Persistence of Continuous Glucose Monitoring Use in a Community Setting 1 Year After Purchase

James Chamberlain, MD, Dana Dopita, RN, MSN, CDE, and Emily Gilgen, RD, CDE

Several large clinical trials have shown that frequent, consistent use of continuous glucose monitoring (CGM) can significantly improve glycemic control in people with insulin-treated diabetes.[1–6] However, despite the clinical benefits associated with this technology, many patients who start CGM soon reduce their frequency of use or discontinue use entirely.[7] Although lack of reimbursement for CGM is generally perceived to be the major reason for discontinuation,[8,9] this perception may be erroneous.

Because commercial insurance coverage for CGM in type 1 diabetes is now fairly common in the United States,[10] it is reasonable to assume that other factors may be influencing patient behavior. For example, in a recent survey of 58 pediatric patients who were started on CGM, 64% of respondents (patients or family members) reported problematic equipment or sensor inaccuracy as the leading cause for discontinuing CGM, whereas only 29% reported insurance issues as their main reason for discontinuation.[7] Even in clinical trials in which the cost of CGM was fully covered, a significant percentage of patients discontinued participation because of potential sensor-related issues (3.7%[2] to 15.2%[3]), difficulties with CGM use or alarms (3.1%[2] to 64.3%[11]), or their own failure to comply with the study protocol (1.4%[12] to 41.8%[3]).

Although some of these issues may be inherent limitations of CGM technology, it is important to consider that current CGM devices differ considerably from each other in terms of accuracy of glucose values, reliability, usability, duration of sensor life, and calibration requirements. These factors may play a major role in influencing both patient and clinician satisfaction and confidence in using (or prescribing) CGM as a component of diabetes management. Findings from a recent survey of current and previous CGM users suggest that continued use of this technology is related to patients' trust in the accuracy and reliability of the data, the usability of the device, and patients' confidence in their ability to use the glucose data generated by their devices.[13]

We conducted a survey of adults with type 1 diabetes who had at least 1 year of experience using their current CGM devices to explore whether their frequency of sensor use was related to CGM technology in general or to differences among currently available CGM systems.

IN BRIEF

Realization of the clinical benefits of continuous glucose monitoring (CGM) in diabetes management is dependent on the frequency with which patients use their CGM devices. This article describes an eight-item survey used to explore whether patients' frequency of CGM use is related to CGM technology in general or to differences among available CGM systems.

Research Design and Methods

We designed an eight-item questionnaire for current CGM users to assess whether and to what degree differences between commercially available CGM systems may influence patient perceptions and frequency of CGM use (Figure 1). Patients with type 1 diabetes were recruited from a major, urban internal medicine clinic that sees between 700 and 800 patients per year on both an inpatient and outpatient basis and a hospital-based diabetes education center that sees 600–700 patients per year on both an inpatient and outpatient basis. The average A1C in the clinic is 7.4%; the average A1C in the diabetes education center is 7.7% after 3–6 months of diabetes education.

Patients who had at least 1 year of experience with their current CGM device were eligible to participate in the study. Patients were recruited on an as-seen basis. Once consent was obtained, the questionnaire was given to patients and completed during the clinic visit. Other than sex and age, no demographic information was collected.

Responses to the survey were collated and analyzed by standard descriptive statistics using Excel (Microsoft Corp., Redmond, Wash.). Results are presented below as either number or percentage of patients. The survey was approved by the institutional review board of

