RESEARCH ARTICLE

Decreasing the Time to Insulin Administration for Hospitalized Patients With Cystic Fibrosis–Related Diabetes

Allison Smego, MD,[a] Sarah Lawson, MD,[a] Joshua D. Courter, PharmD,[b] Deborah Warden, RN,[c] Sarah Corathers, MD[a]

ABSTRACT

OBJECTIVES: Children with cystic fibrosis–related diabetes (CFRD) represent a commonly hospitalized pediatric population whose members require insulin for blood glucose (BG) control. The aim of this quality improvement initiative was to increase the proportion of hospitalized patients with CFRD receiving insulin within 30 minutes of a BG check while decreasing severe hypo- and hyperglycemia episodes.

METHODS: Quality improvement methodology (gathering a team of stakeholders, identifying metrics, implementing iterative plan-do-study-act cycles and analysis of data over time) was applied in the setting of a cystic fibrosis unit in a tertiary care children's hospital. The percentage of patients with CFRD who received rapid-acting insulin within 30 minutes of a BG check and the rates of hypoglycemia (BG <70 mg/dL) and hyperglycemia (BG >200 mg/dL) were measured. Improvement interventions were focused on efficient communication among patients, nurses and providers; refining carbohydrate calculation; and sharing expectations with patients and caregivers.

RESULTS: The proportion of rapid-acting insulin doses given within 30 minutes increased from a baseline mean 40% to a sustained mean of 78%. During active improvement interventions, success rates of 100% were achieved. Hyperglycemic events (BG >200 mg/dL) decreased from 125 events to 85 events per 100 rapid-acting insulin days. Hypoglycemic events (BG <70 mg/dL) remained low at <5 events per 100 rapid-acting insulin days.

CONCLUSIONS: Systematic implementation of low-cost interventions successfully resulted in measurable improvement in timely rapid-acting insulin administration for hospitalized patients with CFRD and lower rates of severe hypo- and hyperglycemia on the unit. Future efforts will be directed to increase the reliability of interventions to maintain optimal performance and outcomes.

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Address correspondence to Allison Smego, MD, Outpatient Services, Primary Children's Hospital, Intermountain Healthcare, 81 North Mario Capecchi Dr, Salt Lake City, UT 84113. E-mail: allison.smego@hsc.utah.edu

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Dr Smego designed the study and drafted the initial manuscript; Dr Lawson conceptualized and designed the study and reviewed and revised the manuscript; Dr Courter designed the study, coordinated data collection, conducted the initial analyses, and reviewed and revised the manuscript; Ms Warden and Dr Corathers designed the study and reviewed and revised the manuscript; and all authors approved the final manuscript as submitted.

[a]Divisions of Endocrinology, [b]Pharmacy, and [c]Patient Services, Cystic Fibrosis/Complex Pulmonary Unit, Cincinnati Children's Hospital Medical Center, Cincinnati, Ohio

Hyperglycemia, hypoglycemia, and increased glucose variability in hospitalized patients are associated with increased morbidity and mortality.[1] One commonly hospitalized pediatric population receiving insulin for treatment of hyperglycemia is children with cystic fibrosis–related diabetes (CFRD). Appropriate treatment of the population with CFRD with insulin is associated with improved nutritional status and pulmonary function.[2,3] The population with CFRD was chosen specifically because this unit has a high volume of rapid-acting insulin doses required. Insulin is a high-risk medication,[4,5] which necessitates extra attention in ordering, dispensing, and administration[6–8] to assure patient safety. Generally, long-acting basal insulin is administered once daily. Rapid-acting insulin is dosed multiple times daily to correct high blood sugars and control the anticipated rise in glucose associated with carbohydrate containing food. Rapid-acting insulin has an onset of action in 5 to 15 minutes, with a peak at 30 to 90 minutes.[9] If insulin is not given in a timely manner, when compared with food consumption and/or blood glucose (BG) checks, morbidity and mortality rates can increase. This type of insulin misuse typically presents as significant hypoglycemia and hyperglycemia.

Despite best practice guidelines for the appropriate administration of rapid-acting insulin, barriers in care (including insulin ordering process, dispensing the medication, and communication among multiple caregivers) often limit the timeliness of administration in hospital settings. The creators of this quality improvement (QI) project sought to decrease the time from a BG check to rapid-acting insulin administration to within 30 minutes in hospitalized patients with CFRD. An additional aim was decreasing glucose variability on the cystic fibrosis (CF) hospital unit as measured by rates of hyperglycemia events (BG >200 mg/dL) and hypoglycemic events (BG <70 mg/dL) per 100 rapid-acting insulin days.

