



# Barriers to Continuous Glucose Monitoring in People With Type 1 Diabetes: Clinician Perspectives

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The purpose of this study was to determine clinician attitudes about the distinct barriers to uptake of continuous glucose monitoring (CGM) among people with diabetes. Survey data were collected measuring individual barriers, prerequisites to CGM, confidence in addressing barriers, and clinic staff resources. Results show that clinicians commonly report barriers to using CGM among people with diabetes in their clinic. Furthermore, clinicians who report a high number of barriers do not feel confident in overcoming the barriers to CGM. Interventions that attempt to empower clinicians to address concerns about CGM among people with diabetes may be warranted because low uptake does not appear to be directly related to available resources or prerequisites to starting CGM.

Diabetes technologies such as continuous glucose monitoring (CGM) improve glycemic control and reduce hypoglycemia in people with type 1 diabetes (1,2). Use of CGM can also increase health-related quality of life and satisfaction with the treatment regimens and is associated with fewer depressive symptoms (3–5). Despite these benefits, the rate of CGM uptake has been low, at only 5–23% depending on the age-group (6).

Many barriers may prevent people from CGM, including device cost, wear discomfort, and social factors (7,8). Clinicians' perceptions of the barriers faced by people with diabetes in their clinic may affect their willingness to prescribe CGM devices and encourage and support their use among people with diabetes. Clinicians for people with type 1 diabetes tend to perceive more barriers to device use and to rate these barriers as being more significant than they actually are for adults with type 1 diabetes (9); yet it is important for clinicians to help people with diabetes develop realistic, as opposed to overly high, expectations of CGM so they will not be disappointed by their device upon initiation (10,11).

Addressing barriers requires time and resources, which are often scarce among clinicians and staff. Research has shown that adequate time and clinic resources are necessary to promote continued use and maximize benefits of CGM devices (12–14). Clinicians may also expect people with diabetes to meet certain criteria before prescribing a CGM system, such as having family support (15) or

performing frequent blood glucose measurements (16). These prerequisites may help people with diabetes use their devices to the full potential, but they are not uniform across clinics and are often based on subjective decision-making. For these reasons, we sought to determine the specific barriers that clinicians perceive as most crucial to CGM uptake and to compare clinicians who perceive higher barriers to CGM to those who perceive lower barriers to inform future efforts to efficiently and effectively increase CGM uptake.

A previous study of clinicians' perspectives on diabetes technology use and barriers by Tanenbaum et al. (17) identified three clinician personas based on readiness to promote CGM uptake: "Ready," "Cautious," and "Not Yet Ready." Results showed that clinicians most resembling the Cautious persona held positive attitudes toward CGM devices and technology in general, but they perceived that people with diabetes face significantly more barriers to CGM use and therefore would not encourage their use (17). The Not Yet Ready clinicians held negative attitudes toward technology and perceived the people with diabetes that they treat to face a moderate number of barriers to CGM use. The Ready clinicians perceived the people with diabetes that they treat to face a low number of barriers to CGM use and held positive attitudes toward these devices.

In this study, the Cautious clinician cluster was compared with the Ready clinician cluster to better understand why these clinicians perceive such high barriers despite having

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<https://doi.org/10.2337/ds19-0039>

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positive attitudes toward diabetes technology. The aims of the study are to 1) further examine clinician-perceived barriers to CGM use in people with diabetes and their link to clinician characteristics and 2) compare in greater depth clinicians perceiving a high number of barriers to CGM use among people with diabetes (the Cautious group) and clinicians perceiving a low number of barriers to device use among people with diabetes (the Ready group) to understand differences between the two clinician groups. This study adds to the literature by better outlining the differences between these personas that may lead to higher perceived barriers to CGM use among clinicians. By understanding these differences, possible interventions or educational materials can be created to help clinicians better promote uptake of CGM.

## Research Design

The study sample consisted of 127 providers (Ready [ $n = 42$ ] and Cautious [ $n = 85$ ]). Participants were recruited through the T1D Exchange Clinic Network, a group of 75 endocrinology practices based in the United States, as well as dQ&A, a company that conducts market research through diabetes proprietary panels that include educators and physicians.