1. Which continuous glucose monitoring device did you purchase?
   - ☐ Medtronic Real-Time Mini-Link
   - ☐ Guardian Real-Time
   - ☐ Navigator
   - ☐ Dexcom
   - ☐ Dexcom 7
   - ☐ Dexcom 7+
2. Did you use an insulin pump during the first year of using your CGM system?
   - ☐ Yes
   - ☐ No
3. One year after purchasing your CGM system, would you purchase the same system over again if given the chance?
   - ☐ Yes
   - ☐ No
4. One year after purchasing your CGM system, would you rather try a different system if given the chance?
   - ☐ Yes
   - ☐ No
5. How much training did you receive on using your system effectively?
   - ☐ None
   - ☐ Used online resources/tutorials
   - ☐ Initial session with trainer only
   - ☐ Initial training and 1-2 follow-up sessions
   - ☐ Multiple training/follow-up sessions
6. Exactly one year after starting with your CGM system, how often were you wearing your CGM system?
   - ☐ Almost every day (proceed to question 7)
   - ☐ About 3 weeks or 3/4 of each month (proceed to question 8)
   - ☐ About 2 weeks or 1/2 of each month (proceed to question 8)
   - ☐ 1 week or less of each month (proceed to question 8)
7. What are the reasons you continued to use the CGM almost daily? (Check all that apply and circle the single biggest reason that you continued to use your CGM.)
   - ☐ I felt it improved my glucose control
   - ☐ It helped prevent very high or low blood glucoses
   - ☐ It helped me make better decisions in managing my diabetes
   - ☐ I liked knowing where my blood glucose was at all times
   - ☐ Other _____
8. What were the reasons you decided to use your CGM less often? (Check all that apply and circle the single biggest reason that you continued to use your CGM.)
   - ☐ I felt that my glucose control had improved significantly and I no longer needed to use the CGM system continuously
   - ☐ The cost of wearing CGM continuously was too expensive for me
   - ☐ The CGM system did not seem accurate enough for me
   - ☐ I became frustrated with "bad" sensors or getting no signal from the sensor
   - ☐ I became frustrated with how frequently it alarmed
   - ☐ I was tired of having two infusion/insertion sites under my skin (insulin pump users)
   - ☐ The CGM sensor sites were frequently painful or irritating
   - ☐ The CGM sensor transmitter/receiver stopped working and I chose not to purchase another transmitter
   - ☐ Other _____

Figure 1. CGM questionnaire.

the medical center at which it was administered.

Survey Results

A total of 87 patients were invited to participate in the survey, which was conducted from August 2011 to August 2012. All of the patients completed the survey. The average age of participants was 45.7 ± 14.2 years (range 19–74 years). Among responders, 43 used the Medtronic MiniLink REAL-TIME CGM system (ML; Medtronic, Northridge, Calif.), 38 used the Dexcom SEVEN PLUS system (SP; Dexcom, San Diego, Calif.), 4 used the Medtronic Guardian RT system, 1 used the Dexcom SEVEN system, and 1 used the original Dexcom system.

To perform an equitable comparison, we included in our analysis only those surveys from users of the ML and SP systems. All ML users (16 male, 27 female) were on insulin pump therapy during the first year of their CGM use. Among the SP users (10 male, 28 female), 25 were on insulin pump therapy during their first year of CGM use.

Approximately 95% (n = 41) of ML users reported participating in at least one formal training session with a certified trainer. Of these patients, 20 also had one to two follow-up sessions and 5 reported multiple training sessions. Among SP users, 82% (n = 31) participated in at least one formal training session; 15 of these patients had one to two follow-up sessions, and 4 had multiple training sessions.

Survey results showed that 76% of SP users reported wearing their devices "almost daily" compared to 19% of ML users (Table 1). Approximately 65% of ML users wore their device ≤ 1 week per month compared to < 3% of SP users. Among the "almost daily" ML users, the most common reason for frequent use was, "I felt it improved my glucose control." The most common reason for CGM frequency among SP patients was, "I liked knowing where my blood glucose was at all times."

The most common reason for infrequent CGM (< 3 weeks per month) use among ML patients was, "The CGM system did not seem accurate enough for me," followed by cost, pain/irritation at sensor site, and bad sensors/signal loss. Of the 28 ML users who wore their device < 1 week per month, 50% reported problems with accuracy (n = 10) or bad sensors/signal loss (n = 4) as their primary reason for infrequent use.

Reasons for infrequent use among SP patients were evenly distributed among cost, pain/irritation at sensor site, and having two insertion sites. The one SP user who wore the device < 1 week per month reported "too expensive" as the main reason for infrequent use.

