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Diabetes Education Revisited: Addressing Inpatient Diabetes Care Through An Interactive Educational Video Module For Registered Nurses

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DIABETES EDUCATION REVISITED: ADDRESSING INPATIENT DIABETES CARE THROUGH AN INTERACTIVE EDUCATIONAL VIDEO MODULE FOR REGISTERED NURSES

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This DNP Project is accepted in partial fulfillment of the requirements for the degree Doctor of Nursing Practice.

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Chapter 1

Introduction

The prevalence of diabetes has increased over the past few decades in the United States (US). According to the National Diabetes Statistics Report (2017), 9.7% of the U.S. population or 30.2 million people had diabetes in 2015. Of this group, 7.2 million people were not aware of their diagnosis. Prevalence also increased with age with 25.2% of those above the age of 65 having diabetes (Centers for Disease Control and Prevention (CDC), 2017). Due to this increased prevalence of diabetes, the number of hospitalized patients with diabetes has also increased. For example, in 2014 diabetes was reported as one of the diagnosis listed in 7.2 million hospital discharges for patients over the age of 18. (CDC, 2017). In many common conditions, diabetes is often a comorbidity. In 2014, 1.5 million patients with major cardiovascular disease, 108,000 with lower extremity amputations and 168,000 with diabetic ketoacidosis had diabetes (CDC, 2017). Additionally, there were 14.2 million emergency department visits reporting diabetes as any listed diagnosis for adults 18 years or older, including 245,000 for hypoglycemia and 207,000 for hyperglycemia (CDC, 2017).

Insulin-related errors are common in the hospital setting (Citty, Zumberg & Chappell, 2017, Deal, Liu, Wise, Honick, Tobin, 2011). These errors can cause hypoglycemia and hyperglycemia, which are linked to increased mortality and longer hospital stay in patients with diabetes. Hellman (2004) found that insulin-related error was the cause of 33% of deaths related to a medical error of hospitalized patients. Another study reviewed 28,353 cases from eight different hospitals and found an association between variability in inpatient blood glucose and increased long-term mortality (Timmons, Cunningham, Sainsbury, & Jones, 2017). Other studies have also demonstrated a connection between hypoglycemia and increased mortality (Cakir,

Altunbas, Karayalcin, Umpierrez, & Kitabchi, 2003; Garg, Hurwitz, Turchin, & Trivedi, 2013; Smiley & Umpierrez, 2008). Another study by Umpierrez et. al., (2002) found a 2.7-fold increase in all-cause mortality in patients with diabetes with hyperglycemia and an 18.3-fold increase in mortality in patients with hyperglycemia without diabetes. Other studies have shown an association between hyperglycemia and increased mortality in patients who suffered acute myocardial infraction (Wahab, Cowden, Pearce, Gardner, Merry, & Cox, 2002), Chronic Obstructive Pulmonary Disease (Baker et. al., 2006) and stroke (Weir, Murray, Dyker, & Lees, 1997; Parappil, Depczynski, Collett & Marks, 2010). Since insulin errors can cause hyperglycemia or hypoglycemia which may lead to increased mortality and length of hospital stay, targeted education focused on insulin dosing and administration is warranted for clinical staff. This project aims to improve the quality of care patients with diabetes receive in the hospital setting by increasing registered nurses' systematic and procedural knowledge about insulin therapy through an interactive educational video module designed and piloted in partnership with the nursing leadership of a large academic medical center.

Background

Insulin is the most common medication used to treat diabetes in the hospital setting (Citty, Zumberg & Chappell, 2017), with approximately one-third of hospitalized patients receiving insulin (Citty, Zumberg & Chappell, 2017). Insulin is classified as a high alert medication by the Joint Commission on Accreditation of Healthcare Organizations (JACHO). High alert medications have a high risk of causing injury during a medication error and despite the fact that insulin has received this designation, it is still frequently involved in medication errors. It is estimated that drug errors related to all injectable medications cost the US payer an extra $2.4 billion a year (Lahue et. al, 2012), and insulin had the highest risk of error per

administration in this category. A case study by Florida Hospital System reviewed glucose data from 2015-2016 for 43,659 patients on insulin. This study found that patients on insulin therapy who experience severe hypoglycemia (blood glucose < 40 mg/dL) experienced 84.6% longer hospital stay, 61.5% higher readmission rate and 187.5% increase mortality rate than patients on insulin who had normal blood glucose. These patients also had an average cost per stay of $10,405 (94.3% more) compared to patients who had normal blood glucose (American Hospital Association, 2019).

Prevalence of insulin-related medication errors is variable and depends on each institution and its infrastructure for safety and prevention. There are, however, common errors that most hospitals experience. One of the most common types of insulin errors is dose related. For instance, in a report involving 2,685 insulin-related events reported by Pennsylvania healthcare facilities from January 2008 to June 2009, 24.7% of the errors reported were a result of dose omission (Pennsylvania Patient Safety Advisory, 2010). In addition, over 52% of the 2,685 errors were caused by either dose omission, over-dosage, under-dosage, incorrect rate or additional dosage. Another study by Deal, Liu, Wise, Honick &Tobin (2011) found a rate of 0.5-1 error per patient per day in a 1200 bed hospital with 64% of the patients experiencing at least one insulin error during their hospital stay. The most common errors found in this study were absence of documentation of insulin dose and dose omission without an order. The authors note that absence of insulin dose documentation could be attributed to lack of computerized order-sets for insulin orders at the institution at the time of the study. Another study also found omission of coverage insulin in 23.4% of 833 randomly selected blood sugar measurements (City, Zumberg and Chappell, 2017). In addition to the insulin errors mentioned above, other examples of insulin errors include administration at the wrong time, administration of an incorrect dose or of the

wrong kind, improper insulin adjustment and administration to a wrong patient (American Society of Health-System Pharmacists, 2004). Insulin errors can occur during the ordering phase, the interpretation phase or the administration phase.

The problem of insulin errors is so significant that it was address by a 21-member expert panel assembled by the American Society of Health-System Pharmacists Research and Education Foundation in 2013 (Cobaugh, 2013). This group created expert consensus recommendations for safe use of insulin in the hospital setting. The expert panel included individuals from the fields of medicine, nursing, pharmacy, and consumer advocacy groups. The clinicians on the panel were from the specialties of endocrinology, critical care, emergency medicine, and anesthesiology.

The panel came to a consensus with 10 recommendations for safe insulin use in the hospital. Included was the recommendation to provide site and profession specific diabetes education to health care professionals that work with insulin. Periodic competency assessments for clinicians that work with insulin were also recommended (Cobaugh, 2013).

Statement of the Problem

The prevalence of diabetes has increased over the past few decades increasing the number of hospitalized patients with diabetes (CDC, 2014). Patients with diabetes in a hospital setting are most commonly treated with insulin. Insulin-related errors are common in the hospital and injectable drug errors such as insulin errors cost the US health payer about $2.4 billion a year (Lahue et. al, 2012). Registered nurses play an important role managing patients with diabetes, yet they may sometimes lack the comprehensive knowledge required to manage patients according to current guidelines and recommendations. Thus, education about diabetes management and insulin administration targeted at registered nurses in the hospital is warranted

to address the knowledge gap. This DNP project proposes to systematically implement the specific education recommendation given by the American Society of Health-System Pharmacists and the expert panel guidelines for the safe conduct of insulin therapy and direct this education specifically towards registered nurses.

Working with the leadership team in a major academic medical center, and using an educational module modified for the setting, this translational DNP project will systematically educate registered nurses in a large hospital setting on inpatient diabetes management with a focus on insulin therapy. This pilot will evaluate program outcomes with respect to increased post-program nursing knowledge and nursing satisfaction.

Significance of Addressing the Problem

There are more than 30 million people who had diabetes in the US in 2015 which has increased the number of hospitalized patients with diabetes (CDC, 2017). In 2014, 7.2 million hospital discharges had diabetes as one of the listed diagnosis (CDC, 2017). In New York City in 2011, patients with diabetes accounted for 24% of all hospitalizations, a 37% increase since 2000 (Chamany, Wu & Parton, 2013). Insulin is a medication that is commonly used to treat hospitalized patients with diabetes and insulin errors are one of the most common drug errors that occur in the hospital setting (Classen, 2010). Drug errors increase mortality, hospital length of stay and overall cost per stay of patients (New England Health Institute, 2011; Lahue et. al, 2012; McCarthy, Tuiskula, Driscoll, Davies, 2017). Given the large size of the diabetes patient population, the use of insulin to treat these patients in the hospital, the commonness of insulin errors and the significant impact errors have on quality of care and cost, interventions targeting insulin errors are warranted.

Nurses play an important role in the admission, management, treatment and discharge of patients with diabetes. Registered nurses monitor blood glucose, administer insulin and other diabetes medications, coordinate meal and insulin delivery time, and assess and treat hypo- and hyperglycemia. Teaching nurses about diabetes care, specifically insulin therapy, is important because insulin is frequently used in the hospital and insulin errors are common in that setting (Classen, 2010). The purpose of this insulin-focused diabetes management education program is to decrease insulin errors and improve quality of care of hospitalized patients with diabetes, a substantial segment of the hospitalized population.

Chapter 2

Review of the Literature

Introduction. A review of literature was completed using MEDLINE-Ovid, CINAHL, Scopus, PubMed, and Google Scholar. In addition to these databases, a search was also conducted in the websites of the CDC, American Diabetes Association (ADA), and American Association of Clinical Endocrinologists (AACE). Inclusion criteria were inpatient-focused studies and the English language. Excluded from review were patient-focused diabetes education studies and research unrelated to healthcare. The keywords and synonyms used are: “inpatient diabetes management” (diabetes and hospital, diabetes and inpatient), "inpatient diabetes education”, “diabetes management and nurse”, “insulin errors” (hospital and insulin errors, hospital and medication errors), “hyperglycemia and complications” (hyperglycemia and hospital, hyperglycemia and inpatient, hyperglycemia and chronic obstructive pulmonary disease, hyperglycemia and stroke), “hypoglycemia and inpatient” (hypoglycemia and hospital),“web-based learning and healthcare” (web-based learning and hospital, computer based learning, web-based learning and nurse, online education and nurses). The literature review revealed five themes, including insulin errors are common in the hospital setting; a nursing knowledge gap exists about diabetes; diabetes education for nurses working in a hospital setting is strongly recommended; diabetes-focused education may reduce insulin errors; and computer based learning is effective in delivering knowledge.

Insulin errors are common in the hospital setting. Insulin is one of the drugs most commonly associated with drug errors in the hospital setting (Classen, 2010). While there are limited recent studies discussing insulin errors in the hospital setting, a cross-sectional observational study by Kuo, Touchette & Marinac (2013) used an online data collection form to

collect drug errors over a course of 14 consecutive days from 62 clinical pharmacists. A total of 779 reports were submitted and revealed errors in the hospital and outpatient settings. Endocrine and metabolic agents, which includes insulin, were one of the five drug types frequently associated with medication errors. Insulin was also one of the five drug classes associated with frequent medical errors.

In a cross-sectional study by Amori et. al. (2008), 21 health care organizations in the U.S. voluntarily reported medical errors using an electronic error-reporting system over a course of 5 years. A total of 44 health facilities reported data as some of the health-care organizations had more than one facility reporting data. The study found insulin and oral diabetes agents were involved in 3.5% of reported drug errors. This amounted to 2,598 errors involving insulin and oral diabetes agents in which insulin constituted 82% of the errors. Two-thirds of the errors from these diabetes agents reached the patient (meaning patients were actively involved) with 39% of these errors leading to some modification in care. From the errors that reached the patient, 26% did not cause harm, 21.2% did not cause harm but led to closer monitoring, 13.6% caused harm needing treatment and 1.5% caused major harm.

Further, Classen (2010) also reported insulin-related errors were common in the hospital. The study used a Medicare Patient Safety Monitoring System (MPSMS) to monitor adverse drug events (ADE) in fee-for-service Medicare patients. Insulin was part of the six medications included in this surveillance. The study found 10.7% of patients who received insulin or other hypoglycemic agents had ADEs, and these patients experienced increased 30-day mortality and length of stay.

