Published in final edited form as:

Curr Diab Rep. 2013 December ; 13(6): 886–893. doi:10.1007/s11892-013-0428-2.

Utilization of Blood Glucose Data in Patient Education

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Abstract

Many studies have tested clinical and behavioral approaches for improving glycemic control in people with diabetes. We review research to identify how blood glucose (BG) values have been used in patient-focused clinical research and interventions. We sought to describe the frequency that BG values have been the focus of patient education research and to characterize the different methods to integrate BG into an intervention, the approaches implemented to support patient education and behavior change, and the nature of communication about BG values. Thirty-four eligible studies were identified that included patient education using BG values. Information regarding the study and intervention characteristics include: 1) Characteristics of the study sample, 2) How BG values were obtained, 3) Use of a graphical interface for BG values, 4) Use of a BG log, 5) BG interpretation and regimen adjustments, 6) Recommended actions to patient, 7) Modality of intervention, and 8) Intervention communication schedule. The review demonstrated that new BG technologies provide outstanding opportunities for greater access to BG data, and for patient support and intervention. However, it also indicated a need to improve and expand support for people with diabetes in their daily use of BG values to maintain and improve glycemic control. In order to make the most sustainable impact on behavior, generalizable skills such as problem solving need to be integrated into BG education.

Keywords

Diabetes; Patient Education; Teaching; Blood Glucose; Interpretation; Intervention

Introduction: Background

Self-monitoring of blood glucose (BG) levels is critical to the daily self-management for people with diabetes. In people with type 1 diabetes (T1D) the Diabetes Control and Complications Trial (DCCT) demonstrated that intensive insulin regimens and BG control corresponded with better glycemic control and resulted in a significant decrease in the macro- and microvascular complications of diabetes [1, 2]. A similar finding was noted in the type 2 diabetes (T2D) population with the United Kingdom Prospective Diabetes Study (UKPDS), which also demonstrated evidence of improved outcomes when participants engaged in a more intensive management course compared to the standard therapy [3].

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Conflict of Interest

Yaa Kumah-Crystal and Shelagh Mulvaney declare that they have no conflict of interest.

Human and Animal Rights and Informed Consent

This article does not contain any studies with human or animal subjects performed by any of the authors.

While A1C was the major outcome variable in the DCCT and UKPDS, it is a person's level of adherence and blood glucose control that largely determines A1C [4]. A critical component of adherence is BG monitoring to guide insulin and behavioral adjustments on a day-to-day and meal-to-meal basis [5].

Patient education around interpretation of BG values initially occurs shortly after diagnosis with diabetes when patients are taught target BG ranges, and how to adjust carbohydrate and insulin intake to maintain euglycemia. In T1D and insulin treated T2D, patients are given an algorithm by which to interpret a BG value, determine their dosing based on their meal intake, and to use a sliding insulin scale to compensate for varying BG values. This is the fundamental concept behind how a closed loop BG monitoring and insulin-dispensing device would operate [6]. However, when a person with diabetes is solely responsible for these assessments, and the adjustments are based on just a few BG values from meals, it can be very challenging to achieve good BG control [7]. In reviewing BG data and trend patterns, providers and patients ideally collaborate to make decisions about the adequacy of dosing and timing of insulin, exercise, and diet, in order to educate the patient, incorporate important individual information, and tailor the best approach for each individual person.

One impediment to using BG data in patient education is access to the BG data itself. Behavioral and technical issues negatively influence both patient and clinician access to timely and complete BG data. Missing values may be related to a person's psychosocial issues, health literacy, or disengagement with one's health [8, 9]. Missing values may provide a focus point for improving adherence, but interfere with pattern recognition and prevent fully informed decision-making. Polonsky et al found that in adults with T2D many insulin users (42%) and noninsulin users (50%) do not bring self-monitored blood glucose (SMBG) data regularly to medical visits [9]. Because there is still controversy surrounding the utility of SMBG in people with T2D who are not taking insulin [5], some of these people may have less motivation to continue to monitor their BG values due to conflicting recommendations. In a study by Farmer et al of that followed 453 people with non- insulin treated T2D, no additional benefit was found in the non-insulin treated T2D participants who monitored their BG compared to controls that did not monitor their BG [10]. A limitation of this study was that it was unclear what education took place around the BG values obtained by the participants [5]. But overall, unlike a person on insulin who can take direct actions to mitigate a BG reading that is out of range, the options available to people with T2D not taking insulin are less immediately impactful and include adjustment of their diet and exercise regimens, and speaking to their physicians about adjusting oral medications. While these actions can impact the person's glycemic control, their connections to BG values are not immediate or readily apparent. Finally, economic factors may also pose a barrier to multiple daily BG monitoring in T2D due to the high cost of BG strips, and the reality that insurance companies generally limit the amount of strips covered in people with T2D [11].

