Journal of Student-Run Clinics
Original Study

Experiential Learning With Continuous Glucose Monitors: A Novel Curriculum for Volunteers in a Student-Run Free Clinic

Annie E Altman-Merino[1]*; Shreyas G Krishnapura[1]*; Sachin K Aggarwal[1]; Christopher Terry, PharmD[2,3]; Jordan Wright, MD, PhD[2,4]; Eleanor O Weaver, MD[1,2]; Babatunde Carew, MD[1,2]; Robert F Miller, MD[1,2]; M Cooper Lloyd, MD[1,2]

[1]School of Medicine, Vanderbilt University, Nashville, Tennessee, USA
[2]Department of General Internal Medicine and Public Health, Vanderbilt University Medical Center, Nashville, Tennessee, USA
[3]Clinical Pharmacy, Vanderbilt Health Affiliated Network, Nashville, Tennessee, USA
[4]Division of Diabetes, Endocrinology and Metabolism, Department of Internal Medicine, Vanderbilt University Medical Center, Nashville, Tennessee, USA
*These authors contributed equally.

Corresponding Author: Shreyas Krishnapura; email: shreyas.g.krishnapura@vanderbilt.edu

Published: February 14, 2024

Abstract

Background: Growing evidence suggests that medical students and faculty preceptors have limited familiarity with continuous glucose monitors (CGMs), which may negatively affect how care teams counsel patients and monitor the use of CGMs. Although studies have shown that structured training for care teams may improve knowledge and comfort with various healthcare tools, to our knowledge, no study has attempted to do so for CGMs.
Methods: We designed a user experience course for medical students and faculty mentors to address this gap at a student-run free clinic. This course allowed twenty participants to wear a CGM for two weeks and participate in three interactive didactic sessions and group reflections. We evaluated how knowledge and comfort with CGMs among participants changed after the course with a survey and focus group.
Results: The cohort showed improvement in self-reported confidence in using the device, teaching patients how to use the device, and interpreting data ($p<0.001$). The majority of participants demonstrated improvement across all survey domains with higher post-intervention scores than pre-intervention scores. Qualitative analysis of group reflections elucidated three primary themes across participant experiences: the emotional impact of wearing the device, attitude changes with prolonged use, and behavior modification in response to glucose data.
Conclusion: This novel educational initiative may improve knowledge about CGMs, ability to counsel patients to use the device, and understanding patients' experiences among medical students and faculty mentors. We plan to expand this educational opportunity to additional clinic volunteers, include patient perspectives, and share the curriculum with other student-run clinics.

Introduction

Glycemic control among Americans with diabetes is suboptimal. In 2020, of those receiving treatment, over 50% had a hemoglobin A1C (HbA1C) of 7.0% or greater, and 16.3% of adults under 44 had an HbA1C of 10% or greater.[1] Continuous glucose monitors (CGMs) measure interstitial glucose and send data wirelessly to the wearer's phone or reader device and also to their provider via a shared web portal.[2] CGMs confer real-time glucose monitoring, decreasing the need for traditional fingerstick glucose measurements. CGMs have shown promise in improving

diabetes management, and their use for patients with type 1 diabetes mellitus (T1DM) and type 2 diabetes mellitus (T2DM) is rapidly expanding.[3-6] Randomized clinical trials have demonstrated improved HbA1C and fewer hypoglycemic events in patients with T1DM and insulin-dependent T2DM who use CGMs compared to traditional fingerstick glucometers. In addition to clinical improvement, patients report better quality of life, treatment satisfaction, and empowerment to participate in disease management.[7-12]

Despite strong evidence supporting the benefit of CGMs, there are barriers to their widespread and equitable use, including high costs, wearer discomfort, and social factors.[13,14] For example, low socioeconomic status (SES) is a barrier to specialist care and preventative services. Furthermore, insurance providers maintain strict eligibility criteria, and access can vary by region within the US.[15,16] Studies have demonstrated that some providers refrain from prescribing CGMs based on insurance status, race/ethnicity, perceived health literacy, and SES.[17,18] Without dedicated effort by healthcare providers, new technology may exacerbate existing health disparities for marginalized patients. Finally, while primary care clinicians are interested in providing CGMs for patients, many report a lack of knowledge and comfort using the technology.[19] This suggests the need for educational training and support for physicians at all stages of training and practice.

