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Implementation of an Evidence-Based Bundle to Educate Nurses in the Care of Adult Post-Transplant Diabetes Mellitus Patients

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By

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Abstract

Background: After solid organ transplantation, between 10-40% of patients develop post-transplant diabetes mellitus (PTDM) due to the immunosuppression regimen, infection, stress response and pain. Hyperglycemia events are common and managing glycemic targets is critical to decrease the likelihood of graft failure and mortality.

Purpose: To determine the impact of an evidenced-based bundle education strategy on the perceived confidence/knowledge of nurses and on their documentation compliance in the care of adult solid organ post-transplant diabetes mellitus patients.

Methods: A single group, pretest-posttest design was implemented to evaluate the effectiveness of the electronic educational program on the nurses perceived confidence/knowledge regarding glycemic management of adult solid organ post-transplant diabetes patients. Retrospective patient chart reviews were conducted pre-and post-intervention to examine bundle element compliance discussed in the online education.

Results: A statistically significant improvement in the nurses' perceived confidence/knowledge with trending blood glucose levels in the electronic health record were noted. Compliance with individual bundle elements pre-and post-intervention were not statistically significant.

Conclusions: While limited by small sample size, the findings of this study suggest further education on the PTDM evidence-based bundle for glycemic management is warranted. Specifically, focused training on the functionality of the Glucose Monitoring Timeline would assist clinicians to track and trend the glycemic management of PTDM patients more efficiently.

In addition, continued monitoring of PTDM bundle compliance should reduce practice variations and standardize the care provided to post-transplant patients receiving insulin.

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Dedication

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Table of Contents

List of Tables

List of Appendices

Background and Significance

Post-transplant diabetes mellitus (PTDM) describes "newly diagnosed diabetes mellitus in the post-transplantation setting, irrespective of timing or whether is was present but undetected prior to transplant" (Sharif et al., 2014, p.1993). Between 10-40% of patients who have undergone solid organ transplant experience post-transplant diabetes mellitus (Chowdhury, 2019). Hyperglycemia is associated with a higher rate of graft failure and mortality and early post-operative hyperglycemia is common (Chowdhury, 2019). The treatment for PTDM is the same as Type 2 diabetes mellitus. Post-transplant patients experience higher rates of severe hypoglycemia and hyperglycemia which make managing glycemic targets challenging for nurses caring for them (Chowdhury, 2019).

Problem Statement

Glycemic management for patients after solid organ transplant, both in the immediate post-operative period and subsequent hospitalizations, is challenging due to many factors including fluctuation of kidney function, changes in nutrition status, immunosuppression medications that increase glucose intolerance and other events like infection or pain that can exacerbate insulin resistance (Boerner et al., 2015).

Context, Scope and Consequences of the Problem

Risk factors for PTDM are the same as those for Type 2 diabetes mellitus, but transplant-related risk factors include immunosuppression medications and hepatitis C or cytomegalovirus infection (Chowdhury, 2019). Additional risk factors for the development of PTDM include older age, familial history, obesity, hypomagnesemia, use of corticosteroids, and

calcineurin inhibitors (Han et al., 2016). Hyperglycemia due to stress response, infection, pain, immunosuppression and parenteral/enteral feeding is ideally managed using insulin (Chowdhury, 2019).

At the institution where the study was conducted, a Hypoglycemia No Harm committee was chartered in 2020. The goals of the committee included improving safety for patients by reducing hypoglycemia events for patients receiving insulin, review trends and drive change through evidence-based practices. In fiscal year 2023 (July 1, 2022 – June 30, 2023), the enterprise reported that 212 severe hypoglycemia events (blood glucose $\leq$ 50mg/dL) occurred with a 12-month rate of 2.78. Each week, the organization conducts a severe hypoglycemia huddle to review the causes of these events. In FY23, the most common causes for severe hypoglycemia included interruption of nutrition with no insulin adjustment, blood glucose trend not recognized, inappropriate timing of insulin administration (average time from obtaining blood glucose to insulin administration was 40.6 minutes [SD=29.2]), lack of documentation of meal consumption (50.4% [SD=29.7]), and missed opportunities to utilize the hypoglycemia prevention protocol (58.8%). Prior to this project, the post-transplant sub-group of patients with diabetes had not been evaluated independently at this institution.

The complexity of management of PTDM patients and data suggesting a lack of consistent compliance with individual elements of the nursing treatment plan led the principal investigator to "bundle" the evidence-based practice elements that should be implemented by nurses caring for post-transplant patients on insulin. The PTDM Bundle infographic was developed in the Spring of 2023 by the principal investigator. The seven elements were identified through the institution's weekly review of severe hypoglycemia events and lack of

documentation compliance noted through patient chart review. Each element was formatted so that the mnemonic “DIABETES” was developed and this educational strategy was intended to assist nurses in remembering evidence-based practices by utilizing a bundled approach. This study was designed to examine the nurses’ confidence and knowledge of glycemic management of PTDM patients admitted to the progressive level of care using a mnemonic “DIABETES” as an educational strategy.

Current Evidence-Based Interventions/Strategies Targeting the Problem

The American Diabetes Association (2019) recognizes post-transplant diabetes in a category of diabetes related to other causes (drug-or chemically- induced diabetes due to glucocorticoid use). In the PTDM population, very few studies of the use of antihyperglycemic therapies have been conducted (ADA, 2019). Insulin therapy is the recommended treatment of hyperglycemia in the hospitalized patient, including the PTDM patient (ADA, 2019). Strategies to prevent PTDM remain elusive, and it is recommended that “immunosuppression regimens are chosen based on their evidence to prolong graft survival and not to avoid PTDM” (Shivaswamy et al., 2015, p.37).