A high incidence of insulin errors can also be seen outside the United States. In a study in England and Wales, 16,000 insulin-related incidents were reported between November 2003 and

November 2009 (Cousins, Rosario, & Scarpello, 2011). The majority of the errors (61%) happened during insulin administration. Prescription error accounted for 17% and dispensing for 10% of the errors. There were severe consequences or fatality in 18 errors and moderate harm was caused in 1,042 errors. Other studies that have reported the increased prevalence of insulin errors include Santell, Hicks, McMeekin, & Cousins (2003) and Gurwitz, Field, Judge, Auger, Bates (2005). Though it is known that nurses play a large role in working with insulin, the error data spans across all clinical sectors. There presently is not a lot of data on who is committing these errors.

A Nursing knowledge gap exists about diabetes. Nurses have a knowledge gap in diabetes-related care of a hospitalized patient. A study by Drass, Muir-Nash, Boykin, Turek, & Baker (1989) tested hospital staff nurses' knowledge about diabetes and compared their perceived level of knowledge about diabetes with their actual level of knowledge. The study found that perceived knowledge was inversely related to actual knowledge ($r = -.36$, $p < .001$). Nurses also had a mean score of 64% on a diabetes basic knowledge test. The areas of deficit were treatment of hypoglycemia, where 84% of the participants selected treatment by drinking orange juice with two teaspoons of sugar and blood glucose monitoring. [The correct treatment of hypoglycemia is consumption of 15 grams of fast acting carbohydrate such as half a glass of orange juice or soda, four glucose tablets or 1 tablespoon of sugar or honey and rechecking blood sugar every 15 minutes and repeating the above treatment until blood sugar is above 70 mg/dL (ADA, 2019).] While this study was not recent, some of its results including the inverse relationship between perceived knowledge and actual knowledge are still reflected in later studies as seen below.

Modic, et. al. (2014) implemented a diabetes education program and examined nursing knowledge about inpatient diabetes management before and after a 4-hour education program. The study was done on 2250 bedside registered nurses and used a curriculum focused on hyperglycemia, insulin therapeutics, hypoglycemia and diabetes skills. The study initially measured nurses' comfort and knowledge of inpatient diabetes management using a diabetes management knowledge assessment test which had eight items on comfort, and six items on familiarity. Nurses also completed a 20 pre-and-post questions provided before and after the education class. The study found that nurses rated themselves high in levels of comfort and familiarity with diabetes. However, the baseline knowledge of nurses was lower than expected, indicating that nurses may lack awareness of the knowledge gap they have regarding diabetes management. There were four specific questions that were challenging even after the education. One of the questions was about causes of hyperglycemia (38% nurses did not answer the question) and three questions concerned insulin regimens. In one question about a clarification of an insulin order that contained an error, 68% of nurses did not answer the question correctly. Another question frequently missed by nurses asked to identify the insulin type that needed to be reduced after occurrence of repeated hypoglycemia around the same time every day. This required an understanding of the pharmacokinetics of the various insulin types. The study did not find a relationship between diabetes knowledge and level of education or years of experience. In addition, age was inversely related to diabetes knowledge ($r = -.182$; $p < .001$). Overall, the study found the 4-hour education program improved the knowledge of nurses about diabetes management but revealed the existence of "perplexing knowledge gaps related to insulin" (Modic, et. al., 2014, p. 180), with a recommendation of allocating more time going over insulin regimens in future education.

Another study by el-Deirawi & Zuraikat (2001) reported that nurses did not have adequate knowledge to assist patients with diabetes survival skills. Contrary to Drass, Muir-Nash, Boykin, Turek, & Baker (1989), this study found a small but statistically significant positive correlation ($r = 0.402$, $p < 0.0001$) between actual knowledge and perceived diabetes knowledge. A study by Thomas (2004) used diabetes basic knowledge test on 150 nurses to determine the diabetes knowledge in pediatric nurses. The study found that 54.5% of nurses were not able to answer how insulin worked, 75.2% did not identify the correct procedure for patients with diabetes scheduled for surgery, 76.5% did not know complex carbohydrates should be part of a patient's diet and 72.9% did not understand lipohyperthrophy can be caused by injecting insulin frequently on the same site. A study by Gerard, Griffin, & Fitzpatrick (2010) and others such as Wakefield (2014) and Heatlie (2003) described below have all reported poor nursing diabetes knowledge in the hospital setting.

Diabetes education for nurses working in a hospital setting is strongly recommended. Diabetes-focused nursing education is an important part of diabetes patient care in the hospital setting. Uding (2002) examined the level of diabetes knowledge in nursing staff and the benefit of a diabetes focused education for nurses in a 400-bed hospital. The study found that 53% of the registered nurses had not received any continuing education about diabetes in the past 2 years and 26% have never received a continuing education class about diabetes. After examining the existing knowledge using a pre-test-post-test design, Uding compared the knowledge of nurses in two groups. The experimental group received a 45-minute PowerPoint education presentation delivered in person, but education was not provided to the control group. The results of the study indicated that the knowledge of nurses in the experimental group was

significantly improved after attending the education session ($p < .001$). The authors concluded by specifying the need for diabetes education for nurses.

In a descriptive study, el-Deirawi & Zuraikat (2001) used a survey to determine the relationship of nurses' perceived and actual knowledge about diabetes. Though it was not the intention of the study, el-Deirawi & Zuraikat (2001) found that 79.7% of the participants in the study had never received an in-service related to diabetes or have not received an in-service in the past two years. The authors indicated that in-services using various teaching methods have the potential to improve diabetes knowledge in nurses.

Manchester (2008) recommends achieving professional competency for nurses, dieticians, pharmacists and physicians in taking care of patients with diabetes in the hospital by using case scenarios, simulation exercises and web-based competency tests. This author also recommends insulin focused tests to measure professional competency for clinicians working in the hospital. A study by Coffey (2016) examined if an education program directed at nurses improved the knowledge of nurses in the care of patients with diabetes. The study used a diabetes knowledge test and concluded that nurses who went through the education program had improved knowledge about diabetes. However, the study did not examine whether improvement in knowledge translated to improved care. Another study by Rubin, Moshang, Jabbour (2007) examined diabetes knowledge in 48 registered nurses and 115 resident physicians using a 21-question survey that the author developed based on diabetes standards of care. The study found improved knowledge in nurses who had previous diabetes training. However, the study found an overall diminished knowledge in regards to diabetes in both physicians and nurses. The study recommended that additional diabetes education is needed in order to provide quality care of hospitalized patients with diabetes. Nurses themselves recognize the need for a diabetes

education as shown in a survey by Gibson, Pasierb, Andrea, Sunday, Cavlovich (2014) which identified diabetes among the four top topics nurses preferred covered in their monthly nursing grand rounds.

Diabetes-focused education may reduce insulin errors. Studies show that education is an effective tool in reducing insulin-related errors. A performance improvement study using a pre-and post-intervention design by Sullivan (2010), sought to determine if an online education module for pediatric nurses has an effect on the reduction of insulin errors. The study was completed at a 150-bed children's hospital and was completed in about 2 years. 100% of the nursing staff at the hospital completed the online education module. The authors initially reviewed 24 charts before the start of the education module and reviewed 22 charts after the intervention was completed. Opportunities for error and actual errors carried out by nurses were identified. Opportunity for error was defined as "each time the blood glucose should have been checked per physician order or the hypoglycemia protocol" (Sullivan, 2010, p. 1745). An error was defined as "any dose of insulin given or omitted that deviated from the physician order (omission of an insulin dose, wrong insulin dose or type, wrong administration time, blood glucose not checked per order or hypoglycemia protocol, and blood glucose not documented in the record)" (Sullivan, p. 1745). During the pre-intervention period, there were 131 errors found from 882 opportunities for errors. In the post-intervention period, there were 19 errors found from 1119 opportunities for errors. There was a statistically significant decrease in error rates from 14.8% to 1.7%, which was sustained over 6 months ($p=<.001$). A limitation of this study is the small sample size. There were only 22-24 charts that were reviewed during the study period. While the study took place in a different type of setting (children's hospital), and the sample size

was small, the authors did demonstrate that the use of an online education module could be a promising intervention for reducing insulin errors.

A quality improvement project by Szelc & Nicolaus (2018) with a goal of reducing critical hypoglycemia in non-critically ill patients, was completed at a 425-bed community hospital. The project team initially conducted a root cause analysis and found an association between morning hypoglycemia and bedtime correction insulin administration. They discovered that nurses were basing the amount of correction insulin based on the blood sugars taken shortly after patients have eaten their bedtime snacks. To solve this error, they partnered with nutritional services and had the snacks delivered directly to the nurses. In addition, they focused on diabetes education. Some units used multiple in-service education on diabetes, insulin, insulin administration timing, insulin pump, hypoglycemia, oral medications, and NPO patients. From 2014 to 2017, insulin error rates decreased from 2.6% to 1.6%. In addition, there was reduced time between insulin nutritional intake, blood glucose monitoring, and insulin administration. Critical hypoglycemia was also reduced by 20% for 12 consecutive quarters Szelc & Nicolaus (2018).

With a similar goal to the above study, Heatlie (2003) examined ways to reduce insulin errors and prevent the delays in point-of-care testing and insulin administration. The objectives of the study were to encourage the use of insulin order-sets, to perform nursing education about insulin and insulin errors and to promote a blood glucose testing within 1 hour of administration time for regular insulin. The study was conducted in three hospital units with a total of 204 beds. The study used nurse educators to create a diabetes education plan for nurses. This education was given to individualized units using education packets or a teaching video. The study examined the time interval between point-of-care testing and insulin administration to assess the effect of

the interventions. The results indicated that patients who were cared for by nurses who received this education had a significantly shorter time between point of care testing and insulin administration. The authors, however did not measure the effect of the study in other types of insulin errors.

In another study, Najarian, Bartman, Kaszuba, and Lynch (2013) provided three nursing education opportunities for staff at a designated hospital. The types of education the nurses could choose from were (1) an 8-hour online learning module about diabetes with continuing education credit, (2) working with an in-unit educator for 8-hour shift during dispensing of medications including insulin administration and, (3) 2-hour nursing education regarding insulin and other diabetes-related topics. After completion of the education program by the nurses, the study compared quarterly blood sugar data in various units of the hospital. The study found the unit where the education program was completed had the lowest hyperglycemic and hypoglycemic rates than most of the other comparative units.

A quality improvement project by Watts (2018) aimed to increase blood sugar re-checking time by 50% in hypoglycemic patients. Blood sugar re-check time is the amount of time it takes to recheck blood sugar of a patient after hypoglycemia or hyperglycemia. In cases of hypoglycemia, blood sugar should be rechecked every 15 minutes until blood sugar is above 70 mg/dL (ADA, 2019). The project by Watts identified nursing knowledge gaps in the management of hypoglycemia and used educational sessions and in-services together with emphasis on use of hypoglycemia protocol in order to reduce re-check time. In order to measure the effect of the educational sessions, the project established a trackable tool which contained key elements such as initial glucose value and glucose value after re-check, the times in which those actions occurred, and the treatment used. The project then created a report that calculated

the recheck time and compared the recheck time before and after the education occurred. The project determined that the combination of education, in-services and emphasis on hypoglycemia protocol was successful in reducing recheck time. This result was sustained for over 6 years. These above studies show that nursing education can improve patients' glycemic status, insulin errors and reduce the time between blood sugar testing and insulin administration. Other studies have also used nursing education adjacent to other interventions to reduce errors. For example, Citty, Zumberg & Chappell (2017) reduced omission of coverage insulin by 54% by changing the ordering process of as needed short acting insulin in electronic medical record (EMR) system. Coverage insulins are only given based on a scale and usually ordered before each meal and at bedtime or every 6 hours if patients are NPO (ADA, 2019). Coverage short acting insulin was entered in the EMR system as a standing order instead of an as needed order by providers for this change to occur. By changing the correction insulin from as needed to standing, it forces nurses to acknowledge whether the correction insulin was given or not.

Other studies involving non-diabetes cases have used education adjacent to other interventions to reduce drug errors. Leahy and colleagues (2018) reduced medication errors in anesthesia patients by 69% in 3 years by a combination of interventions that include education, a drug library, two provider verification and dose standardization. Keiffer et. al. (2015) saw a significant reduction in medication errors in a pediatric cardiothoracic intensive care unit after interventions that include huddles after a medication error, medication bar coding, implementation of a distraction-free zone and quality process education.