METHODS

Setting

Our medical center is a large urban tertiary care center with 11 beds on the CF unit, serving a population of 45 patients with CFRD. The average length of stay for a patient admitted with CF on insulin is 10 to 14 days. The most frequent indication for admission is bronchopneumonia requiring intravenous antibiotic therapy.

Participant Inclusion Criteria

All patients admitted to the CF inpatient unit with the diagnosis of CFRD receiving rapid-acting insulin were included as eligible over a 4-month timeframe of active improvement interventions. Our baseline data included 9 unique patients, and intervention data included 7 unique patients, with some patients having multiple admissions during the baseline and intervention periods.

Measures

BG was measured by a bedside point-of-care glucometer on the inpatient CF unit and reported in the electronic medical record (EMR) in milligrams-per-deciliter units. The timing of doses of rapid-acting insulin, including insulin lispro and insulin aspart, were extracted from the medication administration record within the EMR. Queries for the most proximal glucose check performed and those values with associated collection time stamps were extracted from the EMR. Nursing staff collected quantitative data on the timing of steps from BG check to insulin administration and also provided qualitative feedback on changes in the process.

Baseline measurements of 945 discrete insulin doses included the BG value, the time of the BG check, and the time of rapid-acting insulin administration. Review of the EMR revealed less than half (40%) of all rapid-acting insulin doses being administered within 30 minutes of the previous BG check among hospitalized patients with CFRD. The mean time from BG check to insulin administration for these patients was 64 minutes (with a range of 16–85 minutes and a median of 38 minutes). In comparison, the mean time to insulin administration on a neighboring inpatient unit dedicated to the care of patients with type 1 diabetes was 35 minutes (with a median of 29 minutes).

To standardize how we reported the timing of insulin administration, the process measure was expressed as the percentage of rapid-acting insulin doses given to patients with CFRD within 30 minutes of a BG check. The process outcome was defined as the rate of hypoglycemia and hyperglycemia. Insulin-associated hypoglycemia was defined as a BG measurement of <70 mg/dL within 24 hours of receiving a dose of rapid-acting insulin. Hyperglycemia while on insulin therapy was defined as BG >200 mg/dL within 48 hours of receiving a dose of any insulin.

Design

A multidisciplinary team composed of pediatric endocrinologists, a pharmacist, and a CF clinical nurse manager was assembled to establish goals and conduct the project. A specific, measurable, time-bound aim was developed after reviewing baseline data; this aim was to increase the percentage of rapid-acting insulin administered within 30 minutes of a BG check from 40% to 90% in patients with CFRD. Rates of hyperglycemia per 100 rapid-acting insulin days and hypoglycemia per 100 insulin days were collected as clinical outcome measures, with a global aim to reliably administer timely insulin doses and thereby decrease glucose variability in hospitalized patients with CFRD. At the time of the project, the institution had a house-wide policy that long-acting insulin orders could be scheduled, but rapid-acting insulin orders were individually ordered at the time of service, which often contributed to significant delays. There were standards set by the Divisions of Endocrinology and Pharmacy for all short-acting insulin to be given no closer than every 3 hours, unless otherwise directed. Four key areas for improvement were identified after observing the process and discussing it with doctors, nurse practitioners, and nursing staff. A key driver diagram (Fig 1) with 4 essential elements or drivers critical for success was developed. For each key driver, potential interventions were designed and PDSA (plan, do, study, act) cycles were implemented.

Strategy

QI methodology informed the design and iterative testing of interventions. The existing process was observed, and each step in the process was timed. There was

