Structured scaffolding for reflection and problem solving in diabetes self-management: qualitative study of mobile diabetes detective

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ABSTRACT

Objective To investigate subjective experiences and patterns of engagement with a novel electronic tool for facilitating reflection and problem solving for individuals with type 2 diabetes, Mobile Diabetes Detective (MoDD).

Methods In this qualitative study, researchers conducted semi-structured interviews with individuals from economically disadvantaged communities and ethnic minorities who are participating in a randomized controlled trial of MoDD. The transcripts of the interviews were analyzed using inductive thematic analysis; usage logs were analyzed to determine how actively the study participants used MoDD.

Results Fifteen participants in the MoDD randomized controlled trial were recruited for the qualitative interviews. Usage log analysis showed that, on average, during the 4 weeks of the study, the study participants logged into MoDD twice per week, reported 120 blood glucose readings, and set two behavioral goals. The qualitative interviews suggested that individuals used MoDD to follow the steps of the problem-solving process, from identifying problematic blood glucose patterns, to exploring behavioral triggers contributing to these patterns, to selecting alternative behaviors, to implementing these behaviors while monitoring for improvements in glycemic control.

Discussion This qualitative study suggested that informatics interventions for reflection and problem solving can provide structured scaffolding for facilitating these processes by guiding users through the different steps of the problem-solving process and by providing them with context-sensitive evidence and practice-based knowledge related to diabetes self-management on each of those steps.

Conclusion This qualitative study suggested that MoDD was perceived as a useful tool in engaging individuals in self-monitoring, reflection, and problem solving.

Keywords: chronic disease, self-care, diabetes, intervention, qualitative study

BACKGROUND AND SIGNIFICANCE

In the United States alone, nearly 26 million adults and children have diabetes, and Hispanic and non-Hispanic black individuals are disproportionally affected by the condition.[1] Self-management is a critical component of diabetes care.[2] The American Association of Diabetes Educators identifies seven essential self-care behaviors. These include: 1) healthy eating; 2) being active; 3) monitoring; 4) taking medication; 5) problem solving; 6) reducing risks; and 7) healthy coping.[3]

One of these behaviors, problem solving, is defined as individuals' "ability to recognize personal, environmental, social, and knowledge-based barriers to regimen management and an ability to implement effective solutions to overcome those barriers."[4] Well-developed problem-solving skills are essential to successful diabetes self-management,[4–6] result in better diabetes self-care behaviors,[7–9] and improve clinical outcomes.[10] Problem solving is central to many self-management and behavior change programs.[11–13] Over the years, researchers have developed a structured and systematic view of problem solving. For example, Hill-Briggs proposed a problem solving framework that identifies problem-solving skills, orientation, disease-specific knowledge, and transfer of past experience as key components of successful problem solving.[4] Glasgow et al. described problem solving as consisting of a sequence of steps, including *problem orientation*, *generation of alternatives*, *selection of strategies*, and *evaluation of outcomes*.[14]

An integral component of problem solving is the ability to reflect. Reflection has become an area of study in many disciplines and generally refers to individuals' ability to critically examine their past experiences with the goal of drawing lessons that they can apply to future actions.[15] In the context of chronic disease self-management, reflecting on past experiences can help individuals identify negative health impacts of their past behaviors and actions and learn how to modify these behaviors in the future.[16,17]

Although both problem solving and reflection have received considerable attention from the informatics research community, there are few informatics interventions that facilitate either of these behaviors and even fewer that attempt to integrate them. Most of the electronic interventions for problem solving focus on the development of problem-solving skills using generic scenarios, rather than users' own past experiences.[18–20] On the other hand, there is a rich body of work on personal informatics applications that "help people collect personally relevant information for the purpose of self-reflection and gaining self-knowledge."[21–24] However, most of the existing personal informatics applications focus on collecting and presenting different types of self-monitoring data, but they rarely provide any explicit scaffolding for reflectively analyzing these data.[17,21]

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In this paper, we discuss a novel electronic tool designed to facilitate reflection and problem solving in diabetes self-management – Mobile Diabetes Detective (MoDD). MoDD follows the tradition of personal informatics applications in that it helps individuals collect data related to their health and use these data to increase self-knowledge. Moreover, it extends this tradition by providing individuals with structured scaffolding for engaging in reflection and problem solving as part of diabetes self-management. First, MoDD organizes the processes of reflection and problem solving into a series of steps; these steps are both theoretically grounded[14] and consistent with the best practices of diabetes self-management education (DSME) programs that focus on problem solving and discovery.[25] Second, for each of these steps, MoDD provides individuals with evidence- and practice-based knowledge related to diabetes self-management. MoDD was designed following a user-centered participatory design process involving individuals with type 2 diabetes recruited from several community health centers (CHCs) in New York City that deliver care to economically disadvantaged communities and ethnic minorities.

