

# Real-Time Continuous Glucose Monitoring Facilitates Feelings of Safety in Older Adults With Type 1 Diabetes: A Qualitative Study

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## Abstract

**Background:** Older adults with long-standing type 1 diabetes (T1D) have a higher risk for hypoglycemia and hypoglycemia unawareness. Hypoglycemia can be dangerous, even fatal. Real-time continuous glucose monitoring (RT-CGM) effectively supports diabetes management and well-being in adult and pediatric populations. Little is known about older adults and RT-CGM use. The purpose of this study was to identify why RT-CGM was important for diabetes management in individuals with T1D 65 years of age.

**Methods:** A convenience sample of older adults with T1D participated in one of two online surveys about RT-CGM. Categorical data were analyzed using descriptive statistics. A qualitative content analysis was conducted for open-ended responses.

**Results:** Participants (N = 22) included in this study were those using RT-CGM (n = 11) and those who were not using RT-CGM, but desired to do so (n = 11). Those using RT-CGM were less likely to experience severe hypoglycemia (P = .02) or hypoglycemia resulting in a fall or inability to operate a motor vehicle (P = .01). Three major themes were identified: (1) RT-CGM facilitates feelings of safety by preventing hypoglycemia, (2) RT-CGM improves well-being, and (3) access is a barrier to RT-CGM use.

**Conclusions:** RT-CGM improves safety and well-being in older adults with T1D by preventing hypoglycemia and associated injury and worry. Older adults without access to RT-CGM experience more severe hypoglycemia events that negatively affect their safety and well-being. Improving access to RT-CGM in older adults is critical to improving health and safety, and demands more attention from stakeholders in diabetes care.

## Keywords

continuous glucose monitoring, hypoglycemia, type 1 diabetes, older adult, safety

Individuals with type 1 diabetes (T1DM) are living longer.<sup>1</sup> The risk for severe or fatal hypoglycemia associated with taking insulin increases with age.<sup>2,3</sup> The risk for severe hypoglycemia is markedly increased in older adults due to reduced awareness of hypoglycemic warning symptoms, reduced counterregulatory response (epinephrine, norepinephrine, and glucagon secretion), and altered psychomotor performance (preventing affected individuals from taking corrective action).<sup>2</sup> In older adults with T1DM, hypoglycemia increases the risk of cardiovascular<sup>4</sup> and cerebrovascular events, falls,<sup>5</sup> seizures, emergency department visits,<sup>6</sup> and hospitalizations.<sup>7</sup>

Hypoglycemic events can be difficult to diagnose in older adults who are often unaware of their hypoglycemia and can often be missed by the intermittent nature of self-monitored blood glucose (SMBG) measurements.<sup>8</sup> Less intensive glucose

control had been recommended by the American Geriatrics Society and American Diabetes Association for vulnerable patients, glycosylated hemoglobin (HbA1c) <8% instead of the standard recommendation of <7%.<sup>9,10</sup> However even with relaxed glycemic goals, 65% of older adults (≥69 years) with T1 and T2 DM with HbA1c >8% using blinded CGM still had hypoglycemia or severe hypoglycemic events.<sup>8</sup> For older adults, rates of hospital admissions for hypoglycemia far exceed the admissions for hyperglycemia indicating that hypoglycemia

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poses a greater health threat than hyperglycemia.<sup>7</sup> In this study, overall rates of hyperglycemia were improved in older adults but concurrent hypoglycemia rates increased which is the central problem CGM was designed to solve. In another study of older adults ( $\geq 60$ ) using blinded CGM ( $N = 199$ ), hypoglycemia was found to be strongly associated with glucose variability. Time spent in hypoglycemia was shown to be greater in those who were younger had shorter diabetes duration, lower HbA1c, and undetectable C-peptide, but did not differ by insulin method, education level, number of blood glucose checks per day, cognition, activities of daily living, or fear of hypoglycemia. This descriptive information about older adults at risk for hypoglycemia provides guidance about individuals who may benefit most from RT-CGM.<sup>11</sup>

Tactics to avoid hypoglycemia in older adults are critical to promote safety and well-being. "Technological Advances in the Treatment of Type 1 Diabetes" identifies the importance of RT-CGM is effective at supporting diabetes management and well-being in adult and pediatric populations.<sup>12</sup> RT-CGM studies have traditionally excluded older individuals and therefore, little is known about older adults and RT-CGM use. The purpose of this study was to identify why RT-CGM was important for diabetes management in both current and former RT-CGM users  $\geq 65$  years of age.