Regarding patients' satisfaction with their CGM systems, > 92% of SP patients reported they would

Table 1. Summary of Key Survey Results

Frequency of CGM wear

	Almost daily	3 weeks/month	2 weeks/month	≤ 1 week/month
ML (*n* = 43)	8	6	1	28
SP (*n* = 38)	29	3	5	1

Reason for almost daily CGM wear

	Improved glucose	Prevent hypo- or hyperglycemia	Better decisions	Knowing blood glucose at all times	Other
ML (*n* = 8)	4	3	0	1	0
SP (*n* = 29)	4	10	0	15	0

Reason for less frequent CGM wear

	Blood glucose improved	Too expensive	Not accurate	Bad sensors/ signal loss	Frequent alarms	Two insertion sets	Painful, irritating	Other
ML (*n* = 35)	1	7	11	4	2	3	6	1*
SP (*n* = 9)	0	2	0	1	0	2	2	2**

Purchase same system?			**Try another system?**		
	Yes	No		Yes	No
ML (*n* = 43)	19	24	ML (*n* = 43)	19	24
SP (*n* = 38)	35	3	SP (*n* = 38)	9	28

**"Sensors expired; frightening to put on and I didn't think they worked well."*
***"Did not want to see high numbers frequently" and "I felt every other week was enough, less irritating; so I didn't have the system alarming all the time (late at night and while at work)."*

purchase the same CGM system again compared to 44% of ML patients. Moreover, more ML than SP users would rather try a new system: 44 vs. 24%.

Discussion

Studies have shown that use of CGM improves glycemic control in children and adults with insulin-treated diabetes when patients wear their devices frequently and use their glucose data to make therapy-appropriate adjustments.[1–6] Our survey results revealed striking differences between ML and SP users in their perceptions of the performance and usability of their CGM devices that may affect the frequency of device use. Although we cannot conclusively link frequency of use with perceptions, some potential relationships are noteworthy. For example, users' perception of accuracy and reliability may significantly influence their frequency of CGM use. Among the 28 ML users who wore their device < 1 week per month, 50% reported problems with accuracy and reliability (bad sensor/signal loss) as their main reason for infrequent use, whereas, "too expensive" was the main reason reported by the one SP user in the same frequency category.

Although the expense of CGM can potentially affect frequency of use, it does not explain the differences in frequency seen in our study, given that the two CGM systems are comparably priced. As shown in Table 1, only 5% of all SP users reported "too expensive" as a major concern compared to 16% of all ML users. Thus, it is possible that at least some of these CGM users based their response more on value (cost vs. benefit) rather than actual affordability.

Recent meta-analyses[14–17] and reviews have often grouped all CGM devices into a single category of technology without differentiating between the various systems. As a result, the performance and usability features unique to each device are seldom reported or considered. Given the emerging evidence that links CGM frequency and long-term persistence of use to patients'

trust in the accuracy, reliability, and usability of their CGM devices,[13] it is important for patients, clinicians, and payers to carefully evaluate these performance factors when selecting a CGM system for clinical use and/or insurance coverage.

Additional randomized, controlled trials will be needed to assess the accuracy and performance of new devices as the technology evolves. However, there is also a need for head-to-head, "real-life" studies that focus more extensively on patients' perceptions of the new CGM devices in terms of daily performance, usability, and perseverance of use. Results from these studies will enable manufacturers to design CGM systems that more effectively meet patient needs and will provide needed information to help patients, clinicians, and payers make more informed decisions when evaluating the various CGM systems available.

ACKNOWLEDGMENTS

This was an investigator-initiated study and was designed and executed independently by the investigators without industry support. Dexcom, Inc., provided funding to support the writing of the article. The authors thank Christopher G. Parkin, MS, for his editorial assistance.

