Evidence has shown that inpatient blood glucose control is essential to patient healing and prevention of complications, but it is difficult to achieve because of the fear of hypoglycemia and the timing of treatment. Hypoglycemia, if not treated in a timely manner, can put a patient at risk for injury or death (1). According to Braithwaite and Campbell (2), “Fear of hypoglycemia is the principal barrier to normoglycemia.” This fear “can lead to insufficient dosing of hypoglycemic therapies, particularly in patients who are treated with insulin” (3).

Hypoglycemia is prevalent in the hospital setting (4). Although protocols have been developed to prevent and manage inpatient hypoglycemia, there are challenges in implementing and enforcing such protocols. To address these challenges, a pilot was conducted to test an innovative...
intervention to improve adherence to existing hypoglycemia protocols.

Background

According to the American Diabetes Association, hypoglycemia is defined as a blood glucose level <70 mg/dL, which “correlates with the initial threshold for the release of counter regulatory hormones” (5). Early recognition and treatment of mild to moderate hypoglycemia (40–69 mg/dL) can prevent deterioration to a more severe episode with potential adverse sequelae (5).

Dangers of Hypoglycemia

Hypoglycemia is detrimental to patient safety, posing both short- and long-term dangers. Short-term effects include early adrenergic responses (i.e., sweating, shaking, and palpitations) and later central nervous system responses (i.e., confusion, headache, seizures, coma, and eventual death) (6,7). Cardiac arrhythmias also have been linked to hypoglycemia in patients with cardiac disease (8,9). Studies have shown that inpatient hypoglycemia increases patients’ length of stay and mortality in the hospital (1,10). There is increasing evidence that episodes of hypoglycemia also can cause long-term effects. Several studies have demonstrated a relationship between inpatient hypoglycemic episodes and patients’ length of stay, 1-year post-discharge mortality, and dementia rate (10,11).

Hospital Management of Hypoglycemia

Although there is a rich body of research on the effects and management of hyperglycemia in the hospital (12–14), the literature is sparse in relation to the description and implementation of protocols to manage hypoglycemia. A key element of all hypoglycemia management protocols is to treat the patient with 15–20 g of glucose and to follow with a recheck of the blood glucose level 15 minutes later, sometimes called the “15-15 rule” or the “Rule of 15” (15–18). If the patient is still hypoglycemic after 15 minutes, the process is repeated (5). The recheck is a crucial step to treating the unresolved hypoglycemia to ensure patient safety and prevent recurrent episodes.

One of the standards for Joint Commission Disease-Specific Certification for Advanced Inpatient Diabetes Care requires an evidence-based plan for the treatment of hypoglycemia. This standard stipulates that “the [certified] program uses data analysis to modify performance improvement activities in support of clinical practice guidelines” to identify causes for hypoglycemia and to prevent its recurrence (19).

Although a hypoglycemia protocol was developed at the authors’ institution for hypoglycemia treatment, analysis of point-of-care testing data showed that blood glucose rechecks 15 minutes after hypoglycemia treatment were not being performed consistently enough to meet the hospital-established goal of 90%. Education was provided and other interventions were attempted to improve compliance with the 15-minute recheck, but the goal still was not being met. The objective of this quality improvement project was to develop a procedure that would become ingrained among staff to improve the timing of blood glucose rechecks after treatment for hypoglycemia to reach compliance goals.

Literature Review

According to a study by Maynard et al. (20), risk factors for inpatient hypoglycemia include poor adherence to hypoglycemia protocols, interruptions in patient nutrition, and poor timing of insulin administration around meals (20). Interruptions in nutrition include patient NPO (nothing by mouth) status, nausea, emesis, and refusal to eat. Patients on NPO status also may experience hypoglycemia if their glyceremic medications are not adjusted accordingly (8). Patients with recurrent hypoglycemia are also at risk for developing hypoglycemia unawareness, which prevents them from recognizing and reporting symptoms of low blood glucose (21). Timing of insulin administration around meals must be a coordinated effort between dietary and nursing staff, and many institutions struggle with this endeavor.

The study by Maynard et al. (20) also noted that patients who had one episode of iatrogenic hypoglycemia during their hospitalization tended to have more hypoglycemic episodes, which could have been preventable. A study by Smith et al. (22) noted similar issues: decrease in oral nutrition with poor disease management and poor communication increased episodes of hypoglycemia. Maynard et al. (20) emphasized that an institution’s efforts should focus on simplifying hypoglycemia protocols and monitoring adherence to institutional standards of treatment, assessment, notification, and documentation of hypoglycemia episodes.