Bedside patient testing, support of a dedicated inpatient diabetes team, and utilization of standard insulin protocols will help the PTDM patient achieve and maintain glycemic targets, while reducing the risk of hypoglycemia (ADA, 2022). At the institution, the Glycemic Management team oversees the development and implementation of evidence-based protocols and order sets for the glycemic management of hospitalized patients, specific to the type of diabetes and clinical setting (ICU, acute/progressive, outpatient). Based on these clinical

protocols and order-sets, an evidence-based bundle for PTDM was developed by the principal investigator and was endorsed by this multidisciplinary team.

Purpose and Objectives

Overview of the Project Purpose

The purpose of this clinical project was to determine the impact of an evidenced-based bundle education strategy on the perceived confidence/knowledge of nurses and on their documentation compliance in the care of adult solid organ post-transplant diabetes mellitus patients.

Specifically, the objectives of this clinical project were:

a. Develop a PTDM Bundle, utilizing the mnemonic “DIABETES” to assist nurses in remembering the evidence-based bundle elements for glycemic management.
b. Educate nurses caring for PTDM patients on the evidence-based bundle elements using an online education program.
c. Evaluate nurses’ perceived confidence/knowledge via a pre-and post-implementation survey.
d. Measure documentation compliance of all PTDM bundle elements pre-and post-intervention.

Review of the Literature

Summary of Literature Search

A review of the literature was conducted using PubMed and CINAHL databases. A total of 2719 articles were located using the search terms post-transplant, diabetes, post-transplant diabetes, solid organ transplant, bundles, self-confidence. After refining the search to include adults (18 years and older) with PTDM and articles published between 2013-2023, this yielded 299 articles of which 95 were reviewed and 27 found relevant to this study. Only two of the articles describe the nursing management of PTDM in solid organ transplant and 25 focused on the causes, diagnosis, pathophysiology and medical/pharmaceutical management.

Gap Identification and Need for Proposed Practice Change

The evidence shows that in the post-transplant phase, most patients will experience hyperglycemia due to the use of glucocorticoids and calcineurin inhibitors for immunosuppression. Even though hyperglycemia increases the risk of graft failure and mortality, the evidence strongly supports the use of immunosuppression regimens despite the increased risk of developing PTDM (ADA, 2019; Boerner et al.,2015; Chowdhury, 2019; Shivaswamy et al., 2016; Ahmed et al., 2020; Sharif et al., 2014). The treatment recommended for PTDM is the same as Diabetes Mellitus Type 2 (DMT2), with insulin being widely used to meet glycemic targets of hospitalized patients. Published guidelines recommend the use of subcutaneous insulin and basal bolus regimens in non-critically ill diabetic patients, with a target blood glucose range between 140-180 mg/dL. Hypoglycemia (blood glucose $\leq$70 mg/dL)

in the inpatient setting at the institution can be attributed to failures in insulin prescribing, blood glucose monitoring, timing of insulin administration, as well as, nutritional factors. The evidence supports the use of standard protocols for insulin administration and hypoglycemia treatment, matching nutritional intake to insulin dosing, and tracking/trending blood glucose measurements to avoid hypoglycemia through regimen adjustment (ADA, 2022; Atkinson et al., 2021). All articles discovered in this literature review that discussed reduction in hypoglycemia were focused on patients with DMT2, and there is a gap in exploring interventions specifically in the post-transplant diabetes mellitus patient population.

Many of the studies implemented an electronic platform to track/trend hypoglycemic events, standardized approaches to identify root causes and/or utilized clinical decision support tools to aid in the reduction of hypoglycemic events (Sinha Gregory et al., 2018; Cobaugh et al., 2013; Milligan et al., 2015; Cruz et al., 2017). Standardized order sets and protocols have been implemented in the electronic medical record (EMR) at the institution of interest in this project. Embedded in the EPIC EMR is the Glucose Monitoring Timeline report to assist the clinicians in tracking and trending blood glucose results. In addition, a corresponding date/time of the administration of medications that can influence blood glucose is displayed and meal consumption documentation can be viewed. However, many of the clinicians are unaware of this functionality since it is not a part of the EPIC EMR introductory training and education.

In 2012, the Institute for Healthcare Improvement (IHI) developed the concept of a bundle and stated a bundle was “a small set of evidence-based interventions for a defined patient segment/population and care setting that, when implemented together, will result in

significantly better outcomes than when implemented individually" (Resar et al., 2012, p.2). Per the IHI, bundle compliance was evaluated by the documentation of adherence to all elements of the bundle unless medically contraindicated (Resar et al., 2012). One article reported using a "bundled" interdisciplinary approach to inpatient glycemic management for non-ICU patients but lacked the specificity for PTDM (Maynard, et al., 2015).

With the prevalence of diabetes continuing to rise, nurses have the responsibility to provide care to these individuals (Yacoub et al., 2015). There is compelling evidence that nurses report knowledge deficits regarding clinical aspects of diabetes care including types of insulin, trending of blood glucoses, treatment of hypoglycemia, and the impact of diet and nutrition (Yacoub et al., 2015; Alotaibi et al., 2018). The literature supports providing education to nurses regarding evidence-based care of patients with diabetes using different modalities such as in-person didactic classroom, online modules, and printed material (Alotailbi et al., 2018; Coonfare and Miller, 2020; Yacoub et al., 2015; Eaton-Spiva & Day, 2011). None of the studies explored education and the impact on nurses' perceived confidence/knowledge regarding PTDM specifically.

Theoretical/Conceptual Framework

The Iowa model of Evidence-Based Practice to Promote Quality provided the theoretical framework for this clinical project. The simplicity of the Iowa model promotes clarity and understanding for all clinicians and it is used by many academic and healthcare settings. In 2017, The Iowa Model Collaborative revised and validated the model utilizing feedback via an electronic survey (Buckwalter et al., 2017). The steps of the Iowa Model include identification

of problem-and knowledge-focused triggers, establishing if the topic is a priority for the organization, forming a team, performing a review of the literature, verifying there is sufficient research for use in practice, piloting the change in practice, evaluating whether the change is appropriate for adoption into practice, monitoring and analyzing the structure, process and outcome data and finally, disseminating results (Titler, et al., 2001). The application of the original Iowa Model was demonstrated through all phases of this project.

