

Internal Experts Collaborate to Reduce Critical Hypoglycemia and Insulin Errors and Improve Insulin Administration Timing

Kelley Szclc and Linda Nicolaus

■ **IN BRIEF** “Quality Improvement Success Stories” are published by the American Diabetes Association in collaboration with the American College of Physicians, Inc., and the National Diabetes Education Program. This series is intended to highlight best practices and strategies from programs and clinics that have successfully improved the quality of care for people with diabetes or related conditions. Each article in the series is reviewed and follows a standard format developed by the editors of *Clinical Diabetes*. The following article describes a project aimed at reducing inpatient critical hypoglycemia episodes in a community hospital setting.

Describe your practice setting and location.

The University of Pittsburgh Medical Center’s Passavant Hospital is a 425-bed community hospital in a suburb of Pittsburgh, Pa., that has received a Magnet designation for nursing excellence from the American Nurses Credentialing Center (ANCC). The hospital is a state-of-the-art tertiary care center delivering a full range of quality medical services, including highly specialized medical and surgical treatment, to the residents of its service area. The organization recognizes diabetes as one of its top community health needs and assesses this every 3 years.

Describe the specific quality gap addressed through the initiative.

This quality improvement (QI) project focused on reducing hospital-wide critical hypoglycemia events, defined as glucose levels ≤ 50 mg/dL, by 20%.

How did you identify this quality gap? In other words, where did you get your baseline data?

A review of evidence from the American Association of Clinical Endocri-

nologists (1) revealed that hypoglycemia is a common occurrence in hospitals and is associated with poor clinical outcomes and increased mortality. Hospitalized patients who receive insulin therapy are at risk for both spontaneous and insulin-associated hypoglycemia episodes (1). Because insulin accounts for the majority of hypoglycemia events in the hospital setting, the Joint Commission and the Institute for Safe Medication Practices has labeled insulin a “high-alert” medication (1).

Because of the serious nature of hypoglycemia and poor clinical outcomes, a detailed root-cause analysis was conducted to assess our hospital hypoglycemia incidence and evaluate our opportunities to improve patient care and safety. When critical hypoglycemia episodes are identified (either by a capillary blood glucose measurement or a laboratory glucose value ≤ 50 mg/dL), the data are captured in the electronic health record (EHR) and included in a 24-hour hypoglycemia report. This report was reviewed, tracked, and investigated by the diabetes programmatic nurse specialist (PNS).

University of Pittsburgh Medical Center
Passavant Hospital, Pittsburgh, PA

Corresponding author: Kelley Ann Szclc,
szclcka2@upmc.edu

This series is published by the American Diabetes Association in collaboration with the American College of Physicians, Inc., and the National Diabetes Education Program. The American College of Physicians and the American College of Physicians logos are trademarks or registered trademarks of American College of Physicians, Inc., in the United States and shall not be used otherwise by any third party without the prior express written consent of the American College of Physicians, Inc. Likewise, products and materials that are not developed by or in partnership with the National Diabetes Education Program are prohibited from using the National Diabetes Education Program logo.

<https://doi.org/10.2337/cd17-0058>

©2018 by the American Diabetes Association. Readers may use this article as long as the work is properly cited, the use is educational and not for profit, and the work is not altered. See <http://creativecommons.org/licenses/by-nc-nd/3.0> for details.

This investigation involved discovering the root cause of each critical hypoglycemia episode in the EHR. Its findings identified issues related to the timing of insulin administration, the timing of capillary blood glucose measurement, the percentage of meals or snacks consumed, and the timing of bedtime snacks in relation to the bedtime correction insulin doses administered.

The PNS in diabetes collaborated with the clinical pharmacy specialist (CPS) in medication safety to present the identified issues to the organization's Medication and Diabetes Safety Committee (MDSC). Through discussion with the committee, we identified an area of concern involving a knowledge gap among nurses related to the timing of bedtime snacks for patients with diabetes. The PNS and CPS believed there was a potential connection between early bedtime snacking due to the timing of snacks being delivered from nutrition services and unusually high bedtime blood glucose readings. This possible connection might explain a pattern of overnight critical hypoglycemia events if insulin coverage was based on early snacking and resultant high blood glucose.