REFERENCES

[1]JDRF Continuous Gluose Monitoring Study Group: Effectiveness of continuous glucose monitoring in a clinical care environment: evidence from the Juvenile Diabetes Research Foundation Continuous Glucose Monitoring (JDRF-CGM) trial. *Diabetes Care* 33:17–22, 2010

[2]Deiss D, Bolinder J, Riveline JP, Battelino T, Bosi E, Tubiana-Rufi N, Kerr D, Phillip M: Improved glycemic control in poorly controlled patients with type 1 diabetes using real-time continuous glucose monitoring. *Diabetes Care* 29:2730–2732, 2006

[3]Raccah D, Sulmont V, Reznik Y, Guerci B, Renard E, Hanaire H, Jeandidier N, Nicolino M: Incremental value of continuous glucose monitoring when starting pump therapy in patients with poorly controlled type 1 diabetes: the Real Trend study. *Diabetes Care* 32:2245–2250, 2009

[4]O'Connell MA, Donath S, O'Neal DN, Colman PG, Ambler GR, Jones TW, Davis EA, Cameron FJ: Glycaemic impact of patient-led use of sensor-guided pump therapy in type 1 diabetes: a randomised controlled trial. *Diabetologia* 52:1250–1257, 2009

[5]Battelino T, Phillip M, Bratina N, Nimri R, Oskarsson P, Bolinder J: Effect of continuous glucose monitoring on hypoglycemia in type 1 diabetes. *Diabetes Care* 34:795–800, 2011

[6]Bailey TS, Zisser HC, Garg SK: Reduction in hemoglobin A1C with real-time continuous glucose monitoring: results from a 12-week observational study. *Diabetes Technol Ther* 9:203–210, 2007

[7]Ramchandani N, Arya S, Ten S, Bhandari S: Real-life utilization of real-time continuous glucose monitoring: the complete picture. *J Diabetes Sci Technol* 5:860–870, 2011

[8]Hermanides J, Phillip M, DeVries JH: Current application of continuous glucose monitoring in the treatment of diabetes. *Diabetes Care* 34 (Suppl. 2):S197–S201, 2011

[9]Bartelme A, Bridger P: The role of reimbursement in the adoption of continuous glucose monitors. *J Diabetes Sci Technol* 3:992–995, 2009

[10]Dexcom CGM resource center: Practice management: CGM reimbursement. Available from http://thecgmresourcecenter.com/practice-management/cgm-reimbursement. Accessed 1 August 2012

[11]Messer L, Ruedy K, Xing D, Coffey J, Englert K, Caswell K, Ives B: Educating families on real time continuous glucose monitoring: the DirecNet Navigator pilot study experience. *Diabetes Educ* 35:124–135, 2009

[12]Hirsch IB, Abelseth J, Bode BW, Fischer JS, Kaufman FR, Mastrototaro J, Parkin CG, Wolpert HA, Buckingham BA: Sensor-augmented insulin pump therapy: results of the first randomized treat-to-target study. *Diabetes Technol Ther* 10:377–383, 2008

[13]Hessler DP, Polonsky WH, Bowman F, Price DA: The subjective experience of CGM-RT use: comparing current users with ex-users. *Diabetes* 61:A215, 2012

[14]Szypowska A, Ramotowska A, Dzygalo K, Golicki D: Beneficial effect of real-time continuous glucose monitoring system on glycemic control in type 1 diabetic patients: systematic review and meta-analysis of randomized trials. *Eur J Endocrinol* 166:567–574, 2012

[15]Langendam M, Luijf YM, Hooft L, Devries JH, Mudde AH, Scholten RJ: Continuous glucose monitoring systems for type 1 diabetes mellitus. *Cochrane Database Syst Rev* 1:CD008101, 2012

[16]Meade LT: The use of continuous glucose monitoring in patients with type 2 diabetes. *Diabetes Technol Ther* 14:190–195, 2012

[17]Pickup JC, Freeman SC, Sutton AJ: Glycaemic control in type 1 diabetes during real time continuous glucose monitoring compared with self monitoring of blood glucose: meta-analysis of randomised controlled trials using individual patient data. *BMJ* 343:d3805, 2011

James Chamberlain, MD, is a diabetologist and medical director for diabetes services; Dana Dopita, RN, MSN, CDE, is a certified diabetes educator and diabetes center coordinator; and Emily Gilgen, RD, CDE, is a certified diabetes educator at St. Mark's Diabetes Center and St. Mark's Hospital in Salt Lake City, Utah.