## Methods

### Participants

A convenience sample of older adults with T1D were recruited using a snowball sampling technique from the Diabetes Online Community within Facebook to participate in one of two online surveys about RT-CGM. The first survey queried individuals who were current RT-CGM users. The second survey, occurring 1 month later, examined individuals who were not currently using RT-CGM, but had a desire to do so. Open-ended questions were focused on why participants were/wanted to use RT-CGM, and how RT-CGM was/would affect diabetes management and safety. Questions also addressed hypoglycemia, severe hypoglycemia episodes, and hypoglycemia unawareness. In this report, hypoglycemia is defined as a low blood glucose level less than 70 mg/dl, severe hypoglycemia is defined as a hypoglycemia episode requiring assistance from another person, and hypoglycemia unawareness is defined as occurring when an individual with diabetes is experiencing hypoglycemia, but feels no symptoms.<sup>13</sup> See Table 1 for additional details about survey questions. Participants were eligible for the study if they were  $\geq 65$  years, had been diagnosed with T1D, and could read/write English. All participants volunteered to participate.

### Procedure

We notified key opinion leaders well known to the primary author, including one older adult key opinion leader within the Diabetes Online Community about the research and

provided them with a link to the online surveys. The Diabetes Online Community includes any website in which individuals affected by diabetes can interact with one another, including social media sites. The key opinion leaders shared the link to the online survey via social media (eg, Facebook, Twitter). Notable, the older adult key opinion leader shared the survey link on the private Facebook Page "Joslin Medalist Group." This study has been approved by the Institutional Review Board at the University of Utah.

### Data Analysis

Categorical data were analyzed using descriptive statistics. A qualitative content analysis was conducted for the open-ended responses.<sup>14</sup> The data were analyzed line by line, using an open-code approach, to develop a codebook which included codes and categories. Interpretive analysis was used to compare and contrast the categories between groups, to support the emerging themes. Quantitative data were analyzed using nonparametric two-sample *t*-tests, Fisher's exact test, and exact binomial tests.

## Results

A total of 22 participants (males = 11, females = 11) were included in this qualitative study, those using RT-CGM ( $n = 11$ ) and those who were not using RT-CGM, but desired to do so ( $n = 11$ ). Six participants who were not current RT-CGM users had used RT-CGM technology in the past. Participants were Caucasian, mean age  $70 \pm 4.7$  years, diabetes duration  $59 \pm 9.6$  years, and self-identified as high technology users. Groups were not statistically different with regards to age, diabetes diagnosis duration, gender, race, and education level. RT-CGM users wore Dexcom ( $n = 9$ ) and Medtronic ( $n = 2$ ) devices and most often wore their RT-CGM device all of the time ( $n = 10$ ). Individuals who were wearing RT-CGM were less likely to experience severe hypoglycemia requiring the assistance of another person ( $P = .02$ ) or hypoglycemia resulting in a fall or inability to operate a vehicle ( $P = .01$ ) when compared to those not using RT-CGM (see Table 2).

## Results

This qualitative study provided insight about older adults with T1D and RT-CGM use. The analysis resulted in the identification of three major themes, discussed below: (1) RT-CGM facilitates feelings of safety by preventing hypoglycemia, (2) RT-CGM improves well-being, and (3) access is a barrier to RT-CGM use. See Table 3 for representative quotes, categorized by group.

### *RT-CGM Facilitates Feelings of Safety by Preventing Hypoglycemia*

*Current RT-CGM Users.* RT-CGM alarms and glucose trends allowed older adult participants to successfully avoid hypoglycemia. Watching closely at the trends and listening for

