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Improving Timing of Capillary Blood Glucose Monitoring and Insulin Administration through Patient Education

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Improving Timing of Capillary Blood Glucose Monitoring and

Insulin Administration through Patient Education

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Honors Research Project

Illinois Wesleyan University, School of Nursing

2020

Abstract

For patients with diabetes in acute care settings, researchers report that it is challenging for the healthcare team to coordinate capillary blood glucose (CBG) monitoring and insulin administration with mealtimes. If insulin dosage is calculated from CBG values that are not updated, patients may experience dosing errors and uncontrolled CBG. Uncontrolled CBG increases patients' risk of complications. To improve diabetes management, some hospitals have implemented policies aimed at improving the coordination of CBG monitoring, insulin administration, and mealtimes. In this study, the researcher studied the effectiveness of including an educational card on patient meal trays on the timing of CBG monitoring, insulin administration, and meal tray delivery. The effect on glycemic control was also examined. The educational card was placed on patient meal trays and prompted the patient to contact the nurse to receive meal-time insulin before the consumption of the meal. Data were collected on 60 patients (control group n = 30, test group n = 30) at a 433-bed level-1 trauma center in central Illinois. The educational card did not significantly decrease the timing between CBG monitoring, insulin administration, and meal tray delivery, but the implications from this study can be replicated or modified to meet the needs of other hospitals interested in improving diabetes management.

Improving Timing of Capillary Blood Glucose Monitoring and

Insulin Administration through Patient Education

In the acute care setting, 38-46% of patients with diabetes experience hyperglycemia (Mendez & Umpierrez, 2014). Per the guidelines of the American Diabetes Association (ADA) (2019), capillary blood glucose (CBG) should be maintained between 140-180 mg/dL in the inpatient setting, and can be maintained between 110-140 mg/dL for selected, non-critical patients. Any CBG above 180 mg/dL is considered hyperglycemia while anything below 70 mg/dL is considered hypoglycemia. Diabetes management in hospitalized patients is inadequate and does not meet standards. Uncontrolled CBG increases the risk of complications and results in longer hospital stays, increasing the financial burden for the patient and hospital (Majumdar et al., 2013).

Glycemic management in the hospital setting is challenging, but can be improved through modifiable factors. CBG monitoring, insulin administration, and meal consumption in the inpatient setting are not done within the appropriate timeframe (Freeland, Penprase, & Anthony, 2011; Lampe, Penoyer, Hadesty, Bean, & Chamberlain, 2014; Mendez & Umpierrez, 2014). Inadequate coordination between CBG monitoring, insulin administration, and meal consumption results in uncontrolled CBG. According to current recommendations by the ADA (2019), CBG monitoring should occur closely before the administration of insulin (a time interval was not specified), and rapid-acting insulin, Novolog or Humalog, should be administered 15 minutes before or directly after meal consumption. Few researchers identified barriers at adhering to guidelines, but insufficient communication and coordination between the healthcare team and low inadequate staffing are key factors (Kaisen, Parkosewich, & Bonito, 2018).

The purpose of this study was to examine the effect of an educational card on the time intervals between CBG monitoring, insulin administration, and meal tray delivery. Time of meal tray delivery served as a proxy for timing of meal consumption, as the hospital requested the researcher have no direct patient contact. The aim of the study was to address the following questions:

1. Does the placement of an educational card on patient meal trays shorten the time intervals between:

   a. CBG and meal tray delivery,

   b. the administration of insulin and meal tray delivery,

   c. and CBG and the administration of insulin?

2. Is the incidence of hypoglycemia, defined as any CBG <70mg/dL, decreased in the interval after meal tray delivery and before the next meal after the implementation of the educational card?

3. Is the percentage of patients in blood glucose range, measured by a target range of 70-180 mg/dL, increased after the implementation of the educational card?

Literature Review

Research published from 2010 to 2019 is limited on interventions to improve glycemic management in the inpatient setting, but some researchers were successful at lowering the incidence of uncontrolled CBG and improving the timing between CBG monitoring, insulin administration, and meal consumption (Engle, Ferguson, & Fields, 2016; Yamamoto, Malatestinic, Lehman, & Juneja, 2010). For example, instead of dietary staff, nurses delivered meal trays to patients receiving insulin, which improved CBG management and timing. This

additional responsibility strained the nursing staff, interrupted work flow, and was not feasible during times of high census (Engle et al., 2016).

Other researchers developed markings and identification for patient meal trays, which improved the coordination of CBG monitoring and insulin administration. These interventions are low-cost, but require the coordination between nursing and dietary staff (Yamamoto et al., 2010). Coordination of CBG monitoring and insulin administration improved with increased communication between nursing and dietary staff. Nurses could plan insulin administration accordingly as they were informed of meal tray delivery (Engle et al., 2016; Yamamoto et al., 2010). Improved communication with certified nursing assistants (CNAs) also facilitated CBG monitoring closer to insulin administration (Kaisen et al., 2018).

According to researchers and the ADA, inpatient diabetes education is essential at improving diabetes management (Powers et al., 2015). Inpatient glycemic management improves when patients are able to identify the need to have insulin before meal consumption. Inpatient diabetes education also promotes replication and adherence to teaching upon discharge. Patient education increases autonomy, promotes healthy habits, and provides a greater sense of health awareness (Cobaugh et al., 2013; Engle et al., 2016; Kaisen et al., 2018).

