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Empowering Hospitalized Patients With Diabetes: Implementation of a Hospital-wide CGM Policy With EHR-Integrated Validation for Dosing Insulin

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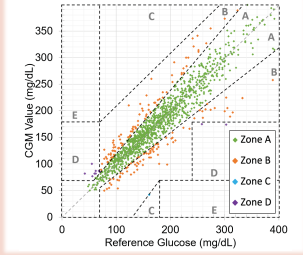
Hospital CGM Policy With Accuracy Monitoring and EHR Integration Is Feasible and Favorably Received by Nurses and Patients

Real-world hospital-wide implementation of a policy to monitor and support inpatient use of personal CGM

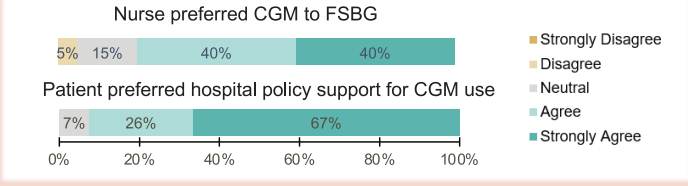
- EHR-based orders and documentation
- Patient agreement
- Requirements and contraindications for CGM use by device type
- Workflow for ongoing CGM accuracy validation
- Default CDCES consultation

Retrospective review of protocol use and CGM agreement

- 135 patients & 185 encounters
- 1,506 paired CGM:FSBG (POC) values
- 44% on G6 & 43% on Libre 2/14-day
- Successfully validation (via %20/20 criterion) in 87.8% of attempts
- Overall MARD 9.6%
- 99.3% within Clarke Zones A or B



Surveys of patient and nursing experience



This study demonstrated feasibility of a hospital-wide inpatient CGM policy with high clinical accuracy and alignment with patient and nurse preferences.

%20/20, continuous glucose monitoring values within 20% or 20 mg/dL; CDCES, certified diabetes care and education specialist; CGM, continuous glucose monitoring; EHR, electronic health record; FSBG, fingerstick blood glucose; MARD, mean absolute relative difference; POC, point of care.

ARTICLE HIGHLIGHTS

- **Why did we undertake this study?**
  As the use of continuous glucose monitoring (CGM) grows, there remains a gap in formal guidance regarding optimal support for inpatient use.
- **What is the specific question we wanted to answer?**
  We sought to evaluate the feasibility, clinical accuracy, and acceptability of a hospital-wide CGM usage policy.
- **What did we find?**
  Accuracy validations were successful 87.8% of the time across all CGM models, and the overall mean absolute relative difference was 9.6%. The CGM policy also received positive feedback from both patients and nurses.
- **What are the implications of our findings?**
  The results highlight the viability and benefits of a standardized CGM policy in enhancing inpatient diabetes management. Such policies can make inpatient diabetes care more efficient and patient friendly, potentially reshaping how hospitals approach diabetes management.

Empowering Hospitalized Patients With Diabetes: Implementation of a Hospital-wide CGM Policy With EHR-Integrated Validation for Dosing Insulin

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ORIGINAL ARTICLE

OBJECTIVE

We aimed to assess the feasibility, clinical accuracy, and acceptance of a hospital-wide continuous glucose monitoring (CGM) policy with electronic health record (EHR)–integrated validation for insulin dosing.

RESEARCH DESIGN AND METHODS

A hospital policy was developed and implemented at Stanford Health Care for using personal CGMs in lieu of fingerstick blood glucose (FSBG) monitoring. It included requirements specific to each CGM, accuracy monitoring protocols, and EHR integration. User experience surveys were conducted among a subset of patients and nurses.

RESULTS

From November 2022 to August 2023, 135 patients used the CGM protocol in 185 inpatient encounters. This group included 27% with type 1 diabetes and 24% with automated insulin delivery systems. The most-used CGMs were Dexcom G6 (44%) and FreeStyle Libre 2 (43%). Of 1,506 CGM validation attempts, 87.8% met the 20% or 20 mg/dL (%20/20) criterion for CGM-based insulin dosing and 99.3% fell within Clarke zones A or B. User experience surveys were completed by 27 nurses and 46 patients. Most nurses found glucose management under the protocol effective (74%), easy to use (67%), and efficient (63%); 80% of nurses preferred inpatient CGM to FSBG. Most patients liked the CGM protocol (63%), reported positive CGM interactions with nursing staff (63%), and felt no significant interruptions to their diabetes management (63%).

CONCLUSIONS

Implementation of a hospital-wide inpatient CGM policy supporting multiple CGM types with real-time accuracy monitoring and integration into the EHR is feasible. Initial feedback from nurses and patients was favorable, and further investigation toward broader use and sustainability is needed.