Computer based learning is effective in delivering knowledge. Computer based learning also referred to as eLearning, web-based learning or online learning has been a big part of education after the beginning of the internet era. Multiple researchers have studied computer

based learning and have compared it with traditional in-person learning. A meta-analysis by Cook et. al. (2008) looked at 201 studies to compare web-based learning with non-web-based learning and web-based learning with absence of learning on health care professionals. The study found that web-based learning was more effective than absence of learning in knowledge outcomes, skills, learner behaviors and patient effects. It also found that web-based learning was as effective as non-web-based learning or traditional way of learning. Cook et. al. (2010) performed another meta-analysis to analyze factors that improve computer based learning. The study looked at 51 studies where 30 were randomized trials. It found practice exercises, interactivity, feedback and repetition were associated with higher learning in people who complete web-based learning.

In a prospective randomized controlled study, Wakefield (2014) examined the impact of an online education for inpatient registered nurses on nursing care of patients on basal-bolus insulin. The online education was an interactive, self- paced, PowerPoint with audio that took 4.2 hours for nurses to complete. The study aimed to determine if this form of education improved the nurses' knowledge about diabetes and whether the knowledge gained was able to be retained after 3 months. The study also evaluated the relationship between perceived knowledge and actual knowledge about diabetes in nursing. The experimental and control group were both given a pre-and post-test with multiple choice questions which examined the nurses' knowledge and clinical application. The experimental group completed the online education whereas the control group did not. The study found a significant improvement in knowledge in the experimental group and this knowledge was retained after 3 months through another test. Though the pre-test scores between the control group and the experimental groups were similar, the experimental group significantly improved on the post-test compared to the control group ($p < .001$). The

study also found a big difference in nurses' perceived knowledge and actual knowledge about diabetes which was consistent with other studies discussed above.

An integrative literature review by Bluestone et. al. (2013) analyzed the literature to find methods that have been beneficial for in-service education for healthcare professionals. The literature included studies which demonstrated that case-based education, practice and feedback, and interactional learning were effective educational techniques. The authors pointed out that passive lecture like teachings were not associated with improved learning outcome. This study also reported that when approaches such as case-based learning, clinical simulations, practice and feedback are used, web-based learning is as effective or more effective than live instructional learning.

Web-based learning can also be cost efficient and less time consuming. In a descriptive study Degerfält and colleagues (2017) reviewed data from 2005-2014 about oncology related web-based educational programs and the informative self-perceived value they have. In the study, there were 2,359 registered nurses, 759 medical doctors and 1575 other health care workers. Over 99% of these health care professionals rated the web-based education as either excellent (68.6%) or good (30.6%), demonstrating that online education is received well by health care professionals.

Summary. Insulin errors are common in the hospital setting and there is a lack of adequate knowledge related to diabetes in registered nurses working in the hospital. Nurses' perceived knowledge about diabetes does not translate to actual knowledge. Diabetes-focused nursing education is as an important part of diabetes patient care and could aid in the improvement of glycemic control, reduction of insulin errors and quality of care for patients with

diabetes. Computer based learning has been proven to be an important educational tool and will be useful as a modem to disseminate inpatient diabetes education to registered nurses.

Theoretical Framework

We will use the Reach, Effectiveness/efficacy, Adoption, Implementation, and Maintenance (RE-AIM) framework to guide this project. RE-AIM is a framework that is approximately 19 years old and is used to translate research into practice (Gaglio, Shoup, & Glasgow, 2013). This framework has a logical structure and contains five components; reach, effectiveness/efficacy, adoption, implementation and maintenance. Reach refers to the population receiving the intervention, effectiveness refers to the overall impact of the program including the possible negative impacts, adoption refers to the setting which will adopt the program, implementation is the commitment of the intervention towards the various delivery methods, timelines and budget and maintenance refers to the part where the intervention becomes part of the institutional policy and its long lasting effect on the individuals that have partaken in the program (Gaglio, Shoup, & Glasgow, 2013).

Reach. The DNP project will use an education module to provide insulin-focused diabetes education to inpatient registered nurses at a large academic medical center. Teaching registered nurses about insulin is critical as they administer insulin in hospitals where insulin errors are common (Citty, Zumberg & Chappell 2017). Insulin is also classified as a high alert medication by JACHO (The Joint Commission, 1999). High alert medications have a high risk of causing injury during a medication error.

Effectiveness. The project will be designed and delivered in partnership with nursing leadership at a large academic medical center. Once piloted, the effectiveness of the project will be evaluated through participant evaluation of the educational program and a pre-and posttest.

Adoption. The project will be adapted by the large academic medical center and the project will be implemented to a group of inpatient registered nurses. The project is important for the organization where the pilot will take place because of the large number of patients with diabetes admitted to hospitals and 1/3 of these patients are treated with insulin (Citty, Zumberg & Chappell, 2017).

Implementation. We will adapt with permission a previously-developed web-based module on insulin from another academic medical center. We will also complete analysis of insulin errors from a medical error reporting system (MERS) of the hospital where we will implement the project. MERS is an internal data collecting system for errors available to all clinical and non-clinical staff. The MERS analysis will guide development of case studies to add to our module. There will be pre-test, a post-test, and a satisfaction survey before and after the nurses complete the education.

Maintenance. Once the project is piloted and evaluation is completed, we will recommend it for full application at the large academic medical center based on feedback obtained. An organization such as the American Association of Diabetes Educators may also be a great platform to disseminate the educational module.

Objectives/Aims

There are three aims for the project:

1. Analyze the MERS report for the 2018 calendar year to record insulin-related errors at a large academic medical center.
2. Adapt an insulin-focused diabetes management curriculum from another academic medical center and use the MERS analysis results to create case studies for the program.

3. Pilot, and evaluate the insulin-focused diabetes management curriculum to registered nurses at a large academic medical center.

Chapter 3

Methodology

Aim 1: Analyze the MERS report for the 2018 calendar year to record insulin-related errors at a large academic medical center. MERS is an internal database of a large academic medical center where medical errors are voluntarily reported. A MERS report has a patient's medical record number, event date, the location of the event, the location of discovery, the involved discipline, the medication's name, event description, whether the patient was harmed or not, a manager's comments, and comments from the pharmacy. While there is not an available analysis of prior years' MERS reports on insulin, the MERS report for this project will only focus on insulin for the 2018 calendar year. A pharmacist will extract the MERS report from the database using the hospital's MERS portal. The pharmacist will initially pull all medication related to the MERS report into an excel sheet and filter for insulin-related errors. Using the error analysis form in Appendix A, the pharmacist will extract the data and will organize and analyze it for any common themes. The error analysis form is organized by the insulin error type, the discipline involved and the frequency in which the errors have occurred. MERS is a voluntary self-reporting system and is prone to under-reporting. Thus, the number of errors and types of errors obtained from this report will not give a complete accounting of all errors that occur within the hospital but is currently the only systematic data collection record available.

Aim 2: Adapt an insulin-focused diabetes management curriculum from another academic medical center and use the MERS analysis results to create case studies for the program. The project will adapt an inpatient diabetes management module from another academic medical center to teach nurses about insulin therapy. Sullivan et. al. (personal

communication, June, 2019) created these interactive web-based educational modules to educate nurses, physician assistants, nurse practitioners, and medical doctors about inpatient insulin therapy at a major academic medical center. These modules were created as part of a quality improvement project based on quality improvement data. The academic medical center requires all of its inpatient nursing staff to complete the modules.

In 2010, Sullivan et al. examined whether another insulin-focused interactive web-based educational module would reduce insulin-related errors in a 150-bed pediatric hospital. This module in Sullivan et. al. (2010) was created before implementation of a computerized physician order entry form (CPOE) and was successful in reducing insulin-related errors. The data from this module was used to create the CPOE that is included in the inpatient diabetes training module that will be adapted for this project.

The inpatient diabetes training module that will be adapted has eleven sections. These sections are (1) inpatient diabetes: general introduction (2) insulin basics part 1: types of insulins, insulin pharmacodynamics, basic insulin regimens (3) insulin basics part 2: starting and adjusting insulin on patients that are eating (4) insulin basics part 3: patients on glucocorticoids, patients who are NPO and patients on TPN or tube feeds (5) DKA and hyperosmolar coma (6) insulin pump use in the hospital (7) patient education:10 minutes with diabetes (8) how to teach your patient about diabetes in < 10 minutes (9) introduction to the hospital's SQ insulin algorithm (auto-titration for NPO, TPN, enteral feeding) for physicians and NPs (10) introduction to the hospital's SQ insulin algorithm (auto-titration for NPO, TPN, enteral feeding) for nurses (11) a shorter video of an introduction to the hospitals SQ insulin algorithm (auto-titration for NPO, TPN, enteral feeding) for nurses.

Permission has already been obtained to adapt the content of the web-based educational module from a major academic medical center (M. Sullivan, personal communication, June 9, 2019). We will take the following steps to adapt this web-based educational module. Initially, we will identify the content of the module that focuses on insulin. Subsequently, we will identify and mark sections that do not use protocols and order-sets specific to an institution. These sections will be adapted with slight modifications. We will add the CPOE and protocol of our institution to adapt sections that use a protocol and CPOE not specific to our institution. The adapted content will then be placed in multiple slides in Microsoft PowerPoint and each slide will be converted to an image. Each image will then be embedded into Qualtrics, a secure online survey software that gathers and analyzes data (Qualtrics, 2019). This software will be used to distribute the educational module.

We will adapt two videos from the module. One of the videos describes basic physiology of insulin and is less than three minutes long, whereas the second video describes how to make daily insulin adjustments and is approximately five minutes long. In order to insert these videos into our educational module, we will use Screencast-O-Matic, a video creating software available to the general public (Screencast-O-Matic, 2019). Screencast-O-Matic will record the educational videos from the module we are adapting and generate a link for each video. These links will then be embedded within Qualtrics as part of our educational video module.

Case studies and quizzes. There will be three case studies with five to six questions each that will be inserted within Qualtrics along with the slides and videos to form our educational video module. An expert panel will validate these case studies that will make up a large portion of the educational module. Three experts will review the case studies, as recommended (Lazenby, Dixon, Coviello, & McCorkle, 2014). These experts will determine if the questions

are relevant to the case study and appropriate to teaching hospital-based registered nurses about inpatient insulin therapy. They will also be asked to comment on the clarity of the questions. These experts will be educators, nurse practitioners, and endocrinologists that work with inpatient diabetes management with at least five years of experience. Experts that fulfil the criteria received requests to participate on the panel via email by the Author (AT).

The content experts are Mary M. Sullivan, RN, DNP, ANP-BC, CDE, diabetes clinical nurse specialist at University of California San Francisco and one of the developers of the module whose research was discussed in the ROL; Lucille Hughes MSN/Ed, CDE, BC-ADM, FAADE, Director of diabetes education for South Nassau Communities Hospital and a board member for the AADE; and David W. Lam M.D., medical director of the Clinical Diabetes Institute at Mount Sinai Hospital.

We will provide the rating tool found in Appendix D to content experts to identify the relevance and appropriateness of the case study questions. In accordance with Lazenby, Dixon, Coviello, & McCorkle (2014), we will require a 78% consensus among the content experts to use any of the case study questions and answers. If a 78% consensus is not obtained, the case studies will be revised and resubmitted via email to the experts until consensus is achieved. Case study questions will be derived from the MERS analysis. Answers to the case studies will be obtained from the educational module, the academic medical center's existing protocols, and inpatient diabetes management standards of care from ADA and AACE. ADA and AACE have a consensus statement on diabetes management in hospitals (Moghissi et. al., 2009). The consensus statement describes the significance of glycemic control, monitoring blood glucose goals in hospitalized patients, what to consider when transitioning patients with diabetes to an

outpatient setting, and treatment options to obtain optimal blood glucose values (Moghissi et. al., 2009).

The ADA has updated recommendations on the topics above and other subjects related to diabetes in the inpatient setting (ADA, 2017). The ADA (2017) recommends a target blood glucose level of 140-180 mg/dL for hospitalized critically ill and non-critically ill patients. Insulin is also recommended for patients with persistent blood glucose above 180 mg/dL. The recommended treatment of patients with diabetes who have good nutritional intake is a long-acting insulin, a mealtime short-acting insulin, and additional short-acting insulin for correction. The recommendation for those with poor oral nutrition intake or those who are not eating anything by mouth (NPO) is a long-acting insulin and correctional short-acting insulin. These and other recommendations will be used for the answers for the case study questions.