Even in people with T1D, however, where there is a direct connection with BG values and subsequent actionable steps that can be taken, psychosocial barriers to monitoring BG values such as motivation, anxiety, and perceived susceptibility can also impact the person's willingness to monitor. Although a person may perceive that they are engaging in all the steps required of them to monitor their BG, calculate their insulin dose and sliding scale, and administer insulin, they may still have BG values that do not reflect their effort and planning because of other external factors like stress, illness, exercise, puberty, and other hormones that can affect BGs [12–15]. Perceived and real lack of control can be demotivating and lead to decreased self-efficacy, which may affect a person's willingness to continue checking their BGs [16]. In youth, a lack of perceived susceptibility risk to the long term consequences of poor management may lead to further lack of motivation for BG

monitoring [17]. In all ages of T1D and T2D, anxiety over glycemic variability may further dissuade people from BG monitoring and lead to more missed values [18, 19]. While BG technologies, such as continuous glucose monitoring (CGM), may help with these missing values by providing multiple readings per hour, if a person is still not checking regularly to calibrate a CGM, the output itself will not be reliable [20]. Finally, other psychosocial obstacles to BG monitoring such as inadequate numeracy may serve as barriers that may influence a person's willingness to monitor their BG values [21]. If a person does not feel confident interpreting the numeric values they obtained from self-monitoring, they will not likely recognize the value in monitoring BG values.

Once BG values are appropriately obtained, a person must be educated about and carry out several steps in the problem solving pathway such as interpreting the value, problem solving around the BG data, making adjustments to their regimen based on the data, and iterating the process several times through each day in order to maintain glycemic control. Many studies have tested a variety of clinical and behavioral approaches for improving glycemic control in people with T1D and T2D. However, we were specifically interested in understanding how blood glucose values obtained from people with diabetes have been integrated into patient education and support programs within the research literature. Here, we review intervention studies to identify the frequency that BG values have been the focus of patient education research and the nature of those interventions designed to improve glycemic control. Specifically, we sought to characterize the use of different methods to integrate BG into an intervention, the approaches implemented to support patient education and behavior change, and the nature of communication about BG values.

Methods

Data Sources

The search strategy focused on MEDLINE for eligible articles using a combination of the following key words “education”, “teaching”, “blood glucose”, “glucose value”, “interpretation”, “intervention”, each crossed with the term *diabetes mellitus*. In addition, we contacted experts in the field to identify studies, and hand-searched references of key articles.

Inclusion and Exclusion Criteria

No limitations of publication date were used in the search. Articles that did not use blood glucose values for education, tested interventions but did not discuss how the values were obtained or used, or were not published in English were excluded from the review.

Study Selection and Data Extraction

The full text of potentially eligible articles was examined to determine whether they contained relevant information. One investigator (YKC) initially abstracted information from the articles, then both investigators reviewed articles together. Any discrepancies between the initial review and combined review were resolved through discussion and reference to the original articles. Thirty-four eligible studies were identified that included patient education using BG values. Information regarding the study and intervention characteristics include: 1) Characteristics of the study sample, 2) How BG values were obtained, 3) Use of a graphical interface for BG values, 4) Use of a BG log, 5) BG interpretation and regimen adjustments, 6) Recommended actions to patient, 7) Modality of intervention, and 8) Intervention communication schedule.

Results

Table 1 lists the studies and their characteristics. Of the 34 studies reviewed 21 (62%) focused on T1D and 13 studies (38%) focused on T2D. The age range of participants with T1D in these studies varied from 5 to 58. The age range of the participants with T2D ranged from 18 to 72. The studies that included people with T2D were managed with diet alone, diet and oral medications, or diet, oral medications and insulin.

How Blood Glucose Values Were Obtained

The first and most critical step in providing BG education and support is to reliably and regularly obtain that data. In these studies, BG values were obtained using a variety of methods, including traditional hand written log books and more recently developed methods such as automated uploads from wireless meters. The methods that BG values were obtained and delivered for further analysis were characterized as manual or semi-automated. No fully automated BG systems were utilized in these studies.