**Table 1.** Survey Questions.

	Topic	RT-CGM user	Non-RT-CGM user
Qualitative	RT-CGM use	Why did you start using continuous glucose monitoring?	Have you used continuous glucose monitoring in the past? If so, please explain. Why do you want to use continuous glucose monitoring?
	Hesitation to use RT-CGM	Were you initially hesitant to start continuous glucose monitoring? If so, please explain.	Besides cost, what would make you hesitant to use continuous glucose monitoring?
	Diabetes management	How does continuous glucose monitoring affect your diabetes management?	How would continuous glucose monitoring affect your diabetes management?
	Safety	How does continuous glucose monitoring affect your safety?	How would continuous glucose monitoring affect your safety?
	RT-CGM use	What are the reasons that you do not wear the continuous glucose monitor, if any?	N/A
	Successful RT-CGM user	What makes you a successful user of continuous glucose monitoring?	N/A
	Insurance coverage	What should Medicare consider when deciding whether or not to cover continuous glucose monitoring?	What should Medicare consider when deciding whether or not to cover continuous glucose monitoring?
	Hypoglycemia		If you have had a severe hypoglycemia event in the past year, please explain.
	Hospitalization		If you have been hospitalized for diabetes in the past 2 years, please explain.
Quantitative	Hypoglycemia	On average, how many hypoglycemia events are you experiencing in a week?	On average, how many hypoglycemia events are you experiencing in a week?
	Severe hypoglycemia	Have you experienced a severe hypoglycemia event (requiring the assistance of another person) since using continuous glucose monitoring?	Have you experienced a severe hypoglycemia event (requiring the assistance of another person) in the past year?
	Hospitalization	Have you been hospitalized for your diabetes since you started using a continuous glucose monitor?	Have you been hospitalized for your diabetes in the last year?

alarms, older adults were acutely aware of fluctuations in blood glucose and proactively made behavior adjustments (eg, adjusting insulin doses, using a temporary basal rate, ingesting rapid glucose) to prevent hypoglycemia events. One participant noted, “[I am able] to detect a drift toward hypoglycemia when I can treat it myself rather than waiting to a point where assistance from someone else is needed. The continuous glucose monitor allows a real time control of blood glucose that cannot be achieved with 3 or 4 fingersticks a day.”

Several participants noted that RT-CGM saved their life by warning them of an impending low blood sugar. Since RT-CGM users had warnings about impending hypoglycemia, and were able to treat this trend independently, participants’ spouses no longer needed to administer life-saving glucagon. In addition to preventing hypoglycemia, older adults were able to prevent hyperglycemia as well. Participants reported RT-CGM allowed for an improvement in A1C while also decreasing hypoglycemia events (although A1C data were not collected for this study).

**Non-RT-CGM Users.** Participants who were previous RT-CGM users, and now not using this technology, noted an

increase in hypoglycemia-related concerns. Non-CGM users noted distressed about hypoglycemia unawareness, with the majority ( $n = 7$ ) reporting they had experienced a severe hypoglycemia event that required the assistance of another person in the past 12 months. These severe hypoglycemia events oftentimes ( $n = 6$ ) resulted in a fall or inability to operate a vehicle. Representative quotes include:

My spouse had to help me up from the kitchen floor, get fruit juice from the refrigerator, pour some into a glass and hold the glass to my mouth so that I could drink it. I was shaking too much to either stand on my own or hold the glass of juice.

I had [severe hypoglycemia] after supper, when I fell and hit my head and my husband found me in the floor.

### RT-CGM Improves Well-Being

**Current RT-CGM User.** RT-CGM users appreciated the ability to track the effects of food and activity on their blood glucose level, allowing them to learn more about their diabetes. Furthermore, RT-CGM users appreciated being able