Methods

Design

A quasi-experimental, one group, pretest-posttest design was implemented to evaluate the effectiveness of the educational program on the nurses perceived confidence/ knowledge regarding glycemic management of adult solid organ post-transplant diabetes patients. An evaluation of clinician adherence to the PTDM Glycemic Management bundle was determined by pre-and post-intervention documentation of the care received by PTDM patients.

Setting

Agency Description

The setting of the study included two acute/progressive units caring for adult, solid organ post-transplant diabetes patients at an urban, 991-bed academic medical center located in central Kentucky. The Transplant Center performed the most transplants in calendar year 2022 in the institution and the state's history. For more than 10 years, the academic medical

center has remained both the largest transplant and donor hospital in the state, performing more than 200 solid organ transplants each year.

At this institution, post -heart and/or lung transplant patients are admitted to the cardiovascular progressive unit and post-kidney and/or liver transplant patients are admitted to the surgical progressive unit. Typically, nursing care technicians perform point-of-care blood glucose checks as meal trays are delivered on the unit. The blood glucose results from the glucometers are synchronized with the electronic medical record (EMR), with an automatic date and time stamp. Blood glucose results are manually entered into the EMR as a redundancy for unanticipated issues with the glucometer synchronization. Correction insulin (dose based on pre-meal glucose results) and prandial insulin (based on percentage of meal consumption) are usually administered together by the nurse using a barcode label printed at the automated dispensing unit. The barcode label is scanned at the bedside for patient safety immediately prior to administration. The insulin type, dose administered, date and time are automatically uploaded into the EMR.

Congruence of Project to Selected Agency's Mission/Goals/Strategic Plan

The stated mission, vision and values of the organization are centered around a commitment to create a healthier Kentucky. The mission of the organization includes the pillars of research, education, and clinical care. A strategic objective of the agency is to provide safe care and reduce patient safety events. Hypoglycemia in patients receiving insulin is one of the metrics being monitored in the institution, with dedicated teams focused on this initiative. This

project aligns with the agency's mission, goals and strategic plan both at the nursing and enterprise level.

Description of Stakeholders

A meeting with the key stakeholders for this project was conducted in-person, with a virtual option on April 6, 2023. These individuals included the transplant providers on the acute/progressive treatment team, the nursing leadership team (Director, Patient Care Manager, Assistant Patient Care Manager, Clinical Nurse Specialist and Staff Development Specialist) for the two adult inpatient acute/progressive units, the diabetes clinical nurse specialist, a member of the inpatient endocrine team, the endocrine team pharmacist, transplant coordinators, and the transplant dietician. The roles and responsibilities of these stakeholders were to evaluate and endorse the bundle elements of the project and support the nurses in adopting the bundle elements into standard practice. Patients and families receiving PTDM care are the ultimate stakeholders.

Site-Specific Facilitators and Barriers to Implementation

There were several facilitators to the project implementation, including the patient admission to a specific progressive unit where nurses routinely provide care to patients who have received a solid organ transplant. One of the inpatient areas is a 32-bed acute/progressive unit which is a part of the Cardiovascular Service Line. The unit has a Patient Care Manager, Assistant Patient Care Manager, a Staff Development Specialist, a Clinical Nurse Specialist and a Charge Nurse. The average patient to nurse ratio is 3-4 patients assigned to one nurse. The staff

are familiar with caring for patients post heart and/or lung transplant. On average, 7-10 post-transplant patients are on the unit. The principal investigator was familiar to the staff and leadership team who helped facilitate open communication with the staff about the goals and requirements of this EBP project. This staff group has participated in Enterprise Hypoglycemia No Harm Committee for three years and have adopted some practices to reduce hypoglycemia for all diabetic patients on the unit, not just PTDM patients. The principal investigator, previous to this project, provided guidance to the nurses regarding glycemic management upon request. This patient population is admitted to the unit for frequent, sometimes, extended stays and is known to be at high risk for severe hypoglycemia events.

The other progressive inpatient unit is a 20-bed universal unit that cares for kidney, liver and pancreas transplant patients. The leadership team and nurse-patient ratios are similar. Another facilitator to implementation of this EBP projection was the support of the two clinical nurse specialists for the trauma/surgical service line. The two clinical nurse specialists assisted by validating the nurse pre/post survey, previewing the Post-Transplant Diabetes Mellitus Evidence-Based Bundle for Glycemic Management infographic, as well as, reminding staff to participate in the EBP project. This unit has not participated on the Enterprise Hypoglycemia No Harm Committee.

Barriers to project implementation included unit staff workload, staff perception of increased workload resulting from bundle, staff temporarily assigned to unit but not included in online education, and the complexity of glycemic management for PTDM patients.

Sample

Target Population

The target population of this intervention was the nurses on the two identified units that routinely care for acute/progressive adult PTDM patients. A total of 93 nurses were invited to participate. Inclusion criteria included: any nurse hired into a full-time, part-time, weekend (WEPP) or per diem position on one of the two identified units as a bedside clinician. Traveler/agency staff with regular assignments on the two units of interest were also invited to participate. Participation was voluntary and no exclusions were made for age or years of experience. Exclusion criteria included float pool staff or a staff nurse temporarily assigned to one of the identified units.