In this paper, we report on the results of a qualitative study of how individuals from the participating CHCs engaged with MoDD and their experiences with the structured scaffolding for reflection and problem solving that the application includes. This study was conducted as part of a randomized controlled trial of MoDD's efficacy in enabling improved glycemic control, problem-solving abilities, and diabetes self-management behaviors.

METHODS

MoDD

MoDD is a web-based application with integrated short message service (SMS) capabilities. Notably, MoDD was designed for independent use by individuals with diabetes and does not rely on the involvement of healthcare professionals. Using MoDD, individuals record their daily blood glucose (BG) readings either by typing them directly into the MoDD website or by sending them to a MoDD-dedicated phone number using SMS or voice calls. Based on these daily readings and their associated temporal context (when the readings were captured in relation to an individual's daily activities – eg, before breakfast or after lunch), MoDD identifies daily glycemic control patterns that are systematically higher or lower than the ranges recommended by healthcare providers (between 70 and 130 for fasting BG, and between 70 and 180 for after-meal BG). MoDD organizes these readings into patterns (upon waking, before or after a meal, before bed, etc.), displays them to users in a way that highlights deviations between average readings for each pattern and the recommended BG ranges, and asks users to engage in a problem-solving process that includes the following steps: 1) select a *glycemic control pattern* they wish to improve (eg, "High blood glucose after breakfast"); 2) choose a potential *behavioral trigger* – a behavior that is a known contributor to the selected glycemic control pattern (eg, "Lack of protein for breakfast") – from an extensive MoDD knowledge base; 3) select an alternative healthier behavior from a list of offered choices and set an *action-oriented goal* related to this behavior (eg, "Include a tablespoon of peanut butter or a boiled egg with breakfast"); and 4) implement the new behavior while monitoring for possible changes in the selected BG readings (eg, changes in BG after breakfast) and progress towards achieving the BG target range. These steps were identified during our formative studies of DSME and are consistent with the published literature on problem solving in diabetes self-management.[14]

In addition, on each of the steps identified above, MoDD uses data collected through self-monitoring to retrieve and display evidence- and practice-based knowledge related to diabetes self-management. The foundational engine of MoDD is its extensive knowledge base, which includes eight common glycemic control problems and over 200 behaviors related to diet, lack of exercise, sleep patterns, and stress (among many others) that are known to contribute to these glycemic control problems. Each of these behavioral triggers is coupled with a short educational text explaining why this particular behavior may lead to spikes or drops in BG levels, a motivational message encouraging users to persist with self-care, and up to five alternative behaviors that may lead to improved glycemic control. Moreover, all the content in the knowledge base is tailored to individuals' level of nutritional literacy, their current dietary patterns, their amount of exercise, and their readiness to improve these behaviors, which are all assessed, using validated measures, as part of the MoDD registration process. The knowledge base was designed through a participatory design process with academic Certified Diabetes Educators (CDEs) and was evaluated on its accuracy, coverage, and appropriateness with practicing diabetes educators, as part of the MoDD project.[26]

Because MoDD primarily targets individuals from economically disadvantaged communities, who may have limited access to computing technologies, it relies on text messages as the primary mode of two-way interaction between the application and users. These messages are used to remind individuals to use MoDD on a regular basis. Once a day (at 9 a.m.), MoDD users receive an automatically generated text message; the content of the message is dependent on the individual's use of the system. For example, these text messages may note that no new BG reading has been reported within the last 24 hours or that no new goal has been set within the last 7 days. In addition, individuals can elect to receive reminders to check their BG levels at their chosen times. Finally, once the users set their goals, the messages are used to provide users with feedback on changes in their BG levels after setting specific goals. The MoDD web interface is optimized for periodic use, to review captured data and set new goals (once per week). For individuals who do not have access to a computer or the Internet, kiosks were installed at the participating CHCs. At these kiosks, the study participants could log onto their MoDD pages, review their collected data, and progress through the other steps of the problem-solving process independently or with the assistance of a research assistant.