Aim 3: Pilot, and evaluate the insulin-focused diabetes management curriculum to registered nurses at a large academic medical center. Once the modules and case studies have been finalized, they will be embedded into Qualtrics. The case studies and other interactive components will also be placed in sections before, during, or after the videos on Qualtrics. To minimize skipping videos or sections, the participant will not be able to advance the page until they have provided a response to the case study questions.

A pre-and post-test will be created to evaluate the effectiveness of the modules in increasing the knowledge of registered nurses about insulin. The pre-test and post-test will be in multiple-choice format, contain at least 10 questions with one question from each section. The test will be administered prior to beginning the educational module and immediately after completion. The multiple-choice questions will be the same in the pre-test and the post-test but will be given in different order during the post-test.

The pre-and post-test will be formulated using the following methods: (1) identification of important information to impart in the curriculum, (2) examination of existing tools with questions that are appropriate to this curriculum with permission acquired to incorporate them, and (3) the development of new questions for areas of content not covered in existing tools. The pre-and posttest includes 12 questions. Nine of those questions were adapted with permission from the publication "Management of inpatient hyperglycemia - an interactive seminar" (R. Gianchandani, personal communication, August 21, 2019). Three of the twelve pre and posttest questions were drafted by the author based on the learning objectives of the module. Once the three questions were drafted, they were given to three experts for review to obtain face validity. Once the pre-and posttest questions are formulated and evaluated, they will be administered using Qualtrics together with the educational video modules.

Pilot testing. At least ten nurses will pilot the proposed project. The nurses will be recruited from four medicine units at the academic medical center using convenience sampling. Participation in this pilot will be voluntary and completing the pre-and post-test and video modules will be used as implied consent. The Director of Nursing of Medicine units as well as nurse managers of each medicine unit will be engaged before beginning the pilot. The nurse managers will provide the email addresses of the nurses. To recruit nurses for the pilot program, the author (AT), will send an email to the nurses on the four medicine units where this project is being piloted. This email will describe the purpose and the content of the educational module and the duration of involvement. This email will also contain an individualized Qualtrics link that contains a pre-test, the educational video module, a post-test, and a satisfaction survey all embedded in one link. The pre-test will be completed prior to watching the video and the post-test and satisfaction survey will be competed after watching the video. Qualtrics will be set up to

only allow access to the post-test after completion of the modules. Through the partial completion option on Qualtrics, the nurses will be given the option to partially complete and resume the study where they left off as long as they complete it in 30 days. The nurses can complete this study during their work time. Qualtrics will obtain and store the data.

Evaluation/Analytical plan

In accordance with the RE-AIM framework, the project and aims will be evaluated for their effectiveness/efficacy.

Aim 1: We will complete analysis of the 2018 MERS report using the table found in Appendix A.

Aim 2: The project will adapt a large academic medical center's inpatient diabetes management module and use a MERS analysis to create case studies for the program. Three content experts will evaluate the case studies using the tool found in Appendix D.

Aim 3: We will pilot the project to registered nurses at a large academic medical center and evaluate using a validated pre-and post-test. Once the pre-and-post tests are completed, we will compile and analyze the data using paired t tests in SPSS statistical software package (v. 25, IBM Corp., Released 2017).

In addition to the pre-and post-test, there will be an anonymous five-question satisfaction survey with an open-ended question for feedback administered after the post-test on Qualtrics. The satisfaction survey will evaluate and harvest positive and negative feedback about the overall impact of the curriculum from those that completed the module. The survey is important because it will give information and guidance on how to make the curriculum more useful for the nurses. This survey will be given in a Likert Scale format as shown in Appendix I and will leave additional room for comments. The satisfaction survey will be formulated using Sharma (2007),

Mini-Quest Questionnaire for evaluation of materials. Descriptive statistics will be used to analyze the results of the satisfaction survey. All data will be stored in a secure Microsoft Excel file without identifiers. Dissemination of the curriculum throughout multiple units will be recommended if positive results are obtained from the evaluation. Since the MERS report is underutilized and errors are underreported and subject to the reporting practices of whoever is discovering the error, reports on past and present reports will not be compared.

As discussed above, insulin errors can cause hypoglycemia and hyperglycemia which result in severe economic and financial burden. Both conditions are associated with increased mortality, length of stay, and readmission rate. Severe hypoglycemia (blood glucose <40 mg/dL) in hospitalized patients on insulin costs $10,405 (94.3%) more per stay than hospitalized patients on insulin that did not have severe hypoglycemia (American Hospital Association, 2019). Lahue et al. (2012) estimated that injectable medication errors cost $2.4 billion a year with insulin having the highest risk for error in that category. Newton & Young (2006) were able to save $2 million a year after implementation of an inpatient diabetes management program which helped optimize patients' blood glucose levels in the hospital. Addressing insulin errors can reduce the risk for hypoglycemia, hyperglycemia, and the cost associated with both conditions. It can also unburden patients from the physical implications of hyper and hypoglycemia such as frequent blood glucose checks, increased risk of infections, increased length of stay, and other complications including death.

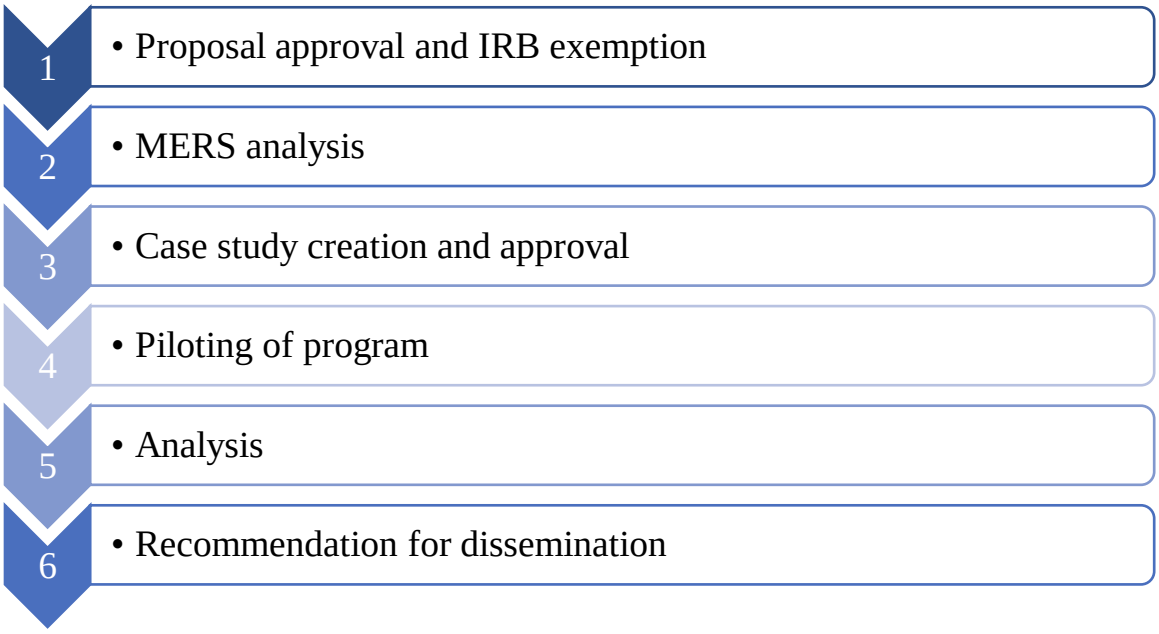
If the web-based educational module is successful, the author (AT) will recommend implementation of a policy to have all current and onboarding registered nurses complete this module at the academic medical center. Subsequently, dissemination to other hospitals will be recommended. The steps required to accomplish the process of piloting and evaluating the

curriculum to a group of registered nurses are as follows: (1) meet with nurse managers and directors at the academic medical center where the module will be implemented (2) provide the nurses access to the pre-and post-test, the satisfaction survey, and the educational module through Qualtrics (3) allow the nurses to complete the project in 30 days (4) analyze the results and (5) make recommendations for possible revision and dissemination of the curriculum. The participation in this quality improvement project is voluntary. The inclusion criteria are a registered nursing license and currently working in the inpatient setting of the large academic medical center.

Time Line

The project is estimated to take ten months to complete. Since Yale's IRB guidelines have determined this to be a quality improvement project, it will not need IRB approval. IRB clearance from the academic medical center will be obtained by end of October 2019. We will complete the MERS analysis by November 7, 2019. Video modules, case studies, pre-and post-tests and the patient satisfaction survey evaluation tool will be completed by December 15, 2019. Roll out of the curriculum will begin by January 3, 2020. We will complete data analysis by end of February 29, 2020. The compete project timeline is found in the table below

Project Timeline



Complete Timeline

Task	**Target Date**
Proposal approval	August 1, 2019
IRB approval/exemption	October 30, 2019
Analyze the medical error report pertaining to diabetes	November 7, 2019
Secure content experts	August 10, 2019
Create case studies and send questions related to content experts	August 16, 2019
Finalize case studies	September 1, 2019
Complete the web-based modules	September 1, 2019
Upload the pre-and post-test, videos and case studies onto Qualtrics	October 1, 2019
Roll out the education module	January 3, 2020

Analyze results of the pre-and post-test	February 29, 2020
Analyze results of the satisfaction survey	February 29, 2020
Finalize and submit poster presentation	April 30, 2020
Write final project paper and submit to publication	May, 6 2010

Statement related to human subjects.

This project is a quality improvement project and is not human subject's research. Thus, it does not require an Institutional Review Board (IRB) review at Yale University. The project has been granted an exempt status by the academic medical center where the project will be implemented.

Immersion plan

A large academic medical center is the site for the DNP project immersion. One of the biggest components of the leadership immersion is the frequent meetings involved in the development and implementation of the project. A team of nurse educators, nurse managers, pharmacists, endocrinologists, and inpatient diabetes nurse practitioners, had previously met to discuss insulin error rates and possible interventions. Nursing education has been mentioned as an important tool in order to improve the error rates and the quality of care the patients with diabetes receive.

If this DNP pilot project is successful, it will be proposed to the nursing education department that the educational program be provided to additional units. The administration/nursing education department will also be advised to complete an analysis of errors using medication-use evaluation or a complete chart review to determine if insulin error has occurred. Unfortunately, analysis of the MERS data pre-and post-education likely cannot be

completed because the MERS report is not a reliable measuring tool in measuring error rates. However, the Departments of Pharmacy, Nursing and Quality Improvement will be stakeholders in future projects that can better assess error rates, so that the efficacy of educational projects such as this DNP project can be evaluated.

Summary

The goal of this project is to provide registered nurses with the knowledge and skills needed to better take care of patients with diabetes in the hospital. Specifically, the project gives nurses knowledge that should translate to better care of patients with diabetes in the hospital setting.

Chapter Four

Results

The purpose of this DNP project was to educate registered nurses at a major metropolitan academic medical center about inpatient diabetes management focused on insulin therapy. The content of the education was based on a medical error analysis of the 2018 calendar year and included some content from a current inpatient diabetes module of another major medical institution. The content of the education was presented as an online module and dispersed through Qualtrics, an online survey software.

Part of the educational module was created using analysis of MERS (see Appendix B), an online portal where incidents such as medication errors are reported voluntarily by hospital staff. To obtain the insulin-related MERS report, a hospital pharmacist extracted and filtered voluntarily reported insulin-related medication errors from the 2018 calendar year. These medication errors were then analyzed using the table found in Appendix A. According to the report, there were 95 insulin-related errors, nine of which had more than one error incidents per error reported. For example, one reported error described omission of correction insulin at three different times over a 24-hour period, whereas another error reported two different errors within one report: administration of standing insulin without rechecking blood glucose after hypoglycemia, and not rechecking blood glucose after hypoglycemia. The multiple errors reported per error increased the number of reported errors from 95 to 106. Of the 106 errors, the authors determined 105 were appropriate insulin-related medication errors. One error was excluded because it involved a patient taking his/her own home insulin while hospitalized. From the 105 errors, two involved physicians whereas the rest involved nurses. The most common errors included (see appendix C) omission of rapid acting correction insulin (42), omission of

basal insulin (21), omission of rapid acting insulin (10) and administering bolus rapid acting insulin when patients are NPO (7).

Using the results of the MERS analysis, we created case study questions (see Appendix E), that were part of the educational module. The case study questions were reviewed by three content experts for appropriateness, relevance, and clarity. Questions that were deemed as not appropriate/relevant by one expert but were deemed as appropriate/relevant by two other experts were included in the case study. Questions and answers were reworded and sent to the expert panel to achieve clarity, and other questions and answers were removed or changed according to feedback from all the experts.

