Reducing Inpatient Hypoglycemic Events: A Focus on Mealtime Insulin

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Quality Improvement Success Stories are published by the American Diabetes Association in collaboration with the American College of Physicians 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 an effort to reduce iatrogenic insulin-associated hypoglycemia at the University of Chicago Medical Center in Chicago, IL.

Describe your practice setting and location.

The University of Chicago Medical Center (UCMC) is an academic medical center serving a diverse population in Chicago, IL. The UCMC adult hospitals have ~830 beds, and together with its clinics, UCMC provides primary, subspecialty, and acute care to residents of Chicago's South Side community.

Describe the specific quality gap addressed through the quality improvement (QI) initiative.

The prevalence of diabetes has increased markedly, especially over the last three decades, with ~34 million individuals in the United States currently carrying the diagnosis (1) and close to 18% of the population projected to have the disease by 2060 (2). Notably, this risk is not proportionately borne across the population; there are increased prevalence rates among African Americans and people of Latinx ethnicity, as well as among individuals from lower socioeconomic strata and those having less education (1,3). Each of these groups is enriched in the areas served by our academic medical center, resulting in a diabetes prevalence of ~30% among adults admitted to our hospitals (unpublished internal data).

Insulin is the recommended therapy to treat hyperglycemia during hospitalization, but it has associated risks (4,5). Prevention of iatrogenic hypoglycemia is a major patient safety issue. Data summarized in the U.S. Department of Health and Human Services' *National Action Plan for Adverse Drug Event Prevention* (6) indicate that approximately one-fourth of all patient safety incidents involving insulin result in patient harm, and insulin may be implicated in 33% of medication error–related deaths. In addition to the threat posed to individuals, these errors in diabetes management expose the institution to increased lengths of stay and reduced insurance reimbursements for hospital-acquired conditions.

Our initiative focused on reducing the incidence of insulin-associated hypoglycemia within our institution.

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

A multidisciplinary team was created to understand the causes and reduce the incidence of insulin-associated hypoglycemia. An incident of insulin-associated hypoglycemia was defined as a blood glucose level (plasma or capillary) <70 mg/dL in a nonpregnant adult patient who received insulin within the 24 hours preceding the hypoglycemic event. We also identified an incident of severe hypoglycemia as a blood glucose level <40 mg/dL in the same patient

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population. Our team calculated a baseline rate of 3.97 events of severe hypoglycemia per 1,000 medication days.

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

Over a 15-day period in early 2017, we reviewed every case ($n = 54$) of insulin-associated hypoglycemia in adult patients admitted to the medicine, cardiology, and neurology services. These root cause analyses identified that a common cause of hypoglycemia was rapid-acting insulin administered around mealtimes (~60% of events) but without regard to carbohydrate consumption. Insulin was often given before the delivery of meals or correction-scale insulin was given hours after the blood glucose level had been checked instead of within 30 minutes of capillary blood glucose monitoring. Correction-scale insulin was also administered based on capillary glucose levels collected while (or immediately after) the patient was eating, resulting in higher doses being administered than if the preprandial glucose level had been used. This practice differs from administering nutritional and correction insulin based on preprandial glucose levels after confirming that a patient is eating or has eaten.

In addition to addressing the mealtime process, we noted that our correction-scale (i.e., sliding-scale) insulin ordered with meals and at bedtime had a threshold of 130 mg/dL.

Prior to our intervention, 52.8% of patients had their blood glucose monitored within 30 minutes of receiving mealtime insulin.

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

Our QI effort began in October 2016 and continues. It took ~6 months after baseline data had been collected until the mealtime insulin process had been standardized.

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

Our team consists of an endocrinologist, who serves as project leader to provide expertise on best practices to prevent hypoglycemia. Our team also has representation from nursing leadership, nursing patient care managers from four units, three diabetes clinical nurse educators, pharmacy and food service staff, two hospitalists, a general medicine attending physician, and information technology leaders, as well as members of the medical center's quality performance improvement team, which includes our data and analytics team.

