

DIABETIC KETOACIDOSIS (DKA) INSULIN INFUSION PROTOCOL UPDATE USING  
EVIDENCE-BASED PRACTICE: A QUALITY IMPROVEMENT PROJECT

A Scholarly Project

Submitted to the

Faculty of Liberty University

In partial fulfillment of

The requirements for the degree

Of Doctor of Nursing Practice

By

Susan K. Lacey

Liberty University

Lynchburg, VA

October 2018

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Scholarly Project Chair Approval:

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Shanna Akers, EdD, MSN/MBA-HC, RN, CNE

### **Abstract**

Diabetic Ketoacidosis is a life-threatening side effect to Diabetes Mellitus. Standards of treatment and recommendations are made by the American Diabetes Association. The project was to evaluate and provide the latest evidence-based practice to update the hospital policy for the treatment of DKA in the Intensive Care Unit and Emergency Department. Retrospective chart reviews were conducted to review the number of patients admitted with diabetic ketoacidosis and treated on the DKA Insulin Infusion Protocol before and after the update. Rapid correction of blood glucose levels proved to be an issue at this facility both before and after the updates were made to the DKA Insulin Infusion Protocol. The data supports the need for change in protocol, staff development in the use of the protocol and the need for change in the emergency department as well as the intensive care unit.

*Keywords:* Insulin Protocol, DKA, Diabetic Ketoacidosis treatment, Diabetic emergencies, and glucose monitoring

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List of Abbreviations

American Diabetes Association (ADA)

Collaborative Institute Training Initiative (CITI)

Critical Care Pathway (CCP)

Diabetic Ketoacidosis (DKA)

Dissemination, Implementation and Improvement (DII)

Doctor of Nursing Practice (DNP)

Electronic Health Record (EHR)

Emergency Department (ED)

Health Insurance Portability and Accountability Act (HIPAA)

Institutional Review Board (IRB)

Intensive Care Unit (ICU)

Length of Stay (LOS)

Randomized Controlled Trial (RCT)



## SECTION ONE: INTRODUCTION

Diabetic Ketoacidosis (DKA) can be a life-threatening emergency in both the diagnosed and undiagnosed patients with diabetes. The American Diabetes Association (ADA) makes recommendations on the treatment of diabetes mellitus as well as treatment of DKA. The ADA has established protocols and algorithms for the treatment of DKA.

The site of this project is [REDACTED], which is a Life Point Hospital, located in Northern Virginia ([REDACTED]). [REDACTED] treats adult patients with DKA in the emergency department (ED) and intensive care unit (ICU) using an Insulin Infusion Protocol. This protocol was developed in 2014 and needs updates based on the latest recommendations by the ADA, as well as evidence-based research on the subject. [REDACTED] mission is to make the community healthier ([REDACTED]). Their vision is to create places where people choose to receive healthcare and where both physicians and employees want to work ([REDACTED]). Additionally, their values include the delivery of high quality care, support of the physicians and employees, fiscal responsibility and leadership in the community ([REDACTED]).

Members of the department of nursing, emergency department staff and intensive care unit staff, as well as the informatics physician, felt there was a need to update the current DKA Insulin Infusion Protocol with the latest recommendations by the ADA as well as with evidence-based practice. This scholarly project examined the latest research and recommendations for the treatment of adult's age 18-75 who are admitted with DKA and treated with Insulin Infusion Protocols.

**Problem Statement**

At [REDACTED], when an adult patients are admitted with a diagnosis of DKA, they are treated with an outdated Insulin Infusion Protocol. A possible complication of the use of this protocol is rapid correction that can lead to further complications such as signs or symptoms of hypoglycemia. Additionally, the process regarding the measurement of blood glucose by the nursing staff in the ICU and respiratory therapy as the policy states was in question. To reduce these possible complications, a review of the protocol and the most recent research was examined.

**Purpose of the Project**

The purpose of this scholarly project was to examine the DKA Insulin Infusion Protocol being used in the ICU and ED to update the protocol to the most up to date research by the ADA. A team of health care professionals which included the Informatics Physician, the Director of Pharmacy, the Director of Acute Care Services and the Clinical Coordinator for the ICU reviewed the recommendations for updating the protocol and adopted most of the changes. Afterwards, staff development courses were developed, a poster project for display in both the ICU and ED was presented by the DNP student. In order to improve adherence to the policy, it is important to educate the stakeholders when treating critically ill patients.

**Clinical Question**

The use of the current protocol for adult patients with the DKA insulin infusion at [REDACTED] has led to several patients who were rapidly corrected leading to complications of hypoglycemia. Concern was expressed that blood glucose monitoring in the ICU is not being followed per the protocol by the nursing staff and respiratory therapy staff. The protocol needed

updating with evidence-based practice. Can a change of the Insulin Infusion protocol reduce the incidence of complications due to rapid correction of blood glucose in the adult DKA patient?

## **SECTION TWO: LITERATURE REVIEW**

### **Search Strategy**

A systematic search was conducted for peer-reviewed journals published within the last three to five years using the following: CINAHL, EBSCO, Up-to-date and MEDLINE. This search included the following keywords: Insulin Protocol, DKA, Diabetic Ketoacidosis treatment, Diabetic emergencies, and glucose monitoring. The search revealed multiple articles and peer reviewed journals on the subject. Articles were then reviewed and further scrutinized for relevance ending with 13 articles for review. They were evaluated using Melnyk Levels of Evidence which revealed two level I, two level II, one level III, two level IV, three level V and two level VII (Melnik & Fineout-Overholt, 2015).