The diabetes educational module comprised of the case study questions, as well as content we extracted with permission from another academic institution's diabetes module. Once the educational module was completed, it was embedded in an individualized link sent to 115 registered nurses that work on four medicine units at a major academic medical center. This link contained a pretest, an educational module, a posttest, and a satisfaction survey. The educational module contained slides, two videos and three case studies that each had 5-6 question. Of the 115 emails that were sent out, one email bounced with 114 nurses receiving the individualized link. Twenty-one nurses started the module and nine nurses completed the module, resulting in a 43% completion rate. Two participants completed the pretest and did not complete the full study. There was an incentive of a $5 dollar Starbucks gift card for the first 20 people that completed the module.

Eleven participants completed the 12 pretest questions but did not complete the posttest and satisfaction survey. The mean score of the 11 participants on the pretest was 51%. A paired t-test was used to analyze the impact of the module on the participants. Of the nine participants

that completed the study, eight of the participants improved their knowledge from an average of 52% to 77 % (p = 0.006, CI 95%) while one participant who scored 33.3% on the pretest, and scored 17% on the posttest. When all nine participants who completed the full module are included, the average for the pretest improved from 49% to 71% [(p=0.055, CI 95%), see Appendix G].

To identify correlation between the answers in the pretest and the answers on the posttest for each of the twelve questions, we completed a cross tabulation analysis. The cross-tabulation analysis showed (1) which questions had the most correct response from the same participants both on the pretest and the posttest (2) which questions had the most improvements from the pretest to the posttest, (3) which questions had the lowest pretest score and (4) identified the questions where participants switched from the correct answer to an incorrect answer on the posttest (see table in appendix H).

There were three questions where the same participants identified an increased number of correct answers in the pretest and the posttest. In Question #3 (see appendix F for complete list of questions), seven out of nine participants were able to identify the difference between prandial insulin and correction insulin. On the pretest and posttest for question #6, #8, & #9, five participants correctly identified which type of insulin should never be completely held/stopped for patients with type 1 diabetes, the correct duration of action for glargine, and identified components of 70/30 insulin.

The question which showed the most improvement in participants from pre-to post was question #1, where only three participants correctly identified NPH, glargine and detemir as basal insulins in the pretest, while eight participants correctly identified them correctly in the posttest. Question #11 showed the second most improvement, where only one person correctly

identified the correct target blood glucose range for hospitalized patients on the pretest versus five people on the posttest. Question #12, which inquired about the academic center's hypoglycemic protocol, also improved from three correct answers on the pretest to seven correct answers on the posttest.

Some participants changed from a correct answer on the pretest to an incorrect answer on the posttest. For example, in Question #2, where participants were asked to identify the list of bolus insulins, five individuals correctly identified the correct bolus insulins on the pretest but two participants incorrectly changed their answers on the posttest. Two participants in both Question #5 and Question #7, and one participant in Question #9, also changed a correct answer to an incorrect answer.

The question with the lowest score on the pretest was Question #11, which asked to identify the target blood glucose level in most hospitalized patients. Only one of the nine participants identified the correct response of 140-180 mg/dL on the pretest. The other three questions, where only three participants identified the correct responses on the pretest, are Question #7 (identifying approximate duration of action of insulins aspart, lispro and glulsine,) Question #12 (identifying the academic center's hypoglycemic protocol for patients with hypoglycemia,) and Question #10 (identifying the impact of systemic steroids on blood sugars). Question #10 also had the most incorrect answers on the posttest with six participants identifying an incorrect answer.

After the posttest, a Likert Scale format was used to rate the interest, pace, amount, clarity, and importance of the video module. Nine participants completed this satisfaction survey and the results are as follows (see table one, in appendix J). When participants were asked if they "found the educational model very interesting," the average participant approximately agreed

(mean response = 3.78). When participants were asked if they "found the pace of this educational module just right," the average participant approximately agreed (mean response = 3.67). Further, when asked if they "learned a great deal in this educational module," the average participant approximately agreed (mean response = 3.78). When participants were asked if they "found the material in this educational module very clear," the average participant approximately agreed (mean response = 3.67). When participants were asked if they found what they "learned in this educational module very important", the average participant again approximately agreed (mean response = 3.89). One participant scored 33% on the pretest and 17% on the posttest and completely disagreed with all five variables of the Likert scale. When the one participant was excluded (see table two, in appendix J), the remaining eight participants agreed that they found the module interesting, clear, important and learned a great deal at just the right pace (mean response >/= 4).

There were also three additional optional open response questions after the Likert Scale question. These questions requested the opinions of the participants in regards to the helpfulness of the module and additional content they would like to see in the module. When participants were asked which part of the module they found most helpful, one participant thought the module was a "useful review of which insulins are being used for which purposes" and enjoyed reviewing the academic medical center's hypoglycemic protocol. Another participant "learned what to do to prevent diabetes ketoacidosis" and another participant found the case studies helpful. Two participants identified the case studies as the most helpful part of the module. When participants were asked if they found any sections unhelpful, one participant verbalized that the wording of the questions was "often confusing." One nurse identified adding weight-based

insulin calculations into the module, whereas another nurse wanted more information on the relationship between timing of point of care blood glucose checks and insulin administration.

Chapter 5

Discussion

Registered nurses are one of the main groups of clinicians that work with insulin in the hospital but they sometimes lack the appropriate knowledge associated with inpatient diabetes care and insulin. To promote safe insulin use and teach nurses about insulin in the inpatient setting, we created an interactive video module with case studies, videos and slides. We then measured change in knowledge and overall satisfaction using pre-and posttest and a satisfaction survey. Our results indicated a knowledge gap when it comes to inpatient diabetes management and insulin use; the average score of the 11 participants that took the pretest was 51%. The participants on average showed satisfaction with the video module.

The question most of the participants answered incorrectly asked to identify the recommended target blood glucose level in hospitalized patients. Most of the participants identified a blood glucose range much lower than what the ADA recommends. According to the ADA, the appropriate blood glucose level for most critically ill and non-critically ill patients in the hospital is 140-180 mg/dL. A target of 110-140 mg/dL may be appropriate for selected patients, if this can be achieved without significant hypoglycemia. Targets less than 110 mg/dL are not recommended. Most of the participants identified 80-140 mg/dL as the target blood glucose level, 30-60 points lower than the recommended range. This may be due to the fact that the outpatient normal blood glucose range is lower than the inpatient recommendations and that hypoglycemia is defined as blood glucose <70mg/dL much lower than the recommended inpatient blood glucose range. The fact that most of the participants may not be aware of the target blood glucose range shows an opportunity for further discussion and knowledge dispersion to inpatient registered nurses taking care of patients with diabetes. It is essential that inpatient

nurses are aware of these recommendations, since they are the front-line staff that can identify and act on blood glucose levels that are trending lower.

Another particularly interesting finding in the pre-and posttest is the poor performance on the academic center's hypoglycemia treatment policy. Hypoglycemia prevention and proper treatment is important because studies show patients with hypoglycemia have longer hospitalization stays, higher readmission rates and increased mortality. The average cost per stay is also considerably higher. Thus, it is important that all inpatient nurses are aware of the most appropriate way to treat hypoglycemia based on the protocol established by the academic center. As discussed in the result section, the project showed improvement with the participants' knowledge of the academic center's hypoglycemia treatment protocol which validates the necessity of educational activities such as this DNP project to improve the knowledge base of the staff. Another question that pointed to a knowledge gap involves rapid acting insulin and its duration of action. It is important that nurses are aware of the pharmacodynamics of rapid acting insulin as it is widely used throughout the hospital. This knowledge maybe helpful to inpatient nurses as it can give insight as to when to check and recheck blood glucose after insulin administration and the concept of insulin stacking when administering rapid acting insulin over a course of a short period of time.

Even though the above questions showed some knowledge gap, there were other questions where most of the participants scored well. Two out of the three questions that scored the most correct responses from participants involved basal insulins: correctly identifying which type of insulin should not be completely held for patients with type 1 diabetes and identifying the correct duration of action for glargine. Inpatient nurses sometimes call providers with questions on what actions to take when NPO patients are scheduled to receive basal insulin. Some

institutions have a standing protocol, whereas others leave it to providers to make the decision on a case by case basis. In some cases, basal insulins are held in patients with type 1 diabetes putting patients at risk for DKA. In the 2018 MERS analysis, omission of basal insulin constituted the second most common cause of insulin errors (21 errors), second to omission of correction insulin (42 errors). Since 2019, the medical center started to insert instructional phrases with insulin orders within the electronic medical system. One of the instructions was on the basal insulin order-set and contains instructions to refrain from withholding basal insulin when patients are NPO, as well as for nurses to contact providers for specific instructions, since providers may reduce basal dose by up to 20% when patients are NPO.

Though the questions concerning basal insulins mentioned above garnered the most correct pretest answers, identifying which insulins are considered basal insulins gained only three correct answers on the pretest. However, this question showed the most improvement in participants from pre-to posttest, with eight out of nine participants identifying the correct response on the posttest. Possible reasons the participants did not correctly identify NPH, glargine and detemir as basal insulins maybe the lack of understanding of what “basal” insulin is or the limited use of NPH as basal insulin in the academic center.

In the 2018 MERS analysis, omission of correction insulin constituted the highest number of insulin-related errors. With knowledge of the high incidence rate of correction insulin omission, the academic medical center inserted an instructional phrase within the EMR’s order-set for correction or sliding scale insulin. This instruction states “when patient is NPO, correction insulin should still be given. When patient is PO, correction insulin should be given before meals in combination with standing meal time insulin.” This phrase, gives direction to nurses every time they address an order for correction or sliding scale insulin. This phrase may have

contributed to the fact that most participants identified the difference between prandial insulin and correction insulin correctly in the pretest and posttest.

In some questions, participants chose the correct answer in the pretest, but chose incorrect answers in the posttest. These instances make it difficult to conclusively determine whether the module was enough to teach nurses about certain topics. For example, in Question #5, which asked what insulin should always be held when a patient is NPO, two nurses changed their correct answer of "holding prandial/nutritional insulin" to an incorrect answer on the posttest. However, two other participants that had incorrectly identified the answer to this question later identified the right answer on the posttest. In the questions where participants switched from correct to incorrect answers (questions #2, #5, #6 and #9), there were always the same number or more participants that went from incorrect to correct answers. But the fact that some participants changed from correct to incorrect answers from pre-to posttest gives inconclusive results about whether the module was helpful with these particular questions.

As a final point, all other pre-and posttest questions aside from Question #2, #5, #6 and #9 demonstrated improvement in knowledge based on the number of correct answers on the posttest compared to the pretest. In addition, the participants did not change their answers from correct to incorrect responses on those questions. The module showed an improvement in knowledge as showed in the result from pre-to post test and most participants were satisfied with the module. These are promising findings and demonstrate the potential of interactive online module as a gap filler for some of the knowledge gap that exists in inpatient insulin therapy.

Limitations

The project had various limitations, with one of the main ones being its small sample size. Eleven participants completed the pretest questions and nine of the eleven participants

completed the module. A small sample size affects the reliability of the results with a high variability and increase in margin of error. In addition to the small sample size, another limitation is the that the project was distributed through personalized links to participant's work email accounts in four medicine units. This may have excluded some participants that may not check their work email frequently. Furthermore, the project was limited to those that had time to complete the module. It is difficult to determine if some skipped over the contents of the module without reading or listening to them. Finally, the pretest, the module and the posttest were not done in one sitting, which may have led to participants getting their answers on the tests through other means, such as looking up the answers or coming across the information on their own time.

Conclusion

This DNP project aimed to identify and fill potential knowledge gaps in regard to insulin therapy in the inpatient setting, using a survey and an interactive educational video module. The project started with an insulin focused MERS analysis of the academic medical center, which identified the most common causes of insulin-related errors for the 2018 calendar year.

The project demonstrated registered nurses' knowledge gaps in inpatient diabetes management. The interactive educational module was successful in filling this knowledge gap. This DNP project also demonstrated potential in incorporating insulin focused diabetes educational modules for other inpatient clinical staff such as physicians and advance practice providers who take care of patients with diabetes. Next steps for this DNP project include the dissemination of the module to all current and incoming inpatient registered nurses and the evaluation of the effectiveness of the module in the nurses' clinical practice.