Approximately 24% of studies utilized some form of patient-dependent manual entry of BG values. Manual entries of BG data included hand recording of BG values into logbooks or into a computer website [22–24], providing the BG values by voice over a telephone to a designated person who would then record them [25], or sending the values via short message service texting (SMS) on a mobile phone [26–28].

Approximately 76% of studies used semi-automated methods for obtaining BG values. Semiautomated methods were defined as those that involved automation of uploading or transfer of the values into an electronic database or system. The semi-automated systems varied in the extent to which participants had to initiate actions in order for the BG values to be integrated into the systems. Semiautomated systems either 1) transmitted BG data wirelessly via Bluetooth or infrared after some minor action from the participant such as transmitting the values from a meter to a phone or PDA [29–32] or 2) required the participant to upload their meter through a hard-wired connection to a phone or computer where the information would then be sent to a server and/or downloaded within a clinic setting [33–39].

Blood Glucose Interpretation

Display and Summarization of BG Values—A potentially impactful tool related to BG education is the use of graphical displays of values over time. This critical element of clinical management and patient education allows more efficient pattern recognition and problem solving. Meters and pumps often provide software that will aggregate BG values over time to identify salient patterns and values that are out of range. Within these intervention studies, 9 (26%) provided a graphical display of data for the participants [22, 28, 29, 33, 39–43]. By having graphical data available for view by the participant, the studies could provide another dimension for BG data interpretation.

It was unclear in most studies whether viewing the graphs was a mandatory part of the intervention. The study by Allen et al (2011) using continuous blood glucose monitoring (CGM) did require that the graphical display was viewed and utilized for patient education [43]. Allen et al evaluated the impact of problem solving on physical activity. Participants with T2D received a 90-min CGM education session provided by a certified diabetes educator. Data from the CGM were used to tailor the intervention about the effects of physical activity on each participant's blood glucose levels. Color graphs and summary tables were used along with participants' logged events such as meals, medications, and stress to aid in interpreting glucose values. The results indicated improved problem solving

skills in the intervention group with continuous glucose monitoring plus problem solving compared to a control group of continuous glucose monitoring plus just general education [43].

Participant and Provider Roles—Once BG values are obtained, they are ideally interpreted in the context of the participant's behaviors such as carbohydrate intake, appropriate dosing, and treatment goals. Interpretation, problem solving, decision making around BG values took three general forms in the research. Within these interventions: (1) the participant interpreted the values independently (11% of studies) [22, 23, 44•, 45], (2) the participant interpreted the BG values with providers support (9% of studies) [24, 43, 46] or (3) most frequently, the provider or an automated program interpreted the BG values alone and communicated instructions to the participant (80% of studies) [25–42, 47, 48•, 49–55].

Recommended Actions—The types of decisions that were recommended after the values had been obtained and interpreted depended on the type of diabetes under study. Intervention components included options such as behavior change, medication management, or insulin management. The recommendations made were either to adjust insulin dose or diet and exercise or both. In interventions that just included participants with T2D that were not on insulin, the regimen adjustments included recommendations for lifestyle modifications such as diet or exercise behaviors [43, 48], and dosing adjustments of oral medications [24, 37, 52]. Additional recommendations for participants with T2D also on insulin would include adjustments to the insulin regimen as well [28, 29, 32, 33, 42, 49, 53, 54]. In the T1D studies the intervention recommendations mostly involved just insulin adjustment suggestions [25, 26, 30, 34, 36, 38–41, 46, 50, 55]. Some studies also included suggestions to modify diet and exercise, which is a good overall approach to help the participants understand the full picture of the multiple factors that play into their management [23, 31, 35, 44, 45, 51].

Polonsky et al (2011) provide a good example of an intervention designed to engage people with diabetes in the interpretation of their own BG values. In this 12-month, cluster-randomized clinical trial, insulin naive adults with T2D were randomized to an intervention of collaborative, structured glucose monitoring or no structured monitoring. The experimental group utilized a paper tool that was used to record a 7-point self-monitoring blood glucose (SMBG) profile for three consecutive days prior to their quarterly physician visit. The participants were taught to interpret their own SMBG results and would bring the completed form to their physician visit. Each profile included space to record pre-prandial and post-prandial BG values at each meal and at bedtime, plus ratings of meal size and energy level to enhance visualization of patterns. Participants and physicians interpreted SMBG results together to make medication and lifestyle changes. Intervention participants displayed significantly greater reductions in distress related to regimen adherence than controls and a greater reduction in glycemic control [24, 56] [57]. This structured SMBG monitoring also led to significant increases in self-confidence and autonomous motivation associated with diabetes self-management [58].