**Table 2.** Demographics.

	RT-CGM user (n = 11)	Non-RT-CGM user (n = 11)	P value
Age, mean $\pm$ SD	69.6 $\pm$ 4	70.5 $\pm$ 5.5	.66 <sup>a</sup>
Diagnosis duration, mean $\pm$ SD	59.4 $\pm$ 6.4	57 $\pm$ 12.8	.55 <sup>a</sup>
Gender			
Male, n (%)	6 (55)	5 (45)	1.0 <sup>a</sup>
Female, n (%)	5 (45)	6 (55)	
Caucasian, n (%)	11 (100)	11 (100)	1.0 <sup>b</sup>
Education, n (%)			
High school graduate	0 (0)	2 (18)	.59 <sup>b</sup>
Some college	2 (18)	3 (27)	
Bachelor's degree	3 (27)	3 (27)	
Master's degree	5 (45)	2 (18)	
Doctoral degree	1 (9)	1 (9)	
Technology use, n (%)			
Internet	11 (100)	11 (100)	1.0 <sup>c</sup>
Email	11 (100)	10 (91)	.30 <sup>c</sup>
Text messaging	10 (91)	4 (36)	.007 <sup>c**</sup>
Laptop	10 (91)	8 (73)	.26 <sup>c</sup>
Tablet	9 (82)	5 (45)	.07 <sup>c</sup>
Desktop computer	8 (73)	8 (73)	1.0 <sup>c</sup>
E-reader	7 (64)	2 (18)	.030 <sup>c*</sup>
Diabetes management, n (%)			
Multiple daily injections	2 (18)	2 (18)	1.0 <sup>b</sup>
Insulin pump	9 (82)	9 (82)	
CGM device, n (%)			
Dexcom Gen4	8 (73)		
Dexcom Gen5	1 (9)		
Medtronic Revel	1 (9)		
Medtronic Enlite	1 (9)		
Length of CGM use, n (%)			
<3 months	1 (9)		
3-12 months	2 (18)		
1-2 years	4 (36)		
3-5 years	2 (18)		
>5 years	2 (18)		
Frequency of CGM use, n (%)			
All of the time	10 (92)		
3 weeks per month	0 (0)		
2 weeks per month	1 (9)		
1 week per month	0 (0)		
Less than monthly	0 (0)		
Payment for CGM, n (%)			
Self-pay	4 (36)		
HMO insurance	2 (18)		
Donated	1 (9)		
Medicare per appeal	0 (0)		
Other	4 (36)		
Hypoglycemia unawareness, n (%)	4 (36)	8 (73)	.095 <sup>b</sup>
Hypoglycemia episodes per week, mean $\pm$ SD	3.82 $\pm$ 2.18	2.65 $\pm$ 1.31	.190 <sup>b</sup>
Severe hypoglycemia requiring assistance in the last year, n (%)	1 (9)	8 (73)	.023 <sup>b*</sup>
Severe hypoglycemia resulting in a fall or inability to operate a vehicle in the last year, n (%)	0 (0)	6 (55)	.012 <sup>b*</sup>

<sup>a</sup>Two-sample *t*-test with unequal variances. <sup>b</sup>Fisher's exact test. <sup>c</sup>Exact binomial test. \**p*<.05, \*\**p*<.01.

**Table 3.** Themes.

Theme	RT-CGM user		Non-RT-CGM user	
	Codes	Representative quote	Codes	Representative quote
RT-CGM facilitates feelings of safety by preventing hypoglycemia	Warning of hypoglycemia Ability to be proactive in treating hypoglycemia	Wife has not had to use glucagon once since going on Dexcom! The ability to detect a drift toward hypoglycemia when I can treat it myself rather than waiting to a point where assistance from someone else is needed. The continuous glucose monitor allows a real time control of blood glucose that cannot be achieved with 3 or 4 fingersticks a day.	Not being aware of hypoglycemia Increased SMBG to avoid hypoglycemia	My ability to be aware of an impending hypoglycemic episode has become quite diminished and I usually can only know how low my blood sugar is by taking a blood sample from my finger. I am very concerned about not being timely aware of a hypoglycemic attack. I want to be alerted to dangerous high and low blood sugars and take steps to correct the problems.
RT-CGM improves well-being	Ability to avoid extreme glycemic variability Improved sleep and driving due to CGM alarming if glucose out of range CGM has and can save lives	[I'm] not worried now about losing my life in the night because of a low blood sugar. [I have] better control, [fewer] safety concerns, eg, driving, hypoglycemic unawareness, wife doesn't have to worry. Really a positive game changer.	CGM would prevent avoidance of extreme glycemic variability CGM would prevent complications and injury related to hypoglycemia	[CGM] would help me treat a low or high before it became dangerous, [such as] when driving. I would not be falling and having seizures.
Access is a barrier to RT-CGM use	Medicare does not provide coverage The cost of CGM is not affordable without insurance	I do not understand why Medicare won't pay for the CGM which is such a lifesaver, medical cost saver, and necessity for diabetics. I was about to start on Medicare and was concerned that it doesn't cover supplies. I did not know if I could find a supplemental insurance that would help pay some of the cost.	Medicare does not provide coverage The cost of CGM is not affordable without insurance	I can't believe how much money I would have to pay because Medicare won't help. I do not have a CGM because I cannot afford the costs. I had one until my husband retired and we had to change to Medicare and Supplemental Insurance that does not cover CGM.

to watch trend graphs while driving, exercising, or traveling, and felt that they were able to function better in their daily activities due to RT-CGM. Participants noted that diabetes was more difficult to manage as they aged, those using RT-CGM felt the device could help support a prolonged life by preventing injury and complications. One participant noted:

It makes me more aware of what things affect my blood sugar, like exercise, stress, certain foods, illness, etc. I've always known these things affect my diabetes, but now I understand the level of change. When I recognize a pattern, I know how to deal with it next time and the "worry factor" goes down.