Interest in using continuous glucose monitoring (CGM) in the hospital has been increasing in recent years. CGM use for standalone glucose monitoring or as an integrated component of automated insulin delivery (AID) systems is now standard of care for individuals with diabetes in the outpatient setting, facilitating more in-target

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glycemic control while reducing hypoglycemia risk (1,2). Most current integrated CGM devices used in AID systems do not require calibration with capillary fingerstick blood glucose (FSBG) checks for insulin dosing. As CGMs have become increasingly popular in the ambulatory setting, interest in using them for inpatient diabetes management has also risen (3,4). Use of inpatient CGM increased during the coronavirus disease 2019 pandemic after the U.S. Food and Drug Administration (FDA) granted a temporary enforcement discretion on 1 April 2020 to address an urgent need for solutions that enabled remote monitoring of hospitalized patients and reduced use of personal protective equipment and nursing workload (4–8). Despite the enforcement discretion ending in November 2023, the FDA continued nonobjection to hospital CGM use while active investigation for inpatient use and labeling proceeds (6).

Several hospitals adopted inpatient CGM since the coronavirus 2019 pandemic, as detailed in recent scoping reviews (9,10). However, implementation presented challenges, notably a lack of clear guidance from the FDA on inpatient accuracy requirements (4). In response, Faulds et al. (11) led efforts to use hybrid protocols, using the point-of-care (POC) FSBG, that are already a part of standard inpatient clinical care in dosing insulin and managing hypoglycemia as reference values to assess and validate CGM accuracy. Studies reporting inpatient CGM accuracy using FSBG as a comparator have generally returned mean absolute relative differences (ARDs) ranging from 9 to 15% in critically and noncritically ill populations (4).

At the start of 2022, Stanford Health Care had policies in place to support continued use of insulin pumps during hospital admissions but lacked a formal policy for CGM. While the frequency of inpatient use of these diabetes technologies were not tracked systematically, an increase in interest was noted. In 2022, Stanford's multidisciplinary Inpatient Diabetes Task Force identified conflicts between patients and nurses due to inconsistent CGM practices. For example, some patients were permitted to use their home CGM devices while others were not, and for those who did, the frequency of POC FSBG monitoring varied. The task force identified the lack of hospital policy as an important root cause and recognized the need to support the patients' and nurses' safe use of inpatient diabetes technology. Simultaneously, Stanford Health Care was involved as a site in the multicenter Automated Insulin Delivery for Inpatients with Dysglycemia (AIDING) study (ClinicalTrials.gov identifier: NCT04714216), evaluating the use of a commercial AID system in the hospital (12). The study protocol, which included CGM accuracy validation based on POC FSBG as the reference, had received FDA and Centers for Medicare & Medicaid Services approval and was implemented in select acute care units, yielding positive participant feedback. We adapted and implemented the CGM validation protocol into a hospital-wide standardized clinical workflow to support the increasingly common requests to use patient-owned CGMs for inpatient insulin dosing and reduce the frequency of POC FSBG. We report our experience with the protocol and evaluate implementation feasibility, clinical accuracy, and nurse and patient acceptability.

RESEARCH DESIGN AND METHODS

Multidisciplinary Task Force for Centralized Review and Policy Development

Stanford Health Care operates an Inpatient Diabetes Task Force, similar to other described hospital glucose management oversight committees (13). This multidisciplinary team includes representation from unit nurses, nursing practice leadership, inpatient pharmacy, inpatient certified diabetes care and education specialists (CDCESs), endocrinology physicians, and information technology staff. Incidents of nursing and patient concerns around hospital use of CGM and AID systems were reviewed by the task force. A subcommittee formulated a hospital policy to address inpatient CGM use, specifically to develop a nursing protocol for validating CGMs with POC FSBG testing. The policy was implemented at Stanford Health Care in November 2022.

CGM Policy and Electronic Health Record Integration

The CGM policy included several aspects, including *1*) patient agreement, *2*) delineated requirements and contraindications for CGM use, *3*) workflow for CGM accuracy validation, *4*) electronic health record (EHR)–based orders and flowsheet documentation, and *5*) default CDCES consultation for nursing and staff education. Before using their CGMs in the hospital, patients were required to review and sign a patient agreement. This form was a critical step in ensuring patients' understanding of two key aspects: the lack of inpatient-specific FDA labeling and, correspondingly, the potential for accuracy limitations. Patients who did not sign the agreement were not required to remove their CGM, but the device could not be used for clinical management. Indications and contraindications specific for each CGM model, including Abbott FreeStyle Libre 2, Abbott FreeStyle Libre 3, Dexcom G6, Dexcom G7, Medtronic Guardian 3, Medtronic Guardian 4, and Eversense 3, were included in the policy.