The literature indicates that adherence to existing guidelines and protocols to treat hypoglycemia is poor. Munoz et al. (23) described a study in which hypoglycemic episodes were tracked in hospital gynecology and gynecology/ oncology units. Despite educational interventions, improved compliance with hypoglycemia protocols was not statistically significant.

The study by Maynard et al. (20) also tracked staff adherence to hypoglycemia protocols when treating patients with iatrogenic hypoglycemia. Results showed that such adherence was “suboptimal” in that the treatment of the hypoglycemia often was delayed. The authors concluded that “[t]he mere existence of a complete institutional hypoglycemia protocol provides no assurance that proper care of iatrogenic hypoglycemia is taking place.”

Anthony (24) did a chart review of patients at two hospitals and found that adherence to a hypoglycemia protocol was low, noting that “[t]here was not a single case of adherence to all five steps at either study.
The impetus for this quality improvement project was poor staff adherence to the 15-minute recheck after hypoglycemia treatment, which had persisted despite numerous interventions.

In 1997, a formal policy was written and approved to establish a nursing protocol for the identification, treatment, and prevention of hypoglycemia based on current evidence. Subsequently, staff members were educated multiple times. The hypoglycemia protocol, in an algorithm format, was accessible online with the written policy. In November 2011, the algorithm was placed into every patient chart.

Despite these efforts, adherence continued to be poor, with compliance at 38% in December 2011. Feedback from nursing staff noted that obtaining and administering hypoglycemia treatment can take several minutes, thus not allowing time for the treatment to work according to the "15–15 rule" (also called the "Rule of 15"), which calls for rechecking blood glucose 15 minutes after administering hypoglycemia treatment (15–18). The nurses recommended establishing the recheck at 15–30 minutes after hypoglycemia is identified. The hospital’s interdisciplinary Diabetes Advisory Committee agreed with this recommendation, which was verified as acceptable by the Joint Commission, and the policy was revised accordingly.

Hospital-wide hypoglycemia management education was again provided in February 2012, which resulted in some improvement (41% compliance), but not enough to meet the hospital’s compliance target of 90% for the 15–30 minute recheck. To reinforce the protocol, a hypoglycemia badge reference card was developed that summarized the steps to identify and treat hypoglycemia, including the recheck requirement. To further improve compliance, nursing audits were implemented concurrently by unit managers and nurse clinical educators. The audit forms included each step to be completed by a nurse after hypoglycemia is identified.

Although compliance improved to 65% by June 2012, this still did not meet the hospital’s 90% goal, and the improved compliance was not sustained in the following months. It was concluded that developing a protocol and providing education do not ensure compliance, and a new strategy was needed to prompt the recheck.

Based on a suggestion from a Joint Commission surveyor, the hospital’s interdisciplinary Diabetes Advisory Committee decided to test two different interventions. The first required a patient care technician (PCT) to remain in the patient’s room for the full 15 minutes after hypoglycemia treatment to perform the recheck. The second incorporated the use of timers to remind PCTs and nurses to do the recheck.

**Sample and Setting**

This quality improvement project was implemented at a 309-bed community hospital in a suburb of a large Midwestern metropolitan area.

The group using timers encompassed a telemetry floor with 28 beds and a surgical floor with 32 beds. The group in which PCTs remained in the room encompassed two other telemetry floors with 28 beds each (total 56 beds).

**Methods**

A performance improvement team was assembled and led by the inpatient diabetes clinical nurse specialist and the quality improvement coordinator. A request for exemption from the hospital’s institutional review board was submitted for the pilot, and exemption was granted. Selection of the units to participate in the pilot was based on those with the greatest opportunity for improvement or the highest number of hypoglycemia episodes. The timers, ordered on the Internet, were digital and could be clipped to a pocket or lapel.

The project consisted of monitoring how well each group complied with the protocol requirement of performing timely blood glucose rechecks after hypoglycemia treatment. Staff education was delivered for both intervention groups at unit meetings and daily huddles. Data were collected for 12 weeks, and measurement for compliance was a recheck completed within 15–30 minutes from the monitoring results identifying hypoglycemia. Weekly compliance results were provided to the unit leadership team, consisting of managers and clinical nurse educators. Nurses were reeducated individually when the 15–30 minute recheck was not met.

For the timer group, a process flow chart was developed, including both PCTs and nurses. This process was approved by the unit councils. Two timers were placed by every blood glucose meter. If a PCT identified a blood glucose result ≤70 mg/dL, he or she would notify the nurse, dock the meter, and set the timer for 20 minutes. The PCT would hand the timer to the nurse, who would then assess and treat the patient. The nurse was responsible for rechecking the blood glucose when the timer went off. The 20-minute timer setting was selected to give the nurse enough
time to administer treatment or call for assistance if occupied elsewhere.