Procedure

IRB Approval

After completing human subject protection training including the responsible conduct of research and biomedical investigators and key personnel through the University of Kentucky's Office of Research Integrity, the institutional review board (IRB) submission process was filed electronically. Approval under IRB# 89346 was obtained on September 13, 2023. A waiver of authorization related to HIPAA privacy rules was included in the IRB approval allowing the principal investigator to retrospectively review the medical record for baseline and post-intervention data of PTDM patients admitted to the progressive units. Additionally, support was obtained by the Nursing Research Council at the institution as well as the nursing directors of both service lines.

Description of Evidence-Based Intervention

The principal investigator advertised the study via email and in-person staff huddles/meetings to provide information about the study and inform the staff that they would receive an invitation to voluntarily participate. An electronic survey was emailed to all eligible nurses (see Appendix A). By clicking on the survey, the participant was given access to a document that outlines the purpose, methods, risks/benefits, an overview of the intervention and contact information of the principal investigator. Completion of the survey was considered consent to participate. To fulfill the study requirements, the participants completed a pre-test survey measuring perceived confidence/knowledge of glycemic management of PTDM patients, a pre-recorded voice-over web-based training session and a post-test survey identical to the pre-test. The link to the web-based education was available to all nurses regardless of whether they completed the pre-survey. The pre-test/post-test surveys were electronically formatted using Qualtrics (see Appendix B). Weekly emails including the pre/post survey were sent to eligible participants to encourage participation during both time periods. The participants were able to withdraw or not complete any of the surveys or web-based training at any time.

Measures and Instruments

Two identical surveys were used for data collection with the nurse participants. The pre/post-survey was developed by the primary investigator and reviewed by nurses familiar with general glycemic management, but not part of the sample, to test for inter-reliability. At the start of the pre-test/post-test survey, the participant was asked to create a unique ID to

pair pre/post surveys. The only demographic information solicited on the surveys was years of nursing experience in current position.

The principal investigator conducted retrospective chart audits of adult post-transplant patients admitted to the identified units for demographic information and six elements of bundle for compliance 1.) documentation of meal consumption; 2.) median time from obtaining blood glucose to insulin administration; 3.) endocrine consult for patients receiving insulin; 4.) documentation of 5-day calorie counts for patients receiving insulin; 5.) notification of endocrine team/primary provider for changes in nutritional status or other glycemic-related issues; and 6) implementation of the hypoglycemia prevention protocol or hypoglycemia treatment protocol. The retrospective chart audits were evaluated for admission three months prior to intervention for baseline data to establish current practice (May 15, 2023 – June 30, 2023) and repeated six weeks post-intervention (November 15, 2023 – December 31, 2023).

Data Collection

The nurse pre-and post-survey were collected via Qualtrics and paired by unique identifier provided by the participant.

The Center for Clinical and Translational Services (CCTS) in accordance with IRB approval, identified patient encounters of adult, post-transplant patients admitted to either designated progressive inpatient unit three months prior to the intervention or six weeks post-intervention. Both lists were encrypted and sent to the primary investigator. A data collection tool, developed by the primary investigator, was used to perform chart audits on each

encounter that met inclusion criteria (see Appendix C). For post-transplant patients who had more than one admission in the pre-and/or post-intervention time period, each encounter was evaluated independently using the data collection tool.

The primary investigator noted whether or not the patient had an order for insulin and whether a dose of insulin was administered during the encounter. If insulin was ordered, an endocrine consult was expected, as well as, endocrine/provider notification of glycemic issues. If at least one dose of subcutaneous insulin was administered, the median time from blood glucose result to insulin administration was noted. If the route of insulin administration was by intravenous infusion, the median time was not included in the data set. The documentation of percentage of meals consumed was expected in patients with an oral diet ordered, excluding enteral nutrition. Glycemic ranges of 71-89 mg/dL, 51-70mg/dL and less than 50mg/dL were included if the patient received at least one dose of insulin. Documentation of the corresponding hypoglycemia prevention and hypoglycemia treatment protocols were included for any events that were noted in the previous ranges.

Data Analysis

Data analysis was performed using SPSS. Descriptive statistics were used to identify nurses perceived confidence/knowledge of post-transplant diabetes glycemic management. A paired sample t test was used to measure the difference between matched pre-test and post-test score. The data were evaluated and presented as a mean and standard deviation, with the *p* value considered significant if <0.05.

Descriptive analysis was performed on patient encounter demographic data. All admissions of post-transplant patients on both units within the time frames were included in the analysis. Some patients had more than one hospital encounter within the pre/post-intervention time frames. The continuous variables of age, median time from blood glucose result to insulin administration and documentation of meal consumption were evaluated and reported as a mean and standard deviation. Categorical variables race, ethnicity, gender, type of transplant, initial transplant admission, diabetes type, insulin ordered, endocrine consult and notification of endocrine/provider were evaluated and reported as numbers and percentages.

Results

Demographics and Findings

Four of the nurses (*N*=8) who completed both a pre/post survey reported they worked in their present position for 3-5 years. The remaining responses (n=4) were spread across each of the other four response options. The participants were asked to rate their perceived confidence/knowledge regarding PTDM and the bundle elements using a 5-point Likert scale 1 "not confident at all" to 5 "extremely confident". The pre/post survey confidence/knowledge scores ranged from 2 – 5 on the Likert scale. A paired samples *t*-test was conducted and found the post survey mean scores increased for all five questions, with a statistically significant increase with the question "I am confident that I can trend the blood glucose levels of the patient using the EPIC electronic medical record" (Pre-intervention Mean = 4.13, SD = 0.64; Post-intervention Mean = 4.63, SD = 0.52, p = .03, see Table 1).

There were 170 hospital encounters included in this analysis; 78 and 92 encounters pre- and post-intervention, respectively. There were 63 and 80 unique patients in each of the time periods, with a range of 1-3 encounters and 1-4 encounters per patient in each time period. Across both time periods, 32 (18.8%) encounters were initial transplant visits (patient received solid organ transplant during that encounter).