A CGM validation workflow outlined the requisite accuracy monitoring parameters for using CGM readings for insulin dosing. The scheduled accuracy assessments (validations) occurred either once daily in the morning or twice daily (morning and bedtime), depending on the CGM model. CGM values were compared with reference FSBG performed using FreeStyle Precision Pro glucometers (Abbott Laboratories, Abbott Park, IL). To validate a CGM, nurses obtained an FSBG and then the current CGM reading, ideally within a 5-min window, but up to a maximum of 10 min was allowed to minimize a repeat FSBG and address potential workflow disruptions, such as interrupted Bluetooth connection. Both glucose values were entered into a nursing flowsheet in the EHR, which provided a yes or no output to indicate whether the CGM met validation criteria.

The validation flowsheet in the EHR used the 20% or 20 mg/dL (%20/20) criterion from the AIDING study (12), which is a modified version of the FDA criteria for integrated CGMs (14) and similar to protocols developed by others (11). The %20/20 criterion requires a CGM reading to be within ±20% of FSBG when FSBG is $\geq$70 mg/dL or within ±20 mg/dL of FSBG when FSBG is $<$70 mg/dL for successful validation (Supplementary Material 1). Successfully validated CGMs were permitted to be used instead of FSBG values for medical treatments but only until the next scheduled validation was due.

Unsuccessful validations required use of FSBG for insulin dosing until either a successful validation occurred or a new

sensor was placed and validated. Because this policy encompassed both CGMs with calibration capability and those without, we deliberately refrained from imposing a specific calibration requirement or protocol. Nurses were required to use FSBG for insulin pump boluses if validation criteria were not met. However, patients using AID systems were not immediately required to discontinue automated modes; this was left to the discretion of the endocrinology consult service, whose involvement is required for patients treated with AID.

Specific CGM alert thresholds were not mandated by the policy. Use of CGM readings were not permitted to guide insulin or hypoglycemia treatment under the following conditions: current CGM reading $<$70 mg/dL or $>$350 mg/dL; oxygen saturation $<$92%; hemoglobin $<$7 mg/dL; current use of vasopressors; or any suspicion of CGM reading inaccuracy (i.e., based on patient symptoms or recent history). CGM removal was required for procedures involving magnetic resonance imaging, diathermy (including cautery or radiofrequency ablation), or electrical manipulation (e.g., cardioversion).

The provider order set, outlined in Supplementary Material 2, was developed for use in the hospital's EHR (Epic; Epic Systems Corporation, Madison, WI). It was included as an independent order set and as a part of subcutaneous insulin order sets. Ordering providers were prompted to choose the appropriate CGM model, which automatically generated the relevant orders to guide the device-specific ongoing validation requirements and to outline contraindications and criteria for device removal. The EHR integration included timed orders for the POC FSBG and CGM assessments, nursing documentation flowsheets, an embedded CGM validation calculator formatted similarly to existing designs (15), and links to the hospital policy, reference materials, and patient agreement form. The order set also defaulted a CDCES consultation for nursing education and support regarding the validation workflow and CGM policy.

Prior to implementation, nurse education was provided by a CDCES and clinical nurse specialist. Nurses were oriented to details about the hospital policy, workflow for validation and documentation, digital reference materials on the intranet, and CDCES consultation for just-in-time education. Hospital staff were not otherwise trained on use or interpretation of CGM data.

Study Design and Participants

We retrospectively reviewed the cohort of individuals hospitalized at Stanford Health Care from November 2022 to August 2023 who engaged with the new inpatient CGM policy and underwent at least one validation during their admission. To evaluate user experience, surveys were distributed to a subset of patients and nurses over the 7-month period following implementation. Approval for analyses and publication were obtained from Stanford University's institutional review board.

Analysis of CGM Validation and Agreement

All paired CGM and FSBG values from times of attempted validation were exported from the EHR flowsheet for analysis. The CGM and FSBG reference values were compared for agreement—reported as the mean ARD, by Clarke error grid–associated zone (16), and using %10/10, %15/15, %20/20, and %30/30 agreement criteria as defined above. The frequency of CGM use as the percentage of hospital days with documented CGM data was determined through chart review. The frequency of documented validation attempts each day was compared with the minimum required by device type (once or twice daily) and categorized as fewer than, equal to, or more than the minimum required. Additional validation attempts due to prior unsuccessful validations were included in more than minimum counts. For partial hospital days with an afternoon admission or a morning discharge, only one documented CGM validation was considered a sufficient minimum for CGMs requiring twice-daily validation.

Patient and Nursing Experience Surveys

Nurses engaging with the policy completed a modified System Usability Scale (SUS) (17) and additional questions specific to inpatient CGM use (Supplementary Material 3). Study staff attempted to contact all patients by phone after hospitalization to complete a custom survey on inpatient CGM use (Supplementary Material 4). Both surveys used five-point Likert scale responses. Surveys were revised once during the study to include an additional user experience metric. Both nursing and patient surveys included a final free-response question. These comments were reviewed to identify common themes. The SUS scores from nurses were calculated and interpreted according to established methods (17).