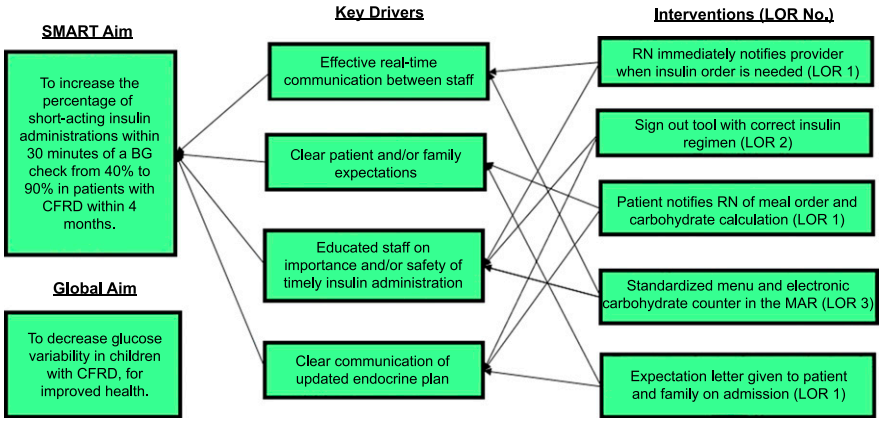

FIGURE 1 Key driver diagram. A pictorial display of a structured improvement framework, including primary drivers that directly contribute to achieving the aim and interventions that influence each driver. The LOR indicates likelihood of consistent reproducibility. Higher LOR indicates more consistent performance and/or outcome. LOR, level of reliability; MAR, medication administration record; SMART, specific, measurable, attainable, relevant, and time-bound.

high variability noted. The time from the BG check to the insulin order being placed was identified as the longest step in the process, with 80% of delays occurring somewhere in this process. Interventions were initially tested with 1 nurse and 1 patient with spread over time. The following interventions were tested sequentially over time with ramps of each PDSA cycle as indicated.

PDSA 1: Real-Time Communication

Nursing staff were instructed to page the provider for a needed insulin order while in the room with the patient, instead of waiting until the patient care was complete. After a BG reading was obtained, a nurse paged the prescriber via an in-room computer. The provider was expected to enter an insulin order within 5 minutes of receiving the notification of a BG check.

PDSA 2: Sign Out

An electronic sign-out tool was created to detail necessary information on a patient's insulin regimen. This was used by residents to decrease errors during hand off and to facilitate quick access to the information needed to place an appropriate insulin order.

PDSA 3: Premeal Carbohydrate Counting

Each patient was asked to notify his or her nurse at the time a food tray was ordered so that carbohydrate totals could be determined before the tray arrived in the patient room. The hospital-wide carbohydrate counting menu was standardized and transferred to electronic format for ease of counting carbohydrates.

PDSA 4: Expectations

A patient letter was developed to detail the expectations of BG monitoring and insulin administration during the admission. This letter was reviewed with the patient and family on arrival to the unit. Questions about expectations were answered at that time.

Data from the EMR were collected on a weekly basis and tracked over time. Multidisciplinary team meetings were held weekly or biweekly to review progress and discuss future interventions. The interventions were tested, adapted, and adopted over a 4-month trial.

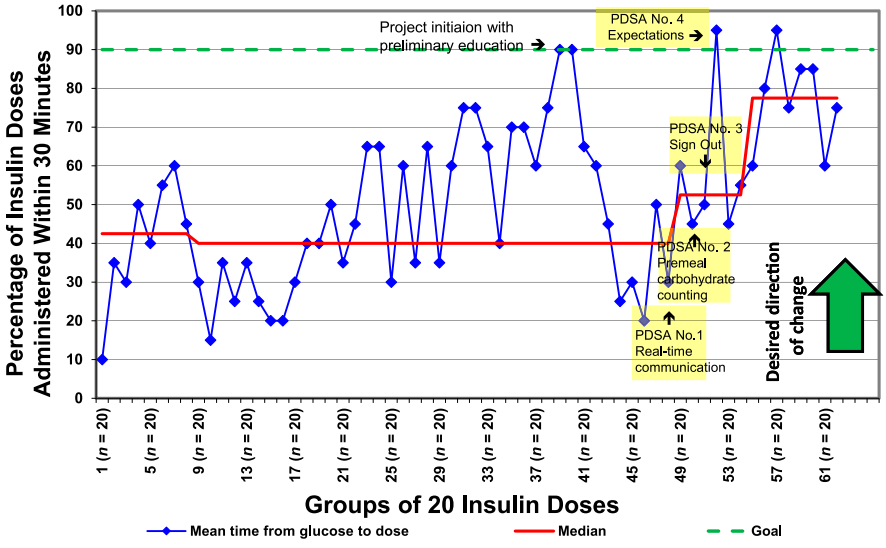

FIGURE 2 Proportion of CFRD rapid-acting insulin doses administered within 30 minutes of a BG check.