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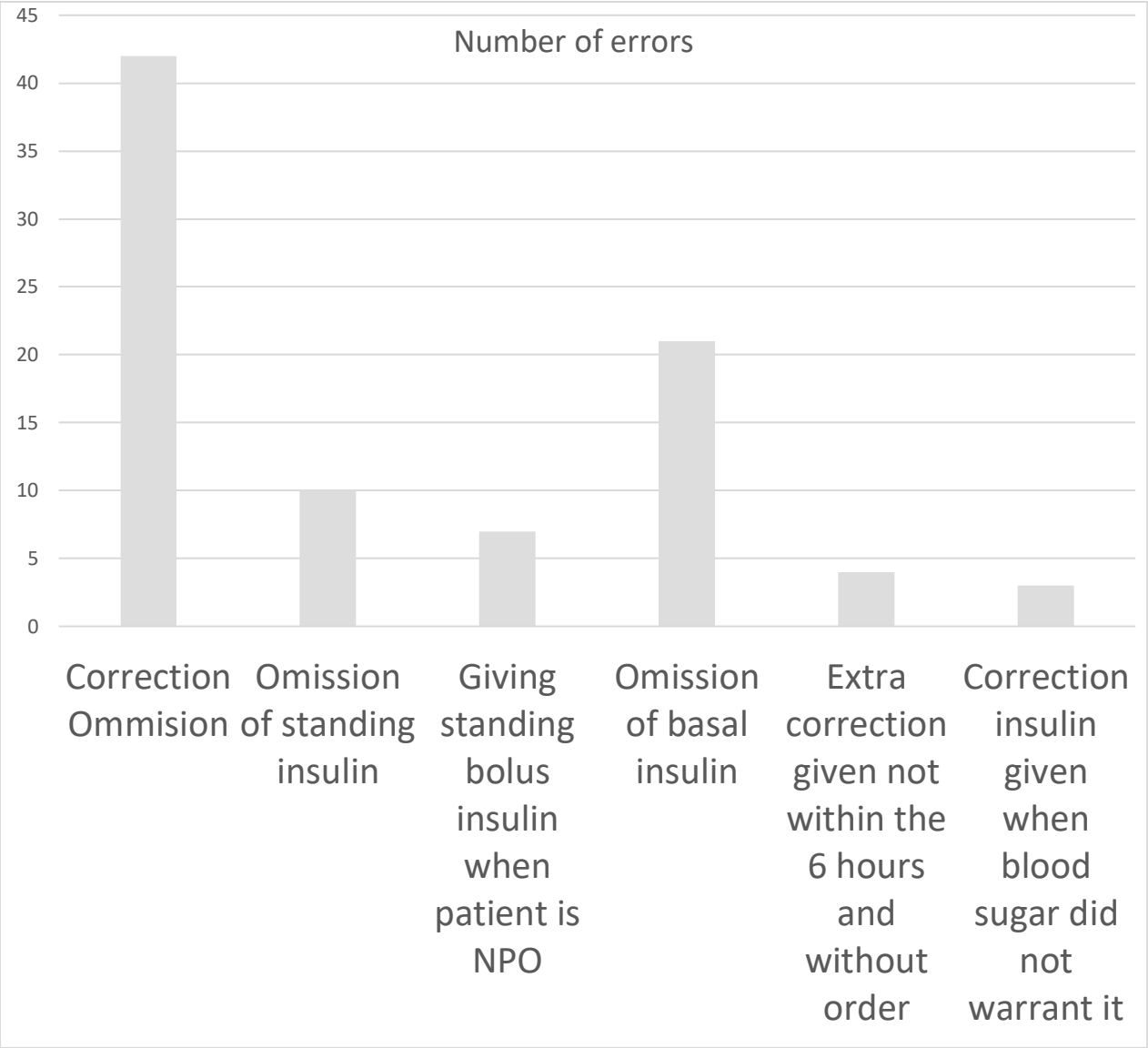
Appendix A: Medical Error Analysis Form

Error type	Frequency	Discipline
Description of error type, error 1	# of errors	Nursing (# of errors) - Name of unit (# of errors) - Name of unit (# of errors) - Name of unit (# of errors) etc. Pharmacy (# of errors) Physician (# of errors) - Internal medicine (# of errors) - Cardiology (# of errors) - Surgery (# of errors) etc.
Description of error type, error 2 etc.	# of errors	Nursing (# of errors) - Name of unit (# of errors) - Name of unit (# of errors) - Name of unit (# of errors) etc. Pharmacy (# of errors) Physician (# of errors) - Internal medicine (# of errors) - Cardiology (# of errors) - Surgery (# of errors) etc
Description of error type, error 3 etc.	# of errors	Nursing (# of errors) - Name of unit (# of errors) - Name of unit (# of errors) - Name of unit (# of errors) etc. Pharmacy (# of errors) Physician (# of errors) - Internal medicine (# of errors) - Cardiology (# of errors) - Surgery (# of errors) etc.

Appendix B: Medical Error Report Analysis

Error type	Frequency	Discipline
Giving standing insulin when patient is NPO	7	Nursing (7)
Giving standing insulin without rechecking for hypoglycemia	2	Nursing (2)
correction omission	42	Nursing (41) Physician (1)
Basal insulin wrong time	2	Nursing (2)
Regular insulin without dextrose for hyperkalemia	1	Physician(1) -Pediatrics (1)
Wrong insulin administered	1	Nursing (1)
Snack time insulin held	1	Nursing (1)
Giving standing insulin too early (food is not there)	1	Nursing (1)
Omission of standing insulin	10	Nursing (10)
Correction insulin given when blood sugar did not warrant it	3	Nursing (3)
Insulin dose change, both doses given	1	Nursing (1)
Extra correction given not within the 6 hours and without order	4	Nursing (4)
Omission of basal insulin	21	Nursing (21)
Adjusting of standing insulin without an order	1	Nursing (1)
Given correction insulin when not ordered at bedtime	1	Nursing (1)
Insulin given despite allergy	1	Nursing (1)
Hypoglycemia, no recheck in 15 minutes	1	Nursing (1)
Improper solution for insulin drip	1	Nursing (1)
Giving intermediate insulin without tube feed	1	Nursing (1)
Intermediate insulin held	2	Nursing (2)

Appendix C: Most Common Insulin-Related Errors



Appendix D: Expert Panel Evaluation Form

These case study questions below were derived from a medical error reporting system analysis for insulin based errors for the 2018 calendar year. These case study questions will be included in a web-based educational module on inpatient insulin therapy for inpatient registered nurses. Using the evaluation form below, please mark either YES or NO on each questions' appropriateness and relevance to the case study and the target audience. Also comment on the clarity of the questions.

Case study	**Questions**	**Relevance- Is this case study relevant to include?**		**Appropriateness – Is this case study appropriate to the target audience (inpatient RNs)?**		**Suggestions**
		YES	**NO**	**YES**	**NO**	
I.	Question 1.0					
	Question 1.1					
	Question 1.2					
	Question 1.3 etc.					
II.	Question 2.0					
	Question 2.1					
	Question 2.2 etc.					

Appendix E: Case Study Questions, Answers, and Rationale

Case study	**Questions**	**Rationale**
1. J. J. is a 65-year-old female with a PMH of type 2 diabetes, COPD, hypertension, coronary artery disease with multiple past PCIs, admitted for chest pain. She is ordered Lantus glargine 20 units at bedtime, Humalog lispro 5 units three times a day with meals and Humalog lispro correction scale as noted below. For glucose 180 mg/dL or lower, give no additional insulin. For glucose 181-230 mg/dL, give 1 unit of insulin. For glucose 231-280 mg/dL, give 2 units of insulin. For glucose 281-330 mg/dL, give 3 units of insulin. For glucose 331-380 mg/dL, give 4 units of insulin. For glucose 381-430 mg/dL, give 5 units of insulin. For glucose greater than 430, give 6 units of insulin and notify physician.	1A. The patient's blood sugar **before breakfast was 181** and she is about to eat. How much insulin should the patient receive at breakfast? A. Basal dose Lantus glargine 12 units B. Nutritional dose Humalog lispro 5 units C. Nutritional dose Humalog lispro 5 units plus correctional dose Humalog lispro 1 unit, total dose 6 units D. Correctional dose Humalog lispro 1 unit	The correct answer is Nutritional dose Humalog lispro 5 units plus correctional dose Humalog lispro 1 unit, total dose 6 units Rationale: The patient should receive 6 units of Humalog lispro. Nutritional (5 units of Humalog lispro) because the patient is about to eat and correctional (1 unit of Humalog lispro) because the blood glucose is 181 and 1 unit is required for a blood glucose of 181 according to the correction scale.
	1B. If the patient had NOT received prandial/nutritional insulin yet and the blood glucose was checked after breakfast, and it was181 how much insulin should the patient receive? A. Basal dose Lantus glargine 12 units B. Nutritional dose, Humalog lispro 5 units C. Nutritional dose 5 units plus correctional dose 1 unit, total dose Humalog lispro 6 units D. Correctional dose Humalog lispro 1 unit	The correct answer is nutritional dose only, Humalog lispro 5 units Rationale: Blood sugar of 181 does not reflect pre-meal blood glucose thus patient should only receive nutritional Humalog lispro of 5 units. Correctional insulin should be held since blood sugar was checked after the patient ate.
	1C. Patient is scheduled for a heart cath the next day and will be **NPO** starting midnight. She has not had episodes of hypoglycemia. Her bedtime blood glucose was **142**. Which is the most appropriate nursing action?	The correct answer is to contact the primary team to reduce Lantus glargine dose.

<table>
<tr>
<td></td>
<td>A. Contact primary team to reduce Lantus glargine dose.
B. Contact primary team to hold Lantus glargine dose as patient is NPO
C. Hold Lantus glargine
D. Hold correctional and nutritional Humalog lispro</td>
<td>Rationale: When patients are NPO basal insulin, Lantus glargine should not be held. Basal insulin may be reduced, thus primary team should be contacted</td>
</tr>
<tr>
<td></td>
<td>1D. The morning of the next day, the patient wakes up with a blood sugar of 240. The patient is still NPO for her upcoming heart cath. What should the nurse do?
A. Give correctional dose 2 units Humalog lispro
B. Give nutritional dose Humalog lispro 5 units
C. Hold nutritional and correctional lispro as patient is NPO
D.</td>
<td>The correct answer is to give Correctional dose 2 units Humalog lispro

Rationale: Correctional insulin (insulin used to treat high blood glucose based on a correction scale) should be given when patients are NPO. Nutritional/Prandial insulin should be held.</td>
</tr>
<tr>
<td></td>
<td>1E. The patient’s cath is cancelled. It is lunch time and the patient’s blood glucose is 169. She receives 5 units of prandial insulin and patient ate her entire lunch. When you check her blood glucose at1800 before dinner, her blood glucose was 69 as illustrated in the table below. You treat the hypoglycemia and blood glucose normalizes. You have the patient the next day and you realize no changes have been made to her insulin regimen. Which changes would have been appropriate based on the pre-dinner hypoglycemia the patient experienced?
<table>
<tr><th></th><th>0600</th><th>1200</th><th>1800</th><th>2200</th></tr>
<tr><td>Yesterday</td><td>130</td><td>169 (received 5 units of Humalog lispro)</td><td>69</td><td>179</td></tr>
<tr><td>Today</td><td>179</td><td>140</td><td></td><td></td></tr>
</table>
</td>
<td>Rationale: The correct answer is to reduce pre-lunch prandial Humalog lispro. The glucose level before dinner will indicate whether the insulin given at lunch was appropriate. In this case, the patient received 5 units of nutritional Humalog lispro insulin with her lunch and her blood sugar at 1800 (before dinner) was 69. Thus, the pre-lunch prandial Humalog lispro should be reduced for the next day.

