



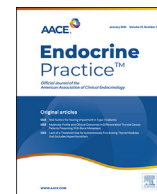
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Facilitators and Barriers to Nursing Implementation of Continuous Glucose Monitoring (CGM) in Critically Ill Patients With COVID-19



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ABSTRACT

Objective: We describe our implementation of a continuous glucose monitoring (CGM) guideline to support intravenous insulin administration and reduce point of care (POC) glucose monitoring frequency in the coronavirus disease 2019 medical intensive care unit (MICU) and evaluate nurses' experience with implementation of CGM and hybrid POC + CGM protocol using the Promoting Action on Research in Health Services framework.

Methods: A multidisciplinary team created a guideline providing criteria for establishing initial sensor-meter agreement within each individual patient followed by hybrid use of CGM and POC. POC measures were obtained hourly during initial validation, then every 6 hours. We conducted a focus group among MICU nurses to evaluate initial implementation efforts with content areas focused on initial assessment of evidence, context, and facilitation to identify barriers and facilitators. The focus group was analyzed using a qualitative descriptive approach.

Results: The protocol was integrated through a rapid cycle review process and ultimately disseminated nationally. **The** Diabetes Consult Service performed device set-up and nurses received just-in-time training. The majority of barriers centered on contextual factors, including limitations of the physical environment, complex device set-up, hospital firewalls, need for training, and CGM documentation. Nurses' perceived device accuracy and utility were exceptionally high. Solutions were devised to maximize facilitation and sustainability for nurses while maintaining patient safety.

Conclusion: Outpatient CGM systems can be implemented in the MICU using a hybrid protocol implementation science approach. These efforts hold tremendous potential to reduce healthcare worker exposure while maintaining glucose control during the COVID-19 pandemic.

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Abbreviations: BG, blood glucose; CGM, continuous glucose monitoring; CNS, clinical nurse specialist; COVID, coronavirus disease; EHR, electronic medical record; ICU, intensive care unit; IV, intravenous; MICU, medical intensive care unit; NP, nurse practitioners; PARIHS, Promoting Action on Research in Health Services; POC, point of care; PPE, personal protective equipment.

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Introduction

COVID-19 has proven particularly devastating for individuals with chronic illness, including diabetes.^{1,2} Individuals with diabetes have higher rates of severe COVID-19,² account for a large percentage of hospital admissions,¹⁻⁴ and have higher mortality compared to the general population.^{1,5} Early data suggest that among hospitalized patients with COVID-19, poor glycemic control may be associated with higher mortality.^{6,7} For patients in intensive

care units (ICU), guidelines recommend intravenous (IV) insulin with goal blood glucose (BG) 100 to 180 mg/dL.^{8–10}

Health care workers caring for patients with COVID-19 on IV insulin assume increased risk and utilization of personal protective equipment (PPE) due to the need for hourly point of care (POC) BG testing.¹¹ As a result, institutions have taken unprecedented measures to reduce exposure, including bundling medication administration times and positioning IV infusion pumps outside of COVID-19 patient rooms. Therefore, the ability to safely perform remote glucose monitoring would greatly support these efforts.

Continuous glucose monitoring (CGM) is a safe and effective alternative for BG testing in the outpatient setting and has potential to reduce the frequency of POC BG testing in the ICU.¹² On April 1, 2020, the Food and Drug Administration notified manufacturers that it will not object to the provision of CGM systems for the treatment of patients in hospital settings to support COVID-19 health care-related efforts.¹³ Current evidence supports the overall safety of CGM, with similar glucose control as the standard of care in hospitals.^{14–19} However, many studies are small; focused on accuracy as opposed to efficacy, safety, or implementation; and utilize older technology.^{14–18,20} There is concern that changes in tissue perfusion, edema, hydration, acid-base balance, and sensor compression due to patient positioning and medication interference may affect CGM performance.²¹ Newer generation devices demonstrate improved accuracy, provide factory calibration, and have minimized interference from acetaminophen, all key elements required for inpatient utilization.²² Moreover, the use of more frequent glucose measurement (eg, every 5 minutes),²³ setting higher threshold alerts,²⁴ and predictive alerts²⁵ may compensate for total error and improve safety.

However, the implementation of these devices in the inpatient setting presents unique challenges. The purpose of this manuscript is twofold: (a) describe our experience implementing a CGM guideline to support IV insulin administration and reduce the need for fingerstick POC glucose monitoring in ICU patients with COVID-19 and (b) evaluate nurses' experience with implementation of CGM and hybrid POC + CGM protocol using the Promoting Action on Research in Health Services (PARIHS) framework for implementation. Multisite analysis of outcomes data is underway and will be reported separately.

