inform 2011;3:10.5210/ojphi.v3i1.3561

38. Fox S. Peer-to-peer health care. Available from http://www.pewinternet.org/2011/02/28/peer-to-peer-health-care-2. Accessed 3 July 2015

39. Rocheleau M, Sadasivam S, Baquis K, Stahl H, Kinney L, Pagoto L, Houston K. An observational study of social and emotional support in smoking cessation Twitter accounts: content analysis of tweets. J Med Internet Res 2015;17:e18

40. Napolitano MA, Hayes S, Bennett GG, Ives AK, Foster GD. Using Facebook and text messaging to deliver a weight loss program to college students. Obesity 2013;21:25–31