Describe the *structural* changes you made to your practice through this initiative.

We established an Inpatient Diabetes Management Workgroup and convened monthly meetings with the multidisciplinary team. Structural changes implemented by this team included:

- Creating an interactive data analysis dashboard to monitor trends (Figure 1) (This dashboard allows us to track the time between glucose monitoring and insulin administration, as well as hypoglycemia and severe hypoglycemia event rates. We also stratify hypoglycemic events by unit, blood glucose value, type of insulin received, and timing of hypoglycemic events.)
- Creating an "I" sign ("I" for insulin) to be placed on the doors of all patients with prandial insulin orders
- Incorporating clinical decision support tools into the electronic medical record (EMR) system to encourage diabetes management best practices
- Adjusting our correction scale so that the threshold for correction is now consistent with the American Diabetes Association's target glucose range for most hospitalized, nonpregnant adult patients (140–180 mg/dL) (4)

Describe the most important changes you made to your *process* of care delivery.

We designed and implemented a system in which our food service attendants alert our nursing staff in real time that patients' food has arrived at the bedside. At the time of our intervention, patients ordered their meals directly from the food services department via telephone. Before the intervention, food was delivered directly to the patient rooms without nursing staff being aware.

We also created an "I" sign ("I" for insulin) that is placed on the door of all patients with prandial insulin orders. Our goal is that, for all patients who are ordered prandial insulin, nursing staff will be alerted at the time of food arrival so that glucose monitoring can be conducted within 30 minutes of mealtime insulin administration.

A clinical decision support tool was created within the EMR system to confirm that all inpatients with insulin orders also have active orders for glucose monitoring, nursing-driven hypoglycemia treatment, and a nursing

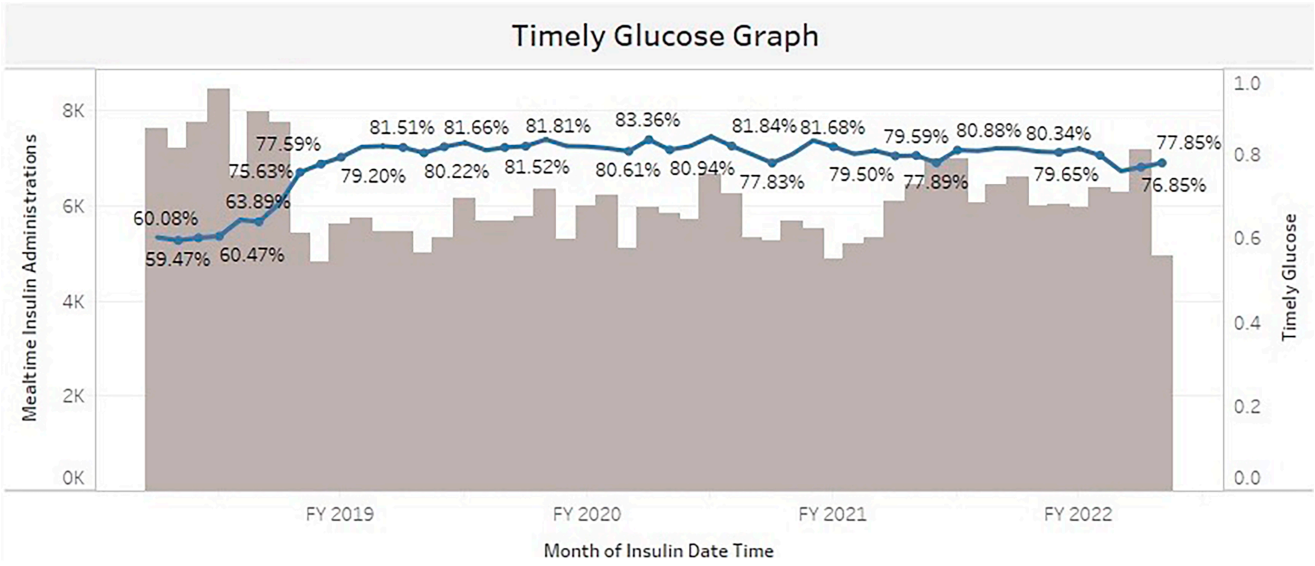

FIGURE 1 The blue line illustrates the percentage of mealtime insulin (as prandial and/or correction-scale doses) administered within 30 minutes of blood glucose monitoring. The gray bars reflect the total number of mealtime insulin administrations. This number decreased with change in the threshold for correction-scale insulin.