RT-CGM users' ability to avoid hypoglycemia decreased worry about dying in their sleep or driving a vehicle, providing an overall sense of relief. Less worry about hypoglycemia and improved metabolic control from extremes in blood glucose levels

supported well-being. Furthermore, RT-CGM use allowed for users to feel more independent, not having to rely on others to address hypoglycemia. One participant noted, "Wife has not had to use glucagon once since going on Dexcom!"

**Non-RT-CGM Users.** Those who were not using RT-CGM reported stress related to not knowing when and if they would experience a hypoglycemia unawareness event. Improvement in mental health and sleep was noted as a major factor in wanting to use RT-CGM. Participants also felt that having RT-CGM would allow them more independence and confidence when they are alone. One participant noted, "It would alert me to the fact my blood glucose was going down, at times I don't feel that happening. In so doing, it would give me the opportunity to help myself before I needed emergency help from others. I would have a more restful sleep at night."

Participants desired RT-CGM to avoid the complications that can be associated with hypoglycemia. One participant noted, “I would not be falling and having seizures.” Some participants reported they would feel more secure in their ability to manage the day-to-day glucose fluctuations if they had RT-CGM. One participant noted, “I believe it would provide me with a level of confidence in my ability to prevent severe hypoglycemic events and also to catch rapidly raising blood glucose levels.”

### **Access Is a Barrier to RT-CGM Use**

**Current RT-CGM Users.** Participants welcomed RT-CGM, but were concerned with the cost and bureaucracy related to accessing the technology. Current RT-CGM users had received older devices from another person with diabetes, had a secondary insurance to support coverage, or were paying out of pocket. One participant noted:

Medicare should understand that a diabetic is “blind” to his [blood glucose] trends without a CGM. [CGM] prevents costly emergency room trips and out of control BG. Also, a CGM makes a huge difference in the lives of diabetics who want to maintain good A1Cs and prevent complications, all leading to less medical expense for Medicare in the future. I do not understand why Medicare won’t pay for the CGM which is such a lifesaver, medical cost saver, and necessity for diabetics.

**Non-RT-CGM Users.** RT-CGM was viewed as a cost-effective device in preventing hospitalizations, preventing emergency and paramedic visits, and decreasing medical costs associated with complications and potential injury. One participant noted, “The use of CGM could cost far less than the cost for emergency care in a hospital + rehab expenses, etc. as a result of injury from having a hypo event. Health Care cost in general would be less in the long run.”

All noncurrent RT-CGM users were unable to use RT-CGM due to lack of insurance coverage and inability to pay out of pocket. Those who had used RT-CGM prior to turning 65 were disheartened that they could not continue use of the technology due to insurance issues. Participants expressed frustration with the barriers to accessing RT-CGM, especially since the participants’ health care provider had recommended the use of RT-CGM. One participant noted, “I wore a CGM for about 3 years, but had to stop because Medicare and insurance will not cover it. Without the CGM, I find myself saying and doing things that I normally would not do if I had a CGM to warn me.”

## **Discussion**

This qualitative study examined older adults with T1D to identify why RT-CGM was important for diabetes management in both current and noncurrent RT-CGM users. The results indicate that RT-CGM is a well-accepted technology that improves perceived safety and well-being in older adults

with T1D by preventing hypoglycemia and associated injury and worry. Older adults have financial and insurance coverage barriers to accessing RT-CGM. This research examines an understudied population, older adults with T1D, in how they can benefit from RT-CGM technology.