Research is limited on the effectiveness of interventions to promote glycemic management in the inpatient setting. Inpatient glycemic management can improve through the coordination of CBG monitoring, insulin administration, and meal consumption. Few researchers have identified solutions at improving timing; therefore, further research is needed. It is possible that facilities have made practice changes to improve the coordination of CBG and insulin administration, but have not published, evaluated, or disseminated that change. Appendix A provides greater detail on the current published research within this literature review.

Methods

Study Design

A quasi-experimental, non-equivalent control group before-after design with retrospective chart reviews was used in the study. Data was collected from the control group without the educational card, and then data was collected from the test group with the educational card. The control and test groups consisted of different participants and data collection occurred on separate days.

Participants and Sampling Procedures

The total sample size was 60 with 30 participants in the control group and 30 participants in the test group. Inclusion criteria included English-speaking patients prescribed rapid-acting meal-time insulin admitted to non-critical, acute care units. Over the period of two months, the researcher worked with an advanced practice register nurse (APRN) with a specialty in diabetes to select participants for the study. Each day, the APRN examined unit census and created a list of patients on rapid-acting meal-time insulin in non-critical, acute care units. Exclusion criteria included patients not prescribed rapid-acting meal-time insulin, not assigned to non-critical, acute care units, or non-English speaking.

The study was conducted at 433-bed level-1 trauma center in central Illinois. Institutional Review Board (IRB) approval was granted from Illinois Wesleyan University. The hospital IRB approved the study as a quality improvement (QI) project with no direct participant contact. Participant consent was not obtained as there was no direct participant contact and minimal risk to participants. The educational card was created on the basis of accepted and published guidelines on diabetes care. The waiver of consent did not adversely affect the rights and welfare

of the subjects and all data collected were de-identified and stored in a password protected and

encrypted computer to minimize risk of exposure of health information.

Patient Education Card

The patient education card (Appendix B) was created by the researcher in collaboration

with the APRN diabetes specialist. The goal of the education card was to catch the attention of

the participant and prompt the participant to call the nurse to receive insulin before proceeding to

meal consumption. Nurses, CNAs, dietary staff, and unit managers were notified of the

intervention via email. The card used plain and simple language. The researcher used Microsoft

Office PowerPoint® and images in the Creative Commons labeled for reuse to create the card.

Data Collection

Data collection occurred in collaboration with the APRN and dietary staff. At the

beginning of the day, the APRN informed dietary staff of the room numbers associated with

study participants. Dietary staff informed the APRN when the participant ordered and when the

meal tray left the kitchen. The researcher or the APRN went to the unit and recorded the time of

meal tray delivery to the nurse's station and subsequently to the patient room. Paired data were

not available for every patient because of physical availability limitations of the researcher and

APRN. For example, meal trays were often delivered at the same time which made it impossible

to record the time the tray reached the nurse's station for multiple units. Data collection occurred

first with the control group and then proceeded with the test group. For the test group, the

researcher or APRN placed the educational card directly on patient meal trays prior to delivery

into the patient room.

The researcher and APRN used retrospective chart reviews to collect demographic

information, clinical characteristics, CBG values, and the timing of CBG monitoring and insulin

administration. CBG values before and after the observed meal were recorded. Paired data were

not available for every participant due to discharges and procedures; therefore, some results from

the control and test groups have sample size less than 30. Insulin timing was only recorded if

insulin was administered. Some patients refused insulin or insulin was not given due to clinical

indications not met (e.g., hypoglycemia). Participant unit, age, gender, hemoglobin A1C,

diabetes type, primary diagnosis, length of stay (LOS), meal observed and diet order were

recorded. Data collection occurred from November 2019 through January 2020.

Data Analysis

Data were analyzed using IBM SPSS Statistics version 26. Descriptive statistics were

used to analyze and report data using percentages, means, and standard deviations. Demographic

data from the control and test groups were compared through descriptive analysis, chi-squared

tests, and independent samples t-tests. Mean time intervals and CBG values from the control and

test groups were compared through chi-squared tests and independent samples t-tests. Percent of

the control and test groups in range was compared using chi-squared tests. Subgroups were

created within the data from hemoglobin A1C, diet ordered, and meal observed and analyzed

using independent samples t-tests.

<center>**Results**</center>

Demographic Characteristics

The demographic characteristics of the control and test groups did not differ significantly

(Appendix C), indicating both groups had similar participants. The average age in the control

group was 67.03 (SD = 13.86) and 65.07 (SD = 12.08) in the test group ($t(58) = 0.59$, $p = 0.56$).

Gender did not differ significantly between groups ($X_2(32, N = 60) = 31.82$, $p = 0.48$). In the

control group, 43% of participants were male and 57% of participants were female. In the test

group, 37% of participants were male and 63% of participants were female. Average hemoglobin A1C in the control group was 7.93 (SD = 1.49) and 8.03 (SD = 1.95) in the test group ($t(56) =$ -0.23, $p = 0.82$).

Almost all participants had type 2 diabetes, only two participants had type 1 diabetes in the test group. Primary diagnoses were placed into nine categories: musculoskeletal, infection, gastrointestinal, cardiac, renal, neurologic, endocrine, pulmonary, and psychiatric. The primary diagnoses of the control and test groups did not differ significantly ($X_2(8, N = 60) = 9.05, p =$ 0.34). The most common diagnoses between groups were infection and cardiac related. About 37% of participants had infection as the primary diagnosis in the control and about 27% in the test group. Both groups had 20% of participants with a cardiac-related diagnosis.