Sullivan-Bolyai et al (2012), incorporated parents in the interpretation of BG values, with a pilot study to test the use of pediatric human patient simulators to teach parents diabetes management for children newly diagnosed with T1D. Participants received standard hypoglycemia education using vignettes and pediatric simulations to illustrate care. The teaching sessions included review of glucose monitoring, daytime and nighttime hypoglycemia, drawing up and administering insulin and glucagon, and observation and treatment of tremor and seizure activity. Focus group participants enthusiastically supported

the use of the pediatric simulated patients after diagnosis for the education of hypoglycemia and also to focus on more complex diabetes management concepts [44].

Intervention Communication Characteristics

The frequency of communication with participants in the studies varied widely from multiple times a day [22, 41, 48] to monthly [23, 39, 43]. Modalities that were automated to give feedback generally had more frequent communication than modalities that required face to face or clinician contact [37, 41, 48].

Modality of Intervention Communication—In addition to how the BG data was obtained, displayed, and interpreted, we identified predominant methods by which the participants communicated with the interventions: these methods included email [29], in person communication with the intervention group [24, 39, 44, 45], phone [25, 34–36, 38, 40, 43, 46, 50, 51], SMS [26–28, 30, 31, 33, 37, 41, 42, 47–49, 52–55], Internet [22], and letters [32].

One study utilized a novel multi-modal approach to communication. A study by Froisland et al (2012) sought to improve diabetes care for young people with T1D through visual learning on mobile phones. The intervention used an application that contained a picture-based diabetes diary to record physical activity and photos taken with the phone camera of food eaten, where the phone also communicated with the glucometer by Bluetooth technology to capture blood glucose values, and a Web-based SMS where participants could send messages to their providers when they faced obstacles, and also could receive educational messages. At the end of the study, participants reported an increased understanding of applied knowledge of self-management with associated improvement in diabetes self-care, and reported that SMS gave them a feeling of increased access and security [31].

Improving the frequency of communication was evident in most of the studies. In a study of adults with T2D by Yoo et al.(2009) participants in the intervention groups received a cellular phone with a modular blood glucose measuring device which reminded the participant to measure their blood glucose twice a day, and would also remind them to measure blood pressure and body weight. As soon as the participants transmitted their glucose measurement through their phones, they would immediately receive messages of encouragement, reminders, and recommendations for lifestyle changes from a pre-defined algorithm developed by an endocrinologist. After the 12 week intervention the study found significant reduction in A1C in the control group compared to the intervention group, and significant improvement in additional parameters such as blood pressure and cholesterol in the intervention group.

Discussion

A review of relevant research indicated that interventions primarily incorporated methods to improve clinician access to BG data, to improve the frequency of communication with participants, and to provide regimen adjustments for participants required to improve their diabetes management. There was no predominant approach to implementing these processes. Many systems sought to provide advice to participants regarding insulin dosing around a specific BG value, but did not educate or engage the participants in the process of discovery and problem solving around their BG values.

There was a wide range of approaches to obtaining BG values, ranging from traditional paper log books to semi-automated wireless systems. One potential value of using manual BG collection methods is that the act of recording or stating the values may bring awareness

to specific high or low values. However, manual delivery of BG values may lead to more missing data, data entry errors, and recall bias if not looking at a meter. Another potential disadvantage of manual BG entry is that it may lead to disengagement if a person feels burdened by repetitive entry of their data. Recent advances in the integration of the Internet and wireless technologies have changed the nature of this process and provided much greater access to BG data for people with diabetes and their providers. Integrating meter-uploaded data within clinical research may reduce missing values, enhance data reliability, allow real-time or near real-time support, and provide the quantity of data needed to examine trends over longer periods of time. Although currently available, we could not identify any fully automated BG transmission systems. All systems required the participants to take additional steps beyond monitoring their BG in order to transmit their information.

Regardless of the method of obtaining BG data, interpretation and the ability to identify patterns and make actionable insights can be enhanced through data visualization techniques. Approximately one quarter of the interventions described using a graphical BG display. However, it was often unclear how data was displayed, what specifically was displayed, or how the graphical display was used for the provider or the participant. Graphical displays are able to provide a richer understanding of data, but just as easily could lead to confusion for people unfamiliar with that modality of communication. Graphical communication, and its integration with verbal and written materials, are unexplored areas of patient BG education.