Description of CGM and Protocol Implementation

Assembling a Team

We assembled a multidisciplinary team of stakeholders that included representatives from endocrinology, critical care medicine, nursing, and critical care pharmacy to draft an ICU protocol. CGM was piloted within a single medical intensive care unit (MICU) at the institution, which was already positioning IV insulin pumps outside the room, enabling the greatest potential for reduced health care worker exposure and conservation of PPE. We obtained approval from the institution's multidisciplinary COVID-19 Clinical Care Workgroup.

Training and Start-Up

Implementation team members participated in a 1-hour manufacturer training session focused on overall device implementation. Two educational documents, 1 focused on sensor insertion and initiation and the other focused on implementation of the protocol, were crafted and stored at the bedside. Content used in these handouts can be found on the manufacturer's website (<https://dexcom.com/guides>). Endocrinology team members provided a single session of one-on-one training with MICU nursing leaders. This small group was tasked with device insertion,

transmitter pairing, and just-in-time training to the bedside MICU nurse focused on CGM validation and use.

Dexcom CGM and Hybrid Protocol Implementation

Figure 1 shows hybrid CGM plus POC glucose monitoring procedures and implementation.

Device Set-Up

Members of the Diabetes Consult Service comprised of endocrinology nurse practitioners (NP) performed the bulk of device set-up tasks (Fig. 1). Both Android phones and Dexcom receivers were paired with Dexcom G6 transmitters. To facilitate Health Insurance Portability and Accountability Act compliant remote monitoring, dummy clinical accounts were created for each device/patient. Android phone set-up required entry of individual Dexcom Clarity account information on each phone. Alert thresholds were programmed into both the Android phones and receivers and set at 100 mg/dL (lower threshold) and 300 mg/dL (upper threshold). The Urgent Low Soon predictive alert was also activated, triggering an alarm when the glucose is predicted to drop below 55 mg/dL in the next 20 minutes. Device set-up ranged from 15 to 17 minutes per CGM.

Patient Identification

MICU nursing leadership identified appropriate patients during daily rounds with MICU intensivist teams. In most cases, CGM was implemented ahead of IV insulin in order to account for sensor initiation time and establish sensor-POC agreement, thereby minimizing hourly POC testing while on IV insulin.

Insertion and Pairing

The transmitter and sensor serial numbers were scanned into the Dexcom app prior to entering the room for device insertion. Android phones and receivers were both kept just outside the patient room, typically 10 to 15 feet from the transmitter and separated by a glass paneled door. The sensor was placed on the patient's upper lateral arm (due to frequent prone positioning) using a single push inserter.²⁶ The transmitter was paired with the Android phone Dexcom app and receiver. Pairing typically occurred in less than 1 minute. Rarely, a transmitter required several attempts to pair. After pairing, a 2-hour warm-up period began in which no CGM data were available. The sensor was worn for up to 10 days. At the time of this publication, all CGM systems initiated were successfully validated; however, time to validation analysis is underway. Each patient could receive up to 2 sensors and would be able to keep the transmitter at discharge (which may be reused for up to 90 days).

Nurse Driven Protocol

Initial sensor validation occurred using hourly paired sensor-meter readings (Fig. 1). The comparison standards (POC meter—StatStrip, Nova Biomedical, arterial blood gas) were otherwise Food and Drug Administration approved for use in each patient. The standard was compared to the CGM value obtained within 5 minutes. The threshold criterion for nonadjunctive use was defined as \geq consecutive sensor-meter pairs approximately 1-hour apart meeting either of the following criteria (Table 1):

- CGM < 20% difference from the reference when the glucose is > 100 mg/dL
- CGM < 20 mg/dL difference from the reference when the glucose is < 100 mg/dL

The IV insulin infusion was titrated every hour using the POC BG value until the initial validation threshold was achieved. Then titration was performed using the CGM with POC BG validation occurring every