The average LOS was 6.17 days (SD = 5.22) in the control group and 6.21 days (SD = 4.20) in the test group ($t(57) = -0.03, p = 0.97$). There was not a significant difference in diet between groups ($X_2(1, N = 60) = 3.27, p = 0.07$). The majority of participants in both groups were on diabetic diets, 77% in the control group and 93% in the test group. The majority of observed meals were from lunch, 77% in the control groups and 67% in the test group. Participants were located in nine different non-critical, acute care units. The majority of participants were located on three different units: a cardiopulmonary unit (30%), a medical surgical unit (22%), and an orthopedic unit (17%). A complete participant distribution between units is found in Appendix D.

Time Intervals

The first aim of the study was to examine if the educational card shortened the time intervals between:

    a. CBG and meal tray delivery,

    b.   the administration of insulin and meal tray delivery,

    c.   and CBG and the administration of insulin.

The first aim of the study was not met. There was actually an increase in the time intervals (in minutes) between:

    a.   CBG and meal tray delivery before (M = 35, SD= 46) and after (M = 47, SD = 68) implementation ($t(56) = -0.83$, $p= 0.15$),

    b.   insulin administration and meal tray delivery before (M = 27, SD = 21) and after (M = 32, SD = 45) implementation ($t(45) = -.47$, $p = 0.07$),

    c.   and CBG and insulin administration before (M = 45, SD = 44) and after (M = 65, SD = 77) implementation ($t(44) = -1.09$, $p = 0.03$).

Of the three measured intervals, the interval between CBG and insulin administration achieved statistical significance, but the time interval increased. Graphic representation of results is found in Appendix E.

The time interval between meal tray delivery to the nurse's station and to the patient room was also analyzed. The educational card did not significantly decrease the mean time interval (in minutes) between tray delivery to the nursing station and tray delivery to the patient room before (M = 34, SD = 72) and after (M = 11, SD = 12) implementation ($t(29) = 1.24$, $p = 0.22$).

Incidence of Hypoglycemia

The second aim of the study was to examine if the incidence of hypoglycemia (CBG of less than 70 mg/dL) decreased in the interval after meal tray delivery and before the next meal. There were insufficient data to run meaningful statistics to test this aim. The control group had one incidence and the test group had three incidences of hypoglycemia.

Percent in Blood Glucose Range

The third aim of the study was to examine if the percentage of patients in range, measured by a target CBG range of 70-180 mg/dL increased after the implementation of the educational card. In range was calculated using ADA (2019) standards of hypo- and hyperglycemia in the inpatient setting. Anything below 70 mg/dL is hypoglycemia and anything above 180 mg/dL is hyperglycemia, with any measure between 70-180mg/dL considered in range. The post-meal CBG was used to determine in range or out of range. There was not a significant increase in patients in range after the implementation of the educational card, (X_2(1, N = 53) = 1.52, p = 0.22). About 58% of participants were in range in the control group and about 41% in the test group were in range.

Glycemic Control

Data were collected for glycemic control through chart review, noting the CBG recorded before the observed meal (pre-meal CBG) and the next CBG recorded after the observed meal (post-meal CBG). The aim was to gauge glycemic control in the non-critical, acute care setting and if the educational card effected post-meal glycemic control. There was not a significant difference between pre-meal CBG in the control (M = 168, SD = 72) and test (M = 174, SD = 81) groups (t(57) = -0.28, p = 0.78). There was also not a significant difference between post-meal CBG in the control (M = 172, SD = 75) and test (M = 177, SD = 91) groups (t(51) = -0.24, p = 0.81). The educational card did not impact post-meal glycemic control in this sample.

Subgroups

Hemoglobin A1C. Hemoglobin A1C was broken into four groups: 1) control group participants with A1C $\leq$ 7; 2) test group participants with an AlC $\leq$ 7; 3) control group participants with A1C >7; and 4) test group participants with an A1C > 7. A1C categories were

based on ADA (2019) recommended A1C target of 7 or less. Hemoglobin A1C tests average

CBG control over a 3-month period. An A1C of ≤ 7 indicates an average CBG ≤ 154 mg/dL and

an A1C > 7 indicates an average CBG > 154 mg/dL. The goal was to determine if glycemic

control varied in response to the educational card when compared to well-controlled CBG and

poorly controlled CBG. Groups 1 and 2 were compared with post-meal CBG using independent

samples t-tests. The same analysis was conducted for groups 3 and 4. Post-meal CBG did not

differ significantly between the control group (M = 151.14, SD = 55.87) and the test group (M =

147.50, SD = 77.65) with an A1C of ≤ 7 ($t(11) = .10$, $p = 0.92$). Similarly, post-meal CBG did

not differ significantly between the control group (M = 179.61, SD = 83.27) and test group (M =

190.70, SD = 93.61) with an A1C of > 7 ($t(36) = -.38$, $p = 0.70$).

Diet order. Diet ordered was broken into four groups: 1) control group participants on a

diabetic diet; 2) test group participants on a diabetic diet; 3) control group participants on a non-

diabetic diet; and 4) test group participants on a non-diabetic diet. The goal was to determine if

glycemic control varied in response to the educational card when comparing diets. Groups 1 and

2 were compared with post-meal CBG using independent samples t-tests. The same analysis was

conducted for groups 3 and 4. Post-meal CBG did not differ significantly between the control

group (M = 181.89, SD = 83.24) and test group (M = 180.64, SD = 92.48) on a diabetic diet

($t(42) = .05$, $p = 0.96$). Similarly, post-meal CBG did not differ significantly between the control

group (M = 144.14, SD = 35.08) and test group (M = 135.00, SD = 67.88) on a non-diabetic diet

($t(7) = .28$, $p = 0.79$).