Themes identified in this research, RT-CGM facilitates feelings of safety by preventing hypoglycemia and RT-CGM improves well-being, supports quantitative research in a similar population.<sup>15</sup> Severe hypoglycemia events, especially in an older adult, can negatively affect safety and well-being. Hypoglycemia unawareness and glycemic variability are associated with severe hypoglycemia in older adults.<sup>16</sup> While there are mixed data regarding whether or not RT-CGM use can restore hypoglycemia unawareness,<sup>17,18</sup> RT-CGM use does decrease exposure to hypoglycemia,<sup>19,20</sup> even in those with hypoglycemia awareness;<sup>18</sup> therefore, RT-CGM is likely a beneficial tool for older adults with T1D who are at high risk for severe hypoglycemia.

All RT-CGM users in this study said the technology helped them ( $n = 11$ ) to prevent hypoglycemia and extremes in blood glucose levels while those who wanted to use RT-CGM, but currently were not, yearned for the technology to avoid hypoglycemia and improve glucose variability. In fact, participants who were not using RT-CGM, but wanted to, had concerns about hypoglycemia and reported a higher frequency of severe hypoglycemia or consequences of hypoglycemia, such as falling. Older adults experiencing hypoglycemia are more likely to have a fall,<sup>21</sup> which can result in untoward effects including injury, fracture, concussion, or even death,<sup>22</sup> affecting well-being and health care costs. In high-risk adults with T1D, RT-CGM has the potential to save \$54 million in hypoglycemia-related hospitalizations,<sup>23</sup> the cost savings would likely be greater in an older adult population.

Access is a barrier to RT-CGM use among older adults with T1D, despite well documented reductions in hypoglycemia with RT-CGM use,<sup>18-20</sup> Coverage for RT-CGM among Medicare beneficiaries is a new phenomenon and will certainly play a role in reaching the Medicare coverage gap commonly referred to as the “donut hole” earlier in the year. Older adults are commonly on fixed incomes, making RT-CGM unaffordable for most to pay out of pocket. Improving access to RT-CGM in older adults with T1D is critical to improving health and safety, and demands more attention from stakeholders in diabetes care, including health care providers and insurers.

This study is not without limitations. The sample size was small with a natural selection bias to those who were able to obtain RT-CGM. The sample consisted of mostly Caucasians that were high technology users, which may not be generalizable to the older adult with T1D. Although, it should be noted that individuals with diabetes do have to use technology (eg, glucometers) on a regular basis, which may impact willingness and ability to use technology. Older adults who were interested in RT-CGM, but not currently using RT-CGM, may have more glucose variability, resulting in biased

responses. Glucose variability has been shown to be associated with more hypoglycemia in older adults<sup>11</sup> and is therefore a targeted population.

To minimize of the limitations of this study, the open-ended survey questions have been provided for future replicability, two researchers were used for the interpretive analysis, and direct quotes were used to support the themes. In this study, we aimed to describe the phenomenon of why RT-CGM was important for diabetes management in both current and former RT-CGM users  $\geq 65$  years of age. Generalizability was not the goal of this research and is not a typical goal of qualitative research. However, this study does provide necessary data to support future quantitative research focused on CGM and safety in older adults with T1D.

In summary, we examined how RT-CGM facilitates feelings of safety in older adults with T1D. Notable, in this study, older adults not wearing RT-CGM experienced more severe hypoglycemia episodes and falls related to hypoglycemia when compared to those using RT-CGM. The potential cost savings in emergency room visits and hospitalizations is significant. With RT-CGM, they reported an improvement in their well-being, characterized by less worry about hypoglycemia while driving and sleeping and an overall sense of independence. The barrier of insurance coverage for older adults is prohibiting access to this technology, although recent changes within Medicare look promising. More studies are needed to drive policy change and insurance coverage to ensure older adults who want RT-CGM have access to the device and the increased safety and well-being associated with its use.

## Conclusions

In this study, RT-CGM improves feelings safety and well-being in older adults with T1D by preventing hypoglycemia and associated injury and worry. Older adults without access to RT-CGM in this small sample experienced more severe hypoglycemia events that negatively affected their safety and well-being. Improving access to RT-CGM in older adults is critical to improving health and safety, and demands more attention from stakeholders in diabetes care.

## Abbreviations

HbA1c, glycosylated hemoglobin; RT-CGM, real-time continuous glucose monitoring; SMBG, self-monitored blood glucose; T1DM, type 1 diabetes.

## Declaration of Conflicting Interests

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