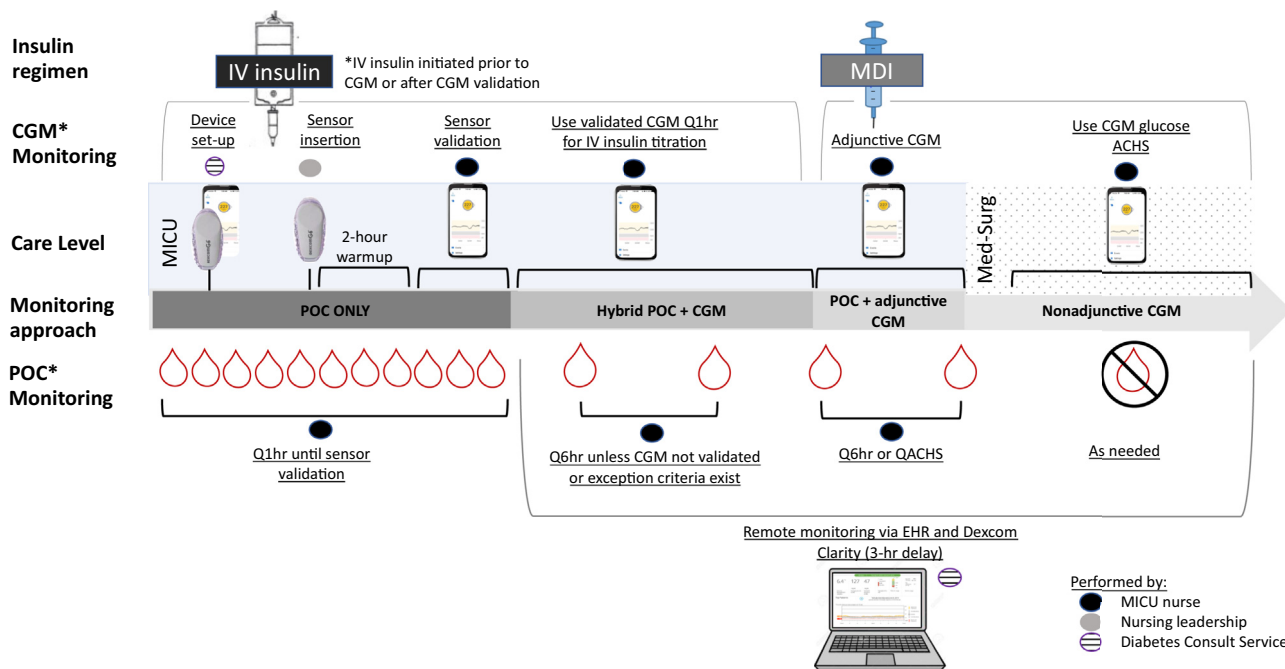


Fig. 1. Hybrid CGM + POC glucose monitoring. Hybrid CGM + POC glucose monitoring occurred in several phases. Diabetes consult service members performed device set-up tasks prior to delivering the devices to the ICU units. The nursing leadership team worked with MICU providers to identify appropriate patients with anticipated or current IV insulin orders. The nursing leadership team performed sensor insertion and paired the transmitter with the cell phone/receiver. Once paired, a 2-hour warm-up period was initiated, followed by a sensor validation period. The IV insulin infusion was titrated every hour using the POC BG value until initial validation was achieved. Then titration was performed using the CGM unless Q6 hour sensor-meter pairs were discordant or other exception criteria occurred. Additional sensors could be placed if the patient had ongoing IV insulin requirements following initial sensor expiration or removal. When patients were transitioned off IV insulin, Q6 hour POC testing was continued along with adjunctive CGM while in the MICU or until sensor expiration. Once transferred to a medical surgical floor, CGM could be used nonadjunctively (to replace POC testing) according to the institution's global *Hyperglycemia in COVID-19 Patients* guideline. The Diabetes consult service utilized Dexcom Clarity, which operates on a 3-hour delay, to retrospectively visualize patient data and analyze glucose trends. BG = blood glucose; CGM = continuous glucose monitoring; COVID-19 = coronavirus disease 2019; EHR = electronic health record; ICU = intensive care unit; IV = intravenous; MDI = multiple daily injection; MICU = medical intensive care unit; POC = point of care (arterial, capillary).

6 hours. The organization's standard guideline was used for IV insulin titration and no modifications were made to incorporate CGM trend data into titration guidelines. Additional POC BG values were obtained according to criteria in Table 1. POC BG monitoring reverted to hourly if any of the sensor-meter pairs were discordant. In order to distinguish CGM values from POC, nurses used a "CGM" annotation (Figure. 2).

Data Transmission and Retrieval

A Clarity Healthcare Professional account was created to visualize data, but retrieval was delayed by 3 hours and therefore only utilized by the Diabetes Consult Service.

Postinfusion Management

When patients were transitioned off IV insulin, POC testing was continued every 6 hours. Once transferred out of the MICU, CGM could be used nonadjunctively (to replace POC testing) according to the institution's global *Hyperglycemia in COVID-19 Patients* guideline (Figure 1).

Diabetes Consult Service

All patients were co-managed by the inpatient Diabetes Consult Service, which, in concert with the intensivist team, determined when to transition patients off IV insulin (Figure. 1).