Meal observed. Meal observed were placed into four groups: 1) breakfast observed for

control group; 2) breakfast observed for test group; 3) lunch observed for control group; and 4)

lunch observed for test group. The goal was to determine if glycemic control and the time

intervals varied in response to the educational card when compared to the observed meal. Groups 1 and 2 were compared with post-meal CBG and time intervals using independent samples t-tests. The same analysis was conducted for groups 3 and 4. Post-meal CBG did not differ significantly between the control group (M = 199.4, SD = 92.85) and test group (M = 128.00, SD = 61.43) during breakfast ($t(7) = 1.32, p = 0.23$). Similarly, post-meal CBG did not differ significantly between the control group (M = 165.14, SD = 70.77) and test group (M = 185.83, SD = 93.18) during lunch ($t(42) = -0.82, p = 0.42$).

There was not a significant difference in the interval of time (in minutes) during breakfast between:

a. CBG and meal tray delivery between the control (M = 98, SD = 68) and test (M= 55, SD = 42) groups ($t(8) = 1.19, p = 0.27$).

b. the administration of insulin and meal tray delivery between the control (M = 26, SD = 21) and test (M = 19, SD = 15) groups ($t(6) = 0.53, p = 0.62$,

c. and CBG and the administration of insulin between the control (M = 102*, SD = 56) and test (M = 73, SD = 65) groups, ($t(5) = 0.63, p = 0.56$). *Mean CBG was calculated manually due to one outlier within the data.

Similarly, there was not a significant difference in the interval of time (in minutes) during lunch between:

a. CBG and meal tray delivery between the control (M = 22, SD = 26) and test (M= 46, SD = 74) groups ($t(46) = -1.51, p = 0.14$).

b. the administration of insulin and meal tray delivery between the control (M = 27, SD = 23) and test (M = 34, SD = 49) groups ($t(37) = -0.58, p = 0.57$,

c.   and CBG and the administration of insulin between the control (M = 32, SD = 30)

and test (M = 64, SD = 80) groups, (t(37) = -1.61, p = 0.12).

Discussion

This study examined the effectiveness of an educational card on reducing the time

intervals between CBG and meal tray delivery, the administration of insulin and meal tray

delivery, and CBG and the administration of insulin. Impact on glycemic control was also

analyzed. When comparing the control to the test group, the educational card was ineffective at

reducing the time intervals and did not have a significant impact on glycemic control. The time

intervals in this sample actually increased with the implementation of the educational card which

was unexpected and inconsistent with similar studies.

Time Intervals

According to current recommendations by ADA (2019), CBG monitoring should occur

closely before the administration of insulin (a time interval was not specified), and rapid-acting

insulin, Novolog or Humalog, should be administered 15 minutes before or directly after meal

consumption. In this study, CBG monitoring did not occur according to current guidelines. On

average, CBG monitoring occurred 45 minutes before or after insulin administration in the

control group and 77 minutes before or after insulin administration in the test group. This is

alarming because if insulin dosage is based on CBG values that are not current, it could lead to

dosing errors and uncontrolled CBG.

Similarly, rapid-acting insulin administration did not occur within current guidelines. On

average insulin administration occurred 27 minutes before or after meal tray delivery in the

control group and 32 minutes before or after meal tray delivery in the test group. Insulin that is

not administered on-time severely increases patients' risk for hyperglycemia. Patient safety is at

risk because of the lack of coordination of CBG monitoring, insulin administration, and meal tray delivery.

The educational card did not decrease the time intervals. All time intervals increased in the test group compared to the control group, but the only interval that increased significantly was the time interval between CBG and insulin administration. Although it is unclear why the increase in time between CBG and insulin administration for the test group was statistically significant, study limitations likely contributed (see Limitations section). The educational card was created based on current recommendations from ADA (2019) and the APRN diabetes specialist. Yamamoto et al. (2010) had success improving the coordination of CBG monitoring and insulin administration through meal tray markings and identification so it is unlikely the educational card was the cause of the increase in the time intervals. More research is needed on the intervention or different ways to improve the coordination of CBG and insulin administration.

The educational card did improve the timing between tray delivery to the nursing station and to the patient room by 23 minutes in the test group. This finding was not significant and could be attributed to the Hawthorne effect. Because the nurses and CNAs knew they were being observed by the researcher and APRN, it could have prompted them to deliver the meal tray into the patient room quicker.

Percent in Blood Glucose Range

The educational card did not significantly impact the percent of participants in range (CBG 70-180 mg/dL), although the percentage of participants in range actually decreased by 17% with the implementation of the educational card in the test group. Again, this can be attributed to study limitations (see Limitations section) and confounding factors that impact

glycemic control. For example, glycemic control is impacted by patient acuity, stress, insulin dosage, and other factors; none of these variables were included in the analysis.

About 41-58% of total study participants were in range during the study. Since there were so few incidences of hypoglycemia, most of those participants experienced hyperglycemia, or a CBG of > 180 md/dL. This is consistent with other studies that examine glycemic control in the acute care setting; about 38-46% of patients with diabetes experience hyperglycemia (Mendez & Umpierrez, 2014). There is a need to re-examine diabetes management in the inpatient setting and research interventions to improve glycemic control.

Glycemic Control

The mean pre-meal and post-meal CBGs of both groups fell within the recommended non-critical, acute care setting recommendations of 140 – 180 mg/dL. However, standard deviations of 72 mg/dL, 81 mg/dL, 75 mg/dL, and 91 md/dL indicate large variations among patients and inadequate glycemic control. The educational card did not significantly impact glycemic control or the large fluctuations of CBGs between groups.