Data were collected during a 6-month period in early 2016. This study was completed before the release of the newest CGM options, including the FreeStyle Libre flash CGM system (Abbott Pharmaceuticals). The survey took approximately 45 minutes to complete, and participants were offered a \$75 gift card or the opportunity to donate this compensation directly to any desired nonprofit diabetes organization. Initial results of this survey have been published (9). The Stanford University institutional review board approved all study procedures.

## Measures

### *Perception of Barriers in People With Diabetes*

Clinicians were asked what barriers the people with diabetes in their clinic face or what they think people with diabetes would say gets in the way of using CGM. A list of barriers was presented (Table 1), and clinicians chose as many as they found applicable. The list of barriers was previously created from literature review and market research results to determine barriers to CGM use in adults (18). The list was adapted and further refined to be appropriate for clinicians in this study. Barriers included both cost-related factors such as “Insurance coverage” and other

potentially modifiable barriers such as “Do not like having diabetes devices on their body.”

### *Clinic Resources Available*

Clinicians selected applicable items from a list of “All clinical resources to which your practice currently has easy access for your people with diabetes.” This list was created specifically for this study. A total of 11 items were presented, including diabetes educators, mental health professionals, support staff, and specialists. Clinic resources were summed, with a higher score indicating more clinic resources available to clinicians (range: 0–11).

### *Confidence in Addressing Barriers*

After selecting perceived barriers to CGM, clinicians were asked to identify the top three barriers to CGM among the people with diabetes seen in their practice. Then, clinicians rated their confidence in addressing each of these barriers by themselves or through another provider in clinic on a scale of 1 to 10, with 1 indicating not confident and 10 indicating extremely confident.

### *Prerequisites to CGM*

Clinicians selected from a list of prerequisites they would like people with diabetes to meet before being considered eligible for CGM. Eight items covered topics such as treatment adherence, education, and social support. This list was created after reviewing available resources and literature. Some examples include “Perform frequent blood glucose monitoring,” “Have support from family or loved ones,” and “Have sufficient educational background.” Each of these items was ranked on a Likert scale, with 1 indicating “strongly disagree” and 5 indicating “strongly agree.” These scores were summed, with a lower score indicating fewer requirements for CGM and higher scores indicating more requirements for CGM. This scale demonstrated adequate internal reliability (Cronbach’s  $\alpha = 0.81$ ).

## Methodology

Simple counts of perceived barriers were calculated first. Then, independent samples  $t$  tests and Pearson  $\chi^2$  analyses were performed to compare the Cautious and Ready profiles on the following measures unless otherwise noted. To control for type I errors when performing multiple tests, the Benjamini-Hochberg procedure was used with a false discovery rate ( $Q$ ) of 0.05 and statistical significance was determined (19).

**TABLE 1** Clinician-Perceived Barriers to CGM

Barrier	Cautious Group, % (n)	Ready Group, % (n)	$\chi^2$	P
Cost of device	98.9 (84)	33.3 (14)	68.423	<b>&lt;0.001</b>
Cost of supplies	97.6 (83)	31.0 (13)	67.767	<b>&lt;0.001</b>
Insurance coverage	98.8 (84)	76.2 (32)	18.202	<b>&lt;0.001</b>
Nervous that the device might not work	25.9 (22)	11.9 (5)	3.281	0.070
Nervous to rely on technology	40.0 (34)	19.0 (8)	5.575	<b>0.018</b>
Too busy to learn how to use a new technology or device	45.9 (39)	9.5 (4)	<0.001	<b>&lt;0.001</b>
Do not like having diabetes devices on their body	78.8 (67)	59.5 (25)	5.245	<b>0.022</b>
Do not like how diabetes devices look on their body	43.5 (37)	21.4 (9)	5.944	<b>0.015</b>
Do not want to take more time from their day to manage diabetes	41.2 (35)	14.3 (6)	9.298	<b>0.002</b>
Do not want to have more information about their diabetes	38.8 (33)	21.4 (9)	3.843	0.050
Do not understand what to do with the information or features of the devices	54.1 (46)	35.7 (15)	3.814	0.051
Do not like diabetes devices because people notice them and ask questions about them	36.5 (31)	16.7 (7)	5.258	<b>0.022</b>
Do not want to share diabetes information with family members	23.5 (20)	7.1 (3)	5.090	<b>0.024</b>
Their family does not think diabetes devices are important for taking care of their diabetes	23.5 (20)	7.1 (3)	5.090	<b>0.024</b>
Too hard to get it to work right	49.4 (42)	16.7 (7)	12.720	<b>&lt;0.001</b>
Too many alarms	75.3 (64)	50 (21)	8.125	<b>0.004</b>
Causes discomfort or pain	52.9 (45)	26.2 (11)	8.160	<b>0.004</b>
Interferes with sleep	50.6 (43)	16.7 (7)	13.551	<b>&lt;0.001</b>
Not enough time during clinic visits to learn about how to use devices	15.3 (13)	2.4 (1)	4.779	<b>0.029</b>