Table 1
Accuracy and Glucose Testing Procedures

| Stage | POC glucose testing procedures |
|----------------|---|
| CGM validation | POC glucose testing Q1 hour compared to CGM glucose Proceed to Q6 hour POC testing when <u>2</u> consecutive sensor-meter pairs approximately 1-hour apart meet either of the following criteria: 1) CGM < 20% difference from the POC when the glucose is >100 mg/dL 2) CGM < 20 mg/dL difference from the POC when the glucose is <100 mg/dL |
| Sustained use | Revert from Q6 hour to Q1 hour POC testing if: 1) CGM < 20% difference from the POC when the glucose is > 100 mg/dL 2) CGM < 20 mg/dL difference from the POC when the glucose is < 100 mg/dL 3) Revert back to Q6 hour POC testing when <u>2</u> consecutive sensor-meter pairs approximately 1-hour apart meet the initial validation criteria Obtain 1 time POC glucose if: 1) No glucose value appears on Android screen (due to signal loss, low/high measure) 2) Predicted low or low threshold alert 3) Signs and symptoms do not match glucose readings, particularly for hypoglycemia 4) Change in clinical status, such as intubation, hemodynamic compromise, or nutrition |

Abbreviations: CGM = continuous glucose monitoring; POC = point of care.

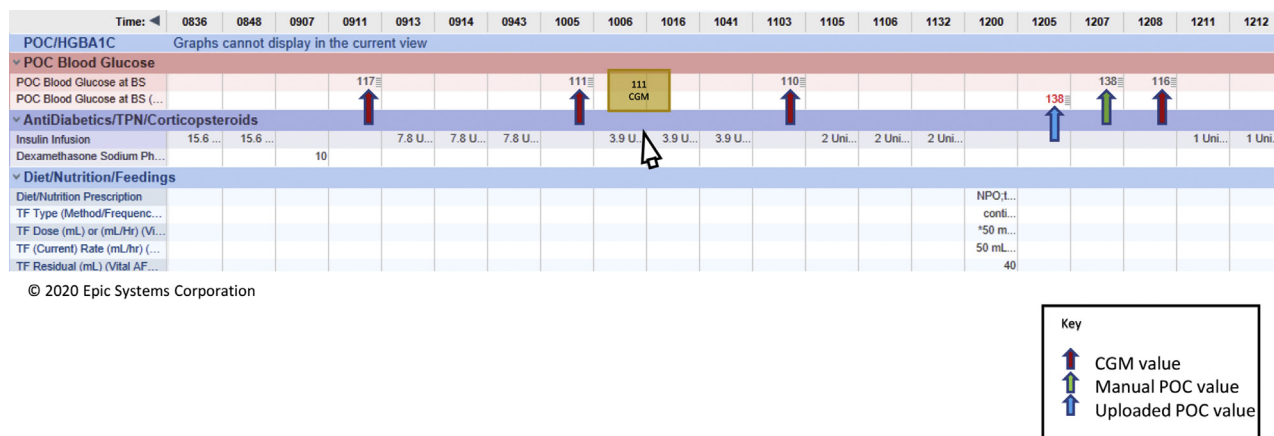


Fig. 2. Documentation of CGM values. Due to concern that CGM would be inappropriately utilized outside of patients with COVID-19, a separate row for CGM data was not added to the glucose flowsheet in the EHR. In order to distinguish CGM values from POC, nurses used a “cgm” annotation, which appears when hovering over the value with the mouse. Per usual practice, all POC BG values were manually entered into the glucose flowsheet at the time of acquisition, and POC devices were downloaded once each shift as per usual practice. Downloaded POC values also automatically populate a separate row in the glucose flowsheet. BG = blood glucose; CGM = continuous glucose monitoring; COVID-19 = coronavirus disease 2019; EHR = electronic health record; POC = point of care (arterial, capillary).

Nursing Protocol and CGM Implementation Focus Group Methods

We conducted a focus group qualitative evaluation among MICU nurses to evaluate initial implementation efforts using an implementation science approach with the PARIHS framework.²⁷ The Ohio State University’s institutional review board approved the focus group protocol. A single session focus group was conducted with nurse leaders (eg, nurse managers, clinical nurse scientists [CNS], MICU staff nurses, and Diabetes Consult Service NPs. Interviews were analyzed using a qualitative descriptive approach.^{28,29}

Participants

Eligible participants included a MICU floor nurse who cared for patients with COVID-19 on CGM; a MICU nurse leader (ie, CNS, nurse manager) who assisted with patient identification, CGM insertion, or hybrid protocol staff education; and a diabetes consult NP who managed consult patients on CGM between June 1, 2020, and August 31, 2020. Nurses provided consent prior to focus group participation.

Data Collection

A single session focus group was conducted virtually. A semi-structured interview guide focused on core components of the PARIHS framework: evidence, context, and facilitation. As such, questions included content regarding perceived accuracy, protocol, CGM training, workflow, facilitators, and barriers to future use. The focus group was audio recorded, professionally transcribed, and reviewed for accuracy.