RESULTS

Patient and Encounter Characteristics

Between 25 November 2022 and 8 August 2023, 135 hospitalized patients used the inpatient CGM policy and order set across 185 inpatient encounters. Table 1 lists the characteristics of patients using the inpatient CGM policy, and Table 2 describes details from their associated hospital encounters. The cohort comprised 43.0% female, 56.3% White, and 83.0% English-speaking patients. Most patients had a diagnosis of type 2 diabetes (51.9%), followed by type 1 diabetes (27.4%), type 3c/pancreatogenic diabetes (8.9%), cystic fibrosis–related diabetes (7.4%), transplant-related diabetes (3.0%), and other secondary diabetes (0.7%). Hospitalizations predominantly involved either the Dexcom G6 (44.3%) or the FreeStyle Libre 2 or Libre 14 day (43.2%) sensors. Insulin pumps were used in 53 encounters (28.6%); of these, 44 (83%) used AID, which comprised 23.8% of the total encounters. Reasons for admission were diverse. Patients were primarily admitted to medical (62.7%) or surgical (34.6%) hospital services, spanning 19 inpatient units. Hospitalizations ranged between 1 and 122 days.

CGM Validation and Agreement

There were 1,506 attempted validations (paired CGM and FSBG values), of which 1,323 (87.8%) successfully met the %20/20 validation criterion. Additional agreement data are described overall and by CGM device type in Table 3. Validation attempts most frequently occurred between 7:00 and 10:00 A.M. (579 events [38.4%]), followed by 8:00 and 11:00 P.M. (328 events [21.8%]) (Supplementary Material 5), consistent with the once- to twice-daily device validation requirements outlined in the policy. Validations were successful 89% and 88% of the time between 7:00 and 10:00 A.M. and 8:00 and 11:00 P.M., respectively.

The 183 unsuccessful validations occurred in 118 distinct episodes. Some patients did not have a subsequent successful CGM validation due to discharge (n = 8) or discontinuation of CGM use (n = 23). Insulin was appropriately dosed based on FSBG

Table 1—Characteristics of patients who used the inpatient CGM policy

Characteristic	Value
Patients, *n*	135
Age (years)	58.3 ± 16.9
Sex	
Female	58 (43.0)
Male	77 (57.0)
Racial or ethnic group*	
White	76 (56.3)
Asian	28 (20.7)
Hispanic	24 (17.8)
Native Hawaiian/Pacific Islander	4 (3.0)
Black	3 (2.2)
American Indian/Alaska Native	2 (1.5)
Primary language	
English	112 (83.0)
Spanish	8 (5.9)
Vietnamese	4 (3.0)
Other	11 (8.1)
Diabetes type	
Type 2	70 (51.9)
Type 1†	37 (27.4)
Type 3c/pancreatogenic	12 (8.9)
Cystic fibrosis–related diabetes	10 (7.4)
Posttransplant	4 (3.0)
Other secondary diabetes	1 (0.7)
History of transplant*	36 (26.7)
Cardiac	6 (4.4)
Hematopoietic	7 (5.2)
Liver	2 (1.5)
Pancreas	2 (1.5)
Pulmonary	16 (11.9)
Renal	9 (6.7)

Data are *n* (%) or mean ± SD unless otherwise indicated. *Data categories are not mutually exclusive; a patient can experience multiple listed subvariables. †Includes immune checkpoint inhibitor–induced diabetes.

until the next successful CGM validation in 146 of 152 (96%) events. No hypoglycemia occurred in the six instances of inappropriate CGM-based dosing after failed validation. The median time between the initial unsuccessful and first subsequent successful validation was 5 h (interquartile range [IQR] 3.6–11.3 h).

CGM use was documented on 915 of 1,602 total hospital days, with a median of 80% (IQR 50–100%) of days per hospitalization. Of the total CGM days, 736 (80.4%) met the requirement for the minimum number of CGM validation attempts. Among these, 291 (31.8% of total CGM days) exceeded the expected number, including attempts after prior unsuccessful validation or device exchange. On 179 CGM days (19.6%), fewer than the required number of validations were performed.

The overall mean ARD from the validations across all CGMs was 9.6%; median ARD was 7.1%. The majority of CGM validations (1,495 of 1,506 [99.3%]) fell within Clarke zones A or B (Table 3 and Supplementary Material 6). Eleven paired values were outside zones A or B, including 1 in zone C and 10 in zone D. No glycemia-related safety events occurred in association with these values. In each instance, an FSBG value was used appropriately for treatment when CGM failed to validate. The single zone C value involved a CGM reading of 42 mg/dL at 3 A.M., which led to an FSBG assessment (161 mg/dL) per protocol and no hypoglycemia treatment. Eight of the 10 zone D CGM values exhibited a high bias compared with POC FSBG. Four of these had a CGM reading <85 mg/dL, triggering confirmatory FSBG tests. In one zone D instance, the CGM reading was 175 mg/dL, while the concurrent FSBG was 258 mg/dL. Insulin was appropriately dosed based on the FSBG value, resulting in the administration of 3 units of insulin lispro instead of 1 unit (if the CGM reading were used). One zone D value occurred in a patient with severe anemia (hemoglobin 4.8 mg/dL) requiring transfusion and end-stage renal disease requiring hemodialysis. Validation was attempted despite contraindications to CGM use in this circumstance; however, insulin dosing was based on FSBG in accordance with policy. For the remaining seven values falling outside zones A or B, no simultaneous factors listed as precautions or contraindications in the policy were identified, including diathermy, electrical manipulation, cardioversion, hemoglobin <7 mg/dL, oxygen saturation <92%, vasopressor requirement, procedures, dialysis, or medications known to affect CGM accuracy. Data on calibrations, CGM trend arrows, duration of CGM wear, sensor changes, and sensor error messages were not collected. The proportions of days with hyperglycemia and hypoglycemia were not significantly different between days with and without documented CGM use (Supplementary Material 7).