Settings

This study was conducted in collaboration with Clinical Directors Network,[27] a well-established primary care practice-based research network, and with two Clinical Directors Network -member CHCs – Morris Heights Health Center in Bronx, NY and Joseph P. Addabbo Health Center in Queens, NY, both of which are Federally Qualified Health Centers funded by the Health Resources and Services Administration.[28] Both of these CHCs provide quality primary healthcare services to members of their communities, which include socially and economically disadvantaged populations.

Participants

The participants of the study were recruited from the individuals currently enrolled in the randomized controlled trial of MoDD. The inclusion criteria for the randomized controlled trial were: (a) a patient of the CHC for $\geq$6 months and a diagnosis of type 2 diabetes mellitus; (b) glycated hemoglobin (HbA1c) $\geq$8.0; (c) age $\geq$18 years; (d) attended a diabetes education program at the CHC; (e) owns a basic cell-phone; and (f) proficient in either English or Spanish. An additional inclusion criterion for participating in the qualitative study described here was: (g) completed the active intervention phase of the study (4 weeks of using MoDD). The exclusion criteria were: a) being pregnant; (b) presence of severe cognitive impairment; (c) existence of

other serious illnesses (eg, cancer diagnosis with active treatment, advanced-stage heart failure, multiple sclerosis); and (d) had plans for leaving the CHC in the next 12 months. At the time of this study, 140 individuals were enrolled in the study; however, only 50 of these individuals completed the active intervention phase and were eligible to participate in the qualitative study. Recruitment was done on a rolling basis; we stopped recruiting new participants after 15 interviews, due to data saturation (no new themes were uncovered).

Because MoDD was designed for independent use, the study participants were instructed to use the application as frequently as was convenient for them and to set as many goals as frequently as they deemed appropriate. Study participants who had access to a computer and the Internet had little or no interaction with members of the research team throughout their 4 weeks of participation in the study. Study participants without such access were encouraged to visit their CHC once per week during the 4 weeks of the study; however, during these visits, they were free to either maintain their goals or set new ones.

Qualitative Study

The study included qualitative open-ended interviews with the participants, conducted at the CHCs in person or over the phone. The interviews focused on individuals' general perceptions of the application, their use of its different features (web application, SMS), their rationale for selecting particular behavioral triggers and goals, and their experience with achieving these goals. During the interviews, each study participant and an investigator reviewed the participant's MoDD page, the data they collected, and the goals they set during the study. All of the interviews were audio recorded and transcribed verbatim prior to analysis.

Usage Log Analysis

To contextualize users' qualitative experiences during their actual use of the application, we maintained detailed logs of their interactions with MoDD. For example, the application tracked how many times users logged in during the 4 weeks of the study, how many BG readings they reported, how many glycemic control patterns they viewed before selecting their goals, how many patterns were above or below the recommended BG ranges, and how many goals they set during the 4 weeks of the study.

Data Analysis

We used inductive bottom-up thematic analysis to analyze the transcripts of the interviews. The investigators first read the transcripts and identified major themes. An open coding approach was used to assign emerging categories to the findings. During axial coding, these emerging categories were grouped to arrive at high-level themes, then their properties and dimensions were identified and described.

Descriptive statistics were used to characterize the participants' use of MoDD.

RESULTS

Demographics

Fifteen individuals participated in the qualitative interviews. Of these, 80% were female. Additionally, 66% of the participants in the qualitative study were African-American, 26% were Hispanic, and 1 individual declined to report their ethnicity. The age of the study participants ranged from 25-63 years old, with a mean age of 53 years old.

Patterns of Engagement for the Participants

We relied on MoDD usage logs to assess the participants' level of engagement with MoDD. The participants in the qualitative study logged into MoDD more than eight times during the 4 weeks of the study, or twice as often as the research team had suggested (see Table 1). During this time, they reported 120 BG readings, or close to 3 readings per day, and had, on average, three daily glycemic control patterns that were outside of the recommended BG ranges. Most importantly, on average, the participants set two goals during the study, indicating that they had gone through the entire problem-solving process twice.