The average age of the transplant patient study population was 55.0 years (SD=12.4) and 55.5 years (SD=13.0, see Table 2). For both time periods, the majority described themselves as white (92.3% and 84.8%), and non-Hispanic (97.4% and 95.7%). The majority of transplant patients were male for both time periods (65.4% and 58.7%, respectively). Lung transplant hospital encounters were the most common type of transplant for both time periods (37.2% and 44.1%, respectively). Nearly 1/3 of the patient encounters did not have a diagnosis of diabetes mellitus, while 48.7% of the pre-intervention encounters and 33.7% of the post-intervention encounters had a diagnosis of steroid induced hyperglycemia (SIH) or PTDM, which mirrors the incidence of PTDM found in the literature. Insulin was ordered for the majority of the total transplant population examined over both time periods (66.7% and 68.5%, respectively).

Independent samples t-tests were performed on the data and found there was a non-statistically significant decrease in the average median time from blood glucose result to insulin administration from the pre-intervention (36.9 minutes [SD=30.4]) to the post-intervention time frame (35.2 minutes [SD=18.7], see Table 3). There was a non-statistically significant

decrease in the percent documentation of meal consumption from pre-intervention to the post-intervention time frame (50.4 [SD=29.7] and 41.8 [SD=26.4], respectively.

The endocrine service was consulted around 50% of the time for both time periods. There was no statistically significant increase in notification of endocrine/provider regarding glycemic management issues (15.4% and 22.2%, see Table 3). There were 17 and 21 encounters, respectively, where the patient received insulin and experienced blood glucose levels of 71-89 mg/dL. There was a non-statistically significant improvement of the hypoglycemia prevention protocol documented- in the pre-intervention period (41.2%) compared to the post-intervention period (47.6%). The total number of hypoglycemic events (blood glucose result of 51-70 mg/dL) was very similar in both time periods. Documentation of the implementation of the hypoglycemia treatment protocol was 80% or better for each time period. One severe hypoglycemia (blood glucose $\leq$50 mg/dL) event occurred in the post-intervention time frame.

Discussion

The first aim of this study was to develop the PTDM bundle. The principal investigator proposed that by utilizing the mnemonic, “DIABETES”, that nurses would remember the evidence-based elements for glycemic management (Appendix D). Fulbrook and Mooney (2003) published a process for developing a new care bundle, stressing the importance of identifying a cluster of evidence-based practices within a theme which are supported by the literature. Nurses at the institution are familiar with the concept of care bundles, although there is not a bundled approach in the care of patients with diabetes or PTDM. The PTDM

Bundle for glycemic management incorporated seven evidence-based interventions that were organized with the mnemonic “DIABETES”. The IHI recommends that a care bundle should have no more than five interventions (Resar et al.,2012). Gilhooly et al., (2019) reported most bundles they reviewed included seven elements and found using fewer elements was associated with better compliance. Based on the overall poor bundle compliance in this study, it may be beneficial to reduce the number of elements in the PTDM bundle. One of the PTDM bundle elements, “Blood glucose performed when meal trays arrive on the floor” was included in the bundle to reduce the likelihood that prandial insulin doses were given more than 60 minutes from blood glucose result. This element of the bundle proved difficult to individually measure by the principal investigator due to variability of tray delivery on the identified units, although it can be an expectation of staff caring for PTDM patients receiving insulin.

The second aim of this study was to educate nurses on the PTDM bundle by introducing the mnemonic “DIABETES” via online education. The nurses were able to access the PTDM bundle online education electronically since it was embedded at the end of the pre-survey. This approach was used to allow nurses who worked on the identified units to access the bundle education regardless of whether or not they wanted to participate in the study. It is unknown how many individual nurses accessed the web-based education on each unit. Eaton-Spiva and Day (2011) used a similar approach to their study, which reported a slight improvement in nurses’ knowledge, skill and confidence related to diabetes, but no statistically significant differences, after an online education.

The third aim of this study was to evaluate the perceived confidence/knowledge levels of nurses who care for adult PTDM patients before and after an online educational intervention. There was only question on the survey that demonstrated a statistically significant improvement- "I am confident that I can trend blood glucose levels of the patient using the EPIC electronic health record". The educational intervention included a tutorial on how to trend blood glucose levels in the EPIC electronic medical record using the Glucose Monitoring Timeline (GMT) tab. Since the GMT is not taught in the introductory EPIC documentation courses, many staff nurses are unaware of this functionality. Studies report an increase in nurses' knowledge after an education intervention, but barriers at the individual level (lack of interest, scheduling issues, lack of clinical experience) and at the organization level (staff shortages, lack of access to resources, missed opportunities to attend a class, poor interprofessional communication) impacted their acquisition of diabetes knowledge (Alotailbi et al., 2018). Since there were only 8 paired responses for this study, the individual and organizational level barriers likely impacted the response rate.

The last aim of this study was to measure documentation compliance with all of the PTDM evidence-based bundle elements in the pre and post-implementation time periods, examining all of the transplant encounters on both units. The study did not find any statistically significant differences on the compliance of the bundle elements between the pre/post time periods. These findings may be attributed to the fact that the cardiovascular progressive unit, who care for the heart/lung transplant patients, had participated in the Hypoglycemia No Harm committee for three years prior to the study period. Some of the elements of the PTDM bundle had been a focus of quality improvement activities on the cardiovascular progressive unit, but

had never been “bundled” to improve consistency in practice. Resar and colleagues (2012) recommend “measuring compliance with each bundle element, as well as all-or-none compliance, is the first step in building a reliable system” (p.4).