Subsequently, the PNS partnered with dietary services staff to ensure that bedtime snacks for patients with diabetes are delivered to the nurses' station and not to individual patients' rooms.

Summarize the initial data for your practice (before the improvement initiative).

Through our process of tracking and investigating critical hypoglycemia episodes, an issue of concern was identified in June 2013. After an additional 3 months of monitoring, there were 169 critical hypoglycemia episodes throughout the hospital, which translated to a rate of 6.59% for that period. The PNS and CPS conducted surveillance and analyzed each case, looking for patterns and

trends. Focusing on the nighttime critical hypoglycemia events led to the discovery that early bedtime snacking led to inadvertently high blood glucose levels when glucose was checked at bedtime, which led to higher-than-needed insulin doses.

The effort to evaluate the root cause of critical hypoglycemia episodes ≤ 50 mg/dL was launched in 2014. Chart audits were performed, and events and contributing factors related to the hypoglycemia events were categorized. The results of this investigation served as the basis of our QI project design. This information was tracked in a computer-generated diabetes worktable that outlined the hospital's incidence and rate of hypoglycemia per 1,000 patient-days.

A baseline 10-day chart audit was conducted by the CPS on 12 inpatient nursing units in 2014. A 10-day chart audit period was chosen to ensure evaluation of an adequate number of correction insulin administration opportunities. For each opportunity, the CPS evaluated the blood glucose result, the correction insulin order, the determination of the correction insulin dose based on the blood glucose result, the administration of the appropriate insulin dose if required, and the time elapsed between the blood glucose check and the insulin administration. These findings were reported individually per unit to account for differences in patient census. The chart audit was conducted by manual review of the EHR of all inpatient nursing units, including nine medical surgical units, two intensive care units, and one physical rehabilitation unit (Table 1). Patients receiving correction insulin were identified by using the roster function of the Theradoc clinical monitoring system, a clinical decision support software program that interacts with the EHR.

The percentage of insulin coverage error outcomes shown in Table 1 were calculated by dividing the number of insulin coverage errors by the total opportunities for error. The insulin

TABLE 1. Initial Chart Audit Data With Insulin Errors and Timing Outcomes for 2014

Unit	A	B	C	D	E	F	G	H	I	J	K	L	M	Total Overall
Dates of audit	7/1/14 to 7/10/14	6/21/14 to 6/30/14	6/1/14 to 6/10/14	6/1/14 to 6/10/14	6/1/14 to 6/10/14	5/11/14 to 5/20/14	5/1/14 to 5/15/14	5/1/14 to 5/10/14	4/21/14 to 4/30/14	4/11/14 to 4/20/14	4/1/14 to 4/10/14	Jan. 14 to Jan. 14	Jan. 14 to Jan. 14	
Days in audit period (n)	10	10	10	10	10	10	15	10	10	10	10	10	31	31
Total opportunities (n)	192	237	279	191	139	239	176	349	280	272	316	260	302	3,232
Total doses administered (n)	103	125	139	130	84	155	111	186	177	149	182	161	193	1,895
Total doses not administered (n)	89	112	140	61	55	84	65	163	103	123	134	99	109	1,337

TABLE CONTINUED ON P. 193 →

TABLE 1. Initial Chart Audit Data With Insulin Errors and Timing Outcomes for 2014, continued from p. 192