Although the educational card was ineffective at improving glycemic control, this study highlights concerning results. In this sample, glycemic control was inadequate which has several negative implications. Patient health and safety is at risk. Patient's with uncontrolled CBG during hospitalization are at greater risk for poor clinical outcomes such as infection and death (Baker et al., 2006). Uncontrolled CBG also results in longer hospital stays which costs the patient and hospitals money. One hospital saved more than $3000 per patient with improved glycemic control (Cardona et al., 2017). healthcare staff have a responsibility to model proper diabetes management in order to promote optimal diabetes management upon discharge.

Subgroups

 Hemoglobin A1C. The educational card did not impact glycemic control in participants

with an A1C ≤ 7 and > 7. An A1C of ≤ 7 indicates an average CBG ≤ 154 mg/dL and an A1C >

7 indicates an average CBG > 154 mg/dL (ADA, 2019). This is consistent with findings as

participants with an A1C ≤ 7 had mean CBGs of 147 – 151 mg/dL and participants with an A1C

> 7 had mean CBGs of 180 – 191 mg/dL.

 Participants with an A1C ≤ 7 have optimal glycemic management which indicates proper

diabetes management in the outpatient setting. Often, patients are not allowed to manage their

diabetes in the hospital, despite having optimal control in the outpatient setting. These patients

could benefit from more autonomy and self-diabetes management within the hospitalized setting.

This reduces the workload of the healthcare staff, results in better glycemic management, and

improves meal-time insulin coordination (Mabrey & Setji, 2015). Diabetes self-management

increases autonomy and satisfaction. For patients without optimal diabetes management, or with

an A1C >7, patient education is essential at promoting healthy habits, increasing health

awareness, and autonomy (Cobaugh et al., 2013; Engle et al., 2016; Kaisen et al., 2018).

 Diet Ordered. Similarly, the educational card did not impact glycemic control in

participants on a diabetic or non-diabetic diet. Surprisingly, participants on a non-diabetic diet

had better CBG control then those on a diabetic diet. CBG ranged from 135 – 144 mg/dL in the

non-diabetic diet participants and 181 – 182 mg/dL in the diabetic group participants. This is

unexpected because the purpose of a diabetic diet is to prevent spikes in CBG and improve

glycemic control through limiting refined sugar intake, foods high in salt, and fried foods

(National Institute of Diabetes and Digestive and Kidney Diseases, 2016). Of course, the

fluctuations in CBG could be caused by other factors outside the researcher's control. For

example, without direct observation the exact contents of the meal were not examined and it was unknown if the participant had a snack before the post-meal CBG was checked. More research is warranted on the effect of diet in the non-critical, acute care setting.

Meal Observed. When considered separately, the educational card did not significantly impact glycemic control during breakfast or lunch. The mean CBG decreased by 71 mg/dL from the control to the test groups during breakfast, but the number of participants in that group were small so the findings were insignificant. A larger sample size may produce significant results. The mean CBG was consistent between breakfast and lunch.

The educational card did not significantly impact the time intervals during breakfast or lunch. All time intervals decreased in the test group during breakfast, but still did not meet standards and was insignificant due to small group sample sizes. A larger sample size may produce significant results. Overall, timing was slightly better for the control and test groups during lunch, which can be attributed to issues at breakfast such as shift change and increased patient needs (e.g., medication orders). Few studies compare diabetes management between meals in hospitals patients. Future research is needed on the impact of meal time on glycemic control. Breakfast and dinner are busy times for the healthcare staff due to patient needs and administration responsibilities (e.g., charting, shift change). Future studies should examine nurse workload throughout the day and the impact on diabetes management.

Limitations

When comparing the control and test groups, the educational card was ineffective at improving the time intervals and glycemic control in this sample. Insignificant results are attributed to study design and confounding variables outside the researcher's control. The researcher utilized a quasi-experimental, non-equivalent control group before-after design in this

study. The non-equivalent control group design may have introduced differences in staffing, unit census, and patient acuity. This can impact nursing care and thus, diabetes management. This study was strictly observational and did not have an experimental design. Meal tray delivery into the patient room was used as a substitute for meal consumption, so the researcher could not record when the patient actually consumed the meal. It is possible that the patient could have started eating long after meal tray delivery. The nutritional content, such as carbohydrate or sugar content, of meals was not accounted for nor were snacks between meals. It was also unknown whether or not the patient noticed the educational card on the tray and called the nurse.

Demographic characteristics were similar between groups, but factors that impact workflow were not accounted for, such as hospital or unit census, and staffing patterns. The lack of intervention randomization may result in unaccounted differences between groups. Sample sizes were also small due to research and APRN time constraints. It is possible that significant results would occur with larger sample sizes.

It is also unknown if the educational card effectively prompted the patient to call the nurse and receive insulin before eating. The patient did not receive formal education on the educational card so it is unknown if the patient understood the educational card or the importance of waiting to eat until insulin is received. The educational card stated, "call your nurse for your insulin shot BEFORE you start eating," which could have prompted the patient to call the nurse first and then start eating; instead of calling the nurse, receiving insulin, and then eating. Rewording of the educational card may be necessary and could include language such as, "call your nurse and wait for your insulin shot BEFORE you start eating." It is important to educate patients on the intervention to promote compliance upon discharge and improve glycemic control (Cobaugh et al., 2013; Engle et al., 2016; Kaisen et al., 2018).