RESULTS

Patients with CFRD admitted during the course of the improvement work were 64% female, with a mean age of 15.8 years (range: 11–22), and 100% identified as non-Hispanic white. Before the intervention phase, the percentage of rapid-acting insulin doses given within 30 minutes of a BG check improved to 90% for 2 consecutive points. Early education of small numbers of staff on upcoming interventions revealed an almost immediate effect, but reliability was low and, therefore, no sustained improvement was noted. During the active intervention phase including 275 discrete insulin doses, the percentage of rapid-acting insulin doses given within 30 minutes of a BG check reached 100% for 2 weeks, with an overall measurable improvement in the trend that is documented in the run chart figure of performance over time (Fig 2, graphed in groups of 20 discrete doses, not by weeks). The rate of hyperglycemic events (BG >200 mg/dL) during the intervention

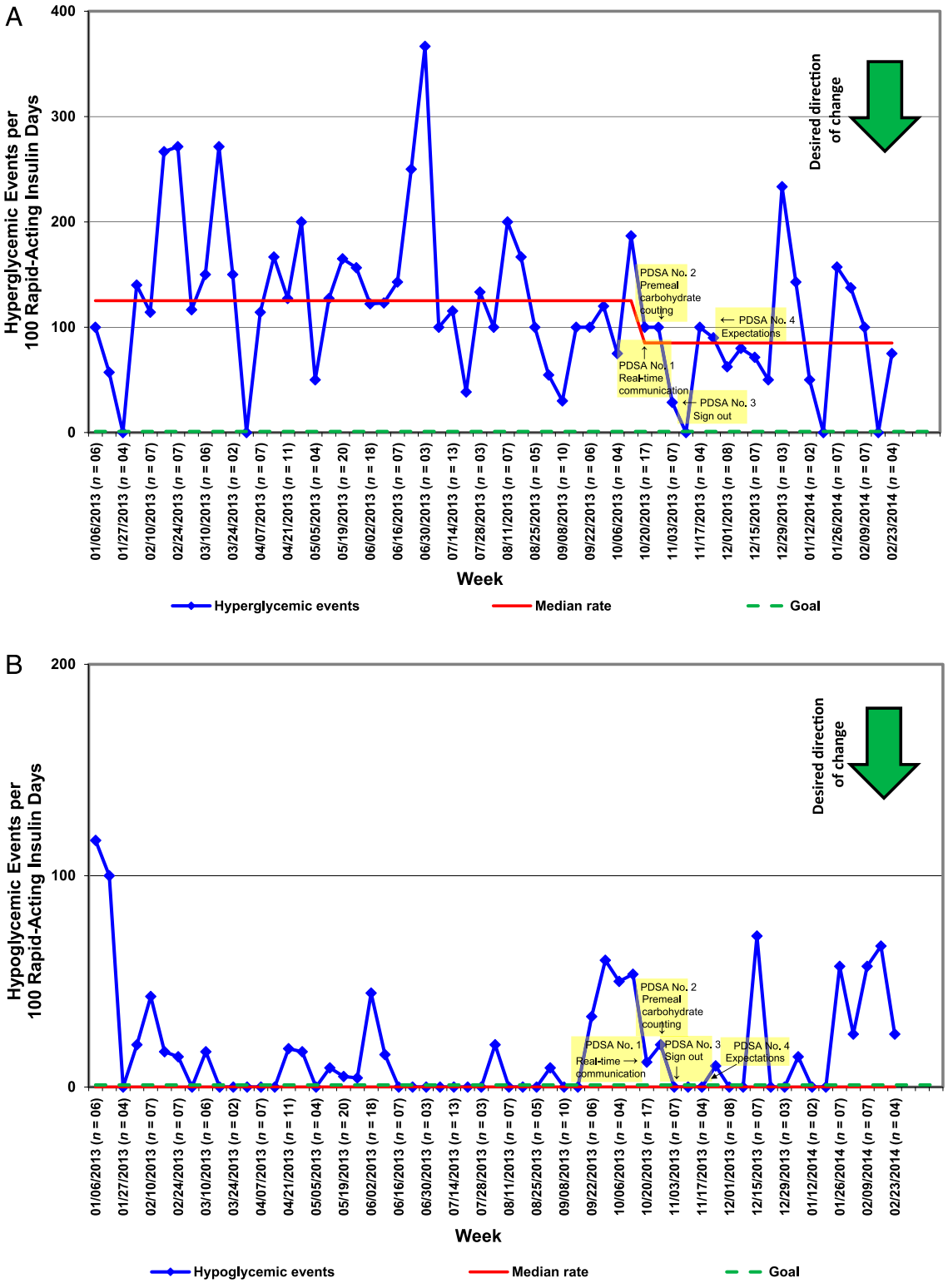

FIGURE 3 A, Hyperglycemic events (BG >200 mg/dL) per 100 rapid-acting insulin days in patients with CFRD. B, Hypoglycemic events (BG <70 mg/dL) per 100 rapid-acting insulin days in patients with CFRD.

period decreased from 125 events to 85 events per 100 rapid-acting insulin days (Fig 3A). The rate of hypoglycemic events (BG <70 mg/dL) remained at a level of <5 events per 100 rapid-acting insulin days (Fig 3B).

After completion of the trial period, interventions were adopted, and weekly monitoring of data were suspended. There was a downtrend in the proportion of insulin doses given within 30 minutes after intensive involvement in the project was suspended, indicating a need for sustainability planning to ensure ongoing high-reliability processes. Sustainability efforts include incorporating training on rapid-acting insulin as part of standard orientation for medical residents and nurses on the unit to address staff turnover-related gaps in knowledge, and further standardization of previously developed interventions (finalization of expectations letter, continued use of hand-off tool). Additionally, the Division of Nutrition Therapy took ownership of updating the electronic patient menu and carbohydrate calculating tool. After this effort, sustained improvement led to the percentage of insulin doses being given within 30 minutes of a BG check increasing from 40% to 78%, and the median time to insulin improved from 38 to 23 minutes.

DISCUSSION