Patient and Nurse Experience

Surveys were completed by 27 nurses and 46 patients (Fig. 1). Most nurses found glucose management under the protocol effective (74%), easy to use (67%), and efficient (63%). In December 2022, an additional question asked nurses to compare using CGM versus routine FSBG in the hospital, and 16 of 20 (80%) expressed preference for CGM. Mean SUS score from nurses was 67.4, which is generally considered to represent ok to good usability (17). Most patients reported positive overall experiences using the CGM protocol (63%), positive interactions with nursing staff about CGM use (63%), and feeling that the number of interruptions related to diabetes management was reasonable (63%). In July 2023, an additional question asked patients to compare their diabetes management experience using the inpatient CGM protocol versus prior admissions using CGM without the protocol, and 25 of 27 (93%) patients preferred the protocol (67% strongly agreed, 26% agreed, 7% were neutral).

Free-response feedback from patients and nurses, organized into five themes including effectiveness, efficiency, subjective satisfaction, learnability, and errors and nine subthemes, highlighted varied experiences with use of the CGM policy (Supplementary Material 8). Hospitalized patients with access to real-time data reported feeling empowered to discuss glucose management with their clinical team and feeling greater control over their glucose levels. They also appreciated the reduced need for FSBG checks. Some patients advocated for even fewer validations, such as only during the initial day or two of sensor use. Both patients and nurses identified a gap in nurse education regarding CGM and insulin pump management in the hospital, even with the new policy. While some nurses appreciated the convenience of CGM systems for coordinating glucose monitoring with mealtime insulin, others considered the system complex and time-consuming. Additionally, some nurses identified potential errors in user handling and workflow associated with use of the CGM order set.

CONCLUSIONS

The implementation of a hospital-wide inpatient CGM policy that supports multiple CGM types and has real-time clinical accuracy monitoring facilitated by the EHR is a significant advancement in promoting use of CGM among hospitalized patients with diabetes. This approach aligns with

Table 2—Characteristics of hospital encounters involving use of inpatient CGM policy

Characteristic	Value
Hospitalizations, *n*	185
CGM type	
Dexcom G6	82 (44.3)
FreeStyle Libre 2 or FreeStyle Libre 14 day	80 (43.2)
Dexcom G7	10 (5.4)
Medtronic Guardian 3	7 (3.8)
FreeStyle Libre 3	6 (3.2)
Insulin pump use	53 (28.6)
Insulin pump without use of AID/HCL	9 (4.9)
Insulin Omnipod DASH (Gen 4)	5 (2.7)
Medtronic MiniMed 670G/770G	3 (1.6)
Medtronic MiniMed Paradigm	1 (0.5)
Insulin pump with use of AID/HCL	44 (23.8)
Tandem t:slim X2 with Control-IQ	28 (15.1)
Insulet Omnipod 5 AID System	9 (4.9)
Medtronic MiniMed 670G/770G	7 (3.8)
Most recent HbA_{1c}*	7.4 ± 1.6
Admitting diagnosis†	
Cardiac	37 (20.0)
Chronic kidney disease	4 (2.2)
Diabetes with complications	7 (3.8)
DKA	5 (2.7)
Hypoglycemia	1 (0.5)
Fluid, electrolyte, and nutritional disorders	23 (12.4)
Infection	43 (23.2)
Sepsis	8 (4.2)
Liver and biliary disease	4 (2.2)
Neurologic	7 (3.8)
Oncologic	24 (13.0)
Pain management	4 (2.2)
Respiratory failure or insufficiency	16 (8.6)
Transplant complications	23 (12.4)
Trauma	5 (2.7)
Others‡	11 (5.9)
Admitting service	
General medicine and medicine subspecialties§	116 (62.7)
General surgery and surgical subspecialties‖	64 (34.6)
Critical care¶	3 (1.6)
Neurology	2 (1.1)
Endocrinology diabetes service consulted	74 (40.0)
Length of hospitalization (days), median (interquartile range)	5.0 (2.0–9.0)