Interestingly, the median time from blood glucose result to insulin administration for both time periods was well below the institution target of less than 60 minutes. This institution allows a 60-minute timeframe for all medication administration, including insulin. There is no published recommendation for a target time frame. In their study, Alwan and colleagues (2017) reported the median time from breakfast blood glucose result to administration of insulin was 93 minutes. One of the documented reasons for hypoglycemia in patients receiving insulin includes inappropriate timing of rapid acting insulin in relation to meals (Alwan et al., 2017; Cobaugh et al., 2013). The rapid acting insulin on formulary at the institution acts within 15 minutes of administration and has effects that last 2-4 hours. The coordination of meal delivery, blood glucose measurement and insulin administration should allow ample time for the PTDM patient to eat the meal. The prandial insulin orders, per the institution’s order set, recommend holding insulin if the patient consumes 50% or less of the meal. The lack of documentation of meal consumption may be due to a number of factors such as variability in patient eating patterns, patients eating food brought in to the hospital, both the nurse and the nursing care technician assuming the other has documented the information and/or the trays being picked up/disposed of before the meal consumption percent can be calculated.

In October 2023 during the post-intervention time frame, the institution added a field in the prandial insulin section of the medication administration record for the nurse to document

the percentage of meal consumption. This has been reported by nurses as a more efficient way to ensure the meal percentage is known and documented in order to administer the appropriate amount of prandial insulin coverage. It would be beneficial to highlight this improved functionality within the bundle education.

Around 50% of the post-transplant patients receiving insulin had a consultation of the endocrine service for glycemic management. If all of the PTDM patients receiving insulin had an endocrine consult, the number of patient encounters would double from 25-30 consults to upwards of 60 consults. Prior to mandating the endocrine consult for PTDM patients, workload and resources of the endocrine service would need to be evaluated to determine the feasibility of such an initiative.

The study examined the patient record for documentation of endocrine/provider notification for glycemic events and found only 8 times in the pre-intervention period and 14 times in the post-intervention were documented. This low rate of notification may be attributed to face-to-face communication with the providers in rounds, notification via EPIC chat messages or there were no issues to report, thus making it difficult to ascertain how many missed opportunities of communication occurred during the study periods.

In November 2023, also during the post-intervention period, the institution launched best practice advisories (BPA) for patients receiving insulin who had a documented blood glucose result within three distinct ranges (less than 50 mg/dL, 51 -70 mg/dL and 71 -89 mg/dL). Each blood glucose range BPA has specific instructions for the clinician to treat and recheck/monitor the blood glucose based on standard protocols. Data are being collected to

evaluate the effectiveness of the BPA alerts and clinician response, in addition to patient outcomes such as reduced severe hypoglycemia events.

Implications for Practice, Education, Policy, and Research

Implications for practice include using a bundled approach to improve consistent implementation of key evidence-based practices related to the glycemic management of PTDM patients. Nurses at the institution are familiar with evidence-based bundles and this approach may promote the increased compliance with all bundle elements to reduce harm and improve patient outcomes. Monitoring for bundle compliance of individual elements and the bundle as a whole, would assist the individual units and the institution on developing strategies to address barriers to reliable care processes.

With regards to requiring a consult of the endocrine service for any post-transplant patient receiving insulin, the institution would need to explore the feasibility of this initiative and the downstream effects on the workflow and resources of the endocrine team. One option may be if the PTDM patient is not within the target range of 140-180 mg/dL within 48 hours of admission or experiences a severe hypoglycemia event, the primary team should consult the endocrine service for glycemic management.

The implications for education from this study identified that using one modality (online education) allowed only passive education of the nurses. In addition, the nurses had to access the pre-survey to view the online education. In the future, the institution could provide post-transplant diabetes education to the nurses through a variety of methods such as in-person

programs, online modules, print materials, case studies and simulation. Educational barriers at the individual and organizational levels should be fully explored and addressed. It is believed by this researcher that impact of a more robust, mandatory multi-modality educational strategy of the PTDM Bundle could be an area of interest for future study.

The nurses at the institution receive focused training on documentation in the EMR upon hire. There is minimal training on the functionality and reports contained within the EMR which leads to a lack of awareness of the Glucose Monitoring Timeline (GMT). This study reported statistically significant improvement in nurses' perceived confidence/knowledge scores after reviewing the educational intervention which provided a guided tutorial of the GMT. It is believed by the researcher that all clinicians should receive focused education on the GMT to promote trending the blood glucoses with corresponding medication administration that can impact blood glucoses, treatment of hypoglycemia, as well as, documentation of meal consumption.

To reduce the timing of blood glucose to insulin administration as well as assist with the trending of blood glucose results, it may be beneficial to explore the utilization of continuous glucose monitors (CGMs). The institution's lab accreditation standards mandate that only blood glucose results obtained by point-of-care glucometers may be used to treat patients while they are hospitalized. Many patients with diabetes wear CGMs and safely trend and treat their blood glucose results at home. During the COVID-19 pandemic, the standards were loosened to allow CGM results to be used to trend and treat blood glucoses to decrease clinician exposure. Currently, the mandate has been reinstated, and the institution has returned to the point-of-

care process that relies on the nurse to track, trend and treat blood glucoses from single, moment-in-time results. Hospitals could partner with the American Diabetes Association and other industry partners to examine the rates of severe hypoglycemia during the pandemic while using CGM to help shape policies that could impact the rates of severe hypoglycemia events for any inpatient receiving insulin, including post-transplant patients.

Limitations

Nurse turnover, as well as, staff not routinely assigned to the study units who did not participate in the educational intervention were limitations to this study. With respect to the nurse survey, there was a very small sample of nurses who completed both the pre-and post-survey. It is possible that those nurses who took the pre-survey viewed the online education but did not complete the post-survey. Barriers and facilitators affecting nurses' acquisition of knowledge cannot be discounted.