The healthcare staff, which include nurses and CNAs, had mixed compliance to the educational card. Some employees verbalized approval of the intervention while others expressed feelings of annoyance and displeasure. Some nurses and CNAs removed the educational card before the tray was delivered. Since those patients did not see the card, they were removed from the study. It is also possible that the healthcare staff removed the card while in the patient room. This reduces intervention fidelity and impacts the data from the test group, which makes insignificant results more likely. The healthcare staff was notified of the intervention via email and many employees reported that they were not aware of the intervention which created confusion on the purpose of the card. Per hospital request, the healthcare staff did not receive formal education or module instructions on the use or importance of the educational card. Formal and trackable education could have enhanced compliance.

Proper diabetes management is important to reduce complications. Diabetes is associated with long-term complications such as retinopathy, kidney disease, heart disease, strokes, and neuropathy (Corsino, Dhatariya, & Umpierrez, 2017). Uncontrolled diabetes also increases risk of mortality and decreases life expectancy up to 15 years (Mannucci, Dicembrini, Lauria, & Pozzilli, 2013). Improved glycemic management can reduce the risk of complications and mortality by 16 – 57% (Holman, Paul, Bethel, Matthews, & Neil, 2008; Mannucci et al., 2013; Nathan et al., 2005).

There are many studies that examine glycemic management in the hospital setting, but few that address the specific time intervals between CBG monitoring, meal consumption, and insulin administration. Research is limited on interventions to improve diabetes management in the hospital setting. Each healthcare system is unique and faces different problems. It is important for healthcare systems to examine diabetes management in their own facilities and

tailor interventions to best meet the needs of the healthcare staff and patients. To the researcher's knowledge, this study is the first to examine the effectiveness of a patient educational card on timing and glycemic control.

The implications of this study inform hospitals of the need to create better education or policies to improve glycemic management. Diabetes management is inadequate in the hospital setting and interventions must be developed to address the problem. Even though the education was ineffective, it can be modified to fit each hospital's needs. It is also important to promote communication between nurses, CNAs, dietary staff, and the patient to promote optimal diabetes management and glycemic control.

Future Research

The educational card may still be a useful tool within hospitals, but further research is needed and should include: standardized and trackable staff and patient education, interdisciplinary coordination between nurses, CNAs, and dietary staff, larger sample sizes, true experimental design, and direct patient contact. The placement of the educational card was the sole responsibility of the researcher and APRN, and was not feasible for all patients if meals were ordered at the same time and on different units. Healthcare facilities face unique challenges on who will place the educational card. Some facilities were successful at dietary staff placing markings on patient meal trays that alerted the healthcare staff of patients on insulin, but that increases the workload of dietary staff and may disclose confidential patient information (Yamamoto et al., 2010).

It would be useful if the patient was educated on the importance of receiving insulin before eating at some point during hospitalization, ideally during admission. An educational card can then be placed in patient rooms to serve as a daily reminder of the education. This removes

the barrier of placement of the educational card and makes the card more noticeable as opposed to on patient meal trays which can be easily missed and removed.

While CBG measurement and automated documentation in electronic medical records are reliable and valid tools, there were limitations with the measurement of time intervals within this study. Interrater reliability must be addressed in future studies to address if data collection occurred consistently between data collectors. Furthermore, meal tray delivery is not a valid way to measure meal consumption. Direct patient contact to observe the exact timing and duration of meal consumption, the contents of the meal, and if insulin was administered before or after meal consumption would enhance both reliability and validity of data collection. There is also a need to identify if patients saw the educational card, if they understood it, and if they called the nurse before meal consumption; understanding intervention fidelity in the test group would improve interpretation of statistical conclusion validity.

Time-in-range (TIR) can also be analyzed in the future. TIR is the percentage a patient spends in-range, with a CBG of 70 – 180 mg/dL. At the beginning of hospitalization for non-critical patients on rapid-acting insulin, patients can be randomly assigned to control or test groups. The test groups have the educational card for their entire hospitalization and CBG is examined for their entire stay. TIR is then compared between the control and test groups. This way allows the patient to receive formal education on the educational card and allows them to see it more than once, which may increase retention and compliance.

TIR is important to consider when implementing any intervention aimed at improving glycemic management because it provides a more wholistic view than mean glucose. Mean glucose only collects data from one point in a patient's hospitalization, which makes it difficult to analyze improvements or fluctuations in blood glucose. Improvements in mean glucose could

also be attributed to outliers, such as extreme incidences of hypoglycemia. Ideally, TIR would be measured with use of continuous CBG monitoring, which is currently not used routinely in inpatient settings.

Conclusion

Following implementation of an educational card, there was no reduction in the time intervals between CBG monitoring, insulin administration, and meal tray delivery. Timing still does not meet current standards which impacts glycemic control. More research is needed to address the needs of hospitalized patients with diabetes. The study had a small sample size and cannot be generalized to all patients due to confounding influences and the many other factors (e.g., patient acuity, unit census) that impact glycemic control and diabetes management. Hospitals can use the results of this study to utilize the educational card in a different manner or tailor other interventions to meet the needs of patients with diabetes.