Data are *n* (%) or mean ± SD unless otherwise indicated. DKA, diabetes-related ketoacidosis; HCL, hybrid closed-loop. *Included HbA_{1c} values are from within 6 months of hospitalization (*n* = 182). Two encounters lacked an HbA_{1c} in this time frame, and another had a reading of <4.2%, which was excluded from the mean calculation. †Data categories are not mutually exclusive; a patient can experience multiple listed subvariables during a single hospitalization. ‡Other admission diagnoses included pancreatitis (*n* = 3), neurosurgery (*n* = 2), gynecologic surgery (*n* = 1), vascular surgery (*n* = 1), orthopedic surgery (*n* = 1), gastrointestinal bleed (*n* = 1), postoperative complications (*n* = 1), and complications of care (*n* = 1). §Primary admitting medical services included bone marrow transplant (*n* = 8), cardiology (*n* = 18), gastroenterology/liver (*n* = 10), hematology/oncology (*n* = 26), infectious diseases (*n* = 1), internal medicine/hospitalist (*n* = 44), pain management (*n* = 2), pulmonary (*n* = 4), and nephrology (*n* = 3). ‖Primary admitting surgical services included cardiac surgery (*n* = 6), cardiac transplant (*n* = 7), general surgery (*n* = 7), gynecologic surgery (*n* = 1), neurosurgery (*n* = 2), orthopedic surgery (*n* = 4), otolaryngology (*n* = 3), plastic surgery (*n* = 1), pulmonary transplant (*n* = 28), thoracic surgery (*n* = 1), trauma (*n* = 1), and vascular surgery (*n* = 3). ¶Patients were admitted to critical care and later transferred to general medicine where CGM was the order set used.

patient preferences, reduces the frequency of painful FSBG checks, and facilitates continuation of CGM alarms and AID systems. Enabling patient access to CGM data fosters constructive dialogue with health care providers about glucose management. Furthermore, the policy supports semiadjunctive use of all commercially available CGM systems for dosing insulin in the hospital, advancing earlier protocols that predominantly supported only one type of CGM device (10,18,19).

The overall mean ARD of 9.6% compares favorably with other real-world inpatient CGM studies reporting mean ARDs of 9–15% but less favorably to the mean ARDs of 5.6–7.8% seen in hospital POC glucometers (4,20,21). A modeling study using clinical data from critically ill patients suggested that while intermittent glucose monitors used in hospitals should achieve a mean ARD <7.1%, CGMs can afford less stringent accuracy because they provide continuous readings. For CGMs, a mean ARD of preferably <11% but tolerable up to 17.8% is acceptable without significantly compromising insulin dosing decisions (22). The most commonly used sensors in this study, Dexcom G6 and FreeStyle Libre 2 or 14 day, both had mean ARDs <11%.

The clinical utility of assessing single-point glucose measurement accuracies for inpatient glucose monitoring warrants further scrutiny. For example, current inpatient policy at Stanford Health Care allows use of FSBG checks performed up to 1 h prior to dosing insulin. Given the potential for a patient's glucose level to change due to factors such as nutrition, physical activity, medications, and existing insulin on board within this time frame, CGMs offer important advantages by providing both the current glucose value and trajectory at the time of insulin administration. Comparing the potential impact of these considerations on real-world patient safety was beyond the scope of this study but should be explored.

This study is limited by its retrospective nature, having included only data documented in the EHR. Full CGM data downloads were not available, preventing more detailed assessments of CGM wear times, new sensor insertions, calibrations, and glycemic metrics. Although Table 3 includes mean and median ARDs for individual CGM types, interpretation is limited by the differing sample sizes, which were notably smaller for several

Table 3—Data from paired glucose validation attempts

	Overall	Dexcom G6	Dexcom G7	FreeStyle Libre 2 or 14 day	FreeStyle Libre 3	Medtronic Guardian 3
Patients, *n**	135	57	7	63	6	5
Encounters, *n*	185	83	10	80	6	7
Total paired glucose values, *n*	1,506	609	45	716	57	79
ARD						
Mean (%)	9.6	10.8	5.1	8.4	14.0	10.9
Median (%)	7.1	7.8	5.1	6.3	11.8	7.4
Clarke zone, paired glucose values						
A	1,321 (87.7)	517 (84.9)	45 (100.0)	654 (91.3)	39 (68.4)	66 (83.5)
B	174 (11.6)	82 (13.5)	0	62 (8.7)	17 (29.8)	13 (16.5)
C	1 (0.1)	1 (0.2)	0	0	0	0
D	10 (0.7)	9 (1.5)	0	0	1 (1.8)	0
E	0	0	0	0	0	0
Agreement,† paired glucose values						
%30/30	1,441 (95.7)	574 (94.3)	45 (100.0)	696 (97.2)	51 (89.5)	75 (94.9)
%20/20‡	1,323 (87.8)	519 (85.2)	45 (100.0)	654 (91.3)	39 (68.4)	66 (83.5)
%15/15	1,188 (78.9)	456 (74.9)	44 (97.8)	600 (83.8)	32 (56.1)	56 (70.9)
%10/10	956 (63.5)	366 (60.1)	39 (86.7)	485 (67.7)	23 (40.4)	49 (62.0)