Qualitative Study Findings

The step-wise problem-solving process discussed above provided the foundation for the design of MoDD's features. One of the goals of this study was to examine whether this process is consistent with participants' own mental process of solving problems with their BG levels, how they engaged with each of the steps of the process, what obstacles they encountered, and how the design of MoDD's features helped them advance through the steps of the problem-solving process. Because of this focus, the findings of the interviews naturally focused on the steps of the problem-solving process. Below, we report the findings using a similar structure.

Identifying Problematic Patterns

The first step of the participants' engagement with MoDD was to identify problematic glycemic control patterns that needed attention and that could be improved by changes in behavior. As shown in Table 1, the study participants had, on average, three daily glycemic control patterns that were above the recommended BG ranges, suggesting that most of them still struggled with achieving glycemic control. Study participants reported different approaches for choosing which pattern they wished to work on. Some were genuinely surprised by their glycemic control patterns and sought an explanation for them:

> *"Because my numbers were always high in the morning so I needed to know why." (P3)*

Some study participants chose glycemic control patterns that they already knew were problematic:

> *"I did that one because I know that problem [after breakfast readings] is the main issue." (P3)*

Several participants reported that they did not fully engage with the application until they saw BG numbers that were not only outside of their recommended ranges but also far outside their own expectations:

> *"Yeah, and at the end of the day, it was like 280 something. That's a lot. I said, oh my... This is not good, you know, this is not good. And I'm saying that night I was so worried, you know, I really had to go back on program." (P5)*

When faced with these numbers, study participants often reflected on their own past behaviors, examining them as possible causes of the observed changes in their BG levels. This theme appeared in all 15 interviews and was the most persistent theme in the study.

Recognizing Behavioral Triggers

Once the study participants identified problematic glycemic control patterns, and as they were naturally contemplating what contributed to the undesired BG levels, they reviewed the list of behavioral triggers recommended by MoDD. Because the application had little knowledge

Table 1: MoDD Usage Patterns for Qualitative Study Participants

MoDD usage aspect	Usage patterns over 4 weeks of the active intervention phase Mean (SD)
Number of log-ins	8.5 (9.7)
Total BG readings reported	120.8 (10.4)
Problematic glycemic control patterns	3.1 (2.7)
Goals set	2.0 (1.0)

BG, blood glucose; MoDD, Mobile Diabetes Detective; SD, standard deviation.

of individuals' lifestyles, it made no attempt to prioritize certain triggers over others. However, it did allow the users to filter the triggers based on their focus (eg, diet, physical activity, etc.).

The study participants reported using different approaches to select personally meaningful triggers. Some carefully examined the entire list of behavioral triggers before making their selection; others picked the first trigger that seemed appropriate and never looked at the entire list. Many approached the list with pre-existing suspicions regarding certain behaviors. When these participants saw triggers that matched these suspicions, they quickly gravitated toward those:

> *"I know it's carbs, I've always known it. I need to cut my carbs." (P2)*

Others approached this step in a more open-minded manner, for example, by choosing triggers that were the most incompatible with their current behaviors:

> *"Okay, so I said okay this will be a good one for me [behavioral trigger related to consistently skipping breakfast] because I'm not a breakfast person." (P7)*

Although most study participants were able to find personally meaningful triggers that resonated with their own behaviors, three participants felt that the list of behavioral triggers was too restrictive. These participants made use of MoDD feature that allows users to suggest their own triggers and submit them for the review by the research team. Upon approval by the diabetes educators on the research team, these triggers were added to MoDD knowledge base.

Choosing Action-Oriented Goals

MoDD's list of behavioral triggers gave the users insights into their current behaviors, and the goals suggested by MoDD gave users ideas for experimenting with different behavioral choices. As with the triggers, the study participants had many different motivations for selecting some goals over others. The majority of the study participants, however, reported selecting goals that seemed doable, for example something they felt confident they could accomplish without the fear of failing:

> *"You know, I don't want to – one thing I've learned with setting goals and expectations is that sometimes you put too much into it and we find ourselves failing and we feel worse than by ourselves. I don't want to start feeling bad about anything I'm doing because I had to shut everything down. So I want to set another goal and try to achieve it and then want to feel good about what I'm doing." (P4)*

As reflected in usage log analysis, users tended to stay with their selected goals, rather than rapidly switch between them, with the average number of goals set during the 4 weeks of the study varying between 1 and 3. The interviews suggested that users took some time examining the goals before selecting the one that presented the best fit for them. However, once the user made their selection, they stayed with a goal until they saw changes in their BG readings or were ready to move on to the next goal.