Chart audit: no coverage needed based on blood glucose (n)	82	111	129	59	45	70	57	154	98	117	129	96	109	1,256
Patient refused (n)	3	0	6	0	5	8	7	7	2	1	5	2	0	46
Patient ate (n)	0	0	0	0	0	0	0	1	0	1	0	0	0	2
Held; patient did not eat (n)	1	0	0	0	3	0	0	0	2	0	0	1	0	7
Patient unavailable (n)	1	0	2	1	1	0	0	0	1	3	0	0	0	9
Not appropriate (n)	2	1	3	1	1	6	1	0	0	0	0	0	0	15
Did not arrive (n)	0	0	0	0	0	0	0	1	0	1	0	0	0	2
Coverage errors (wrong units given) (n)	3	3	7	2	2	8	6	13	10	4	4	18	4	84
Insulin coverage error rate (%)	1.6	1.3	2.5	1.0	1.4	3.3	3.4	3.7	3.6	1.5	1.3	6.9	1.3	2.6
Time between blood glucose check and coverage insulin dose administration (n)														
<30 min	52	105	82	101	34	69	56	73	73	96	90	88	114	1,033
30–60 min	25	12	21	8	29	50	34	41	40	35	55	38	49	437
>60 min	25	8	36	15	21	36	20	70	60	14	37	30	30	402
Dose given with no blood glucose documented	1	0	0	6	0	0	1	2	4	4	0	5	0	23
Percentage administered within:														
<30 min	50.5	84.0	59.0	77.7	40.5	44.5	50.5	39.2	41.2	64.4	49.5	54.7	59.1	54.5
30–60 min	24.3	9.6	15.1	6.2	34.5	32.3	30.6	22.0	22.6	23.5	30.2	23.6	25.4	23.1
>60 min	24.3	6.4	25.9	11.5	25.0	23.2	18.0	37.6	33.9	9.4	20.3	18.6	15.5	21.2
When no blood glucose documented	1.0	0.0	0.0	4.6	0.0	0.0	0.9	1.1	2.3	2.7	0.0	3.1	0.0	1.2

The initial audit encompassed all hospital nursing units, including nine medical surgical units (columns A, C, and E–K), two intensive care units (columns B and D), one physical rehabilitation unit (column L), and one transitional care unit (column M). The audit included all correction insulin administration opportunities on each unit over 10 days except for in unit L and M, which required a longer audit period of 31 days due to a low inpatient census.

coverage error percentage was 2.6% at baseline in 2014. The timing of insulin administration was calculated based on the tally of insulin doses administered within 60 minutes of the capillary blood glucose measurement divided by the total doses of insulin administered. The number of insulin doses given within 60 minutes of blood glucose measurement was 77.6% at baseline in 2014.

What was the timeframe from initiation of your QI initiative to its completion?

The QI project was initiated in 2014 and continued through February 2017.

Describe your core QI team. Who served as project leader, and why was this person selected? Who else served on the team?

The diabetes PNS, who is also a certified diabetes educator (CDE), served as our internal diabetes expert. CDEs add value to patient care by focusing on quality outcomes; integrating evidence-based, patient-centered, cost-effective care; and sharing their expertise to develop other nurses' diabetes care competencies. The CPS served as our internal medication safety expert, evaluating medication event reports, conducting education and process improvement activities related to the prevention of medication errors, promoting medication safety, and providing clinical pharmacy services.

Both experts serve as co-chairs of the MDSC, an interprofessional team that investigates the root causes of medication errors and inpatient diabetes-related safety issues, including critical hypoglycemia episodes. The MDSC meets monthly to review and discuss medication and diabetes safety issues and partners with the health system's Diabetes Patient Safety Committee to identify and implement best practices for patients. Our internal experts work collaboratively with the hospital Pharmacy and Quality Risk and Safety Department

to promote safe care practices. The PNS is an active member of the American Association of Diabetes Educators. The CPS is currently pursuing certification in medication safety through the Institute for Safe Medication Practices. Through participation in such professional organizations and the achievement of specialty certifications, our internal experts gain access to research and evidence-based practice, which fosters improvements in clinical practice.

Describe the most important changes you made to your process of care delivery, as well as the structural changes you made to your practice through this initiative.

Sharing Baseline Findings

The baseline data on critical hypoglycemia episodes and investigation findings were shared and discussed with nursing leadership, the institution's Professional Practice Council, and the MDSC to raise awareness and promote efforts to reduce critical hypoglycemia episodes. This spurred the initiation of our QI project with the specific goal of reducing critical hypoglycemia episodes by 20%.

