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BRIEF REPORT

Challenges with Patient Adoption of Automated Integration of Blood Glucose Meter Data in the Electronic Health Record

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Abstract

Providers often encourage patients with type 1 diabetes (T1D) to contact them with blood glucose (BG) values between visits. However, patients and families find it cumbersome to share their BG values with clinical providers, creating a barrier to communication. Although many phone applications exist to help patients track BG values, most do not integrate with the electronic health record (EHR). Recent advances in technology can integrate the glucose meter (GM) data into the EHR. This pilot and feasibility study aimed to understand how an automated integration system of GM data into the EHR and remote monitoring by health care providers would impact patient–provider communication. Patients or parents of patients with T1D ($n = 32$, average hemoglobin A1c [HgbA1c]: 8.5%, SD: 1.7, average age: 13.9 years, SD: 3.8) who owned an Apple iPod® or iPhone® (5s or higher) participated, and their number of contacts through telephone calls or MyChart™ messages between clinic visits was recorded during each of the three phases: run-in, intervention, and learned. Twenty-eight families completed all phases, and despite guided review of BG trends and automated integration of BG values, the number of patient-initiated calls ($P = 0.23$) and HgbA1c values ($P = 0.08$) did not improve, nor was there a clinically significant change in the number of BG checks per day. Barriers to adoption and effectiveness of this technology exist, and patient motivation is still needed.

Keywords: Electronic health record, Glucose meter, Type 1 diabetes, Pediatric, Self-monitoring of blood glucose.

Background

Patients with type 1 diabetes (T1D) require self-management to regulate blood glucose (BG), and a crucial aspect of self-management is communication with providers in between office visits when questions arise.[1–3] Currently, patients with T1D must take multiple steps to share their BG values with providers, and the process can be cumbersome. Patients upload their glucose meter (GM) data to the manufacturer's web site or a third-party cloud platform. Then, the provider downloads and/or reviews the data from the manufacturer's website. This process is not streamlined and creates barriers to communicating BG data. Patients often resort to manual methods of communication, such as typing BG values in an e-mail.

Technology that increases patient–provider communication may improve self-management and hemoglobin A1c (HgbA1c).[4–7] Recently, Kumar et al. developed a protocol using consumer technology to automatically integrate GM data into the electronic health record (EHR).[8] This pilot feasibility study aimed to understand how this automatic integration system (AIS) would impact patient–provider communication.

Methods

Patients with T1D age 5–20 years, or their parents, at Stanford Children's Health diabetes clinics who used an Apple iPod or iPhone (5s or higher) were invited to participate. The study received IRB approval. Accu-Chek® Aviva Connect (Roche, Basel, Switzerland) GMs and test strips, purchased by the study, were provided to each participant. Participants were guided through downloading the Accu-Chek Connect App, pairing the GMs with the app, setting up

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Table 1. Participant Characteristics ($n=32$)

Age (years, mean and range)	13.9, 5–20
Gender (female, male)	15, 17
Duration of type 1 diabetes (years, mean ± SD)	4.3 ± 3.7
Insulin regimen (multiple daily injections, pump)	24, 8
CGM use, non-CGM	3, 29

CGM, continuous glucose meter, SD, standard deviation.

the Apple Health App (Apple, Cupertino, California), and linking the Accu-Chek Connect App with the Apple Health App through HealthKit™.

Next, they then created an Epic MyChart account (Epic, Verona, Wisconsin) and connected the Apple Health App to the MyChart application. The GM data were transmitted directly to the Epic EHR through Wi-Fi™. Participants were informed that real-time BG monitoring by providers was beyond the scope of this study and to contact the on-call team for urgent issues.

The study consisted of three phases. The first, from enrollment to the 3-month visit, served as a run-in and baseline phase in which staff set up the participants' AIS, informed them that BG values would be integrated into the EHR, and they could contact providers through MyChart or phone. Participants and their parents were instructed to use the connected meter for all BG checks during the study. Next, in the intervention phase, from months 3–6, BG values were reviewed by the physician every 2 weeks, and members of the diabetes team called participants based on BG trends if participant-initiated calls did not occur. Simple messages such as ''Remember to check at least four times a day'' and ''Don't forget to take insulin for food'' were left as a voicemail if the participants or parents did not answer or respond to their MyChart message.