communication to place the "I" sign on the door. For those in our hospital that opened in 1983, our food service attendants report food arrival to the nursing station. In the newer hospital that opened in 2013, a nurse call button specific for food delivery is available on the wall, and this is selected by the food service attendant upon food delivery and sends a text message to hospital devices held by nursing staff. This alert prompts nursing staff to check patients' capillary blood glucose concentration before meals and also to provide the appropriate dose of prandial insulin within 30 minutes of glucose monitoring and at the time of carbohydrate consumption.

The practical result of better standardizing these processes was that patients reported increased satisfaction, noting that glycemic management in the hospital was more similar to their management practices at home. We also surveyed nursing staff from the initial pilot units, and the feedback was positive. Sample written comments from staff included "I think the program is allowing for overall better blood sugar management. It is facilitating better communication between food service and the [nursing support assistant/registered nurse] team" and "No delay in sugar taken, food eaten, insulin given; much smoother process."

After 21 months, 81.6% of patients had their glucose monitored within 30 minutes of prandial insulin administration, representing a 54% improvement from baseline. This improvement has been sustained over the subsequent 2 years, with most recent rates ranging from 77 to 81% (Figure 1). If we note that a particular unit has a decline in what we have termed "timely glucose monitoring," our diabetes clinical nurse educators and the unit nurse manager will provide an in-service training regarding the intervention and its importance.

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

We set a target on our institution's Clinical Priority Scorecard to reduce the overall incidence of insulin-associated severe hypoglycemia (i.e., blood glucose <40 mg/dL) for all hospitalized adult patients, including those who were pregnant or in intensive care units. The scorecard is reviewed at regularly scheduled hospital-wide quality committee meetings. The baseline rate of 3.97 events per 1,000 medication days was reduced to 3.18, surpassing the established scorecard goal. This rate represents seven events of severe hypoglycemia in >2,200 medication days.

What are your next steps?

We continue our QI processes and are using real-time alerts of hypoglycemic events, followed by mini root cause analyses to identify other causes of dysglycemia among hospitalized patients. Most recently, we have made successful changes to our hyperkalemia order set to avoid hypoglycemia after regular insulin is used to treat hyperkalemia. In addition, we are learning from best practices regarding mealtime insulin administration among some units that average >90% of insulin administered

within 30 minutes of glucose monitoring to share these successes with units that have lower rates.

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

We assembled a multidisciplinary team to review the primary causes of insulin-associated hypoglycemia at our institution. Timely and accurate data facilitated and sustained the engagement of nursing managers and their staff, particularly because we also showed a reduction in the number of correction doses needed by pursuing truly preprandial capillary blood glucose levels. The dietary department proved to be an unexpected ally and took pride in their role in improving patient care. After piloting a process change in three hospital units, this change was successfully expanded to the remainder of units in our adult hospitals, and the improvements have proven sustainable.

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DUALITY OF INTEREST

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

AUTHOR CONTRIBUTIONS

C.C.T. helped design and implement the intervention and wrote the manuscript. U.M.D., N.M.J., R.M.W., B.A.H., N.A.M.-S., and J.A.S. helped design and implement the intervention and reviewed/edited the manuscript. J.L.K. helped design the intervention, created the Tableau dashboard, and reviewed/edited the manuscript. C.-K.K. helped design the intervention, led the EMR clinical decision support tool efforts, and reviewed/edited the manuscript. A.M.D. helped design the intervention, contributed to early discussions of the manuscript, and reviewed/edited the manuscript. C.C.T. and A.M.D. are the guarantors of this work and, as such, take responsibility for the integrity of the data and the accuracy of the data analysis.

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