Training Staff

The PNS and CPS led educational in-service training sessions for staff of nursing units found to have an opportunity for critical hypoglycemia improvement. A re-audit was conducted after the nursing education sessions to assess whether there was an improvement in critical hypoglycemia episodes, insulin administration timing, capillary blood glucose timing, percentage of meal or snack consumed, and timing of the bedtime snacks in relation to bedtime correction insulin doses. The re-audit data were shared with the MDSC, whose members were encouraged to share the data with their units to promote further improvement efforts. Chart audits were conducted by the CPS by reviewing inpatient charts on the nursing units. When insulin errors re-

sulting in a hypoglycemia event were identified, this information was entered into an online reporting system for further investigation.

Disseminating Incident Reports and Intensifying Education

The project continued in the 2015–2016 year, during which we started sharing the incident reports with the unit directors and clinicians in a more real-time reporting structure per their request to enable counseling of nurses involved in incidents and help to prevent future errors. We also focused on providing more intense education and discussion of scenarios of hypoglycemia events that involved insulin or blood glucose timing issues with the MDSC to help prevent future errors. The members were asked to share this information with their units and to continue promoting efforts to reduce critical hypoglycemia.

Publicizing the Project

We promoted the project further through our System-Wide Nurse Week poster presentation titled “Insulin and Capillary Blood Glucose Timing Quality Improvement Project” on our medical surgical unit. The PNS also presented the QI project and outcomes at a System Clinical Research Forum. The project was highlighted at our hospital Quality Fair for best outcomes. In addition, we submitted our QI project in our Magnet document to highlight our efforts at reducing our critical hypoglycemia rate by 20%.

Partnering With Individual Units to Foster Continued Improvement

Our project efforts in the 2016–2017 year involved continued work with our MDSC. We planned and conducted meetings with units that still presented an opportunity for improvement. This effort involved partnering with the unit director, clinician, and nurse educator on these nursing units to review their results and implement action plans to improve their critical hypoglycemia

data. One of the medical surgical units initiated a diabetes education series focusing on quick diabetes education in-service training sessions on topics such as defining diabetes, oral medications, insulin, timing of insulin administration and blood glucose monitoring, hypoglycemia, recommendations for patients on NPO status, and insulin pump management, with scenarios to reinforce the educational content. Through our project, we found that education is an ongoing need for staff in the medical/surgical areas. We continue to focus on critical hypoglycemia improvement in these areas because they are larger units with a larger population of patients with diabetes.

Improving Work Processes

Additional work of the MDSC and our internal experts involved promoting process changes to reduce critical hypoglycemia, as described below.

Delaying Evening Snack Delivery
We identified a gap in the timing of the evening snack for patients with diabetes who received correction insulin doses at bedtime. Patients were receiving their evening snack immediately after dinner, which led

to an elevated capillary glucose level at bedtime. As a result, patients were receiving higher doses of correction insulin based on these elevated glucose readings, which in turn led to a critical hypoglycemia events in the late-night to early-morning hours. We promoted an effort to change the timing of bedtime snacks from immediately after dinner to just before bedtime when patients were due to receive their correction insulin dose.

Reducing the Time Lag Between Glucose Monitoring and Insulin Administration

Through our chart audits, we identified issues related to the timing of capillary blood glucose testing and insulin administration. Blood glucose checks were conducted 1–2 hours before meals and bedtime. Through investigation, we found that these checks were downloaded into the EHR at 7:00 a.m., 11:00 a.m., 4:00 p.m., and 8:00 p.m. We promoted a process change to check blood glucose levels within 30 minutes of meals and the bedtime snack. This change provided more accurate capillary blood glucose values with which to determine correction insulin doses.

Reducing the Lag Time Between Insulin Administration and Meals
We reinforced the need to deliver insulin doses with meal and the bedtime snack instead of 1–2 hours before them to promote patient safety, reduce errors, and reduce critical hypoglycemia episodes.

Standardizing Meal Delivery Timing

Our most recent process change in 2017 involved changing the meal tray delivery times on all nursing units. In the past, patients ordered their meals independently, which posed a challenge for the nursing staff because patients were ordering and receiving meals at different times. In January 2017, the hospital dietary department implemented a set meal delivery schedule for every unit. This change allows nursing staff to perform timely capillary blood glucose checks and insulin delivery with regard to meals and snacks.