### **Review of Literature**

Clain, Ramar, and Surani (2015) reviewed 11 major randomized controlled trials (RCT) which investigated the use of intensive insulin therapy and conventional insulin therapy. After reviewing these studies, the authors concluded that the insulin therapies varied greatly, and there was no clear evidence to support one over another (Clain, Ramar, & Surani, 2015). Tran, et al. (2017) completed a review of DKA management protocols to examine strengths or weaknesses of such protocols. The authors found major deficiencies among the evidence for optimal management of DKA (Tran, et al., 2017). The deficiencies included a lack of timing of initiation, titration of IV fluids and replacement of electrolytes. They concluded that further studies were needed as well as the need to include robust evidence-based practices to improve patient outcomes (Tran, et al., 2017).

Wilinska and Hovorka (2014) evaluated three established glucose control protocols for the treatment of DKA. The protocols were tested on 56 virtual patients (Wilinska & Hovorka, 2014). When the authors compared continuous glucose monitoring and hourly blood glucose level monitoring, the three glucose control protocols varied in effectiveness. The authors reviewed management of blood glucose levels in hospitalized patients, which requires a team approach, requires education of all multidisciplinary team members, and careful implementation and use of standardized protocols (Mackey & Whitaker, 2015). Patients with diabetes can present the health care providers with challenges to keep glycemic control, especially those who are critically ill. Mackey and Whitaker (2015) observed some of these challenges as the pharmacodynamics of insulin, types of insulin used and delivery of insulin. Oral agents would not be given to critically ill individuals, which leaves insulin preparations and administration by subcutaneous, basal-bolus, bolus insulin and correction therapy (Mackey & Whitaker, 2015). Correction insulin therapy can be added to other fluids and can be used intravenously as an insulin infusion. Regardless of the method used, the authors stressed the importance of institutional guidelines being used to control blood glucose levels in hospitalized patients (Mackey & Whitaker, 2015).

The creation of an insulin infusion protocol and best practices is the aim of this scholarly project. Clergeau et. al (2017) assessed the efficacy, safety and acceptance of insulin protocols in the ICU. The authors reviewed 131 ICU patients who received continuous intravenous insulin infusions (dynamic infusion protocols) or sliding scale insulin for management of DKA. The conclusion included that the dynamic infusion protocols reduced glycemic variability, and therefore, the risk of patients experiencing hypoglycemic events (Clergeau et al., 2017).

An examination was conducted of the effectiveness of two different insulin infusion protocols in a medical intensive care unit using 57 patients (DeBlock et al., 2016). Twenty-two patients were treated with the Leuven protocol, and 35 patients were treated with the Yale protocol. The Leuven protocol uses continuous intravenous insulin with a target blood glucose level between 80 and 100 mg/dl (DeBlock, et al., 2016). The Yale protocol uses intravenous insulin and a target blood glucose level between 80 and 120 mg/dl (DeBlock, et al., 2016). No significant differences in the median glycaemia between the two protocols were found (DeBlock et al., 2016).

A retrospective cohort study was conducted, which evaluated the clinical efficacy and safety of two types of insulin, human neutral insulin and NovoRapid (insulin aspart) for the treatment of DKA. Forty patients who had been admitted through the emergency department with a diagnosis of DKA were reviewed (Kwok et al., 2017). In this study, the authors found a significant difference in the types of insulin preparations used in the treatment of DKA (Kwok et al., 2017). However, no significant statistical difference was found to support the use of one type of insulin over the other (Kwok et al., 2017).

Martin, McKinney, Hoody and Fish (2016) completed a study at a 426-bed hospital to review treatment outcomes of critical care pathways. Critical care pathways (CCP) used in the treatment of DKA were reviewed in association of length of stay (LOS) and the authors found a decrease in LOS with the use of CCP (Martin, et al., 2016). Important factors to consider in the use of CCP are that it should be mandatory, utilize aggressive IV fluid management and insulin administration and address the patient's electrolyte imbalances (Martin, et al., 2016).

An executive committee examined randomized control trials, which examined the prevalence of diabetes in hospitalized adults (Panikar et al., 2016). Based on the findings the

executive committee developed an in-hospital protocol for recognizing hyperglycemia (Panikar et al., 2016). Using a target glucose of 140-180 mg/dl has been shown to reduce the incidence of hypoglycemia in the critically ill patient on insulin infusion protocols (Soo Hoo, 2015). In the study by Soo Hoo (2015), the author concluded that the factors, which greatly influenced patient outcomes, were adherence to policies and guideline.

Transitioning DKA patients from an insulin infusion protocol to subcutaneous insulin can be a critical piece in the overall favorable outcome of these patients. Kreider and Lien (2015) completed a literature review on this subject. The authors examined interventions to safely transition patients from intravenous insulin infusions to subcutaneous insulin and found that no one protocol worked best for all patients (Krieder & Lien, 2015).

Other situations exist which affect the outcomes of patients admitted in DKA, such as hypoglycemia, metabolic acidosis and electrolyte imbalances. Brutsaert, Carey and Zonszein (2014) examined the incidences of hypoglycemia in hospitalized patients. The authors concluded that there were many gaps in knowledge relating to treatment of hypoglycemia (Brutsaert, Carey, & Zonszein, 2014). A case report was completed on the deterioration of a patient in DKA. Consequently, the finding was similar in that the patient had to be rescued instead of the physicians or nurses recognizing the need for correction of metabolic acidosis and electrolytes (Van de Vyver, Damen, Haentjens, Ballaux, & Bouts, 2017).

### **Conceptual Framework**

The conceptual framework is the IOWA Model, which will be used as a guide for this scholarly project. The IOWA Model is a seven-step process, which starts with selection of a topic and works through a process ending with evaluation (Doody & Doody, 2011). The IOWA Model is a systematic process, which begins with the identification of the trigger or opportunity

for change (Zaccagnini & White, 2017). In this scholarly project, the trigger is rapid correction of blood glucose in patients admitted to [REDACTED] in DKA resulting in adverse reactions. Once the trigger was identified and the clinical question was developed, the author went through the steps of the IOWA Model, resulting in the development of evidence, design of a study, intervention and finally the dissemination of the project (Zaccagnini & White, 2017).