Data are *n* (%) unless otherwise indicated. *Data categories are not mutually exclusive, as some patients used different CGM types during different hospital encounters. †CGM values within ±*X*% of POC value (if ≥70 mg/dL) or within ±*X* mg/dL of POC (if <70 mg/dL). ‡Criterion for validation as specified in the protocol.

devices. Our multidisciplinary collaboration for implementing hospital CGM policy helped to reduce conflicts and undue burdens to other stakeholders. In some institutions, gathering diverse stakeholders may be challenging and hinder implementation. However, doing so likely increases the chances of success. Standardizing inpatient CGM use by regulators and manufacturers could simplify this process. While the CDCESs provided valuable implementation support at our institution, not all institutions have similar staff to support diabetes technology use, thus potentially limiting the broader applicability of our implementation strategy.

The optimal frequency and timing of validation checks remain uncertain. Some real-world inpatient hybrid protocols have used fewer scheduled validations compared with our protocol. For example, the protocol developed by Faulds et al. (23) required validation checks every 6 h for patients in the intensive care unit (ICU) treated with intravenous insulin. The protocol allowed for a transition to no scheduled ongoing validations (nonadjunctive use) once patients were transferred out of the ICU, except in certain conditions, such as the initiation of a new sensor, CGM low alerts, or changes in patient clinical status. Another hybrid protocol used at the University of Colorado allowed nonadjunctive CGM use for insulin dosing in both critically ill and noncritically ill populations after passing two consecutive hourly CGM validations (19). Scripps Mercy Hospital adopted a once-daily validation protocol for Dexcom G6 sensors in the non-ICU setting (18), similar to our protocol's requirements for the G6 sensor. Since some patients expressed a desire for fewer validation checks, it would be worthwhile to investigate how protocols might account for individual patient factors to adjust validation frequency requirements.

Most validations were performed in the morning or at bedtime. Validations occurring outside these times may happen for a variety of reasons, including initial admission validations, starting a new device, addressing confirmed or impending hypoglycemia, and other logistical needs. Overnight validations were less common, yet notable proportions, including 50% between 2:00 and 3:00 A.M. and 33% between 3:00 and 4:00 A.M., were conducted in the setting of hypoglycemia or impending hypoglycemia on CGM. This contrasts with only 0–15% during other times of the day. The success rate of these overnight validations was comparatively lower, at 80% between 1:00 and 2:00 A.M. and 67% between 3:00 and 4:00 A.M., potentially due to a higher rate of hypoglycemia assessments and inaccuracies in CGM readings caused by sensor compression during sleep. Afternoon validations also had lower success rates (77% between 1:00 and 3:00 P.M.), likely from postprandial glucose fluctuations, despite the policy advising against validating during periods of rapid glucose change. Additionally, nearly 20% of days with active CGM use documented fewer than the expected number of validations and six instances of inappropriate insulin dosing based on CGMs following failed validation occurred. These observations suggest that efforts to increase protocol adherence and optimize CGM validation timing and frequency are needed.

The experience surveys provide initial exploration of feasibility, acceptability, and identification of barriers to implementing a successful hospital CGM program. A majority of participants using CGM in the hospital expressed positive experiences, which align with prior reports of positive patient-reported outcomes using CGM and AID systems in the ambulatory setting (24,25). Our findings suggest that factors contributing to positive patient experience include perceived glycemic control, perceived reliability of the CGM, and physical comfort associated with fewer fingersticks. Furthermore, access to real-time glucose readings and CGM alerts empowered some patients to have more productive communication with staff about glucose management. In contrast, nursing experience was more