To facilitate equitable access to the benefits of CGMs among underserved patients, we implemented an educational program for volunteers at a student-run free clinic to experience wearing CGMs. As we implement the use of CGMs into our clinical practice, our volunteers must be familiar with using the devices, analyzing their data, and advising patients on their use. This study reports our implementation of a program that aims to increase our volunteers' knowledge and comfort with CGM use through a novel, two-week user experience course with the FreeStyle Libre 2.

Methods

Study Site and Participants

Our interdisciplinary, student-run free clinic provides care to a panel of 300 uninsured patients. We currently serve 86 patients with diabetes mellitus: five with T1DM, and 81 with T2DM. Individuals who frequently participate in the care of patients with diabetes at our clinic were invited via email to participate in the CGM user experience program. No financial incentive was provided, and participation in the study did not impact the students' grades or evaluations. Twenty volunteers, including medical students, pharmacists, and physicians participated in this program. Volunteers included the clinic's physician and pharmacy medical directors, Patient Health Educators (first-year medical students assigned to communicate treatment plans and health maintenance for a panel of patients), medical students who frequently volunteer to see patients at the clinic (clinical students), and medical students comprising the clinic's student executive board. This project was reviewed by the Institutional Review Board, which determined the project to be exempt (IRB#: 222298).

Informed consent was obtained from all participants. Participants were given access to their glucose data but could not view other participants' data. Study personnel could not view participant data.

Abbott Laboratories provided the FreeStyle Libre 2 sensors as part of the Abbott Professional Medical Education and Fellowship Grant. Analysis of results and decision to publish was fully independent of any oversight or influence from Abbott Laboratories.

Program Details

Participants wore the FreeStyle Libre 2 sensor for two weeks and participated in three didactic or discussion-based educational sessions. This timeframe was chosen because each sensor can be used for two weeks, after which it must be replaced. Participants completed an eight-question Likert scale pre- and post-survey designed to assess general knowledge about CGMs and comfort using the FreeStyle Libre 2 system. The survey was developed with input from a board-certified endocrinologist with clinical and investigational expertise in CGMs. The pre-survey was administered before the first session to assess baseline knowledge. The post-survey was administered after the third session (Full surveys; online appendix A). Surveys were administered online using REDCap.[20] Surveys were de-identified, and

participants were asked to input a unique code to allow pairing of pre- and post-surveys.

The first session included a lecture by a clinical pharmacist with expertise in population health and glucose monitoring systems. The lecture included information about the function of FreeStyle Libre 2 and other glucose monitoring systems, how CGMs differ from traditional glucometers, and how to use and place sensors. During the session, each participant configured the FreeStyle system on their smartphone and applied the CGM sensor to their upper arm with supervision from the clinical pharmacist.

The second session, a semi-structured focus group facilitated by study personnel, occurred halfway through the experience after participants had used the monitor for seven days. During the discussion, study facilitators used five open-ended and more directed questions to elucidate reactions, opinions, and emotions related to CGM use (Discussion guide; online appendix B).

The third session occurred at the end of the 14-day experience, on the final day of monitor use. This session included case-based learning with a board-certified endocrinologist on interpreting CGM data, using data for clinical decision-making, and counseling patients.

Survey Data

Survey responses were converted to numeric values for analysis (1 -" strongly disagree"; 2 - "disagree"; 3 - "neutral"; 4 - "agree"; 5 - "strongly agree"). The Mann-Whitney-U test was used to compare unpaired pre- and post-intervention survey results. Where paired pre- and post-intervention data were available, we report the percentage of participants who improved for each survey item. P values <0.05 were accepted as significant. Statistical analysis was performed using R 4.3.0.