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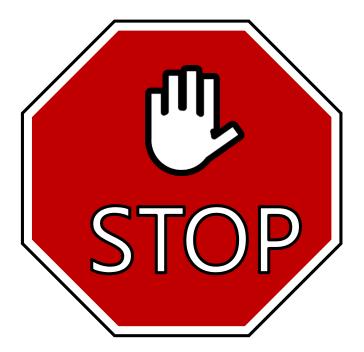   10.1097/QMH.0b013e3181eb137f

Appendix A

Table 1: Literature Review Studies

Author	Study	Aim	Findings	Limitations
Yamamoto et al., 2010	Experimental	Improve timing of inpatient insulin administration related to meal delivery and procedure scheduling	The timing of inpatient insulin administration related to meal delivery and testing improved	Additional protocol may have contributed to improved glycemic control, paired data not available for every patient
Engle et al., 2016	Quality Improvement	Modify the meal delivery process to improve the timing between blood glucose monitoring and insulin administration and improve glycemic control	Blood glucose control and the timing between blood glucose monitoring and insulin administration improved after the change	Additional protocol may have contributed to improved glycemic control
Kaisen et al., 2018	Descriptive-correlational study	Identify factors that lead to timely blood glucose monitoring and insulin administration	Communication with CNAs, fewer patients, and patients waiting for insulin prior to eating were key factors and receiving insulin on time	Response bias, social desirability, Hawthorne effect, limited generalizability
Cobaugh et al., 2013	Expert consensus panel	Provide recommendations for safe insulin administration	Development of insulin protocol, hospitals must coordinate insulin delivery better, and standardize education	Limited knowledge of application within practice

Appendix B

Patient Education Card

Call your nurse for your insulin shot BEFORE you start eating

Appendix C

Table 2: Demographic Characteristics

Characteristic	Control Group	Test Group	*p*-value
Mean age	67 ± 14 N= 30	65 ± 12 N= 30	p = 0.56
Gender	Male: 43% Female: 57% N= 30	Male: 37% Female: 63% N= 30	p = 0.48
Mean Hemoglobin A1C	7.93 ± 1.49 N= 29	8.03 ± 1.95 N= 29	p = 0.82
Diabetes Type	Type 2: 100% Type 1: 0% N= 30	Type 2: 93% Type 1: 7% N= 30	--
Primary Diagnosis	Musculoskeletal: 5 Infection: 11 GI: 6 Cardiac: 1 Renal: 1 Neuro: 1 Endocrine: 1 Pulmonary: 1 Psych: 0 N= 30	Musculoskeletal: 4 Infection: 8 GI: 1 Cardiac: 6 Renal: 0 Neuro: 1 Endocrine: 3 Pulmonary: 5 Psych: 2 N= 30	p = 0.34
Mean Length of Stay	6 ± 5 N= 30	6 ± 4 N= 29	p = 0.97
Diet Order	Diabetic: 77% Nondiabetic: 23% N= 30	Diabetic: 93% Nondiabetic: 7% N= 30	p = 0.07
Meal Observed	Breakfast: 23% Lunch: 77% N= 30	Breakfast: 37% Lunch: 67% N= 30	p = 1.0
No statistically significant differences between groups (all p-values> 0.05).			

Appendix D

Table 3: Participant Unit Distribution

Unit	Unit Type	Control Group N= 30	Test Group N= 30
Unit 1	Orthopedic	17%	17%
Unit 2	Medical Surgical	17%	7%
Unit 3	Medical Surgical	27%	17%
Unit 4	Cardiac Medical Surgical	13%	3%
Unit 5	Cardiopulmonary	27%	33%
Unit 6	Surgical Trauma	0%	3%
Unit 7	Advanced Care	0%	10%
Unit 8	Medical Surgical	0%	7%
Unit 9	Medical Surgical	0%	3%
No statistically significant differences between groups, p > 0.05.			

Appendix E

Table 4: Time Intervals between Control and Test Groups

Time Intervals

*Control Group
*Test Group

*p = 0.03

Appendix F

Table 5: Time Intervals (in minutes)

Group Statistics

	IV	N	Mean	Std. Deviation	Std. Error Mean
Time between CBG and Tray Delivery	Control Group	29	35:18	46:03	08:33
	Test Group	29	48:08	69:35	12:55
Time between Insulin Administration and Tray Delivery	Control Group	22	27:08	21:50	04:39
	Test Group	25	32:12	45:50	09:10
Time between Insulin Administration and CBG	Control Group	22	45:00	44:55	09:34
	Test Group	24	65:40	77:37	15:50
Time between Tray to Nurse's Station and Tray to Room	Control Group	15	34:28	72:04	18:36
	Test Group	16	11:45	12:06	03:01

Note. Paired data were not always available in the control and test groups due to patient discharges, procedures, and lack of insulin administration, resulting in variability in N.

		Levene's Test for Equality of Variances				
		F	Sig.	t	df	Sig. (2-tailed)
Time between CBG and Tray Delivery	Equal variances assumed	2.156	.148	-.828	56	.411
	Equal variances not assumed			-.828	48.583	.412
Time between Insulin Administration and Tray Delivery	Equal variances assumed	3.368	.073	-.473	45	.639
	Equal variances not assumed			-.492	35.291	.625
Time between Insulin Administration and CBG	Equal variances assumed	4.790	.034	-1.092	44	.281
	Equal variances not assumed			-1.116	37.405	.271
Time between Tray to Nurse's Station and Tray to Room	Equal variances assumed	4.551	.041	1.244	29	.224
	Equal variances not assumed			1.205	14.742	.247

Table 6: Percent in Blood Glucose Range

IV * In Range Crosstabulation

Count

		Range (70-180 mg/dL)		
		In Range	Out Range	Total
IV	Control Group	15	11	26
	Test Group	11	16	27
Total		26	27	53

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	1.523a	1	.217		
Continuity Correctionb	.920	1	.337		
Likelihood Ratio	1.530	1	.216		
Fisher's Exact Test				.276	.169
Linear-by-Linear Association	1.494	1	.222		
N of Valid Cases	53				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 12.75.