Data Analysis

A code book was developed a priori based on the semistructured interview questions. Interview data, fieldnotes, and memos were imported into NVivo 12.0 (Doncaster, Australia) for data management and analyzed using a qualitative descriptive approach.^{28,29} Two authors (E.R.F. and M.M.) conducted qualitative analysis. Portions of text were coded with terms that were low inference (“data close”), then grouped into thematic categories and subthemes.²⁸

The data were assessed using the PARIHS framework for implementation, a theoretical framework that has been widely used to implement evidence-based clinical practices in the inpatient setting.²⁷

Results

A total of 9 nurses participated in the focus group and included 3 nurse leaders (eg, 2 nurse managers, 1 CNS), 2 diabetes consult NPs, and 4 MICU staff nurses. Participants were 89% female, ranged in age from 28 to 50 years, and had mean 11.6 years of nursing experience (range, 3-28 years). The MICU nurse leaders and staff nurses (total N = 7) had a mean of 9 years of MICU nursing experience (range, 1-26 years). Among the staff nurses, 2 had cared for patients on CGM during 4 to 6 shifts, 1 for 1 to 3 shifts, and 1 for 7 to 10 shifts. The MICU nurse leaders (N = 3) reported each assisting with CGM insertion, nursing education, or trouble shooting with 4 to 6 patients. The diabetes consult NPs (N = 2) reported caring for 7 to 10 and > 10 consult patients with CGM.

We identified 4 major themes: accuracy, nursing ownership, workflow, and barriers and suggestions, presented within the 3 core elements of the PARIHS framework (evidence, context, facilitation).²⁷ Evidence was derived from the clinical experience of the MICU nurses, consistent with PARIHS definitions. Context included elements about organizational and unit culture, leadership, education, and initial evaluation of use. Facilitation included internal facilitation for streamlined CGM use within the unit and suggested improvements for future use.²⁷ The major themes and inter-connecting subthemes from the focus group data are presented within this PARIHS framework. Table 2 presents major themes and subthemes along with supporting nursing statements.

Evidence

Accuracy

All participants had positive perceptions regarding the accuracy of the CGM systems. Six of the 9 participants commented that they never experienced any inaccuracies in which the POC and CGM values fell outside the 20% or 20 mg/dL threshold for values under 100 mg/dL. Table 2 presents accuracy’s subthemes along with supporting nursing statements.

Table 2
Nursing CGM Implementation Themes, Subthemes, and Supporting Nursing Statements Within the PARIHS Framework for Evidence

| Theme | Subtheme | Exemplar statement |
|-----------------|--------------------|---|
| Accuracy | Initial validation | <ul style="list-style-type: none"> • I've never experienced it where we're doing like the point of care and the CGM that it hasn't like correlated. (MICU Staff RN, participant 4) • I don't know. I feel like my observation, my feeling is that most of the devices once they were up and running, they validated quickly. (Diabetes consult NP, participant 7) |
| | Patient condition | <ul style="list-style-type: none"> • My biggest thing was, it wasn't the accuracy. It was just like the tube feed adjusting... Starting steroids, stopping steroids. Everything like that but I think that's what our biggest issue was 'cause that was all going on when we're trying to correlate everything. (MICU Staff RN, participant 4) |
| | Watch it | <ul style="list-style-type: none"> • And I felt like just titrating it and like, "Oh, should we go down? Should we go up?"—like I'm sure we can hit this button like 52 times this hour if we need to. (MICU Staff RN, participant 6) |

Abbreviations: CGM = continuous glucose monitoring; MICU = medical intensive care unit; NP = nurse practitioners; PARIHS = Promoting Action on Research in Health Services.

Initial Validation. While 5 nursing participants stated they were aware that the CGM values might not be as accurate during the first 24 hours, most reported the CGM systems were validated quickly, typically 2 hours after the first CGM reading or 4 hours after insertion. While device calibration was not mentioned in the protocol or educational materials, several MICU leaders did mention occasionally calibrating CGM systems if accuracy was not initially obtained.

Patient Condition. Two participants, a MICU staff nurse and diabetes NP, discussed 2 examples of inaccuracy. In 1 case, the CGM was validated within the first 2 POC readings; however, values for the subsequent 12 hours were slightly outside the 20% required range before finally regaining and sustaining accuracy. Inaccuracies in this case were attributed to changes in the patient's condition prompting adjustments in the tube feed regimen and initiation of steroids. In the second instance, the NP reported inaccuracies attributed to the close proximity of a cooling blanket. The sensor was repositioned on the patient's abdomen, which resolved the issue.