Focus Group Data

Focus groups were not recorded; study personnel transcribed notable quotations during the discussion. Discussion content was analyzed qualitatively using open coding followed by thematic analysis. Codes were derived directly from raw data using an inductive approach. Each transcribed quotation was ascribed one or more codes. Thematic analysis was performed following the four steps of qualitative analysis described in the current literature: immersion in the data, coding, creating categories, and identifying themes.[21] Qualitative analyses, including coding and thematic analysis, were performed using Microsoft Excel (2021, Microsoft Corporation, Redmond, Washington).

Results

Participant Characteristics

Of 20 participants, 55% (n=11) were female. Participants included five first-year medical students (25%), nine upper-year medical students (45%), one pharmacist (5%), and three physicians (15%), as shown in Table 1. None of the participants had a diagnosis of T1DM or T2DM.

Survey Results

Twenty participants completed the pre-survey, and 19 participants completed the post-survey. Of 19 responses, 11 could be paired based on identifying codes. Eight sets of responses could not be paired as participants did not enter an

Table 1. Characteristics of program participants, including gender, occupation, and role at the free clinic

Characteristic	n (%)
Gender	
Female	11 (55)
Male	9 (45)
Occupation	
1st year medical student	5 (25)
3rd year medical student	7 (35)
4th year medical student	2 (10)
G-phase medical student	2 (10)
Pharmacist	1 (5)
Physician	3 (15)
Role	
Patient Health Educator	5 (25)
Clinical Student	5 (25)
Executive Board member	6 (30)
Pharmacy director	1 (5)
Medical director	3 (15)

G-phase: graduate student in PhD program; PhD: Doctor of Philosophy.

Table 2. Aggregate and paired pre- and post-intervention survey data

Question	Aggregate			Paired (n = 11)
	Pre-survey median (n = 20)	Post-survey median (n = 19)	p-value	% that showed improvement
What is a CGM	3.0	4.0	<0.001*	81.8
How to use CGM	1.0	4.0	<0.001*	100
How CGM system works	2.5	4.0	<0.001*	100
A CGM sensor is easy to apply	2.0	4.0	<0.001*	100
Instructing a patient to apply the sensor	1.0	4.0	<0.001*	100
Comfortable using CGM data portal	1.0	4.0	<0.001*	81.8
Instructing a patient on using CGM phone application	1.0	4.0	<0.001*	100
Comfortable making clinical decisions with CGM data	2.0	4.0	<0.002*	54.5

**indicates statistical significance.*
CGM: continuous glucose monitor.

identifying code on the post-survey or entered a code that did not correspond to a code on the pre-survey.

For all survey questions, there was an increase in the median level of agreement between the pre- and post-surveys (Table 2). For each question, this increase was statistically significant ($p<0.01$).

For paired surveys (n=11), all or most participants had higher post-intervention scores than all survey items. All respondents demonstrated an improved understanding of how a CGM works, how to use it, and how to instruct a patient to apply the sensor and use the phone application. Additionally, all participants demonstrated improved comfort applying the sensor on their own. 81.8% of respondents reported an improved understanding of a CGM device and comfort using the portal to access data. Over half (54.5%) of respondents reported improved comfort in making clinical decisions based on CGM data.

Qualitative Analysis of Focus Group

Through analysis of focus group discussions and free text responses on the post-survey, three primary themes emerged across participant experiences: the emotional impact of wearing the device, attitude changes with prolonged use, and behavior change in response to glucose data.

Theme 1: Emotional Impact

Participants reported anxiety about keeping blood glucose levels in the target range.

> *I found myself getting concerned about low numbers despite not having any symptoms. (Patient Health Educator)*
>
> *It feels very good to be in the "green," and "red" makes me feel bad. (Physician)*

Reflecting on the emotional impact of glucose awareness as people without diabetes, some participants shared how they imagined constant access to blood sugar readings must feel for patients with diabetes, especially those with poor glycemic control.

> *My glucose feels more out of my control than I expected. It makes me wonder what must it be like for a patient with fully dysregulated glucose metabolism. (Upper-level student)*
>
> *It made me appreciate the anxiety that patients may experience as they track their glucose, especially watching it go up. (Physician)*

Theme 2: Attitude changes with prolonged use

Participants reported annoyance or other negative attitudes with prolonged use of the sensor. The Libre 2 phone application is programmed to alarm when a high or low glucose threshold is met.