Bold type indicates significant difference ( $P < 0.05$ ) between Cautious and Ready groups.

### Perception of Barriers in People With Diabetes

Total barriers to CGM, total cost-related barriers, and total modifiable barriers were compared between the Cautious and Ready profiles.

### Clinic Resources Available

To analyze clinic resources available to clinicians, the total number of resources indicated by each clinician was summed and means were compared between the Cautious and Ready groups. A Fisher exact test was then performed for the individual items “CGM trainers” and “certified diabetes educators (CDEs)” because these resources are relevant to CGM initiation and use in clinics. This test was chosen over a Pearson  $\chi^2$  analysis

because the expected frequency of 25% of the cells was  $< 5$  (20,21).

### Confidence in Addressing Barriers

Confidence ratings in addressing each of the top three barriers clinicians listed were summed, resulting in a possible range of 3 to 30. Then, the confidence for the first, second, and third most relevant barriers listed were compared separately between the Cautious and Ready groups.

### Prerequisites to CGM

CGM requirements were analyzed by comparing means between the Cautious and Ready groups. Then, each of the eight measures was compared separately.

## Results

### *Perception of Barriers in People With Diabetes*

Clinicians each identified an average of 8.2 of 19 possible barriers to CGM uptake among people with diabetes in their clinic. The highest rated barrier across groups was insurance coverage ( $n = 116$ , 91%). When not including cost-related barriers, the highest rated barrier was not wanting a diabetes device on their body ( $n = 92$ , 72%). The Cautious group reported an average of 9.9 barriers, whereas the Ready group reported an average of 4.8 barriers ( $P < 0.001$ ). Almost all individual barriers listed were endorsed significantly more frequently in the Cautious group than in the Ready group (Table 1). The only barriers with no significant difference between groups were “Nervous that the device might not work,” “Do not understand what to do with the information or features of the devices,” and “Do not want to have more information about their diabetes.”

### *Clinic Resources Available*

The two groups of clinicians showed no significant difference in the total number of clinic resources, CGM trainers, or CDEs available. The mean total number of clinic resources was 7.4 for the Ready group (SD 2.2) and 7.5 for the Cautious group (SD 2.1) [ $t(125) = -0.22$ ,  $P = 0.826$ ]. The percentage of clinicians who indicated they had access to enough CDEs in their clinic was not different between groups, with 92.9% for the Ready group (SD 26.1) and 91.8% for the Cautious group (SD 27.7) ( $\chi^2 = 0.046$ ,  $P = 1.000$ ). Whereas 92.9% (SD 26.1) of the Ready group had CGM trainers available in their clinic, 85.9% (SD 35.0) of the Cautious group reported having this resource available, although this difference was not significant ( $\chi^2 = 1.313$ ,  $P = 0.382$ ).

### *Confidence in Addressing Barriers*

Clinicians in the Cautious group showed significantly lower confidence in addressing the top-rated barrier to CGM use. Those in the Cautious group rated their confidence with a mean score of 4.4 of 10 (SD 2.7); those in the Ready group rated their confidence with a mean score of 6.0 of 10 (SD 2.9) ( $t = 3.06$ ,  $P = 0.003$ ).

### *Prerequisites to CGM*

No significant difference was found between the Cautious and Ready groups in the total number of requirements clinicians expect people with diabetes to achieve before using CGM (Table 2). There was also no significant difference between the two groups for each of the separate prerequisites.