Summarize your outcome data (at the end of the improvement initiative) and how it compared to your baseline data.

As shown in Figures 1–3, chart audits were repeated periodically from 2014

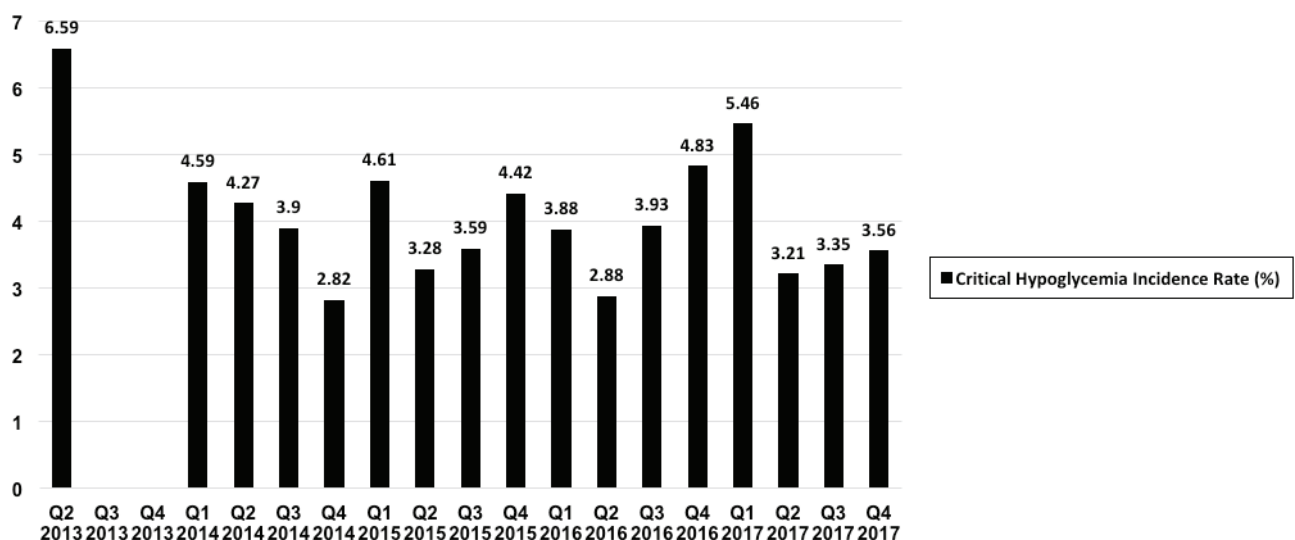