The process for the PCT group was developed by the unit leadership team. When hypoglycemia was identified by a PCT, the nurse would be notified. The nurse would obtain and administer the treatment. The PCT would remain in the patient’s room and perform the recheck 15 minutes after treatment based on the clock in the room. If the nurse performed the blood glucose monitoring and identified a result $\leq 70$ mg/dL, the PCT would be notified to obtain the oral treatment for the nurse to administer. If the treatment was dextrose 50%, the nurse would leave the room to obtain the treatment and then return to administer it. The PCT would remain in the room and perform the recheck 15 minutes after treatment.

**Data Collection**

Point-of-care blood glucose readings were downloaded by the individual performing the blood glucose monitoring at a docking station on the floor, which then loaded into the RALS laboratory system and exported to Meditech, the electronic medical record system in use at the time. A custom report was generated and used for data collection. The report listed hypoglycemic episodes and the timing of the subsequent recheck. Data were manually inspected and scrubbed for accuracy to eliminate episodes that occurred on units other than those included in the pilot project.

**Data Analysis**

Data were analyzed using SPSS version 11 statistical software (SPSS, Inc., Chicago, Ill.). Descriptive statistics were used to determine the mean number of hypoglycemia events per week and the mean time to recheck for adherent rechecks (blood glucose rechecked within 15–30 minutes) during the pilot period. The overall 12-week measure of compliance for each group was calculated as the percentage of hypoglycemic episodes in which blood glucose was rechecked within 15–30 minutes. The two overall compliance percentages of the groups were compared for significance using a one-tailed, two-sample $z$ test for comparison of proportions of two independent samples. A $t$ test was used to compare means for time to treat for adherent rechecks.

**Results**

As seen in Table 1, the timer group had a mean 6.5 hypoglycemic events per week (SD 5.44), compared to 10.13 (SD 5.74) in the PCT group. Table 2 shows that the mean time to treat and recheck a hypoglycemic event was 20.96 (SD 4.047) minutes for the PCT group, and 21.07 (SD 3.221) minutes for the timer group. The difference in means was not significant ($t$ test, $P = 0.812$). This substantiated that the recheck timing of 15–30 minutes after hypoglycemia

### Table 1. Blood Glucose Recheck Compliance for Timer and PCT Groups During 12-Week Pilot Project

<table>
<thead>
<tr>
<th>Patients Having Hypoglycemia Events (n)</th>
<th>Hypoglycemic Events $\leq 70$ mg/dL (n)</th>
<th>Rechecks in Compliance (n)</th>
<th>Hypoglycemic Events Per Week (mean [SD])</th>
<th>Compliance (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Timer group</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unit 1</td>
<td>28</td>
<td>61</td>
<td>53</td>
<td>5.08 (5.42)</td>
</tr>
<tr>
<td>Unit 2</td>
<td>53</td>
<td>95</td>
<td>78</td>
<td>7.91 (5.3)</td>
</tr>
<tr>
<td>Total</td>
<td>81</td>
<td>156</td>
<td>131</td>
<td>6.5 (5.44)</td>
</tr>
<tr>
<td>PCT group</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unit 1</td>
<td>47</td>
<td>95</td>
<td>55</td>
<td>7.91 (4.81)</td>
</tr>
<tr>
<td>Unit 2</td>
<td>60</td>
<td>148</td>
<td>72</td>
<td>12.33 (5.91)</td>
</tr>
<tr>
<td>Total</td>
<td>107</td>
<td>243</td>
<td>127</td>
<td>10.13 (5.74)</td>
</tr>
</tbody>
</table>

Comparison of compliance during 12-week period between total timer group and total PCT group using one-tailed, two-sample $z$ test for proportions: $z = 6.5, P < 0.0001$.

### Table 2. Mean Time to Treat (for Adherent Times Only)

<table>
<thead>
<tr>
<th>Mean Time to Treat (min)</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Timer group</td>
<td></td>
</tr>
<tr>
<td>Unit 1 (noncardiac surgical)</td>
<td>21.85</td>
</tr>
<tr>
<td>Unit 2 (cardiac telemetry)</td>
<td>20.53</td>
</tr>
<tr>
<td>Total</td>
<td>21.07</td>
</tr>
<tr>
<td>PCT group</td>
<td></td>
</tr>
<tr>
<td>Unit 1 (cardiac telemetry)</td>
<td>20.57</td>
</tr>
<tr>
<td>Unit 2 (cardiac telemetry and heart failure)</td>
<td>21.16</td>
</tr>
<tr>
<td>Total</td>
<td>20.96</td>
</tr>
</tbody>
</table>

Comparison of mean time to treat between timer group and PCT group ($t$ test): $P = 0.812$ (difference not significant).
is identified allows adequate time to obtain and administer the treatment.