If the blood glucose level before lunch would have been low, then the breakfast nutritional dose would have to be decreased the next day.</td>
</tr>
</table>

	A. Pre-breakfast prandial Humalog lispro should be reduced B. Pre-lunch prandial Humalog lispro should be reduced C. Pre-dinner prandial Humalog lispro should be reduced D. Lantus glargine should be reduced	
II. 54 yo female with Type 1 diabetes s/p liver and renal transplant November 2015 who is admitted for neurological decline. For diabetes, the patient is ordered Lantus glargine 12 units at bedtime and Humalog lispro 4 units with meals. A Humalog lisprocorrection scale is seen below For glucose 180 mg/dL or lower, give no additional insulin. For glucose 181-230 mg/dL, give 1 unit of insulin. For glucose 231-280 mg/dL, give 2 units of insulin. For glucose 281-330 mg/dL, give 3 units of insulin. For glucose 331-380 mg/dL, give 4 units of insulin. For glucose 381-430 mg/dL, give 5 units of insulin. For glucose greater than 430, give 6 units of insulin and notify physician.	2A. This patient was not feeling well in the evening and went for an emergency procedure and came back a couple of hours later. You realize the patient missed her basal insulin dose due to being off the floor for a procedure. What should you do? A. Administer basal insulin as soon as possible to prevent DKA B. Contact primary team when patient comes back, they may order a dose of NPH as basal insulin or have you administer the glargine dose C. Skip the night time dose of Lantus glargine and administer the next dose the next day at bedtime D. A or B	The correct answer is A or B. (A. Administer basal insulin as soon as possible to prevent DKA or B. Contact primary team when patient comes back as they may order a dose of NPH as basal insulin or have the nurse administer lantus glargine) Rationale: Basal insulin should NOT be held for patients with type 1 diabetes. By holding basal insulin, you can cause diabetic ketoacidosis. In this scenario patient should receive her basal insulin as soon as possible. Contact the primary team if patient comes back to the unit past the medication administration time.
	2B. You call the primary team and inform them that the patient **did NOT** receive the bedtime dose of Lantus glargine because she was off the unit. The resident advises you to **hold the Lantus glargine** and administer prandial Humalog lispro at breakfast. What should be your next step? A. Check the patient's blood glucose and administer correctional Humalog lispro if blood glucose is >180 and administer nutritional Humalog lispro when patient eats B. Hold Lantus glargine and place in comments "held per MD"	The correct answer is A & C. (A. Check the patient's blood glucose and administer correctional Humalog lispro if blood glucose is >180 and C. Administer nutritional Humalog lispro when patient eats and inform the resident that Lantus glargine should not be skipped for patients with type 1 diabetes) Rationale: Individuals with type 1 diabetes have an absolute

	C. Inform the resident that Lantus glargine should not be skipped for patients with type 1 diabetes D. A & C	insulin deficiency and basal insulin should not be held for those who have type 1 diabetes. By holding basal insulin, you can cause diabetic ketoacidosis, which is a clinical emergency. The patient should also receive both nutritional and correctional insulin when she eats in addition to the basal insulin. Thus both A and C are correct.
	2C. The next day, the patient is feeling much better. Her blood glucose at bedtime is **now 65.** Please mark the most appropriate statement A. Hypoglycemia should be treated per protocol. Lantus should be given once blood glucose is above 100 mg/dL B. Hypoglycemia should be treated per protocol. Lantus should be held after management of hypoglycemia. C. Hypoglycemia should be treated per protocol. All insulins should be held after management of hypoglycemia.	The correct answer is to treat hypoglycemia per protocol. Lantus should be given once the blood glucose is above 100 mg/dL Rationale: Hypoglycemia should be treated first. Basal insulin should be given once blood glucose is above 100 mg/dL. Since patient has type 1 diabetes, basal insulin should NOT be held. The nurse can contact primary team to determine if basal dose reduction is appropriate. Basal insulin should NOT be completely held for patients who have type 1 diabetes.
	2D. How would you **treat hypoglycemia of 65**, on a patient who can eat by mouth? A. Give 15 grams of fast acting glucose. Treat every 15 minutes until blood glucose is ≥ 70. Recheck blood glucose every 15 minutes until blood glucose is >100 B. Give 15 grams of fast acting glucose. Recheck and treat every 30 minutes until blood glucose is ≥ 70 C. Give 15 grams of fast acting glucose. Treat every 15 minutes until blood glucose	Rationale: The correct answer is to give 15 grams of fast acting glucose and then treat every 15 minutes until blood glucose is ≥ 70. Glucose should also be rechecked every 15 minutes until blood glucose is >100. Blood glucose should be rechecked until blood glucose is above 100 to make sure hypoglycemia does not persist.

	is ≥ 70. Recheck blood glucose every 15 minutes until blood glucose is ≥ 70	
	2E. The next day, the **patient's blood glucose at lunch is 349**. The nurse administered the correctional Humalog lispro of 4 units and nutritional Humalog lispro of 4 units for a total of Humalog lispro **8 units**. The nurse gets worried about the patient's blood glucose and rechecks it in **1 hour. The** blood glucose is 300. Identify the most appropriate statement. A. The nurse should have waited to check the patient's blood glucose B. Giving another correction dose of insulin 1 hr after eating is not typically advised C. Humalog lispro peaks in 1.5 hours to 2 hours. Checking the blood glucose in 1 hour won't show the full effect of Humalog lispro D. The nurse should now give correctional Humalog lispro of 3 units. E. A, B & C	The correct answers are A B, & C. (A. The nurse should have waited to check the patient's blood glucose, B. Giving another correction dose of insulin 1 hr after eating is not typically advised and C. Humalog lispro peaks in 1.5 hours to 2 hours. Checking the blood glucose in 1 hour won't show the full effect of Humalog lispro) Rationale: Humalog lispro peaks in 1.5 hours to 2 hours. Checking the blood glucose in 1 hour won't show the full effect of Humalog lispro. So the nurse should have waited at least 2 hours to check the patient's blood glucose. In addition giving additional correctional insulin could cause insulin stacking since patient already has 8 units of Humalog lispro on board and Humalog lispro stays in the system for 3-5 hours.
	2F. Patient's blood sugar at dinner time has improved but you notice that her blood glucose at **bedtime is 230**. She is also about to eat a **yogurt as a snack** at bedtime. How much Humalog lispro should the patient receive? Bedtime Correction scale is listed below Below For glucose 180 mg/dL or lower, give no additional insulin. For glucose 181-230 mg/dL, give 1 unit of insulin. For glucose 231-280 mg/dL, give 1 unit of insulin. For glucose 281-330 mg/dL, give 2 units of insulin. For glucose 331-380 mg/dL, give 3 units of insulin.	The correct answer is to contact primary/endocrine team to order snack time insulin to administer with the 1 unit of correction Humalog lispro Rationale: Patient has type 1 diabetes. Patients with type 1 diabetes should receive nutritional insulin before eating a carbohydrate containing meal or snack. In this case, patient did not have a snack time insulin order so it is most appropriate for the nurse to notify the primary team for a snack time

	For glucose 381-430 mg/dL, give 4 units of insulin. For glucose greater than 430, give 4 units of insulin and notify physician. A. Correctional Humalog lispro 1 unit B. Nutritional Humalog lispro 4 units C. Contact primary/endocrine team to order snack time insulin to administer with the 1 unit of correction Humalog lispro D. Correctional Humalog lispro 1 unit and nutritional Humalog lispro 4 units, total Humalog lispro 5 units	insulin and also give the correctional insulin Humalog lispro of 1 unit.
3. G. P. is a 57 y.o. female w PMH of type 2 diabetes, COPD, hypertension, hyperlipidemia, depression and progressive multiple sclerosis admitted with seizure. Patient is currently NPO because of a failed swallow evaluation and has been receiving continuous tube feed of Glucerna at 60 cc/hr using a peg tube. The patient is on NPH 15 units every 6 hours plus Humalog lispro correction scale as shown below for her diabetes. For glucose 180 mg/dL or lower, give no additional insulin. For glucose 181-230 mg/dL, give 2 unit of insulin. For glucose 231-280 mg/dL, give 4 units of insulin. For glucose 281-330 mg/dL, give 6 units of insulin. For glucose 331-380 mg/dL, give 8 units of insulin. For glucose 381-430 mg/dL, give 10 units of insulin. For glucose greater than 430, give 10 units of insulin and notify physician.	3A. The peg tube was unfortunately **dislodged at 9 am** and her tube feed was stopped. The patient received her last dose of NPH at 6 am. Which is the most appropriate next action by the RN? A. Contact team, they may order IV D10 B. Check blood glucose at 9 am, no action necessary if blood sugar is normal C. Check blood glucose at 1800 D. No action needed at this time	Rationale: The correct answer is to contact the team. Interruption in tube feeds is a risk for hypoglycemia. The most appropriate nursing action is to contact the primary team as the patient may need frequent blood glucose check or IV D10.
	3B. It is now 12 pm and the NPH of 15 units is due. The **patient's blood glucose is 201**. Which is the most appropriate next action by the RN? A. Hold both NPH and correctional Humalog lispro B. Give 2 units of correctional Humalog lispro C. Contact primary team. They may hold or reduce NPH insulin D. b&c	The correct answer is B & C (B. Give 2 units of correctional Humalog lispro and C. Contact primary team. They may hold or reduce NPH insulin) Rationale: Since patient is not on tube feeds, it is most appropriate to contact the primary team who may hold or reduce the NPH insulin dose. Correctional insulin (insulin used to treat high blood glucose based on a correction scale) SHOULD be given since the patient's blood glucose is 201. Thus patient can receive Humalog lispro of 2 units.
	3C. Tube feeds are **restarted at 1 pm and NPH 15 units is administered by the RN. The patient's** blood glucose **at midnight, 11 hours**	Rationale: The correct answer is to alert primary team as NPH

	after tube feeds are restarted is 71. You decide to A. Alert primary team as NPH dose may need to be reduced or stopped B. Give full dose of NPH 15 units C. Hold NPH	dose may need to be reduced or stopped Blood glucose of 71 can be indication that patient is receiving too much insulin and is at risk for hypoglycemia, unless there was another easily explainable factor such as tube feed interruptions.
	3D. The next day, patient has a **blood glucose of 55**. The patient is **NPO and has IV access**. What should be the next step? A. Give D50, 25 mL, IV push. Retreat and recheck blood glucose every 15 minutes until blood glucose is ≥ 70 B. Give D50, 25 mL, IV push. Repeat treatment every 15 minutes until blood glucose is ≥ 70. Recheck blood glucose every 15 minutes until blood glucose >100. C. Give D50, 25 mL, IV push. Recheck blood glucose in 30 minutes. Repeat treatment and recheck blood glucose every 30 minutes until blood sugar is > 70.	Rationale: The academic center's hypoglycemia protocol is to treat accordingly until blood sugar ≥ 70 and to recheck blood sugar every 15 minutes until blood glucose is above 100. Blood glucose should be rechecked until blood glucose is above 100 to make sure hypoglycemia does not persist even after blood sugar is above 70. For this question the correct answer is B, give D50, 25 mL, IV push. Repeat treatment every 15 minutes until blood glucose is ≥ 70. Recheck blood glucose every 15 minutes until blood glucose >100.
	3E. Patient is experiencing exacerbation of COPD and is placed on **prednisone 60 mg** daily for 5 days. Her insulin was increased to **NPH 25 units every 6 hours**. Her tube feed and the rate has not changed. After 2 days of steroid therapy, the patient is feeling better and the primary team discontinued the prednisone. Please mark the statements below as either true or false. **Insulin doses should most likely be reduced or stopped when steroid doses are being reduced or stopped.** A. True B. False	Rationale: The correct answer is true, insulin doses should most likely be reduced or stopped when steroid doses are being reduced or stopped.If you notice a discontinuation or interruption of steroid delivery for patients on standing (not correctional) insulin, it is most appropriate to alert the primary team. Examples include patients who are on insulin and refuse their steroids or patients who have completed their steroid therapy.