The nurses on the cardiovascular progressive unit, who care for the heart and lung transplant patients have participated on the Enterprise Hypoglycemia No Harm Team for three years. Individual elements of the PTDM bundle have been included in quality improvement activities for this unit and may be a confounding variable to the results reported in this study. In addition, the researcher is the clinical nurse specialist for this unit and assisted with the hypoglycemia quality improvement activities on the unit.

Unfortunately, during the study period the institution's cafeteria was undergoing renovation and only able to offer a limited menu to the patients. Most transplant patients have

a restricted menu and received both cold breakfast and lunch meals, with the dinner meal being the only "hot" meal served. This could have prompted an observed increase in the amount of food brought in to the patient that made it more difficult to track meal consumption and timing of prandial insulin. Not only did the construction impact menu options, it also contributed to variation in tray delivery times.

Another limitation to this study was the documented inconsistency of the printer for bar code medication administration. When the nurse is selecting "insulin" in the medication dispensing cabinet, they are prompted to select the insulin and dose so that a bar code sticker will print and be attached to the insulin syringe. The insulin dose is based on the pre-prandial blood glucose result and the percentage of meal consumption. This bar code is scanned at the patient bedside immediately prior to insulin administration and is reflected in the MAR as the time the insulin was given. Multiple nurses noted a non-functioning printer on the MAR when documenting why the insulin was administered outside the 60-minute window.

Conclusion

The purpose of this study was to examine the impact of an online educational program on the confidence/knowledge levels of nurses caring for PTDM patients and on the documentation compliance with seven evidence-based bundle elements. Due to small number of nurses participating in the study, survey results pre-and post-intervention were not statistically significant except for the survey question regarding the use of the Glucose Monitoring Timeline in EPIC. Pre-and post-intervention bundle compliance was not statistically significant when comparing all transplant encounters. These findings suggest that mandatory,

multimodal, targeting bundle education for all nurses caring for post-transplant patients receiving insulin could be improve PTDM bundle compliance and patient outcomes.

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Tables

Table 1

Pre/Post education survey for nurses (N=8)

	Pre-education *Mean* (SD)	Post-education *Mean* (SD)	*p*
I am confident that I can list causes of diabetes mellitus in the post-transplant patient	3.75 (0.46)	4.13 (0.64)	.20
I am confident that I can explain the timing and effects for basal, correction and prandial insulin administration.	3.50 (0.54)	4.00 (0.76)	.10
I am confident that I can verbalize the rationale for meal consumption documentation.	3.88 (0.84)	4.38 (0.52)	.10
I am confident that I can trend the blood glucose levels of the patient using the EPIC electronic medical record	4.13 (0.64)	4.63 (0.52)	.03
I am confident that I can implement the UK Healthcare Hypoglycemia Prevention Protocol and the Hypoglycemia Treatment Protocol.	3.88 (0.99)	4.38 (1.06)	.10

Note: Response options range from 1 “Not confident at all” to 5 “Extremely confident”.

Table 2

Sociodemographic and clinical characteristics of the study patient encounters

	Pre-Intervention (*n*=78) *Mean* (SD) or *n* (%)	Post Intervention (n=92) *Mean* (SD) or *n* (%)
Age	55.0 (12.4)	55.5 (13.0)
Race		
White	72 (92.3%)	78 (84.8%)
Black	4 (5.1 %)	13 (14.1%)
Asian	1 (1.3%)	0 (0%)
Multiracial	1 (1.3%)	0 (0%)
Ethnicity		
Non-Hispanic	76 (97.4%)	88 (95.7%)
Hispanic	2 (2.6%)	4 (4.3%)
Gender		
Male	51 (65.4%)	54 (58.7%)
Female	27 (34.6%)	38 (41.3%)
Transplant Type		
Heart	13 (16.7%)	10 (10.9%)
Lung	29 (37.2%)	41 (44.6%)
Kidney	2 (2.6%)	24 (26.1%)
Liver	25 (32.1%)	12 (13.0%)
Kidney/Liver	7 (9.0%)	1 (1.1%)
Heart/Kidney	1 (1.3%)	3 (3.3%)
Lung/Kidney	1 (1.3%)	1 (1.1%)
Initial Transplant Admission		
No	63 (80.8%)	75 (81.5%)
Yes	15 (19.2%)	17 (18.5%)
Diabetes Type		
No Diagnosis of Diabetes	23 (29.5%)	35 (38.0%)
Type I	0 (0%)	2 (2.2%)
Type II	12 (15.4%)	20 (21.7%)
SIH/PTDM	38 (48.7%)	31 (33.7%)
CFRDM	3 (3.8%)	4 (4.3%)
LADM	2 (2.6%)	0 (0%)
Insulin ordered during encounter		
No	26 (33.3%)	29 (31.5%)
Yes	52 (66.7%)	63 (68.5%)

Abbreviations: SIH/PTDM =Steroid Induced Hyperglycemia/Post-Transplant Diabetes Mellitus; CFRDM = Cystic Fibrosis Related Diabetes Mellitus; LADM = Latent Autoimmune Diabetes Mellitus

Table 3

Clinical Characteristics of study transplant patient encounters where insulin was ordered

	Pre-Intervention (*n*=52) *Mean* (SD) or *n* (%)	Post Intervention (*n*=63) *Mean* (SD) or *n* (%)
Average median time from BG to insulin administration (minutes)	36.9 (30.4)	35.2 (19.2)
Mean time from BG to insulin administration (minutes)	40.6 (29.2)	37.3 (18.7)
Meal consumption documented with diet ordered (percentage)	50.4 (29.7)	41.8 (26.4)
	n (%)	*n* (%)
Endocrine consulted		
No	26 (50.0%)	34 (54.0%)
Yes	26 (50.0%)	29 (46.0%)
Endocrine/Provider notification for glycemic issues		
No	44 (86.4%)	49 (77.8%)
Yes	8 (15.4%)	14 (22.2%)
	(*n*=49)	(*n*=57)
Patient with BG 71-89 mg/dL		
No	32 (65.3%)	36 (63.2%)
Yes	17 (34.7%)	21 (36.8%)
Hypoglycemia Prevention Protocol documented		
No	10 (58.8%)	11 (52.4%)
Yes	7 (41.2%)	10 (47.6)
Patient with BG 51-70 mg/dL		
No	44 (89.8%)	51 (89.5%)
Yes	5 (10.2%)	6 (10.5%)
Hypoglycemia Treatment documented		
No	1 (20.0%)	1 (16.7%)
Yes	4 (80.0%)	5 (83.3%)