b. Computed only for a 2x2 table

Table 7: Glycemic Control

Group Statistics

IV		N	Mean	Std. Deviation	Std. Error Mean
Pre-meal CBG	Control Group	29	168.2069	71.78111	13.32942
	Test Group	30	173.8667	81.34504	14.85151
Post-meal CBG	Control Group	26	171.7308	74.66863	14.64372
	Test Group	27	177.2593	90.66362	17.44822

		Levene's Test for Equality of Variances				
		F	Sig.	t	df	Sig. (2-tailed)
Pre- meal CBG	Equal variances assumed	.567	.454	-.283	57	.778
	Equal variances not assumed			-.284	56.540	.778
Post-meal CBG	Equal variances assumed	.645	.426	-.242	51	.810
	Equal variances not assumed			-.243	49.820	.809

Table 8: Hemoglobin A1C Subgroup

Group Statistics

	IV	N	Mean	Std. Deviation	Std. Error Mean
A1C≤7 + Post-meal CBG	Control Group	7	151.1429	55.86719	21.11581
	Test Group	6	147.5000	77.64728	31.69937
A1C>7 + Post-meal CBG	Control Group	18	179.6111	83.26721	19.62627
	Test Group	20	190.7000	93.61123	20.93211

		Levene's Test for Equality of Variances				Sig. (2-tailed)
		F	Sig.	t	df	
A1C≤7 + Post-meal CBG	Equal variances assumed	1.295	.279	.098	11	.924
	Equal variances not assumed			.096	8.953	.926
A1C>7 + Post-meal CBG	Equal variances assumed	.002	.962	-.384	36	.703
	Equal variances not assumed			-.386	35.997	.701

Table 9: Diet Subgroup

Group Statistics

IV		N	Mean	Std. Deviation	Std. Error Mean
Diabetic + Post-meal CBG	Control Group	19	181.8947	83.23654	19.09577
	Test Group	25	180.6400	92.47787	18.49557
Non-Diabetic + Post-meal CBG	Control Group	7	144.1429	35.08290	13.26009
	Test Group	2	135.0000	67.88225	48.00000

		Levene's Test for Equality of Variances				Sig. (2-tailed)
		F	Sig.	t	df	
Diabetic + Post-meal CBG	Equal variances assumed	.070	.793	.047	42	.963
	Equal variances not assumed			.047	40.730	.963
Non-Diabetic + Post-meal CBG	Equal variances assumed	1.949	.205	.275	7	.791
	Equal variances not assumed			.184	1.157	.881

Table 10: Meal Observed Subgroup

Group Statistics

	IV	N	Mean	Std. Deviation	Std. Error Mean
Breakfast + Post-meal CBG	Control Group	5	199.4000	92.84826	41.52301
	Test Group	4	128.0000	61.43289	30.71645
Lunch + Post-meal CBG	Control Group	21	165.1429	70.76813	15.44287
	Test Group	23	185.8261	93.17659	19.42866

		Levene's Test for Equality of Variances				Sig. (2-tailed)
		F	Sig.	t	df	
Breakfast + Post-meal CBG	Equal variances assumed	.850	.387	1.316	7	.230
	Equal variances not assumed			1.382	6.843	.210
Lunch + Post-meal CBG	Equal variances assumed	1.192	.281	-.823	42	.415
	Equal variances not assumed			-.833	40.707	.409

Group Statistics

	IV	N	Mean	Std. Deviation	Std. Error Mean
Breakfast +Time between CBG and Tray Delivery	Control Group	5	98:00	68:17	30:32
	Test Group	5	55:24	42:09	18:51
Lunch + Time between CBG and Tray Delivery	Control Group	24	22:07	26:48	05:28
	Test Group	24	46:37	74:39	15:14
Breakfast + Time between Tray Delivery and Insulin	Control Group	4	26:30	21:47	10:53
	Test Group	4	19:30	15:09	07:34
Lunch + Time between Tray Delivery and Insulin	Control Group	18	27:16	22:28	05:17
	Test Group	21	34:37	49:29	10:47
Breakfast + Time between CBG and Insulin	Control Group	4	*****	56:52	28:26
	Test Group	3	73:20	65:29	37:48
Lunch + Time between CBG + Insulin	Control Group	18	32:03	30:32	07:11
	Test Group	21	64:25	80:28	17:33

| | | Levene's Test for Equality of Variances | | | | |
		F	Sig.	t	df	Sig. (2-tailed)
Breakfast +Time between CBG and Tray Delivery	Equal variances assumed	1.142	.316	1.187	8	.269
	Equal variances not assumed			1.187	6.662	.276
Lunch + Time between CBG and Tray Delivery	Equal variances assumed	7.546	.009	-1.513	46	.137
	Equal variances not assumed			-1.513	28.832	.141
Breakfast + Time between Tray Delivery and Insulin	Equal variances assumed	.283	.614	.527	6	.617
	Equal variances not assumed			.527	5.351	.619
Lunch + Time between Tray Delivery and Insulin	Equal variances assumed	3.858	.057	-.579	37	.566
	Equal variances not assumed			-.610	28.820	.546
Breakfast + Time between CBG and Insulin	Equal variances assumed	.093	.773	.626	5	.559
	Equal variances not assumed			.611	4.041	.574
Lunch + Time between CBG + Insulin	Equal variances assumed	8.064	.007	-1.608	37	.116
	Equal variances not assumed			-1.706	26.410	.100