Watch It. Nurses stated they were likely to accept the CGM glucose values and use those values to titrate the IV insulin, knowing they could continue to monitor the readings. Nurses felt that the ability to continuously monitor glucose values presented a safer alternative to traditional POC glucose testing.

Context

The major themes of nursing ownership and workflow, their subthemes, and supporting nursing statements are presented in Table 3.

Nursing Ownership

Despite its novelty, there was surprising acceptance of CGM technology among MICU nurses. Interestingly, that acceptance did not as readily extend to other members of the MICU care team. Nurses readily and organically took on the bulk of implementation activities including training and patient selection.

Acceptance. Nurses seemed to readily incorporate the technology into the MICU and expressed a desire for continued and expanded use beyond the COVID pandemic and population. While there was general sentiment and description of the technology within the nursing domain, 1 nurse expressed a desire for "nursing ownership."

Training. Training on both the CGM and the protocol appeared to be very organic and nurse driven. Several nurses described receiving initial training from a CNS or from a nurse manager; however,

others described receiving training from other nurses who had developed CGM experience. The diabetes consult NP team played an essential role in ongoing support, especially when managing more difficult patients or trouble shooting a device issue.

Patient Selection. Patient selection and CGM initiation were described as nursing-driven processes. Initially, patient selection was driven by the MICU CNS team; however, once nurses became more comfortable and gained experience using the CGM systems, they began promoting use. The MICU intensivist teams had little involvement in initiating CGM, and nurses described encountering confusion and occasionally pushback from MICU providers regarding initiation of therapy.

Workflow

Nurses discussed use of the devices and protocol and how CGM changed aspects of their workflow.

Decreased Exposure. Nurses described significant changes to workflow and glucose management associated with the addition of CGM. The ability to monitor glucose from outside the COVID patient rooms allowed nurses to spend significantly less time in the room.

Frequent Monitoring. The ability to continuously view glucose values changed the frequency of glucose monitoring. Although the management of IV insulin requires hourly monitoring, nurses reported viewing CGM glucose much more frequently. Changes in patient clinical condition often prompted more frequent glucose monitoring. Alarms played a minor role in glucose monitoring, which was attributed to the fact that alarms were triggered only when readings were "really high."

Eyeball. In addition to viewing the glucose value, nurses evaluated glucose trends. They all referred to the trend arrow as the "eyeball," due to the shape of the icon on the display. Most nurses reported that while they were aware of the trend arrow, it did not really impact their treatment or IV insulin titration. However, 1 nurse indicated that the trend arrows did factor into an adjustment she might make within the IV guideline parameters.

CGM Insertion. Sensor insertion was thought to be very easy and quick. There was a sense that the time savings experienced once the device was validated was well worth the small amount of time required for insertion. Training surrounding device insertion was transmitted between nurse managers and CNSs through demonstration and the sharing of valuable lessons learned. One diabetes NP shared 2 instances in which she experienced difficulty during device insertion despite having worn a Dexcom CGM for many years herself. One involved the novelty of wearing gloves while

Table 3
Nursing CGM Implementation Themes, Subthemes, and Supporting Nursing Statements Within the PARIHS Framework for Context

| Theme | Subtheme | Exemplar statement |
|-------------------|---------------------|---|
| Nursing ownership | Acceptance | <ul style="list-style-type: none"> • I would like nursing to have ownership of it. Like - as far as like physicians are ordering like blood glucose monitoring and that kind of stuff. But I don't want like the resident to say, "Well, we don't want to use that on that patient because of X, Y, Z." And then finding like we can't use it all, because now they've got it in their head that it's not safe or it's some sort of, who knows. But I would really like it to be nurse driven if this patient's appropriate for this type of monitoring. (MICU Staff RN, participant 6) |
| | Training | <ul style="list-style-type: none"> • When I first learned, it was just like a previous nurse told me. And then, I just like skimmed over like the laminated sheet that's like outside the room. And then, I mean, but it was like an easy concept. (MICU Staff RN, participant 1) |
| | Patient selection | <ul style="list-style-type: none"> • Now that you mention the - the pushback, I - the resident on our site actually was, when I had a CGM, he was not willing to consult endo, he wanted like an explanation...And it was just this whole runaround, and then I have to explain myself a million times to a million different people. (MICU Staff RN, Participant 4) • So, I think initially, I know - you know, everyone's very hard to receive change, I think. And it was - no one wanted to do it. It seemed like more work, and they - so, our CNSs were really pushing it initially. But now that we've all seen it and had it and we love it. Now, we're like, "Hi. Come help us. We want to do this. Like right now" So. (MICU Staff RN, Participant 4) |
| Workflow | Decreased exposure | <ul style="list-style-type: none"> • We spend a lot of time in those rooms before we got these (CGM systems)- these monitors. (MICU Nurse Manager, Participant 3) |
| | Frequent monitoring | <ul style="list-style-type: none"> • And let me just check it (CGM glucose) like every 30. Just because I'm - the protocol (IV insulin guideline) says I have to go up. But I'm pretty sure it was only climbing because of the antibiotics and dextrose we just gave. (MICU Staff RN, Participant 6) • I feel like safer with it. With a patient on an insulin drip in a COVID room, or any room really, I feel like it's a safety net. You feel safer. You can check it any point. Whether it's, you know, on the hour, or whether it's 5 minutes after the last time you left. So. (MICU Staff RN, Participant 4) |
| | Eyeball | <ul style="list-style-type: none"> • Well, the guideline we have currently now has like ranges too. So, you can - we do have like our own nursing judgment on that. But and so, in that case, if you're trending down, then I would tend to go with the lower number. You know, for our protocol at least. (MICU Staff RN, Participant 4) |
| | CGM insertion | <ul style="list-style-type: none"> • It's like 2 minutes, like literally a 2 minute, you're not in that room 2 minutes (MICU Nurse Manager, Participant 3) • It takes longer to gown up then it does to place that sensor (MICU Staff RN, Participant 1) • I wear a Dexcom. I've been wearing it for practically 10 years.... I got the sticky part got on the sensor casing. And I almost had to trash the sensor. But I think, you know, just something stupid like having gloves on and messing up that And then there was one that I did that I didn't click the transmitter in all the way. Which is just ridiculous as someone who does it all the time. So, you know, I think you do have to press harder than you think you do. (Diabetes Consult NP, Respondent 7) |