## Discussion

Results from this study indicate that diabetes care clinicians perceive many barriers for people with diabetes in their clinic. Based on their level of readiness (Ready vs. Cautious) to prescribe CGM, as described by Tannenbaum et al. (17), our results indicate that clinicians who are cautious regarding CGM uptake are significantly less confident in addressing the most prominent deterrent to CGM use among people with diabetes in their clinic: cost-related barriers (9). Although this group did not feel equipped to help patients work through these barriers, they did not report differences in availability of resources or perceived prerequisites to using CGM. This study adds to the literature because it details differences between clinician personas and outlines possibilities for future interventions or educational opportunities.

It is important to note that there have been some changes to available CGM devices since this survey was administered, including the release of the FreeStyle Libre flash CGM system (22) and the Dexcom G6 (23). The release of these systems and updates to previously available systems may have caused changes in clinician-perceived barriers, which may explain the increase in CGM use over the past several years. CGM use in people with type 1 diabetes in the United States has grown from 24% in 2016 to 38% in 2018 (24). This increase suggests that a significant number of clinicians have improved their skills in overcoming barriers. However, 41% of total clinicians surveyed were in the “Cautious” cluster, and the observed increase in CGM does not account for the entire population of people with diabetes seen by this cluster. Furthermore, it is expected that many of the barriers studied here will be consistent with the new systems, such as “Do not like having diabetes devices on their body,” “Nervous to rely on technology,” and “Do not want to have more information about their diabetes.” Finally, rapid improvements in these technologies may outpace the speed with which clinicians and insurance companies embrace them. More recent studies have shown that clinicians still find it difficult to navigate cost and insurance issues related to CGM (25). These attitudes may affect attitudes toward or perceived difficulties of closed-loop systems that combine CGM and insulin pump technologies, which could negatively affect user access to these systems (26,27). Thus, this research on clinician-perceived barriers to CGM is still relevant despite the recent advancements in CGM technologies.

As expected, almost all barriers were reported significantly more frequently among clinicians in the Cautious group than among those in the Ready group. Clinicians fitting

**TABLE 2** *t* Tests Examining the Difference Between Clinician Groups by CGM Prerequisites

	Cautious Group, mean (SD)	Ready Group, mean (SD)	<i>t</i>	<i>P</i>
Total CGM use requirements total, <i>n</i>	26.3 (5.1)	26.6 (4.9)	0.366	0.715
Perform frequent blood glucose monitoring, <i>n</i>	3.32 (1.115)	3.52 (1.131)	0.976	0.331
Be willing to change CGM sites frequently, <i>n</i>	3.46 (1.030)	3.67 (1.097)	1.047	0.297
Have frequent clinic visits, every 3–4 months, <i>n</i>	3.81 (0.911)	4.02 (0.680)	1.347	0.309
Download the CGM data, <i>n</i>	3.80 (0.875)	3.57 (1.039)	−1.283	0.202
Speak English, <i>n</i>	2.18 (0.889)	2.07 (0.838)	−0.638	0.524
Have support from family or loved ones, <i>n</i>	3.38 (0.886)	3.36 (0.906)	−0.115	0.909
Have sufficient educational background, <i>n</i>	3.11 (0.988)	3.17 (1.022)	0.341	0.733
Be willing to communicate openly about diabetes with family or loved ones, <i>n</i>	3.34 (0.867)	3.33 (1.028)	−0.045	0.964

No significant difference was found between clinician groups.

both profiles moderately endorsed the barrier that people with diabetes do not understand what to do with the information provided by or features of the devices (54% of Cautious clinicians and 36% of Ready clinicians, *P* = 0.051). Also, clinicians fitting both profiles reported that certain barriers to CGM were not common among their patients, including “Do not want to have more information about their diabetes” (38% of Cautious clinicians and 21% of Ready clinicians, *P* = 0.050) or “Nervous that the device might not work” (26% of Cautious clinicians and 11% of Ready clinicians, *P* = 0.070). The Cautious group endorsed the following barriers much more than the Ready group: “Too busy to learn how to use a new technology or device,” “Too hard to get it to work right,” and “Causes discomfort or pain” (Table 1).

One possible way to empower clinicians in overcoming non-cost-related barriers to CGM is to introduce motivational interviewing. This communication style aims to motivate people with diabetes and help them reach behavior-change goals (28). It has been shown to be effective in promoting adherence in adolescents with type 1 diabetes (29).