### **Theoretical Framework**

The theoretical framework that will be used for this scholarly project is the Transitional Care Model. This theory was designed for use on patients who are transitioning from a hospital setting to home care (Romagnoli, Handler, Ligons, & Hochheiser, 2013). The patients admitted to [REDACTED] will transition from IV Insulin therapy to subcutaneous insulin as well as transitioning from intensive care to discharge. Making this transition can be very difficult in populations of patients newly diagnosed with diabetes or patients who are poorly controlled diabetics.

## **SECTION THREE: METHODOLOGY**

### **Design**

The design of this scholarly project was a retrospective chart review both 90 days prior to implementation and 90 days after. Baseline data was compiled regarding the number of adult patients age 18-75, who were admitted to [REDACTED] in DKA and who were treated with the Insulin Infusion Protocol. Once it was determined that the patient had a diagnosis of DKA and they were placed on the Insulin Infusion Protocol, the chart become part of the retrospective review. After adoption of the updated DKA Insulin Protocol, a second retrospective chart review was conducted for the first 90 days to compare the data from the first retrospective chart review. The charts were examined and reviewed for the amount of time from initiation to correction of

blood glucose if rescue medications had to be given and how the patient tolerated the insulin infusion.

### **Measurable Outcomes**

The DKA Insulin protocol was updated, which outlines how to manage patients admitted with diabetes to the ICU from the ED. In addition to the DKA Insulin Infusion protocol update, an update to the Nursing Guidelines for blood glucose monitoring in the ICU was achieved. This was based on the data collected which showed the difference between a finger stick blood glucose level and a random glucose drawn and process in the lab. The decision was made to change the policy to reflect that patients on the DKA Insulin Infusion Protocol should only have random glucose levels drawn.

Adult patients who present in DKA, with new onset or chronic diabetes will be properly managed with the DKA Insulin Protocol; the amount of time and level of blood glucose correction was monitored which should not exceed 50-70 mg/dl per hour. Additional health care outcomes measured included the mean time of patients admitted in DKA to reach correction of electrolyte imbalance and correction of anion gap after the implementation and dissemination of this updated DKA Insulin Infusion Protocol.

### **Setting**

A for-profit, community hospital in Northern Virginia is the site for this study. This hospital is licensed for 100 beds. The units monitored included the ICU and ED. The project aligns with the organization's mission, values and strategic plan by concentrating on patient care.

### **Population**

This scholarly project included only adult patients age 18-75, admitted to [REDACTED] in DKA and treated in the ICU or ED, 90 days prior to initiation of the updated DKA



Insulin Protocol and 90 days afterwards. However, the month of May was excluded completely due to the initiation of the order set changes without the protocol change implementation. A total of 15 charts were reviewed for the retrospective review of the 90 days prior to initiation. Of those 15 charts, three charts were excluded as they were admitted under the correct diagnostic code although they were never placed on the DKA Insulin Protocol. The sample size for the first retrospective review was an  $n_{pre} = 11$ . A total of seven charts were reviewed for the retrospective review of the 90 days post implementation, of those charts all seven met the inclusion criteria and were placed on the DKA Insulin Protocol. The sample size for the second retrospective review was an  $n_{post} = 6$ .

### **Ethical Considerations**

Ethical considerations for research on human subjects was strictly enforced. An Institutional Review Board (IRB) exemption was obtained from the Liberty University IRB. A letter of support for this scholarly project was obtained from [REDACTED]. Patient privacy was maintained as outlined by the health insurance portability and accountability act (HIPAA). All charts reviewed were coded and no patient names or medical record numbers for identification were used. All correspondence between [REDACTED] and this author have been sent by encrypted email and the computer is password protected.

### **Data Collection**

Information was collected from charts of patients admitted to ICU from the ED who are found to be in DKA and were placed on the initial Insulin Infusion Protocol. Data collection for the 90-day retrospective chart review prior to initiation of the protocol included all patients admitted in DKA from February 1, 2018 through April 30, 2018. The data for the month of May was excluded due to a change in the order set used for DKA without the accompanying written

protocol of the change. The 90-day retrospective chart review of the patients admitted with DKA and placed on the updated insulin protocol included all patients admitted June 1, 2018 through August 31, 2018. Once adult patients with DKA were identified, the charts were reviewed for time frame of correction of blood glucose level, and symptoms of hypoglycemia or other complications post initiation of the DKA Insulin Infusion Protocol.

### **Tools**

A retrospective chart review was completed on all adult patients age 18-75, admitted to the ICU from the ED in DKA who were placed on the initial DKA Insulin Infusion Protocol. The original insulin infusion protocol was examined and compared to the latest evidence-based practice and recommendations by the ADA. The protocol was updated and was distributed for review and approval. After approval and adoption of the updated protocol was completed, a second retrospective chart review was completed including patients admitted in DKA from June 1, 2018 through August 31, 2018. All the data collected was then placed in an Excel spreadsheet to graph the data using time series charts and statistically analyze the findings. In particular, confidence intervals for important descriptors were given and hypothesis tests were conducted to examine if there was statistically significant differences between the two protocols.

### **Data Analysis**

Baseline data was collected at the time of inclusion in the retrospective chart review. All data was then compiled and reviewed for reliability and validity to ensure inclusion criteria was met. Information was collected through a review of charts for adult patients admitted with DKA to the ICU from the ED. The charts were reviewed to establish if the patient had any symptoms of hypoglycemia, were rapidly corrected and had to be given rescue medications after initiation of the insulin protocol. Patient identifiers were not used as the purpose was to assess whether

patients rapidly corrected, have symptoms of hypoglycemia, and must be given rescue medications or exhibit other symptoms after initiation of the insulin infusion protocol only. All data was then compiled and reviewed for reliability and validity to ensure that all inclusion or exclusion criteria.