This second phase demonstrated to participants that providers were reviewing their BG values and that direct communication was simple. Finally, in the learned phase, from months 6–9, participants' self-initiated communications with providers were monitored. In addition, investigators analyzed participant–provider communication 3 months before enrollment as a control phase. The number of contacts through telephone calls or MyChart messages between clinic visits was recorded during each of the three phases. The number of participant-initiated calls per phase was measured and compared for each participant using a paired *t*-test.

The average number of BG checks per day and HgbA1c were also monitored although this pilot feasibility study was not powered to detect a change in the number of contacts, BG checks, or HgbA1c. At each study visit, the participants were asked about their impressions of the system, which provided qualitative data.

Results

Thirty-two participants (Table 1) enrolled for a 6-month period from September 2016 to March 2017. Twenty-eight participants completed all four study visits. Three moved away to college or transitioned to adult clinic, and one did not

Table 2. Quantitative and Qualitative Results

Quantitative results (n = 28)

	Baseline/control phase (3-month period before enrollment)	*Run-in phase: participant-initiated (from enrollment to 3-month visit)*	*Intervention phase: provider-initiated (from 3- to 6-month visit)*	*Learned phase: participant-initiated (from 6- to 9-month visit)*	P
Number of participant-initiated contacts	15	20	12	7	0.23
% of participants who initiated contact	29	36	21	18	0.38
Hemoglobin A1c (%, mean ± SD)	8.6 ± 1.8	8.5 ± 1.8	9.0 ± 1.7	8.9 ± 1.5	0.08
Blood glucose checks per day (mean ± SD)	4.1 ± 2.3	3.8 ± 1.8	3.7 ± 2.7	3.0 ± 1.7	0.02

Qualitative results

Barriers to using the integrated glucose meter	*Examples of participant comments*
Several steps are required to pair the GM with the iPhone and with the EHR.	''Too much hassle,'' ''too complicated,'' and ''too many steps''
The integration system was not compatible with GMs that communicate with insulin pumps.	''Wish it worked with insulin pumps''
The GM had a short battery life, and when the battery died, the GM would disconnect from the iPhone. After changing the battery, the GM then had to be re-paired with the iPhone, and participants often forgot this step.	''Wish the battery life were longer''
Participants used many GMs, leading to inconsistent transmission of data to the EHR.	''Doesn't work with the GM I use at school''
The GM was only compatible with the iPhone or iPod.	''Wish it worked with Android®''

EHR, electronic health record.

show for multiple missed appointments. Of those who completed all visits, only seven participants had at least 8 months' worth of BG data in the EHR, whereas the rest had 1 month's worth or less. These participants only used the connected meter for 1 month or less.

For the 28 participants who completed all study visits (Table 2), there was no change in the number of participant-initiated contacts between the 3 months before enrollment and the final phase of the study (mean difference: –0.29, 95% confidence level [CI]: –0.77 to 0.20, $P = 0.23$) or in HgbA1c (mean difference: 0.35, 95% CI: –0.04 to 0.75, $P = 0.08$). There was a decrease in the number of BG checks per day (mean difference: –1.09, 95% CI: –2.03 to –0.16, $P = 0.02$). In a subanalysis of the seven participants who had at least 8 months of BG data in the EHR, there was no change in the number of participant-initiated contacts (mean difference: 0.00, 95% CI: –0.76 to 0.76, $P = 1.00$), HgbA1c (mean difference: 0.16, 95% CI: –0.70 to 1.02, $P = 0.67$), or in the number of BG checks (mean difference: –0.29, 95% CI: –1.53 to 0.95, $P = 0.59$).

There were no differences in HgbA1c, number of BG checks, or number of participant-initiated contacts between multiple daily injections ($n = 20$) versus pump ($n = 8$) users or among users of a continuous glucose meter (CGM) ($n = 3$). Notably, among the non-CGM group ($n = 25$), there was a statistically significant increase in HgbA1c (mean difference: 0.5, $P = 0.04$) and a decrease in the number of BG checks per day (mean difference: –1.1, $P = 0.03$), but no change in the number of participant-initiated contacts.

In qualitative feedback, 10 participants indicated that it was helpful for BG data to be available in the EHR. Participants responded that barriers to use of the AIS included the multiple steps required to set up the system, the GM's short battery life, and the use of many different GM's—both within a day, such as at a child's school, and a preference for other GMs, which do not work with the AIS.

Discussion

Currently, patients and families find it burdensome to share BG values with clinical providers, creating a barrier to communication. This pilot feasibility study of AIS of BG meter data into the EHR shows that although integration is technically possible, the patient experience was cumbersome and resulted in low adherence to the technology. However, patients demonstrated an interest in further development of such technology.