Surprisingly, clinicians in the Cautious group were not more likely to have prerequisites for CGM than those in the Ready group. Therefore, the high barriers perceived by Cautious group clinicians were unlikely to be the result of their heightened expectations of patients’ disease management abilities, such as carbohydrate counting skills and frequent blood glucose monitoring. This finding, along with the fairly equal number of clinic staff resources between the two groups, suggests that the increased perception of barriers to CGM among Cautious clinicians may result

from perceived limitations not captured by our study measures. For example, Tanenbaum et al. (17) found that Cautious clinicians experienced somewhat greater difficulty than Ready clinicians in staying current with new diabetes technology. Also, Cautious clinicians reported having less clinic time to review device data and adjust insulin doses, which may have undermined their confidence in addressing barriers. These are all possible areas for intervention with providers that may help to decrease perceived barriers and promote CGM use.

There are many reasons why clinicians fitting the Cautious profile may be less confident in addressing financial barriers such as insurance coverage and costs of devices and supplies. Both adults and children with diabetes experience cost-related issues with treatments, and many pay high out-of-pocket costs (30,31). Also, many people with diabetes report that they have received little help or information from their clinicians in addressing high out-of-pocket treatment costs (32).

However, steps can be taken to assist with insurance coverage, and there are many programs available to help people with diabetes afford their supplies (32–34). Further research examining why some clinicians may be more confident than others in addressing cost-related barriers may illuminate ways in which clinicians can overcome these barriers. Such information could help to ensure that all treatment options are offered equitably to people with diabetes across varying socioeconomic levels.

There are several limitations to this study. An online survey was used to determine technology attitudes, which could have skewed the sample self-selection toward more

technology-savvy individuals. Furthermore, although the Cautious clinicians reported high modifiable and non-modifiable barriers among people with diabetes, they also reported a similar percentage of CGM users compared with clinicians identified as more ready for CGM uptake (17). Reporting higher barriers to CGM may be an indication that Cautious clinicians are more aware of various difficulties in using CGM. However, the decreased confidence in addressing barriers demonstrated by Cautious clinicians indicates that there is a possibility of increasing CGM use through targeted trainings on how to address barriers. Also, although the percentage of people with diabetes on public insurance was collected (17), no other measures of socio-economic status were collected. It is possible that the people with diabetes treated by clinicians in the Cautious group truly face more cost-related barriers to device use than those treated by the Ready group.

It is important to understand the factors that limit uptake of CGM given the tremendous benefits of this diabetes technology. One of the most recent advancements in diabetes technology, the closed-loop system, has the ability to decrease treatment distress and improve glycemic control even more than insulin pump and CGM therapies alone, especially in people with type 1 diabetes (35). Use of closed-loop systems has been shown to increase time in the target blood glucose range and decrease overnight hypoglycemia in adults with type 1 diabetes compared with conventional insulin pump use (36). Hopefully, by addressing barriers to CGM at the clinician level, clinicians will be prepared for the eventual availability of these advanced systems and better able to promote their use in people with diabetes.

## Conclusion

Technological advancements have the potential to improve outcomes for people with type 1 diabetes beyond what has been possible in the past. Future efforts to help clinicians overcome barriers to using diabetes technologies may help people with diabetes achieve a higher quality of life and better disease management. The current findings suggest that some clinicians may benefit from additional support or training in helping people with diabetes overcome cost- and insurance-related barriers to increase their confidence in addressing barriers to CGM use. This support may include providing training on resources that are available to people with diabetes or increasing clinic staff who specialize in speaking with insurance and supplier representatives. More research is needed to understand the best methods for overcoming cost-related barriers in the clinic setting.

## FUNDING

This research was funded by The Leona M. and Harry B. Helmsley Charitable Trust.

## DUALITY OF INTEREST

K.K.H. has received research support from Dexcom, Inc., for an investigator-initiated project. He has also received consulting fees from LifeScan Diabetes Institute and MediQ in the past year. No other potential conflicts of interest relevant to this article were reported.

## AUTHOR CONTRIBUTIONS

M.S.L. wrote the manuscript and researched data. M.L.T. researched data and reviewed/edited the manuscript. J.J.W. reviewed/edited the manuscript. K.K.H. reviewed/edited the manuscript and researched data. K.K.H. is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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