### **Statistical Analysis**

The pre-data showed variability in the correction of blood glucose levels. In table 1, the patient had evidence which showed rapid correction. In the hours zero to 1:55, the patient's glucose level dropped from 1029 mg/dl to 551 mg/dl. In table 2, the patient had evidence which showed rapid correction. In hour 1:49 to 3:04 the patient's blood glucose level went from 448 mg/dl to 269 mg/dl. In table 3, evidence exist which shows rapid correction. A drop from 884 mg/dl to 500 mg/dl in 2:21 hours and again from 350 mg/dl to 106 mg/dl in one hour. This is well outside the recommendation of 50-70 mg/dl/hr by the American Diabetes Association (Wilinska & Hovorka, 2014). In table 4, the patient went from 510 mg/dl to 430 mg/dl between hours 3:49 to 4:45. The patient then had another rapid correction between 4:45 to 5:46 where the patient went from 430 mg/dl to 303 mg/dl. This patient had a third episode of rapid correction where the patient went from 303 mg/dl to 135 mg/dl in one hour.

In table 5, patient #14 had multiple episodes of rapid correction. In the hours between zero and 1:14 the patient went from 693 mg/dl to 237 mg/dl. Again at hours 4:30 to 5:32, the patient dropped from 311 mg/dl to 174 mg/dl.

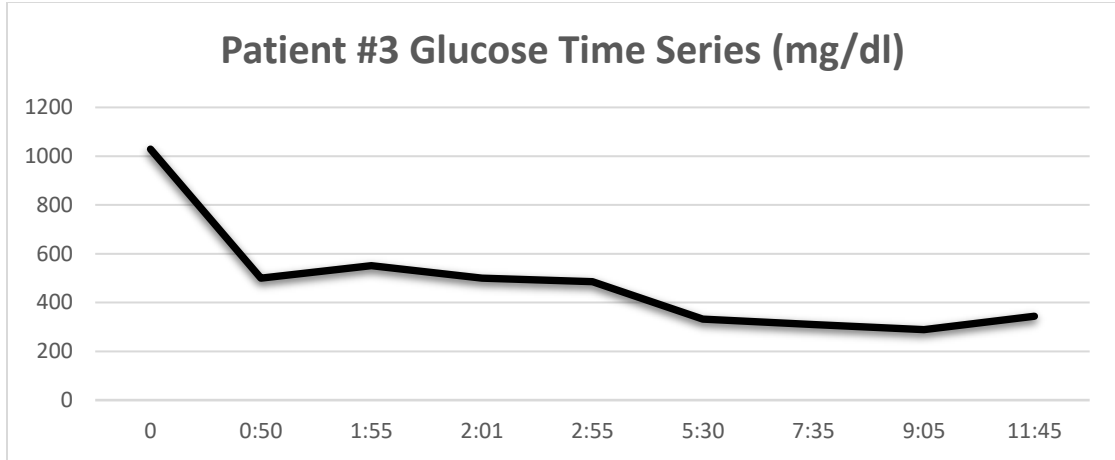


Table 1: Pre-data patient #3 Glucose Time Series (mg/dl).

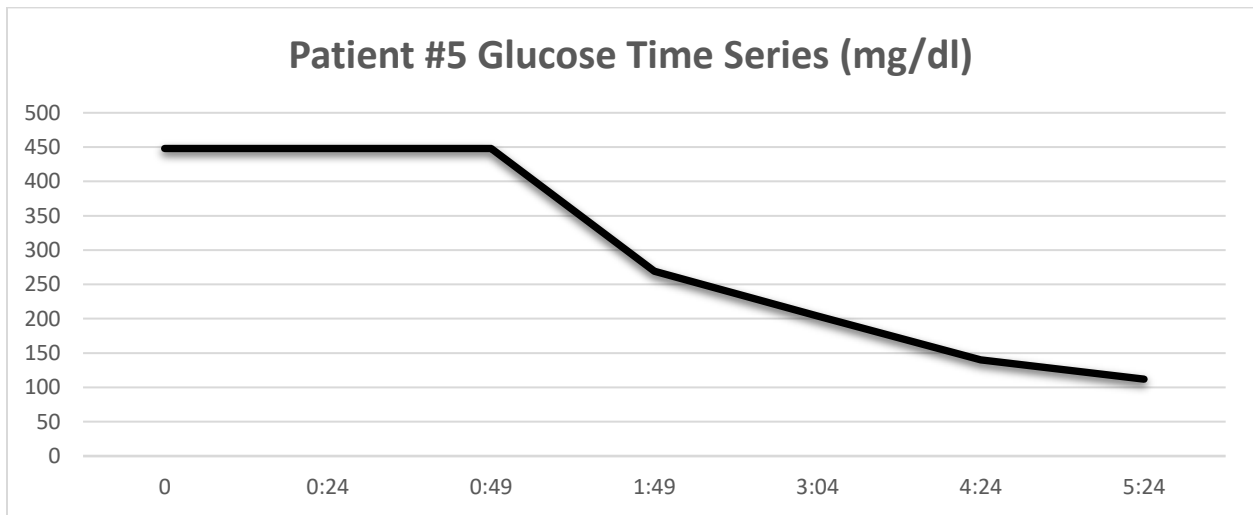


Table 2: Pre-data patient #5 Glucose Time Series (mg/dl).