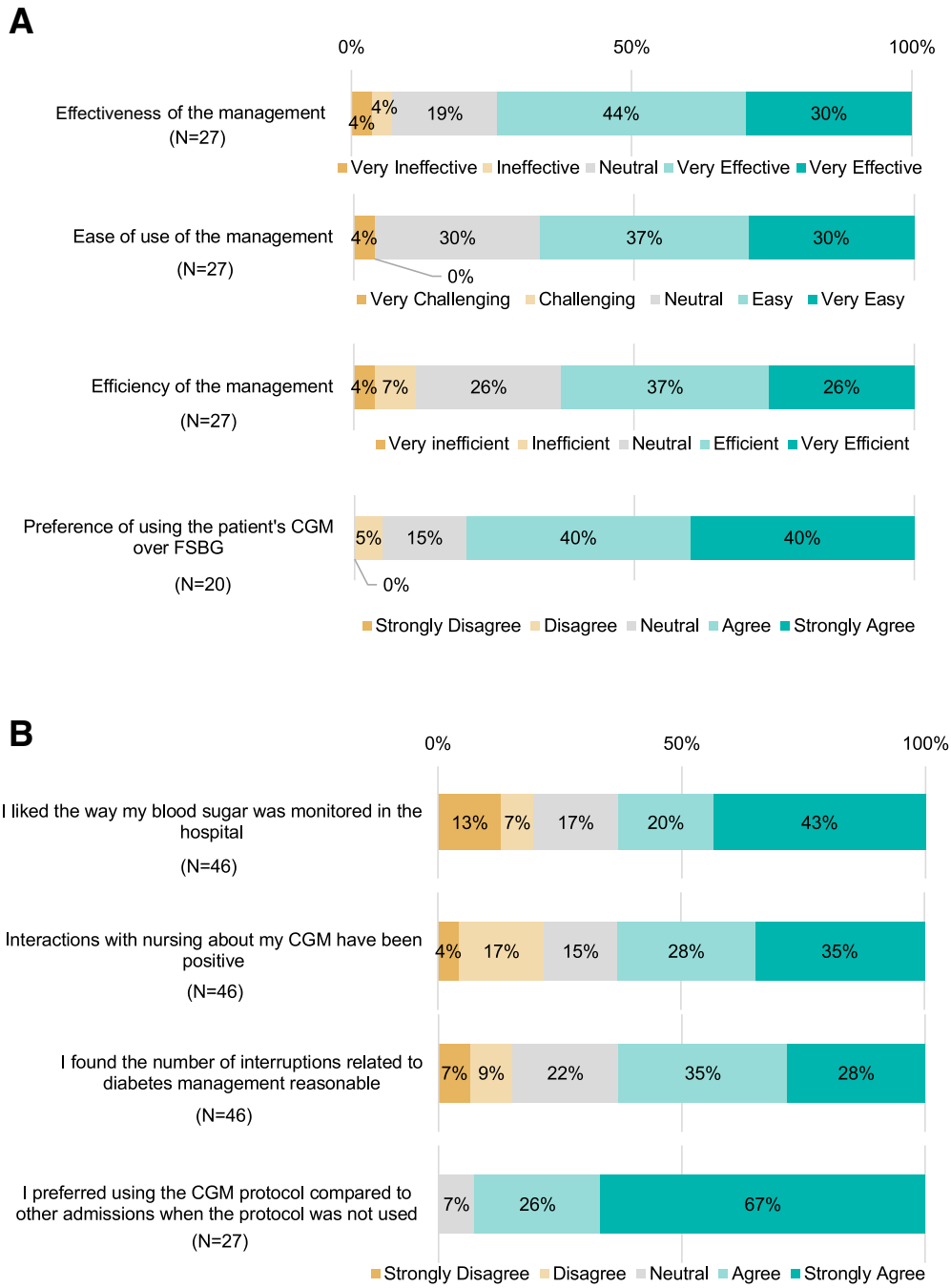

Figure 1—User experience survey results from patients and nurses. *A*: Responses from nurses. *B*: Responses from patients. Survey questions were based on a five-point Likert scale and are depicted with more negative responses on the left (yellow) progressing to more positive responses on the right (blue).

variable. The gap in nursing familiarity with the CGMs and workflow may be an important barrier to acceptability, as both nurses and patients identified additional nursing education needs. More detailed assessment of user experiences with semistructured interviews and/or focus groups may beneficially guide iterative improvement.

As dynamic documents, hospital policies necessitate periodic review and updates. Future expansions may include examining CGM use and accuracy in additional settings (e.g., operating rooms), for additional patient populations (e.g., pediatrics, obstetrics), and with concurrent use of AID. Patients treated with AID systems were not immediately required to discontinue automated modes after unsuccessful CGM validations to minimize the risk of outdated basal rates causing hyperglycemia or hypoglycemia and to allow continuation of adjusted AID modes or glucose targets. Even so, this policy addressed a monitoring gap that was not previously in place. Future updates to the inpatient pump policy will more specifically address the use of automated modes in relation to CGM validations. Additionally, exploring prescribing CGMs for patients at a higher risk of hypoglycemia could further promote high-value care (26–28), and

integrating key CGM data (e.g., glucose readings, calibration, trend arrows, duration of wear, sensor changes, error messages) with the EHR could facilitate assessments of sensor accuracy and safety, eliminate manual data entry, and provide more complete information for clinical and research use.

By sharing our experience in establishing an inpatient CGM policy and workflow as standard clinical care, we aim to encourage similar adoption in other health care facilities. However, it is important to recognize that inpatient use of these devices is currently off label and comes with limitations. Setting clear expectations with patients from the beginning is essential, and the patient agreement plays a vital role in this process. Future efforts should focus on understanding and addressing CGM limitations in inpatient settings and optimizing their use for specific indications to better meet the needs of patients.

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