Appendix A

Cover Letter with Link to Electronic Survey and Online Education

To: UKHC Progressive Care Nurses:

Researchers at the University of Kentucky are inviting you to take part in an online survey about glycemic management of post-solid organ transplant patients diagnosed with diabetes mellitus in the progressive care setting at UK Chandler Hospital.

Although you may not get personal benefit from taking part in this research study, your responses may help us understand more about clinician knowledge and attitudes with respect to glycemic management in the post-transplant diabetes patient. Some volunteers experience satisfaction from knowing they have contributed to research that may possibly benefit others in the future.

Researchers will review and collect information from your completed surveys. If you do not want to be in the study, there are no other choices except not to take part in the study. This is a 2- part survey/questionnaire and will take about 5 minutes to complete each survey. After completion of the initial survey, you will have the opportunity to view an online education on glycemic management of the post-transplant diabetes patient. The second survey will be sent out 4-10 weeks after the initial survey. The online education will take approximately 15 minutes to complete. Researchers will also review medical record data before and after the online education.

There are no known risks to participating in this study.

Your responses to the surveys are anonymous which means no names, IP addresses, email addresses, or any other identifiable information will be collected with the survey responses. We will not know which responses are yours if you choose to participate. You will be asked to provide a unique identifier on the survey (i.e. Mother's maiden name & birth date- Smith0929) to allow researchers to correlate both surveys.

We hope to receive completed questionnaires from about 150 people, so your answers are important to us. Of course, you have a choice about whether or not to complete the surveys/questionnaires, but if you do participate, you are free to skip any questions or discontinue at any time. You will not be penalized in any way for skipping or discontinuing the survey.

Please be aware, while we make every effort to safeguard your data once received from the online survey company, given the nature of online surveys, as with anything involving the Internet, we can never guarantee the confidentiality of the data while still on the survey company's servers, or while en route to either them or us. It is also possible the raw data collected for research purposes will be used for marketing or reporting purposes by the survey/data gathering company after the research is concluded, depending on the company's Terms of Service and Privacy policies.

If you have questions about the study, please feel free to ask; my contact information is given below.

Thank you in advance for your assistance with this important project. To ensure your responses/opinions will be included, please submit your completed survey/questionnaire by November 20, 2023.

To complete the survey, please click on this link in Chrome: https://uky.az1.qualtrics.com/jfe/form/SV_3z22NE2ycL71KgS

Sincerely,

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If you have complaints, suggestions, or questions about your rights as a research volunteer, contact the staff in the University of Kentucky Office of Research Integrity at 859-257-9428 or toll-free at 1-866-400-9428.

Appendix B

Pre/Post Intervention Survey for Nurses

Set up unique ID to compare with post-intervention survey. Suggestion: mother's maiden name and date of birth (i.e Smith0920)

Years in present position:

a. < 1 year
b. 1-2 years
c. 3-5 years
d. 6-10 years
e. >10 years

Please select the number that best describes your confidence level with the following concepts regarding the care of diabetes in the post-transplant population.

	Not Confident at all 1	Slightly Confident 2	Moderately confident 3	Very Confident 4	Extremely Confident 5
I am confident that I can list causes of diabetes mellitus in the post-transplant patient					
I am confident that I can explain the timing and effects for basal, correction and prandial insulin administration.					
I am confident that I can verbalize the rationale for meal consumption documentation.					
I am confident that I can trend the blood glucose levels of the patient using the EPIC electronic medical record					
I am confident that I can implement the UK Healthcare Hypoglycemia Prevention Protocol and the Hypoglycemia Treatment Protocol.					

Appendix C

Retrospective Patient Medical Record Data Collection Tool

Type of Transplant Heart Lung Kidney Liver Pancreas Other

Patient Age

Patient Race

Patient Ethnicity

Patient Gender

Patient LOS (entire hospitalization)

Patient LOS (on progressive unit)

Patient BMI

Last Hgb A1c documented (Date/Time)

Insulin regimen: Nurse administered IV or SQ; patient administered via insulin pump

Insulin administration while admitted on progressive unit:

Date	Time of Blood Glucose reading	Time of Insulin Administration	Total minutes

Blood glucose range during progressive unit admission

Blood Glucose reading 71-89mg/dL YES NO If yes, was Hypoglycemia Prevention Protocol implemented? YES NO

Blood Glucose reading 51-70mg/dL YES NO If yes, was Hypoglycemia Treatment Protocol implemented? YES NO

Blood Glucose reading ≤50mg/dL YES NO If yes, cause of severe event per RCA _____

Documentation of % Meal Consumed/Number of Meals (exclude when NPO)

Date	Breakfast	Lunch	Dinner	Snacks	Total (5)

Calorie Counts completed for 5 Days: YES NO

Endocrine consulted during admission: YES NO

Any documentation of provider notification regarding glycemic management? YES NO

If yes, what was communicated?

Less than 50% meals consumed X2 in 24 hours

NPO status

Patient refused dose

Severe Hypoglycemia event (Blood glucose result ≤50 mg/dL))

Hyperglycemia event (Blood glucose result >400 mg/dL)

Patient request different insulin dosage

Other _____

Appendix D

PTDM Bundle Infographic