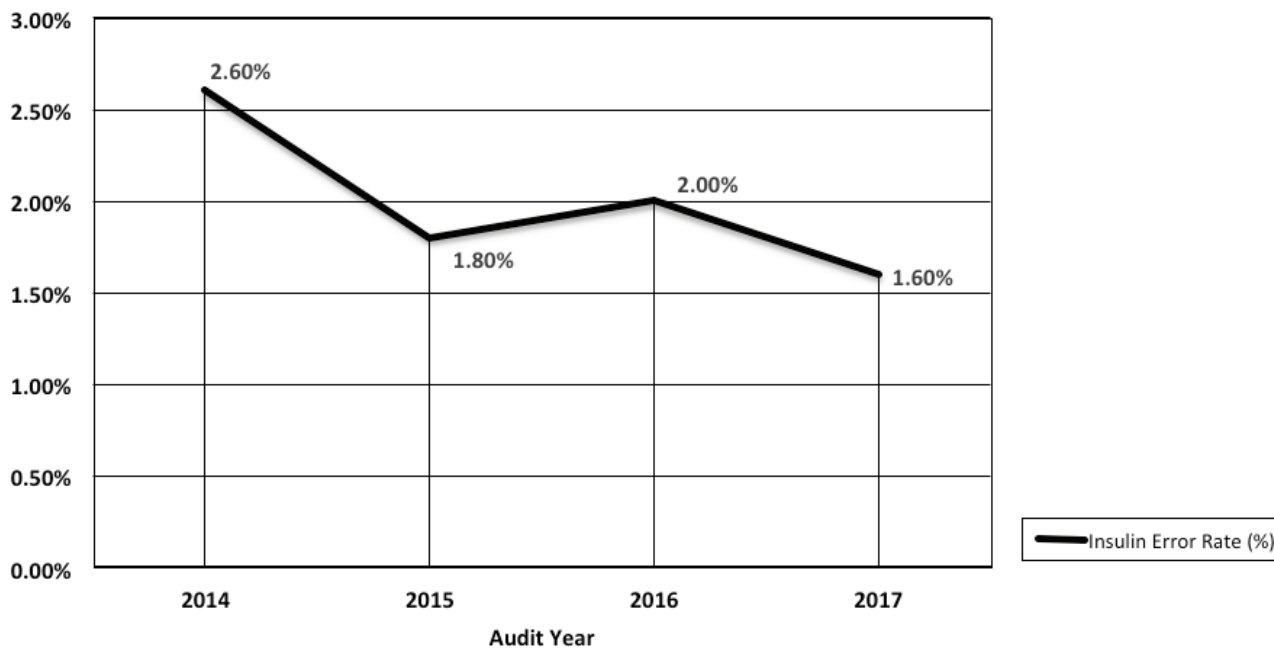
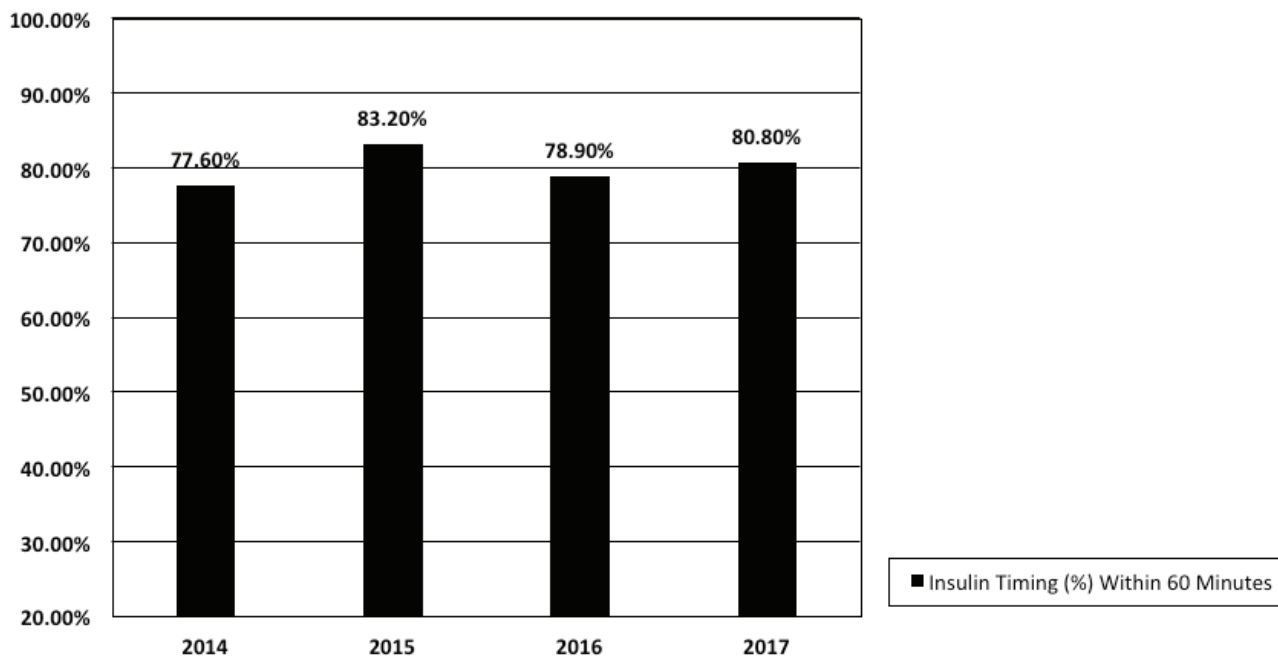


FIGURE 1. Reduction in critical hypoglycemia ≤ 50 mg/dL. Depicted are the incidence rates (%) per 1,000 patient-days for the second quarter of 2013 through the fourth quarter of 2017.