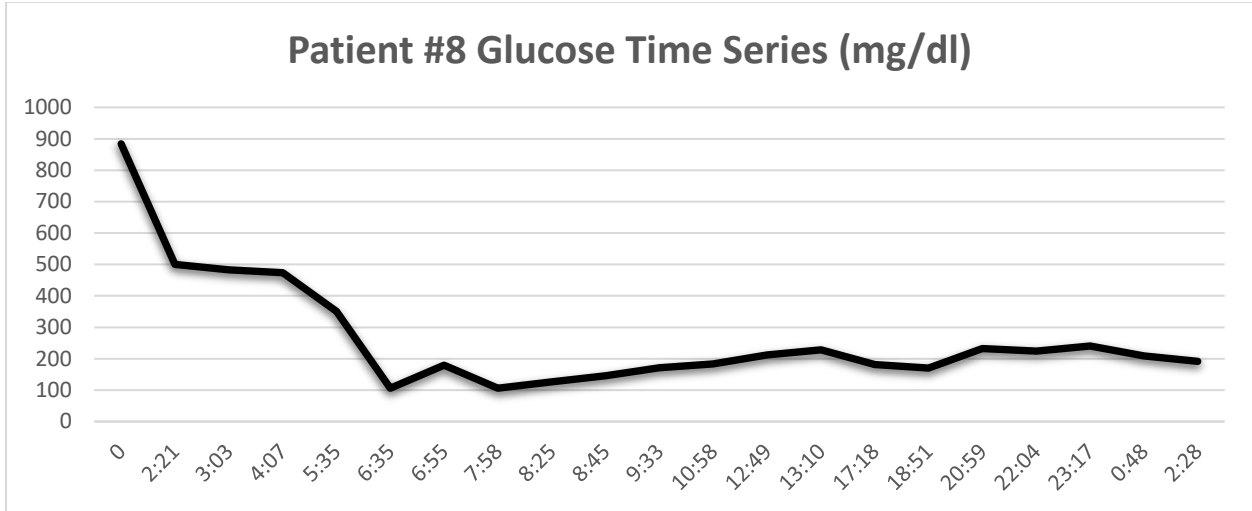


Table 3: Pre-data patient #8 Glucose Time Series.

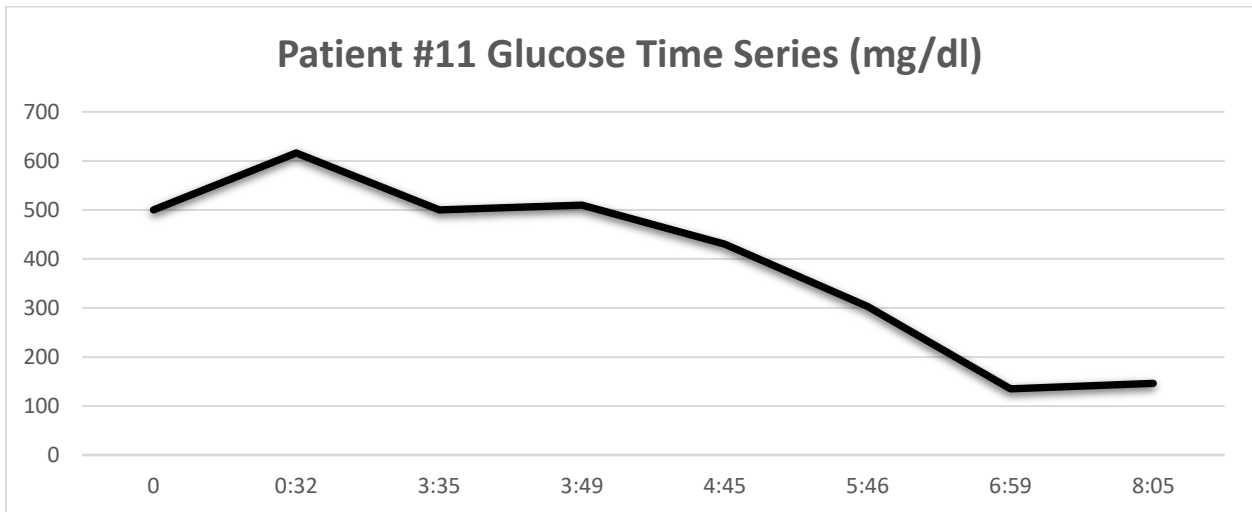


Table 4: Pre-data patient #11 Glucose Time Series (mg/dl).

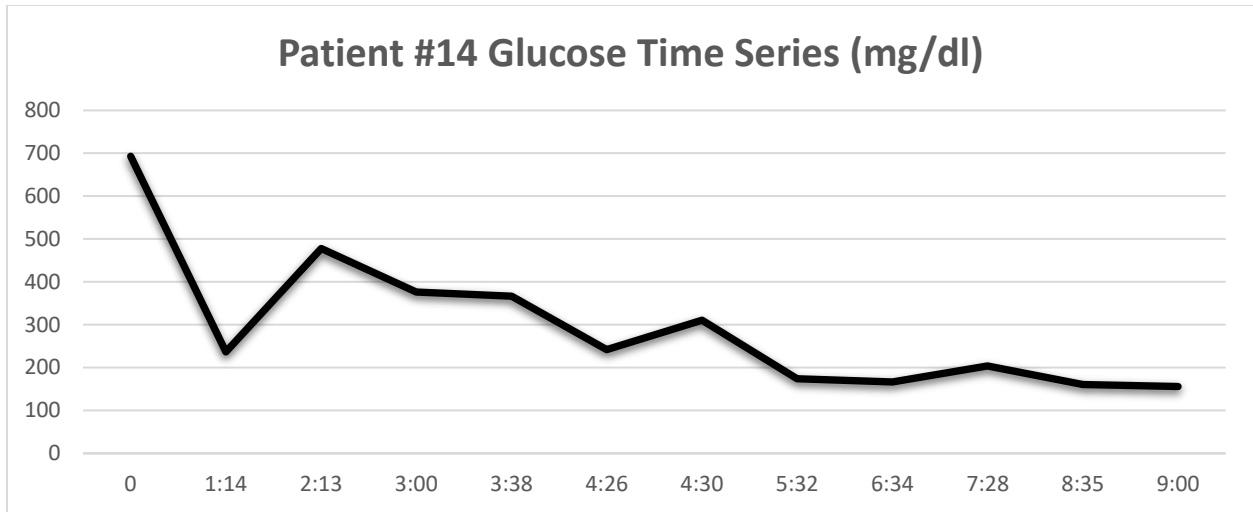


Table 5: Pre-data patient #14 Glucose Time Series (mg/dl).