As seen in Table 1, the timer group had significantly higher compliance with hypoglycemia rechecks than the PCT group (84 vs. 52%, $P < 0.0001$). However, the timer group had fewer hypoglycemic events to manage than the PCT group (156 vs. 243). Figures 1 and 2 display compliance rates from 4 weeks before initiation of the pilot through the 12 weeks of the project for the PCT and timer groups, respectively.

**Discussion**
The group using timers had significantly greater compliance than the group in which a PCT stayed in the room for 15 minutes waiting to perform the recheck. On a busy hospital floor, it is often difficult for a PCT to remain in a patient’s room, unavailable to other patients, for a full 15 minutes because PCTs are continuously called away to assist with patient care.

Noncompliance data were sent to the unit leadership team, which consisted of the unit directors and clinical educators. A member of the leadership team met with noncompliant nurses and PCTs to provide reeducation on the protocol. During this reeducation, the nurses and PCTs were able to contribute to the identification of gaps in knowledge and in the process. Both the PCT and timer leadership team groups agreed that the follow-up with nurses and PCTs on the outliers was a significant component of performance improvement in achieving timely hypoglycemia rechecks.

This institution had received Joint Commission Disease-Specific Certification for Advanced Inpatient Diabetes Management. As a result of the feedback from the unit leadership team, the hospital administration, which supported this certification performance improvement measure, concluded that continuing to receive follow-up data would be essential to further improve performance and sustain improvements in compliance. Weekly reports continue to be sent to unit leadership showing compliance and an analysis of noncompliance results, with specific operator recommendations for improvement.

One of the educational gaps identified through this process was the need to train registry nurses and PCTs who were “floating” to the project units and unaware of the process. To address this, registry nursing and PCT leadership agreed to provide hypoglycemia treatment training...
and badge cards for personnel at orientation.

In the analysis of outlier data, a process gap was noted in the accuracy of the report data. A hypoglycemic event occurring in another unit was showing up in the pilot units’ data. It was also discovered that the reports did not list all patient locations during hospitalization—just the location for the most current unit. As a result, data were scrubbed by the performance improvement coordinator for this inaccuracy before sending reports to the unit leadership team for review.

In feedback sessions, the PCT group noted that clocks were not synchronized from room to room, making the accuracy of recheck times questionable. Because of the accuracy of the timers, the nurses and PCTs in the timer group reported that the timers allowed them the confidence to know they could perform other tasks and not miss a recheck time. Based on the results reported by the timer group, the PCT group expressed the desire to implement the use of timers as soon as possible.

The timer group was able to achieve 100% compliance on different occasions during the pilot project. Discussions with unit leadership about how to achieve 100% compliance consistently revealed that human error and expected turnover of entry-level personnel can affect this goal.

Limitations

There were several limitations to the pilot. The PCT group’s patient population was primarily postoperative heart and heart failure patients with a higher incidence of hypoglycemia. With a larger number of hypoglycemic events to contend with, it may have been more difficult for PCTs to stay in a room to perform the 15-minute recheck.

Since the end of this pilot, the timer recheck protocol was implemented throughout the hospital for the adult, non-pregnant patient population. The nurses and PCTs were educated about the timer protocol in staff meetings taught by the clinical nurse educators following the same process outlined in the pilot. Weekly compliance reports identifying staff members who are out of compliance are sent to unit leadership.

Conclusion

The hypoglycemia treatment and prevention are essential components of diabetes standards of care and have become a Joint Commission Disease-Specific Certification quality measure for patients with diabetes. The overall goal in achieving consistency in meeting this quality measure is to ensure patient safety. Although education is the foundation to achieving the skills necessary to provide quality care, interventions are required to sustain that education. This novel pilot project demonstrated that the use of timers is an effective way to remind nurses to recheck blood glucose after hypoglycemia treatment and does not affect the workload of the staff. Anecdotal evidence suggested that nurses were very satisfied with this process. As a result, the process was implemented throughout the hospital. After implementation, an annual compliance of 75% has been achieved.

Duality of Interest

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

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6. Biscoe VI, Davis SN. Hypoglycemia in type 1 and type 2 diabetes: physiology, pathophysiology, and management. Clin Diabetes 2006;24:115–121