Implementing Changes

Finally, once users set the goals they wished to pursue, they made changes in their daily behaviors and monitored for possible improvements in their BG readings. For some study participants, introducing the change was easy and did not require much effort. These participants were able to work through several different goals during their 4 weeks of active intervention time. More often, however, behavioral changes necessitated a more significant overhaul of participants' lifestyles and daily practices and required a substantial effort not only from them, but also from their families.

For example, for those study participants who were not primarily responsible for grocery shopping and cooking and were relying on others (spouses or adult children), changing their diet required a buy-in from other members of their families:

> *"So you know, it's not just me wanting to – I can say, okay I want to do it. But then I got to bring some icing with me on this too. If I cook, it's a different story. But I don't cook and don't know how to cook. And with fresh vegetables, you have to clean and wash it. So now it's like a teamwork thing." (P4)*

When possible, these participants invited their significant others to review the contextualized education provided within MoDD and used this education to support their campaign for a change in lifestyle. However, some wished for more explicit ways to engage family members in these behavioral changes.

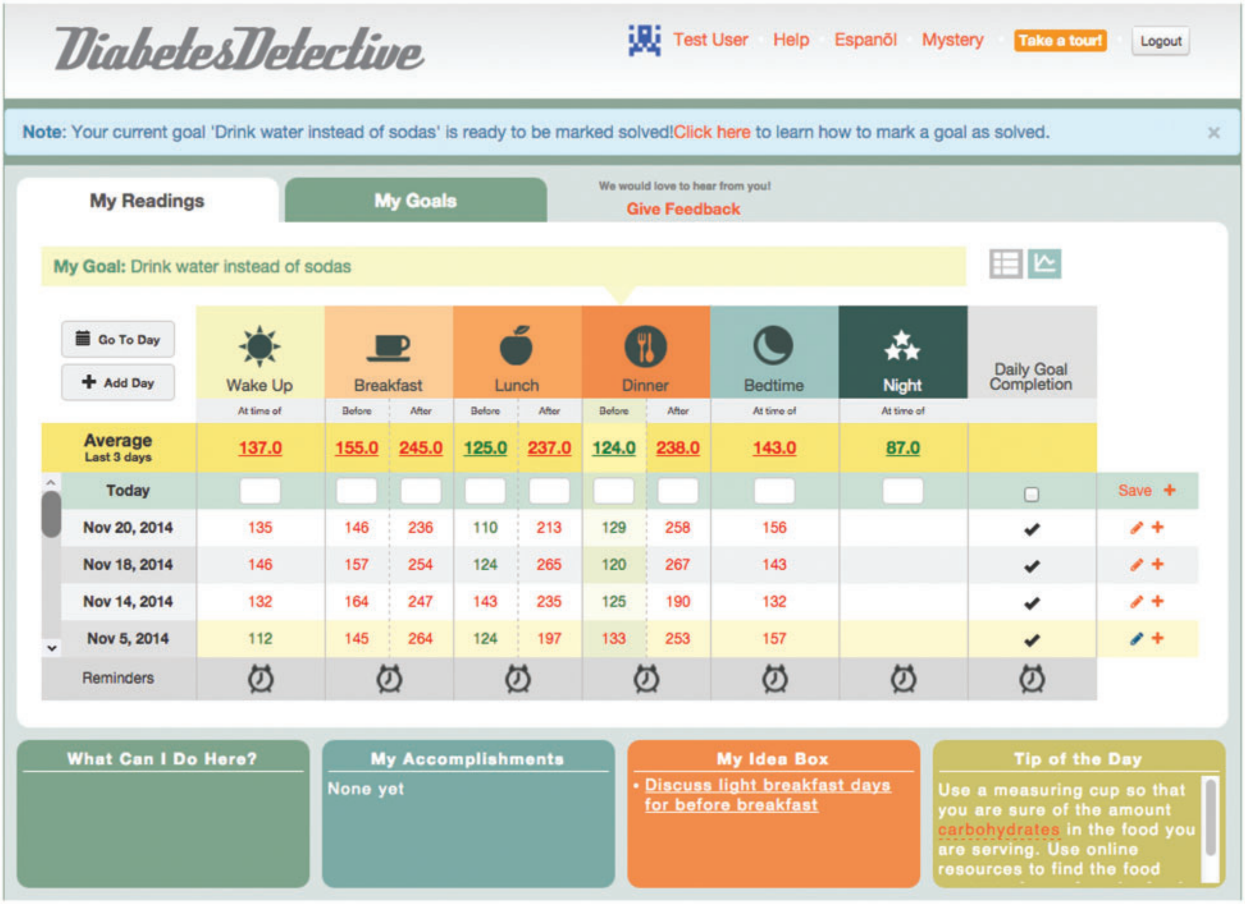
On this stage of their engagement, tailored feedback on changes in the users' BG readings was perceived to be particularly beneficial for helping users persevere with their selected goals. Those who relied primarily on MoDD's web interface could see these BG reading changes in the "My Readings" table, specifically in the "Before and After" table. Seeing these results further encouraged users' active participation in the problem-solving process and increased participants' confidence in their ability to achieve better glycemic control:

> *"Do you see? Do you see what my numbers are? That's what makes me feel I could do this." (P1)*

Those participants who relied on text messages for interacting with MoDD received this feedback through personalized responses to their text messages, along with BG reports. Study participants perceived these messages as one of the most useful features of the application:

> *"And I've been getting messages like that just about every day. So I'm very pleased with myself and they said I've gotten better. And I got to keep doing what I'm doing. So thanks to you too." (P5).*

Figure 1: MoDD user interface: blood glucose readings log.



Lasting Impact

One theme that was persistent in many of the interviews was that using MoDD had a lasting impact on how users perceived their own role in diabetes self-management and how they engaged in selecting and refining self-management strategies. First, for many study participants, engagement with the application created an *increased sense of awareness* of their own health:

> *"I mean I like it, because it helps me to stay up on anything else like I stay up above on everything." (P1)*

For others, the study created an opportunity to become *more engaged with their diabetes self-management* by coming to appreciate their own role in managing their diabetes and the need for them to make a more conscious effort to engage in self-management. Even more importantly, however, exposure to MoDD led to an apparent increase in users' sensitivity to and awareness of the connections between their daily behaviors and changes in their BG readings. Many study participants became more inquisitive and reflective about their glycemic control patterns and even reported making concrete and specific discoveries about these patterns during the study:

> *"I also learned what causes my sugars to go up. Some other things like if I had a certain breakfast, I play with it a little bit. Like I tried one breakfast one day, and then I tried a different breakfast the next day, see the difference, and I go back to what I tried the first time, and I see the difference." (P1)*

Some study participants reported seeing a visible improvement in their BG readings:

> *"I haven't seen the blood – my blood, the sugar got up to 280 for – for about two weeks now it's 130. Sometimes 140, a lot of times as low as 90, especially in the morning." (P5)*

Once the study participants identified certain changes in their behavior as having a positive impact on their BG levels, many adopted these changes as part of their daily routine even after the study was completed:

> *"And now I get into bed like eight, nine. See, I would have never done that, if I didn't read that to tell me that will help me." (P1)*

DISCUSSION

Over the years, researchers in biomedical informatics and human-computer interaction fields have proposed a number of computerized interventions for facilitating self-management of diabetes. In addition, there

Figure 2: MoDD user interface: goal-setting module.

are a great variety of commercially available technologies to aid diabetes self-management. However, most diabetes self-management interventions focus on monitoring BG levels,[29,30] communicating these values to healthcare providers,[31,32] accessing information and education related to the disease,[33,34] and receiving recommendations either from healthcare providers or from decision-support engines.[35] Yet, the increasing popularity of self-monitoring technologies opens new possibilities for informing diabetes self-management by helping users learn from their past experiences through reflection and engage in problem solving.

In this work, we examined an approach to integrating self-monitoring and reflection for emerging personal informatics applications with structured scaffolding in the form of a step-wise process and the evidence- and practice-based knowledge that is necessary to perform each of these steps. First, our study showed that the steps of the problem-solving process were consistent with users' natural reasoning processes. MoDD users fluidly moved from identifying undesirable glycemic control patterns, to examining possible behavioral triggers for these patterns, to searching for alternative behaviors, to implementing these behaviors while monitoring for improvement in their glycemic control. These steps are consistent with previous work in both problem solving[14] and personal informatics.[17] Our study results suggested that incorporating these problem-solving steps into the design features of an application can help individuals with diabetes adopt a more systematic approach to reflection and problem solving as part of managing their condition.