> *Even after just one week I was so tired of the alarms and I had to turn them off. (Patient Health Educator)*

This comment precipitated a discussion about silencing glucose alerts. Some stated that the phone application did not allow alerts to be silenced, and one participant shared tips instructing others about how to alter phone settings to prevent alarms from sounding. Annoyance around glucose alerts was the primary source of sensor fatigue. Participants also remarked on waning excitement and interest after prolonged use. As enthusiasm for the new device waned, participants said they forgot to scan their monitors every 6-8 hours, which is necessary to prevent data loss.

> *I found that by the end, I was less excited about the novelty of having it, so it was harder to remember to scan the monitor for readings. So I can see how long-term use is less fun than the initial days I had it on. (Clinical student)*

Theme 3: Behavior Changes

Participants reported changes in dietary and exercise behavior in response to continuous glucose monitoring.

> *It definitely changed the way I ate and exercised. I hated getting the alarms and seeing the spikes, so I tried to walk a lot after meals. (Clinical student)*

Another participant reported that constant access to their data encouraged them to be more mindful and pay closer attention to their eating and physical activity. Many in the group voiced agreement with this sentiment.

Discussion

To our knowledge, this is the first CGM curriculum to be implemented among student-run free clinic volunteers. Our findings suggest the curriculum may improve participant knowledge and comfort with CGM use. Prior studies investigating graduate and post-graduate medical education revealed that a minority of residents and physicians felt prepared to use CGMs or CGM data in clinical decision making.[22,23] There is a need for medical education initiatives throughout all training levels focused on health technologies for diabetes care. Our findings provide preliminary evidence that the program addresses these basic training needs while preparing volunteers to bring new technology to the care of underserved populations.

Overall, program participants demonstrated a robust improvement in self-reported parameters of CGM knowledge. Before the course, participants generally understood CGM devices but were less comfortable interpreting clinical data, making clinical decisions based on the data, and counseling patients. After the intervention, participants showed improved understanding of CGM data and comfort with clinical management. Our data strongly support the value of the user experience in conjunction with didactic teaching sessions for improving participant knowledge. Most participants for whom paired data were available showed improvement across all survey items. "Confidence in making clinical decisions" showed the least significant improvement (54.5% of participants). Given that most participants were trainees, comfort with clinical decision making is expected to require more than two weeks of experience. This finding suggests medical students may benefit from using CGM devices in additional clinical settings throughout their training.

Qualitative analysis of group discussions allowed for a more nuanced analysis of the program's impact. Three themes that emerged (the emotional impact of wearing the device, changes in attitude towards the device with prolonged use, and behavioral changes in response to glucose data) illuminate how participants better understood the patient experience with CGMs. Negative emotional reactions to glucose levels and alarms and forgetting to scan the sensor were all identified as potential barriers to optimal use of the FreeStyle system. This theme is consistent with the current literature in which patients describe alarm fatigue[24] and feeling overwhelmed by the data provided by their devices.[25] Similarly, as the novelty of the monitor wore off, participants forgot to scan the sensor frequently enough to maintain all data. Concordance of focus group themes and existing literature describing patient experience suggests that the program's potential to cultivate an improved understanding of patient perspectives. Whether and how this enhanced understanding translates into

enhanced communication skills, patient counseling, and patient outcomes warrants investigation in future studies.

Understanding and enhancing the patient experience is a critical skill in medical education and a core component of the Quadruple Aim of healthcare.[26] Our experiential educational model allows participants to encounter behavioral change challenges. Appreciating these barriers is especially important in a free clinic setting with uninsured patients for whom social drivers of health play a significant role in health outcomes. For example, participants reflected on patients' waning motivation to maintain recommended behavioral changes such as postprandial exercise and consuming low-carbohydrate foods. These challenges are exaggerated for patients with reduced access to healthier food options and resources for exercise.