Technology that facilitates patient–provider communication can improve self-management and patient experience.[9,10] One method to facilitate communication is automatic transmission of health data to the EHR.[11–13] Clinical decision support systems work best when they are integrated with the workflow, but the current diabetes provider workflow is not streamlined.[14] Technology that integrates various devices' data into one portal, such as Tidepool® (Tidepool, Palo Alto, CA), is now possible and enables providers and patients to visualize BG and insulin data from their GM, continuous GM, insulin pen, and insulin pump, all in one place.[15,16]

Full integration of this technology into clinical workflow requires integration of the diabetes device(s) through the patient's mobile phone into the EHR, and most young patients have their own mobile phones, including youth from a low socioeconomic status. The larger barrier is that pediatric electronic patient portals require more stringent protocols to ensure secure access,[17–19] which can be costly. Without both technology and EHR access, full AIS into clinical workflows cannot happen.

Since the aim of this pilot feasibility study was to understand how AIS would impact patient–provider communication, illustrative examples of how AIS can be helpful are provided. One parent contacted providers multiple times by MyChart messages and specifically referenced that the child was enrolled in the study and BG data were in the EHR. The physician used this data to provide insulin dose adjustments through MyChart in between visits to the family.

Another family contacted providers six times during the run-in phase, three times during the intervention phase, and three times during the learned phase for high BG management. The parent preferred secure e-mails with pictures of BG logs and did not want to use the AIS, saying that they wanted to ''focus on the child rather than technology.'' Ironically, had the AIS been used in this case, streamlined communication may have provided quicker and easier means to help the child.

One participant expressed burnout with diabetes care, rarely checked BG, and did not want this ''tracked'' in the EHR. This participant was admitted to the hospital twice for diabetic ketoacidosis during the study. After the first admission, the participant was strongly encouraged to re-pair the GM and enable AIS of BG into the EHR to receive close reminders from the health team. However, the participant refused. Participant-identified barriers to adoption of this technology suggest not only the need for further work to streamline the process, but also the need to develop acceptance of the technology as a modality to help control T1D.

The decrease in the number of BG checks per day was not clinically significant despite this difference reaching statistical significance. The number of BG checks per day was based on the number of values transmitted to the EHR per day for participants who used the system, or the number of checks per day reported by download of the GM data in clinic. Because participants inconsistently used the study GM and used many different GMs, the number of checks per day might not reflect the actual BG checks per day.

Limitations

There were several categories of limitations to this study. First, there were barriers to use of the technology. The GM had a short battery life, and after changing the battery, the GM had to be re-paired with the iPhone, which was often forgotten. Participants also used many GMs, leading to inconsistent transmission of data to the EHR. The GM was only compatible with the iPhone or iPod, excluding participants with other smart phones. Most insulin pumps communicate with particular GMs, and patients using those devices did not wish to forgo their current technology to participate in the study.

Next, participants still needed to contact the on-call physician for urgent questions. Real-time BG monitoring by providers would be labor intensive and impractical outside of a research setting. Although this study was not powered to detect a difference in the number of participant-initiated contacts, there seemed to be fewer participant-initiated contacts during the intervention phase than during the run-in phase. This may have been because providers were initiating the contacts during the intervention phase. Furthermore, there were fewer participant-initiated contacts during the learned phase, which may have been because participants had a better sense of how to manage their BG. These trends need to be further studied in a larger longitudinal study, which may include a control group to compare the AIS with e-mailing BG to the provider.

The lack of change in participant-initiated contacts with providers may have been in part due to the lack of change in the transmission of BG data from the participant's perspective. Although BG data flowed automatically to the EHR from the provider's perspective, the participant did not see this change in the form of a new interface or visual display in their medical chart. Although the intervention phase attempted to demonstrate that providers had their BG data, the participants might not have valued the AIS. Further development of new interfaces to display this data for patients may improve utilization of the technology for communication with providers.

Conclusions

Currently, barriers exist in AIS of GM data with the EHR. Further improvement in the transmission of data and development of algorithms that allow for improved communication among all diabetes devices are necessary to remove the major barriers to communication between patients and providers. In addition to aiding in patient–provider communication, AIS in the EHR has the potential to aid in telemedicine for pediatric diabetes patients who do not readily have access to providers.[20] These developments will need to occur concomitantly with studies that examine acceptance of diabetes technology and user feedback in a larger population with a widened scope of diabetes.

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Author Disclosure Statement

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