As a result of a systematic approach to relatively low resource interventions, a measurable change in the proportion of rapid-acting insulin doses given to patients with CFRD within 30 minutes of BG measurement was achieved over a 4-month interval. An inconsistent process was refined to yield more reliable results. Importantly, an increase in the percentage of doses of rapid-acting insulin being administered within 30 minutes of a BG check corresponded with a decline in the hyperglycemia event rates and a continued low frequency of hypoglycemia. The decrease in hyperglycemia most directly related to improved timing of insulin doses, but there was likely a small contribution from more accurate electronic carbohydrate counting. During this intervention, there were no events of severe symptomatic hypoglycemia or BG <45 mg/dL. In addition, there were no hypoglycemic events resulting in treatment escalation, such as the administration of a dextrose bolus. More significantly, this sustained improvement laid the foundation for a larger hospital-wide insulin safety and regulation protocol. QI methodology guided standardization of the process, including efficient communication among patients, nurses and providers; refining carbohydrate calculation; and alerting patients and family to expectations. These simple steps could be applied in a variety of clinical settings where rapid-acting insulin is used. Standardizing the process helped nurses and providers to understand the new practice is now the expectation. Education on this is now incorporated into new-hire orientation.

A limitation of the QI intervention was a relatively low volume of eligible patients, which led to interruptions in data collection and PDSA cycles. Because our measure definition is based on the time stamp of the rapid-acting insulin dose, this project was not able to address situations in which a dose of insulin may have been due but was not given. Staff turnover (including nurses and residents) and shift patterns led to challenges with the spread of successful interventions, and some patients with a long-standing history of previous hospitalization did not want to embrace some of the interventions (eg, change how they ordered food). Over time, sharing the successes of the project fostered increased buy-in from stakeholders. Spread initiatives include the incorporation of insulin safety teaching to all residents and nurses working on floors administering insulin.

CONCLUSIONS

This project revealed delays and inconsistencies in the existing process of administering rapid-acting insulin after a BG check in hospitalized patients with CFRD. Guided by QI methodology, simple, inexpensive interventions increased the percentage of rapid-acting insulin doses given to patients with CFRD within 30 minutes of a BG check. Additionally, this improvement led to decreased glucose variability, as evidenced by decreased rates of hyperglycemia and stable, low rates of hypoglycemia in these patients. During this active improvement project, success rates of 100% were achieved. Over time, improvement from baseline rates of 40% to 78% were sustained. Future efforts to increase the reliability of interventions is indicated to maintain optimal performance and outcomes.

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