This study is limited by a small sample size of 20 participants. Furthermore, all participants expressed interest in this topic and motivation to learn about the technology, which may introduce self-selection bias. Additionally, the decrease in the number of paired surveys does impact the ability to assess individual improvement. Finally, this study used the FreeStyle Libre 2, so our participants did not gain experience using other devices. However, the core principles from the experience apply to any currently available continuous glucose monitoring system.

Conclusion

Diabetes technology is rapidly evolving, and novel educational methods are needed to ensure that providers are well-equipped to translate these advances into practice. We demonstrated the value of experience based CGM training for the volunteer workforce that cares for uninsured patients with diabetes within one free clinic. Teaching providers early in their training sets the stage for adopting new technologies and adapting to new practice elements throughout their careers, including for marginalized populations. In the future, we plan to broaden the reach of this program by offering it to more clinic volunteers, incorporating patient input into discussion-based sessions, and sharing the curriculum available with other student-run free clinics. In addition, further study may include a control group that does not participate in the user experience to evaluate improvements in knowledge and comfort of use with CGM.

Disclosures

The authors have no conflicts of interest to disclose.

References

1. Centers for Disease Control and Prevention. National Diabetes Statistics Report, 2020: Estimates of Diabetes and Its Burden in the United States [Internet]. Atlanta (GA): Centers for Disease Control and Prevention; 2020. [Accessed 2023 May 19] Available from: http://www.cdc.gov/diabetes/pdfs/data/statistics/national-diabetes-statistics-report.pdf LINK
2. Mariani HS, Layden BT, Aleppo G. Continuous glucose monitoring: a perspective on its past, present, and future applications for diabetes management. Clin Diabetes. 2017;35(1):60-5. https://doi.org/10.2337/cd16-0008 LINK
3. Beck RW, Riddlesworth T, Ruedy K, et al. Effect of continuous glucose monitoring on glycemic control in adults with type 1 diabetes using insulin injections: the DIAMOND randomized clinical trial. JAMA. 2017;317(4):371-8. https://doi.org/10.1001/jama.2016.19975 LINK
4. Laffel LM, Kanapka LG, Beck RW, et al. Effect of continuous glucose monitoring on glycemic control in adolescents and young adults with type 1 diabetes: a randomized clinical trial. JAMA. 2020;323(23):2388-96. https://doi.org/10.1001/jama.2020.6940 LINK
5. Pratley RE, Kanapka LG, Rickels MR, et al. Effect of continuous glucose monitoring on hypoglycemia in older adults with type 1 diabetes: a randomized clinical trial. JAMA. 2020;323(23):2397-406. https://doi.org/10.1001/jama.2020.6928 LINK
6. Martens T, Beck RW, Bailey R, et al. Effect of continuous glucose monitoring on glycemic control in patients with type 2 diabetes treated with basal insulin: a randomized clinical trial. JAMA. 2021;325(22), 2262-72. https://doi.org/10.1001/jama.2021.7444 LINK
7. Tansey M, Laffel L, Cheng J, et al. Satisfaction with continuous glucose monitoring in adults and youths with type 1 diabetes. Diabet Med. 2011;28(9):1118-22. https://doi.org/10.1111/j.1464-5491.2011.03368.x LINK
8. Beck RW, Lawrence JM, Laffel L, et al. Quality-of-life measures in children and adults with type 1 diabetes: Juvenile Diabetes Research Foundation continuous glucose monitoring randomized trial. Diabetes Care. 2010;33(10):2175-7. https://doi.org/10.2337/dc10-0331 LINK
9. Halford J, Harris C. Determining clinical and psychological benefits and barriers with continuous glucose monitoring therapy. Diabetes Technol Ther. 2010;12(3):201-5. https://doi.org/10.1089/dia.2009.0121 LINK
10. Polonsky WH, Hessler D. What are the quality of life-related benefits and losses associated with real-time continuous glucose monitoring? A survey of current users. Diabetes Technol Ther. 2013;15(4):295-301. https://doi.org/10.1089/dia.2012.0298 LINK
11. Hommel E, Olsen B, Battelino T, et al. Impact of continuous glucose monitoring on quality of life, treatment