	Time to Correction (min)	Time to Correction (hrs)	High	Corrected Value		Drop per hour (mg/dl/h)
Pt1	739	12.32	544	125		34.02
Pt3	330	5.50	1029	332		126.73
Pt5	264	4.40	448	140		70.00
Pt6	2761	46.02	747	81		14.47
Pt7	3608	60.13	380	166		3.56
Pt8	1588	26.47	884	192		26.15
Pt11	485	8.08	616	146		58.14
Pt12	642	10.70	297	139		14.77
Pt13	917	15.28	377	136		15.77
Pt14	332	5.53	693	174		93.80
Pt15	589	9.82	572	250		32.80
Mean	1114.1	18.57	598.82	171.00		44.56
Median	642.0	10.70	572.00	146.00		32.80
StDev	1103.6	18.39	226.31	68.33		38.60
N	11	11	11	11		11
Df	10					
Error	741.37	12.36	152.03	45.90		25.93
Min	372.7	6.2	446.8	125.1		18.6
Max	1855.5	30.9	750.8	216.9		70.5

Table 6: All pre-data compiled.

In table 10, using the pre-protocol data there is 95% confidence that the true mean is correct. The time to correction was between 6.2 and 30.9 hours. The high glucose concentration during the time on the insulin infusion protocol was between 446.8 mg/dl and 750.8 mg/dl. The glucose concentration at the end of the protocol or at correction is between 125.1 mg/dl and 216.9 mg/dl. The glucose concentration reduction per hour is between 18.6 mg/dl/hr and 70.5 mg/dl/hr. However, this is the mean concentration reduction. When each individual patient was reviewed, this was not the case as some patients were corrected at a much faster rate.

In the post-data, which represents the data obtained from the retrospective chart review after the DKA Insulin Protocol adoption, there were three episodes of rapid correction. Table 7, shows that patient #4 had an episode of rapid correction between hour 7:14 and 8:06 of 220 mg/dl to 131 mg/dl. In table 8, the patient had an episode of rapid correction between hour 1:15 and 2:27, of 471 mg/dl to 154 mg/dl. And finally, in table 9, patient #7 had an overall blood glucose reduction from 959 mg/dl to 140 mg/dl in 6:38 hours. This patient became symptomatic, and the insulin protocol had to be immediately discontinued.

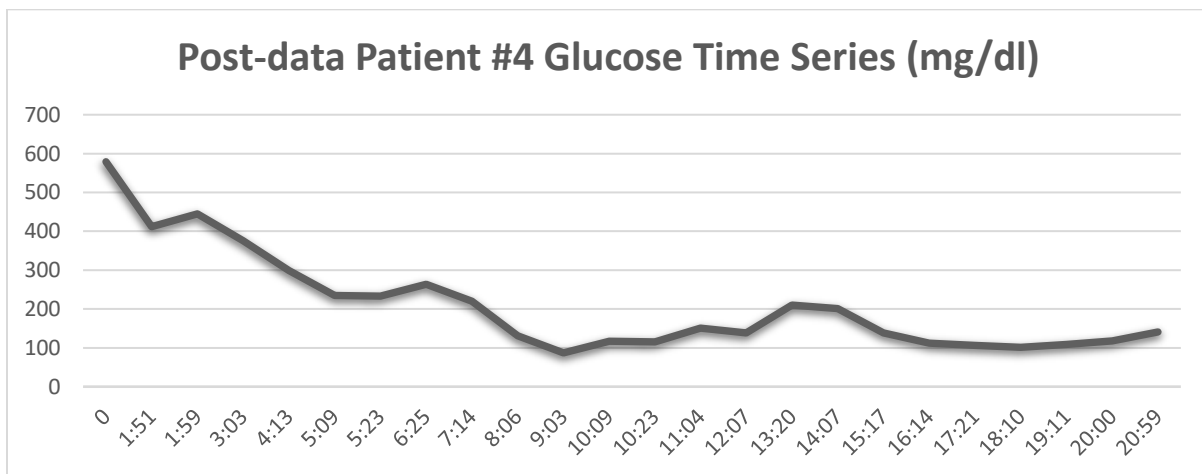


Table 7: Post-data patient #4 Glucose Times Series (mg/dl).