Some of the technological solutions discussed above reduce barriers to BG monitoring, such as numeracy, by directly calculating and recommending regimen changes based on the person's BG so that no additional calculations are required. While this technical advance may be helpful, it may not directly contribute to improvement in a person's understanding of the relationships involved or support self-efficacy in order to empower future self-management decision-making.

Although recommended by professional diabetes organizations like the ADA [59], and integrated in some studies here, collaborative problem solving and goal setting were not commonly utilized. Blood glucose values were utilized primarily by clinicians or automated systems to make unilateral insulin dosing adjustments. Automated response technologies facilitate dosing decisions and likely lead to more accurate dosing. However, those systems and the associated studies, typically did not seek to influence or indicate gains in participant knowledge, or understanding of the relationships between BG, exercise, and diet. Blood glucose data needs to be interpreted within the context of data related to these important self-management behaviors. Missing blood glucose values also need to be examined within the context of psychosocial and behavioral influences.

The most variable aspect of the research was observed in the communication modalities and frequencies between participants and either providers or a "system." Due to highly variable reporting, the relation between communication frequency and participant attrition or missing BG data was not clear. Because many of the studies focused on mobile technology, the communication tended to take place using SMS or real-time phone calls. More research focused on the frequency and modality of communication around BG data is needed, specifically, how to identify triggers and thresholds for different types of communications.

While data supports the important role of monitoring BG values in people with diabetes, there is a disconnect between the recommended guidelines for BG monitoring frequency, the technological tools available to people with diabetes and the provider's ability to facilitate the process, and what is actually being done. The technologies discussed above do not address barriers such as understanding relationships between BG and insulin dose,

adherence problem solving skills, insurance limitations, or self-efficacy. There was a lack of focus on missing BG values, with the assumption that a person with diabetes is generally taking the key steps to obtain their BG values. A primary focus of the studies was on transmitting the BG values to providers who would then specify solutions to the participants.

The interventions tested within many studies were in their initial developmental stage, with no data on implementation. Moving forward, the feasibility of such systems should be taken into account as incorporation of many of the technologies and systems described may be cost prohibitive for clinicians to set up and patients to use on a regular basis. Even with the basic technologies like phone support and simple SMS texting that are readily available, the resource demands to integrate that data into clinical informatics systems and maintain them may be difficult without an existing provider compensation model to justify the additional time and expense. While the data may show that incorporation of these tools may be of some benefit, the evidence may not be overwhelming enough for providers to justify the investment in their current health infrastructure.

Conclusion

The research demonstrates that new BG technologies provide outstanding opportunities for greater access to BG data and intervention focuses for people with diabetes. However, the research also points to the need to improve and expand our education and support for people in their daily use of BG values to maintain and improve glycemic control. In order to make the most sustainable impact on people's self management behaviors, barriers to obtaining BGs must be addressed, generalizable skills such as problem solving need to be integrated into patient BG education, and resources to support the use of these tools should be identified to help facilitate their integration into routine clinical care.

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Table 1

Study Characteristics of Interventions Using Blood Glucose Data in Patient Education