■ FIGURE 2. Chart audit data on correction insulin error rate (%) from 2014 through 2017.



■ FIGURE 3. Chart audit data outcomes related to insulin administration timing (%) within 60 minutes of the last capillary blood glucose check 2014 through 2017.

through 2017. Figure 1 depicts the incidence rates (%) per 1,000 patient days for the second quarter of 2013 through the second quarter of 2017. As shown in Figure 2, the insulin coverage error rate decreased from 2.6%

at baseline in 2014 to 1.8% in 2015, 2.0% in 2016, and 1.6% in 2017. Figure 3 shows that the percentage of insulin doses given within 60 minutes of blood glucose measurement increased from 77.6% at baseline in

2014 to 83.2% in 2015, 78.9% in 2016, and 80.8% in 2017.

Our hospital was granted the ANCC Magnet designation for nursing excellence in April 2017. During our conference call with the ANCC

Magnet Commissioner, our project was recognized as an exemplar based on its 12 consecutive quarters demonstrating a 20% reduction in critical hypoglycemia ≤ 50 mg/dL.

What lessons did you learn through your QI process that you would like to share with others?

We highly recommend incorporating internal experts in the process of extracting and analyzing critical hypoglycemia, insulin error, and insulin timing data. It is essential to have specialized experts involved in leading the QI project to interpret and organize the data, provide staff education, and conduct additional surveillance. Initiating such a project involves devising a method of extracting essential data related to critical hypoglycemia from the institution's EHR and investigating root causes of the results. The next step involves organizing an inter-professional team to review the results, identify issues of concern, and devise a plan of action to improve outcomes.

Education is a key component of efforts to reduce critical hypoglycemia episodes and insulin errors and optimize insulin administration timing. Such a project requires continued surveillance, education, and re-assessment to sustain positive outcomes.

Our QI project has achieved great success because of the collaboration among our internal experts, MDSC, nursing staff, pharmacy staff, and Quality, Risk, and Safety Department. Our project is highly adaptable for implementation in other health care organizations to improve patient care and safety with regard to the incidence of critical hypoglycemia events and ultimately to reduce potential patient harm.

Acknowledgments

The authors acknowledge the following individuals who contributed to the critical hypoglycemia QI project: Margaret Hayden, DNP, RN, NEA-BC, Administrative Director of Nursing Practice and Research/Magnet Program Director, University

of Pittsburgh Medical Center (UPMC) Passavant; Alexis Burke, MS, PharmD, Director of Pharmacy Services, UPMC Passavant; Susan M. Cohen, PhD, CRNP, FAAN, Associate Professor of the Department of Health Promotion and Development, Gender, Sexuality, and Women's Studies Program Faculty, University of Pittsburgh Cancer Institute; Yvonne Weidman, DNP, MBA, RN, CNE, CWOCN, CFCN, Assistant Professor at Duquesne University; Darlene L. Hills, RN, BSN, CCRN, UPMC Passavant; Barb Delbene, RN, CQIA, Quality, Safety, and Risk, UPMC Passavant; John Filipic, MSN, RN, Quality, Safety, and Risk, UPMC Passavant; Karen Skal, MSN, BSN, BSBA, RN, UPMC Passavant; Glenn Hasulak, Lead Database Administrator, Information Services, UPMC Passavant; UPMC Passavant Medication and Diabetes Safety Committee; UPMC System Diabetes Patient Safety Committee.

Duality of Interest

No potential conflicts of interest relevant to this article were reported.

Reference

1. Mathioudakis N, Everett E, Golden SH. Prevention and management of insulin-associated hypoglycemia in hospitalized patients. *Endocr Pract* 2016;22:959–969