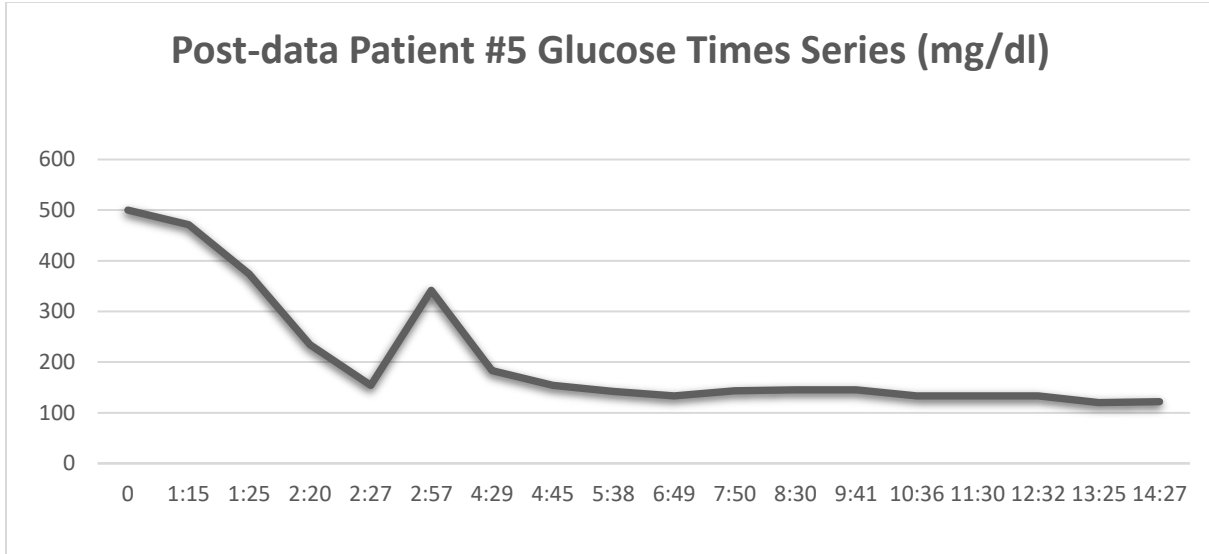


Table 8: Post-data patient #5 Glucose Times Series (mg/dl).

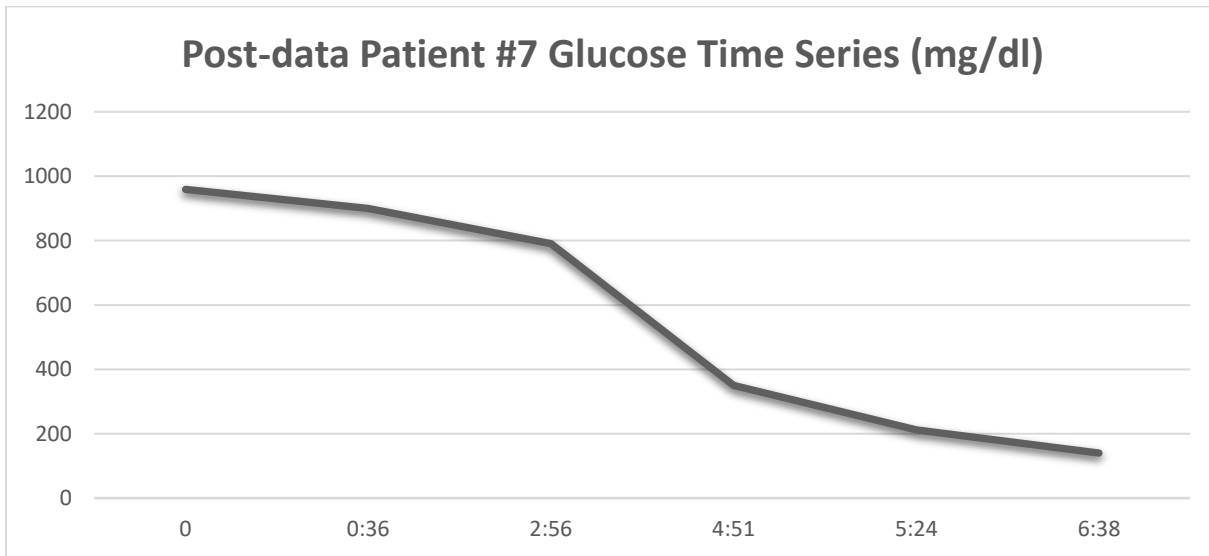


Table 9: Post-data patient #7 Glucose Times Series (mg/dl).



	Time to Correction (min)	Time to Correction (hrs)	High	Corrected Value		Drop per hour (mg/dl/h)
Pt #1	733	12.22	411	187		18.34
Pt #2	778	12.97	435	145		22.37
Pt #4	1259	20.98	579	141		20.87
Pt #5	867	14.45	500	122		26.16
Pt #6	487	8.12	342	171		21.07
Pt #7	398	6.63	959	140		123.47
Mean	753.67	12.56	537.67	151		38.71
Median	755.50	12.59	467.50	143		21.72
StDev	305.56	5.09	221.59	23.64		41.60
N	6	6	6	6		6
Df	5					
Error	320.72	5.3	232.6	24.8		43.7
Min	432.95	7.2	305.1	126.2		-5.0
Max	1074.38	17.9	770.3	175.8		82.4

Table 10: Post-data compiled.

In table 10, using the post-protocol data there is 95% confidence that the true mean is correct. The time to correction was between 7.2 and 17.9 hours. The high glucose concentration during the time on the insulin infusion protocol was between 305.1 mg/dl and 770.3 mg/dl. The glucose concentration at the end of the protocol or at correction is between 126.2 mg/dl and 216.9 mg/dl. The glucose concentration reduction per hour is between -5.0 mg/dl/hr and 82.4 mg/dl/hr. However, this is the mean concentration reduction. When each individual patient was reviewed this was not the case.

A two-sample t-test was used on the means for the two protocols for the blood glucose concentration drop per hour and the time to correction. The hypothesis test was to check if pre-protocol change was different from the post-protocol change. The sample sizes were  $n_{pre} = 11$  for the pre-protocol change group and the  $n_{post} = 6$  for the post-protocol. The null hypothesis is the mean time to correction, for pre-protocol is equal to the post-protocol correction. The

alternate hypothesis is the mean time to concentration is different between the pre-protocol and post-protocol correction. The  $\alpha = 0.05$ . The  $t$  critical = 3.163381, the test stat = 360.43 and the standard test = 1.014261. The standard test is not past the critical  $t$ -test (positive or negative). There is not enough evidence to support the claim that the mean time to correction for the two protocols is different.