Author (Year)	T1 or T2/ T1 + T2	Pediatric or Adult Participants	Number of Intervention Participants	How BG Values Were Obtained	Graphical Interface for BG Values	Log of BG Values	BG Interpretation & Regimen Adjustments	Recommended Actions to Patient	Mechanism of Intervention	Intervention Schedule
Allen (2011)	T2	Adult	14	Semi-automated: CGM uploaded	Yes	Yes	Patient + Provider	Lifestyle	Phone	Monthly
Benhamou (2007)	T1	Adult	15	Semi-automated	No	No	Provider	Dosing	SMS	Weekly
Cadario (2007)	T1	Pediatric	14	Semi-automated	No	No	Provider + Program	Dosing	Phone	2 Weeks
Chase (2003)	T1	Pediatric	30	Semi-automated	No	No	Provider	Dosing + Lifestyle	Phone	2 Weeks
Cho (2009)	T2	Adult	34	Semi-automated	No	No	Provider	Dosing + Lifestyle	SMS	Bi-weekly
Cox (2008)	T1	Adult	17	Manual: Logbook	Yes	Yes	Patient	Monitoring	Internet	Multiple times a day
Faridi (2008)	T2	Adult	15	Semi-automated	No	No	Program	Dosing + Lifestyle	SMS	Daily
Farmer (2005)	T1	Adult	47	Semi-automated	Yes	Yes	Provider	Dosing	Phone	Weekly
Froisland (2012)	T1	Pediatric	12	Semi-automated	No	No	Provider	Dosing + Lifestyle	SMS	3 Days
Gay (2006)	T1	Pediatric	50	Semi-automated	No	No	Provider	Dosing	Phone, Letter	2 Weeks
Hanauer (2009)	T1	Pediatric + Adult	22	Semi-automated	No	Yes	Program	Follow Regimen	SMS	Weekly then Monthly
Hermanns (2007)	T1	Adult	74	Semi-automated	No	Yes	Patient	Dosing + Lifestyle	In Person	Weekly
Howe (2005)	T1	Pediatric	47	Semi-automated	No	No	Patient + Provider	Dosing	Phone	2 Weeks
Istepanian (2009)	T2 +	Adult	72	Semi-automated	No	No	Provider	Unclear	Letter	Unclear
Izquierdo (2009)	T1	Pediatric	23	Semi-automated	Yes	No	Provider	Dosing	In Person	Monthly
Kim (2010)	T2 +	Adult	47	Semi-automated	Yes	No	Program	Dosing	SMS	3 Days
Kim (2008)	T2 +	Adult	18	Semi-automated	No	No	Provider	Dosing + Lifestyle	SMS	Weekly
Kim (2006)	T2 +	Adult	33	Semi-automated	No	No	Provider	Dosing	SMS, Internet	Weekly
Kollmann (2007)	T1	Adult	10	Semi-automated	Yes	Yes	Program	Dosing	SMS	Multiple times a day
Kwon (2004)	T2 +	Adult	185	Manual: SMS	Yes	Yes	Provider	Dosing + Lifestyle	SMS	Unclear
Lawson (2005)	T1	Pediatric	23	Semi-automated	No	No	Provider	Dosing	Phone	Weekly
Lyles (2011)	T2 +	Adult	8	Semi-automated	Yes	Yes	Provider	Dosing	Email	At Will
Marrero (1995)	T1	Pediatric	52	Semi-automated	No	No	Provider	Dosing	Phone	2 Weeks
Nunn (2006)	T1	Pediatric	60	Semi-automated	No	No	Provider	Dosing + Lifestyle	Phone	3 times a week
Panagiotopoulos (2003)	T1	Pediatric	25	Manual: Voice	No	Yes	Provider	Dosing	Phone	Weekly
Polonsky (2011)	T2	Adult	256	Manual: Logbook	No	Yes	Patient + Provider	Dosing + Lifestyle	In Person	3 Months

Author (Year)	T1 or T2/ ¹	Pediatric or Adult Participants	Number of Intervention Participants	How BG Values Were Obtained	Graphical Interface for BG Values	Log of BG Values	BG Interpretation & Regimen Adjustments	Recommended Actions to Patient	Mechanism of Intervention	Intervention Schedule
Quinn (2008)	T2 +	Adult	13	Semi-automated	No	Yes	Program	Dosing + Lifestyle	SMS	2 Weeks
Rami (2006)	T1	Pediatric	18	Semi-automated	No	No	Provider + Program	Dosing	SMS	Weekly
Rossi (2010)	T1	Adult	67	Manual: SMS	No	No	Program	Dosing	SMS	2 Times a Week
Sullivan-Bolyai (2012)	T1	Parents	16	None	No	No	Patient	Dosing + Lifestyle	In Person	Once time
Vähätalo (2004)	T1	Adult	102	Manual: SMS	No	No	Provider	Dosing +Monitoring	SMS	Weekly
Wysocki (1992)	T1	Pediatric	47	Manual: Logbook	No	Yes	Patient	Dosing + Lifestyle	Self	Monthly
Yoo (2009)	T2	Adult	57	Semi-automated	No	No	Program	Lifestyle	SMS, Internet	Multiple times a day
Yoon (2008)	T2 +	Adult	25	Semi-automated	Yes	Unclear	Provider	Dosing + Lifestyle	SMS	Weekly

¹ T1 = Type 1 Diabetes Mellitus; T2 = Type 2 Diabetes Mellitus; T2+ = Type 2 Diabetes Mellitus on insulin