Abbreviations: CGM = continuous glucose monitoring; CNS = clinical nurse specialist; MICU = medical intensive care unit; NP = nurse practitioners; PARIHS = Promoting Action on Research in Health Services.

managing adhesive backing and the other involved not fully pushing the transmitter in place.

Facilitation

Barriers & Recommendations

Nursing participants were asked what changes they would recommend for current and longstanding CGM use in the MICU. Table 4 presents subthemes along with supporting nursing statements. Perceived barriers and nursing recommendations for future use were as follows.

Electronic Health Record and Technology Integration. Suggestions included the need for an improved documentation system and EHR integration. The need for nurses to annotate "cgm" within the POC glucose EHR field was seen as cumbersome and was thus inconsistently performed. Nurses commented that while they appreciated the technology, the receiver, phone, cords, and associated protocols and training materials crowded their workstations. Nurses exclusively used the receivers to view CGM data and remarked that the phones "never worked" and were rarely successfully paired.

Protocol Simplification. There was unanimous consensus that the hybrid CGM + POC protocol was excessively lengthy and nurses expressed a desire for simplification. Nurses reported that confusion surrounding CGM use and the protocol was most likely to occur after insertion during the validation period. This was especially true if the validation period coincided with nursing shift change. Additionally, it was acknowledged that the need to perform mathematical calculations could be a barrier for some nurses. One nurse suggested automatic EHR mathematical calculations in the future.

CGM Insertion. There was general consensus that the CGM sensor insertion process was uncomplicated and quick. CGM sensor insertion was being done by MICU CNSs, nurse managers, and diabetes consult NPs. Participants felt MICU staff nurses were absolutely capable of performing CGM sensor insertions; however, it was recommended that for future and potentially more widespread use, training be extended to only charge nurses initially.

Discussion

This report and evaluation highlight successful implementation of CGM in a MICU among patients with COVID-19 using a hybrid POC plus CGM approach. Expanded inpatient CGM use holds promise to reduce health care worker exposure, conserve PPE, improve hospital efficiencies, and reduce costs, while improving glycemic control.

The cohort of nurses who participated in the MICU focus group represented 3 distinct subsets of nursing care in the MICU (eg, nursing leaders, staff nurses, diabetes consult NPs). Focus group data demonstrated the distinct but integrated roles of these 3 nursing groups in CGM implementation. Nurses appeared to readily accept and integrate CGM technology into the MICU environment. They felt the devices were accurate, with the majority reporting all CGM/POC paired values within target. Interestingly, any reported inaccuracies were attributed to the critical nature of the patients rather than the technology itself.