In addition, the study results suggested that access to personal data and relevant knowledge regarding diabetes self-management is critical to individuals' ability to follow the steps of the problem-solving process. For example, while some study participants found that the behavioral triggers listed by MoDD were consistent with their prior knowledge, others were genuinely surprised and would not have considered these behaviors problematic if MoDD had not offered them as possible triggers of glycemic control problems. Previous studies of personal informatics in chronic disease self-management have argued for the importance of knowledge and expertise to individuals' ability to notice meaningful trends in the data they collect about their condition.[5,17] Our study further confirms this finding and argues for the need to create sharable repositories of knowledge related to self-management of chronic diseases.[26]

At the same time, our results highlight several new opportunities for further engaging MoDD users in reflection and problem solving.

First, the current design of MoDD relies on simple technologies (a web application with integrated text messages) and does not collect any data related to users' daily activities. As a result, MoDD is limited in its ability to reach conclusions about which triggers and goals are more applicable and appropriate for different users. Including richer self-monitoring data (eg, records of meals and physical activity) would enable more extensive computational analysis of the recorded data through personal analytics.

Second, a significant focus of problem solving is addressing barriers to engaging in self-management. Although such barriers are present in MoDD's knowledge base (each action-based recommendation addresses a particular barrier to engaging in self-management), they are implicit and the user's attention is not drawn to them. However, identifying, recognizing, and addressing these barriers can help individuals transfer what they learned by using MoDD to other situations in their daily lives. Moreover, focusing on specific barriers can help users tackle more complex challenges (such as introducing more vegetables into their diet) and break them into a set of more manageable steps.

Finally, MoDD's focus on reflection and problem solving necessitated that users engage with the application during moments when they had time for these analytical activities and were not pressed by the need to take immediate action. However, much of diabetes self-management involves not only quiet reflection, but also the need to make quick decisions under uncertain conditions. Making nutritional choices, deciding on the best time to exercise, and deciding whether or not to take over-the-counter medication all require the ability to incorporate lessons learned from past experiences into making choices in the present. In our previous work, to more explicitly address this focus on action, we adapted the theoretical perspective of sensemaking to chronic disease self-management.[36] We argue that this framework is complementary to both reflection and problem solving, but places greater emphasis on informing action than on self-knowledge. Adopting a sensemaking framework can help establish new directions for the design of informatics interventions for facilitating discovery, experimentation, and learning in chronic disease self-management.

This study has a number of limitations. First, it was conducted with 15 participants, who all elected to participate in the interviews; as such, the findings may not generalize to the entire study sample or to the broader population of individuals with type 2 diabetes. Second, because the study used qualitative methods and relied on participants' subjective reports, we can make no claims as to the accuracy of the discoveries that the study participants made using MoDD, their actual achievement of the goals they set during the study, and whether they made any changes in their behaviors as a result of using MoDD. The ongoing randomized controlled trial for MoDD includes a number of measures to address these questions; however, the results will only be available when the trial is completed.

CONCLUSION

In this qualitative study, we investigated subjective perceptions and attitudes and patterns of use of MoDD, a novel electronic tool for facilitating problem solving and sensemaking in diabetes self-management. Usage log analysis showed that study participants logged into the application at least twice per week during the 4 weeks of the study; reported, on average, 120 BG readings; and set two goals. The qualitative interviews conducted with the study participants suggested that they used MoDD to follow the steps of the problem-solving process laid out by the application, from identifying problematic glycemic control patterns, to exploring behavioral triggers that contribute to these patterns, to selecting alternative behaviors, to implementing these behaviors while monitoring for improvements in their glycemic control.

CONTRIBUTORS

All the authors designed the study. L.M. and E.M.H. served as the main research investigators, and conducted all the described research activities. L.M. wrote the first draft of the manuscript. A.M.S. and P.D. served as the domain experts and were responsible for providing domain expertise during the interpretation sessions. All the authors participated in the interpretation of the study findings, formulation of the study conclusions, and the preparation of the manuscript. There are no other collaborators apart from the authors.

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COMPETING INTERESTS

None.

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