Appendix F: Pretest & Posttest Questions

1. Which answer choice contains ONLY *basal* insulins?
    a. Regular, lispro/Humalog, aspart/Novolog
    b. Regular, NPH, aspart/Novolog
    c. NPH, glargine/Lantus, detemir/Levemir
    d. Glargine/Lantus, regular, lispro/Humalog

2. Which answer choice contains ONLY *bolus* insulins?
    a. Regular, lispro/Humalog, aspart/Novolog
    b. Regular, NPH, aspart/Novolog
    c. NPH, glargine/Lantus, detemir/Levemir
    d. Glargine/Lantus, regular, lispro/Humalog

3. What is the difference between *prandial/nutritional* insulin and *correction* insulin?
    a. Prandial/nutritional = meal coverage, correction = treat high blood sugars
    b. Prandial/nutritional = fasting insulin needs, correction = treat high blood sugars
    c. Prandial/nutritional = treat high blood sugars, correction = meal coverage
    d. Prandial/nutritional = meal coverage, correction = fasting insulin needs

4. What is the difference between *basal* insulin and *bolus* insulin?
    a. Basal = fasting insulin needs, bolus = correction insulin only
    b. Basal = meal insulin only, bolus = correction insulin only
    c. Basal = meal and correction insulin, bolus = fasting insulin needs
    d. Basal = fasting insulin needs, bolus = meal and correction insulin

5. When a patient is made NPO, which type of insulin order should ALWAYS be *held/stopped/discontinued*?
    a. Basal insulin
    b. Prandial insulin/nutritional insulin
    c. Correction insulin
    d. Sliding scale insulin

6. For a patient with TYPE 1 diabetes, which type of insulin order should NEVER be completely *held/stopped/discontinued*?
    a. Basal insulin
    b. Prandial insulin
    c. Correction insulin
    d. Sliding scale insulin

7. What is the approximate duration of action of insulins aspart/Novolog, lispro/Humalog, and glulisine/Apidra?

a. 1-2 hours
b. 3-5 hours
c. 5-6 hours
d. 7-8 hours

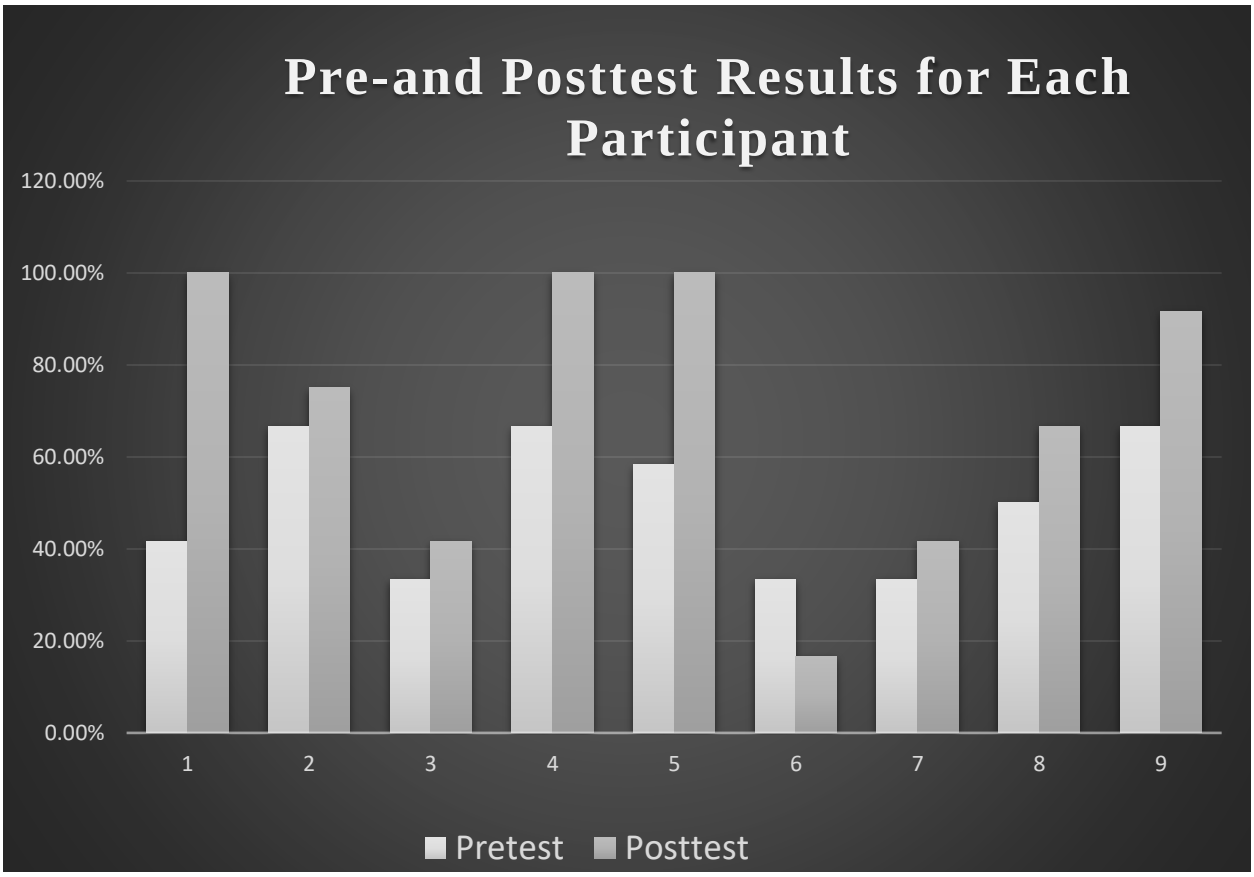
8. What is the approximate duration of action of insulin glargine/Lantus?
   a. 6-8 hours
   b. 9-12 hours
   c. 15-18 hours
   d. 20-24 hours
9. What is 70/30 insulin?
   a. A mixture of 70% glargine/Lantus insulin and 30% fast-acting insulin
   b. A mixture of 70% fast-acting insulin and 30% glargine/Lantus
   c. A mixture of 70% NPH insulin and 30% fast-acting insulin
   d. A mixture of 70% fast-acting insulin and 30% NPH
10. Systemic steroids impact all blood sugars. The GREATEST impact is on which?
   a. Overnight glucoses
   b. Fasting morning glucoses
   c. Pre-meal glucoses
   d. Post-meal glucoses

11. What is the target blood glucose range for the majority of critically ill and non critically ill hospitalized patients with diabetes?
   a. 140-180 mg/dL
   b. 120-160 mg/dL
   c. 80 mg/DL -140 mg/dL
   d. 70mg/dL 180 mg/dL

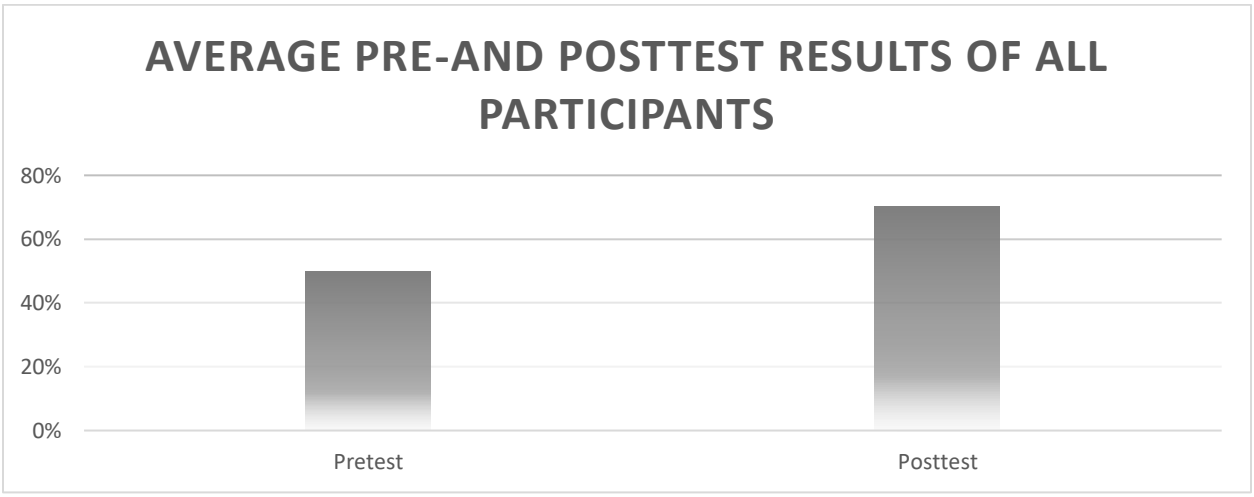
12. What is the academic center's hypoglycemic protocol for a patient who has a blood glucose of 53 and is not NPO?
   a) Give 15 grams of fast acting glucose. Treat every 15 minutes until blood glucose is ≥70. Recheck blood glucose every 15 minutes until blood glucose is >100
   b) Give 15 grams of fast acting glucose. Treat every 15 minutes until blood glucose is ≥ 70. Recheck blood glucose every 15 minutes until blood glucose is ≥70
   c) Give 15 grams of fast acting glucose. Recheck and treat every 30 minutes until blood glucose is above 70
   d) Give 15 grams of fast acting glucose. Treat every 15 minutes until blood glucose is > 70. Recheck blood glucose every 15 minutes until blood glucose is above 90

Appendix G: Pretest and Posttest Results

Graph 1: Pre-and posttest results for each participant



Graph 2: Average pre-and posttest result of all participants



Appendix H: Cross-Tabulation Analysis

Questions with the most correct response from the same participants both on the pretest and the posttest	**Questions with the most improvements from the pretest to the posttest**	**Questions with the lowest pretest score**	**Questions where participants switched from the correct answer on the pretest to an incorrect answer on the posttest.**
Question #3 *What is the difference between prandial/nutritional insulin and correction insulin?* (7/9 correct response)	Question #1 *Which answer choice contains ONLY basal insulins?* (improved from 3 to 8 correct responses)	Question #11 *What is the target blood glucose range for the majority of critically ill and non-critically ill hospitalized patients with diabetes?* (1/9 correct response)	Question #2 *Which answer choice contains ONLY bolus insulins?* (2 participants changed their answers from a correct to an incorrect answer)
Question #6 *For a patient with TYPE 1 diabetes, which type of insulin order should NEVER be completely held/stopped/discontinued?* (5/9 correct response)	Question #11 *What is the target blood glucose range for the majority of critically ill and non-critically ill hospitalized patients with diabetes?* (improved from 1 to 5 correct responses)	Question #7 *What is the approximate duration of action of insulins aspart/Novolog, lispro/Humalog, and glulisine/Apidra?* (3/9 correct response)	Question #5 *When a patient is made NPO, which type of insulin order should ALWAYS be held/stopped/discontinued?* (2 participants changed their answers from a correct to an incorrect answer)
Question #8 *What is the approximate duration of action of insulin glargine/Lantus?* (5/9 correct response)	Question #12 *What is the academic center's hypoglycemic protocol for a patient who has a blood glucose of 53 and is not NPO?* (improved from 3 to 7 correct responses)	Question #12 *What is the academic center's hypoglycemic protocol for a patient who has a blood glucose of 53 and is not NPO?* (3/9 correct response)	Question #7 *What is the approximate duration of action of insulins aspart/Novolog, lispro/Humalog, and glulisine/Apidra?* (2 participants changed their answers from a correct to an incorrect answer)
Question #9 *What is 70/30 insulin?* (5/9 correct response)		Question #10 *Systemic steroids impact all blood sugars. The GREATEST impact is on which?* (3/9 correct response)	Question #9 *What is 70/30 insulin?* (2 participants changed their answers from a correct to an incorrect answer)

Appendix I: Satisfaction Survey Analysis Questionnaire

Question	Strongly disagree (1)	Disagree (2)	Neither agree nor disagree (3)	Agree (4)	Strongly Agree (5)
Interest: I found this educational module very interesting.					
Pace: I found the pace of this educational module just right.					
Amount: I learned a great deal in this educational module.					
Clarity: I found the material in this educational module very clear.					
Importance: I found what I learned in this educational module very important.					

Appendix J: Satisfaction Survey Analysis Results

Table one: Nine Participants

Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
Interest: I found this educational module very interesting.	1	5	3.78	1.47	2.17	9
Pace: I found the pace of this educational module just right.	1	5	3.67	1.25	1.56	9
Amount: I learned a great deal in this educational module.	1	5	3.78	1.31	1.73	9
Clarity: I found the material in this educational module very clear.	1	5	3.67	1.33	1.78	9
Importance: I found what I learned in this educational module very important.	1	5	3.89	1.37	1.88	9

Table two: Eight Participants

Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
Interest: I found this educational module very interesting.	2.00	5.00	4.13	1.17	1.36	8
Pace: I found the pace of this educational module just right.	3.00	5.00	4.00	0.87	0.75	8
Amount: I learned a great deal in this educational module.	3.00	5.00	4.13	0.93	0.86	8
Clarity: I found the material in this educational module very clear.	3.00	5.00	4.00	1.00	1.00	8
Importance: I found what I learned in this educational module very important.	3.00	5.00	4.25	0.97	0.94	8

Graph three: Satisfaction Survey Analysis with nine Participants