There was a strong sense that this was a nursing intervention and a desire to keep the technology as a readily available tool. Patient selection was primarily driven by nurses, initially by the CNS and then the MICU staff nurse. Barriers encountered in patient selection included insufficient knowledge among the ICU care teams regarding CGM availability and use. Rather than using CGM to facilitate IV insulin, teams tended to use subcutaneous insulin in patients without severe refractory hyperglycemia. This was

Table 4
Nursing CGM Implementation Themes, Subthemes, and Supporting Nursing Statements Within the PARIHS Framework for Facilitation

| Theme | Subtheme | Exemplar statement |
|----------------------------|------------------------------|---|
| Barriers & recommendations | EHR & technology integration | <ul style="list-style-type: none"> I think just having a place to chart it (CGM glucose) would be nice. Because right now, they have to put a notation in under the column. (MICU Nurse Manager, Participant 2) Like, there were the papers that go with it. And it plugged in under the - our desks....It's like cords everywhere. And I'm like - we're all very Type A and clean, we like organized things. It was just kind of a lot of stuff. And it didn't really have its own like spot to sit, which kind of drove me nuts. So. (MICU Staff RN, Participant 4) |
| | Protocol simplification | <ul style="list-style-type: none"> Simple steps some, you know, instead of all—(MICU Nurse Manager, Participant 2) Lots of words. Yeah. Less words. But like a Cliff's Notes version. (MICU Staff RN, Participant 6) I think there was one I got called. Oh, it's - not in 20 - you know, one note at 20%. And I'd look, and I'm like, "Okay. So, here's your number." "And we're going to times that by 20%. We're going to add it. Oh my gosh. Yes, it is in range." "Oh, yeah. I guess it is." I think those are some of the people that didn't read the protocol. (MICU CNS, Participant 5) Like day shift, we have it. We set it up, it's all good. And then you, you say (to night shift), "Oh, you have this CGM. And here's what you have to do. And here's how you calculate the changes." And it was like a whole thing that you have to explain to the incoming shift. And then there's people - like I don't know - maybe they're not good with percentages and fractions. (MICU Staff RN, Participant 4) |
| | CGM insertion | <ul style="list-style-type: none"> I think I see maybe charge nurses initially being able to do it. Like every charge nurse getting education on that. And inserting a sensor maybe initially. I don't know that every nurse in the MICU needs to - to know to do it right now. (MICU CNS, Participant 5) I think our nurses are doing a lot more difficult tasks every day than placing a continuous glucose monitor. (MICU Nurse Manager, Participant 2) |

Abbreviations: CGM = continuous glucose monitoring; CNS = clinical nurse specialist; COVID = coronavirus disease; EHR = electronic medical record; MICU = medical intensive care unit; NP = nurse practitioners; PARIHS = Promoting Action on Research in Health Services.

compounded by a lack of strong evidence from randomized controlled trials for a specific glucose target in MICU patients.^{30–32} In addition, MICU teams pulled IV insulin pumps outside of the room only for patients with central IV access, thus making the perception of CGM less valuable when nurses needed to enter the room to titrate IV insulin. Thus, it is important to have an engaged leadership team and open lines of communication.

There was a sense that CGM devices provided an overall time savings for nurses and decreased the time spent in COVID-19 rooms. At the same time, nurses reported that the ability to continuously view CGM glucose data from outside the rooms prompted more frequent glucose monitoring. Additional analysis quantifying these aspects of implementation and time savings is greatly needed. This would include a formal analysis of time spent on each component of CGM implementation (eg, device set-up, insertion, pairing, CGM validation, monitoring, documentation).

Recommendations for future use included improvements to EHR documentation. While nurses did appear to be documenting CGM values as a substitute for hourly POC, the annotation of "cgm" did not consistently occur despite frequent reinforcement. This was certainly substantiated by focus group data. A distinct field in the EHR dedicated to CGM glucose would help alleviate many documentation issues for nursing, but it was not possible to customize this for patients with COVID-19 only. The failure of the Android phones to pair in many cases (13 or 19 phones did not pair), despite their connection to secure Wifi, was likely due to firewall protections that will need to be considered in the future. Glucose telemetry systems using the Dexcom Share feature have also been described.³³ However, no commercial system currently integrates with the EHR or with IV insulin software programs.

Additional considerations not addressed in the focus group data include streamlining the device set-up procedures. While nurses reported successful implementation of device insertion and receiver pairing, retooling Dexcom G6 personal CGM for inpatient use required considerable time and effort, and this process should be streamlined to facilitate widespread implementation.

Limitations

The study was limited by several factors, including the small sample size that is inherent to focus groups. Additionally, the focus

group was at a single large academic medical center, which could limit generalizability of experiences and implementation strategies.

Conclusion

This report demonstrates the feasibility of CGM integration in the ICU in response to the COVID-19 pandemic using an implementation science approach. The emerging use of CGM in the critical care environment holds tremendous promise to improve health care efficiency, reduce cost, and improve glycemic control; however, there is need for further research to quantify changes to nursing workflow, implementation burden, and associated economic implications. Finally, there is a need for prospective multicenter controlled trials to demonstrate feasibility, safety, and efficacy in the broader ICU population.

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Disclosure

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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