satisfaction, and use of medical care resources: analyses from the SWITCH study. Acta Diabetol. 2014;51(5):845-51. https://doi.org/10.1007/s00592-014-0598-7 LINK
12. Kang HS, Park HR, Kim C-J, Singh-Carlson S. Experiences of using wearable continuous glucose monitors in adults with diabetes: a qualitative descriptive study. the science of diabetes self-management and care. 2022;48(5):362-71. https://doi.org/10.1177/26350106221116899 LINK
13. Zgibor JC, Songer TJ. External barriers to diabetes care: addressing personal and health systems issues. Diabetes Spectr 2001;14(1):23-8. https://doi.org/10.2337/diaspect.14.1.23 LINK
14. Liberman A, Buckingham B, Phillip M. Diabetes technology and the human factor. Diabetes Technol Ther. 2014;16(Suppl 1):S110–S118. https://doi.org/10.1089/dia.2014.1513 LINK
15. Miller EM. Using continuous glucose monitoring in clinical practice. Clin Diabetes. 2020;38(5):429-38. https://doi.org/10.2337/cd20-0043 LINK
16. Kruger DF, Anderson JE. Continuous glucose monitoring (CGM) is a tool, not a reward: Unjustified insurance coverage criteria limit access to CGM. Diabetes Technol Ther. 2021;23(S3):S45-55. https://doi.org/10.1089/dia.2021.0193 LINK
17. Addala A, Hanes S, Naranjo D, Maahs DM, Hood KK. Provider implicit bias impacts pediatric type 1 diabetes technology recommendations in the United States: findings from the gatekeeper study. J Diabetes Sci Technol. 2021;15(5):1027-33. https://doi.org/10.1177/19322968211006476 LINK
18. Odugbesan O, Addala A, Nelson G, et al. Implicit racial-ethnic and insurance-mediated bias to recommending diabetes technology: Insights from T1D exchange multicenter pediatric and adult diabetes provider cohort. Diabetes Technol Ther. 2022;24(9):619-27. https://doi.org/10.1089/dia.2022.0042 LINK
19. Oser TK, Hall TL, Dickinson LM, et al. Continuous glucose monitoring in primary care: understanding and supporting clinicians' use to enhance diabetes care. Ann Fam Med. 2022;20(6):541-7. https://doi.org/10.1370/afm.2876 LINK
20. Harris PA, Taylor R, Thielke R, et al. Research electronic data capture (REDCap)—a metadata-driven methodology and workflow process for providing translational research informatics support. J Biomed Inform. 2009;42(2):377-81. https://doi.org/10.1016/j.jbi.2008.08.010 LINK
21. Green J, Willis K, Hughes E, et al. Generating best evidence from qualitative research: the role of data analysis. Aust N Z J Public Health. 2007;31(6):545-50. https://doi.org/10.1111/j.1753-6405.2007.00141.x LINK
22. Morales J, Kuritzky L, Lavernia F, Santiago M. Are residents receiving the training needed within their residency programs to optimally manage patients with diabetes? Postgrad Med. 2021;133(4):388-94. https://doi.org/10.1080/00325481.2020.1857603 LINK
23. Rodbard D. Continuous glucose monitoring: a review of recent studies demonstrating improved glycemic outcomes. Diabetes Technol Ther. 2017;19(S3):S25-S37. https://doi.org/10.1089/dia.2017.0035 LINK
24. Shivers JP, Mackowiak L, Anhalt H, Zisser H. "Turn it off!": diabetes device alarm fatigue considerations for the present and the future. J Diabetes Sci Technol. 2013;7(3):789-94. https://doi.org/10.1177/193229681300700324 LINK
25. Pickup JC, Ford Holloway M, Samsi K. Real-time continuous glucose monitoring in type 1 diabetes: a qualitative framework analysis of patient narratives. Diabetes Care. 2015;38(4):544-50. https://doi.org/10.2337/dc14-1855 LINK
26. Sikka R, Morath JM, Leape L. The quadruple aim: care, health, cost and meaning in work. BMJ Qual Saf. 2015;24(10):608-10. https://doi.org/10.1136/bmjqs-2015-004160 LINK