The null hypothesis is that the glucose concentration drop per hour is the same for both the pre-protocol change and the post-protocol change. The alternate hypothesis is that the glucose concentration drop per hour is different for both the pre-protocol and the post-protocol change. The  $\alpha = 0.05$ . The  $t$  critical = 2.48988, the test statistic = 5.85 and the standardized test statistic = 0.290892.

### **Feasibility Analysis**

This scholarly project was feasible for the organization and in fact was requested by the organization. This organization saw a trend of patients with DKA who were rapidly being corrected, and therefore, sought to find the root cause of the problem. Additionally, this along with many other policies and procedure for this organization were due for updates.

### **Resources**

Outside resources were not needed in order to accomplish this scholarly project. All of the staff and resources are part of the normal routine for the organization. The only outside resource used was the printing company for the poster project in order to disseminate the final outcomes.

### **Personnel**

Those involved in the process of updating the DKA Insulin Infusion Protocol include the Chief Nursing Officer, the Physician Informaticist, the Director of Acute Care Services, the

Director of Quality and Safety, the Director of Pharmacy, and the Clinical Coordinator/Educator Intensive Care Unit. Additional personnel involved include the nursing education department and the staff for both the ICU and ED.

### **Technology**

The technology which is beneficial to this scholarly project included that the organization has its own physician Informaticist. He was able to quickly gather the data needed to determine the number of participants in the retrospective reviews. Once this information was presented to the DNP student, the charts then had to be manually scrutinized to ensure they met the inclusion criteria. Electronic Health Record (EHR) technology was also used. Prior to implementation of the updated DKA Insulin Infusion Protocol, the nurses used paper charting to log the patients' blood glucose levels and what action was taken. After implementation of the updated protocol, a new feature was added to the EHR which allows the nurse to chart the time, blood glucose level, the rate of the insulin infusion and what action was taken. This process has simplified the ability of health care providers to review the patient's condition and outcomes.

### **Significance and/or Implications**

Addressing the reason patients admitted in DKA are rapidly corrected, have hypoglycemic events, or other symptoms after initiation of the insulin infusion protocol benefits all adult patients admitted with DKA. It is important to use evidence-based practices and the latest research when updating existing protocols. Nursing practice will be enhanced through increased knowledge of DKA treatment and favorable patient outcomes.

### **Evaluation and Dissemination**

This author used the evaluability assessment model. This model enables the user to involve stakeholders in the entire process and can test assumptions and guide its adaptations to

real-world conditions (Brownson, Colditz, & Proctor, 2012). Discussions were held between the hospital physicians, the pharmacist, hospital nurse educator and the two clinical directors regarding the project and the dissemination and implementation. Another aspect of the process is finding the right venue to present the project (Hanrahan, Marlow, Aldrich, & Hiatt, 2012). Once the data was collected and analyzed concerning the project's usefulness, the results were disseminated to the interdisciplinary staff.

Dissemination of this project's outcomes were accomplished through distribution of a poster presentation to colleagues. The use of poster presentations and publications are ways to contribute and communicate knowledge among nurses and other healthcare professionals (Hanrahan, Marlow, Aldrich, & Hiatt, 2012). According to Hanrahan, Marlow, Aldrich and Hiatt (2012), clinical work and evidence-based guidelines are suitable for poster presentation for dissemination.

Strategies to successfully disseminate and implement this scholarly project include creating awareness, increasing knowledge and commitment, promoting action and adoption, pursuing integration and sustained use (Iowa Model Collaborative, 2017). Additionally, Moran, Burson and Conrad (2017), suggests the DNP disseminate their results through verbal presentations, podium or poster presentations, written submissions to journals and executive summaries submitted to the organization where the project is intended to be implemented. This can be accomplished in several ways and in several venues. The poster presentation was given to the ICU and ED as well as becoming part of the nursing department's staff development.

### **Recommendations**

██████████ is a hospital in Northern Virginia, which has experienced an increased number of adult patients whose blood glucose is rapidly corrected, suffer hypoglycemic events or

other symptoms after admission for DKA and the initiation of an insulin infusion protocol. In the pre-retrospective chart review and post-retrospective chart review, only one patient was found to have needed rescue medications for a decreased blood glucose level that was symptomatic. That patient happened to be the last patient in the second retrospective chart review. However, several patients were shown to have been rapidly corrected, greater than the recommended 50-70 mg/dl/hr.

The author of this scholarly project has concluded that the next course of action would be to examine and update the DKA protocol in the ED. Currently the ED uses a protocol which includes giving insulin via intravenous push. This practice causes the patients to be rapidly corrected prior to the initiation of the DKA Insulin Infusion Protocol. Further evaluation of both the ED protocol and ICU protocol is needed to benefit the patients admitted with DKA to this facility.

Future research is needed to increase favorable patient outcomes. In this scholarly project the author reviewed the DKA Insulin Infusion Protocol only after its initiation. It would be beneficial for others in the future to review how the patient is treated from the time of admission into the ED and until the DKA Insulin Infusion Protocol is initiated.

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## Appendix A

Article Title, Author, etc. (Current APA Format)	Study Purpose	Sample (Characteristics of the Sample: Demographics, etc.)	Methods	Study Results	Level of Evidence (Use Melnyk Framework)	Study Limitations	Would Use as Evidence to Support a Change? (Yes or No) Provide Rationale.
Brutsaert, E., Carey, M., & Zonszein, J. (2014). The clinical impact of inpatient hypoglycemia. <i>Journal of Diabetes and Its Complications</i> , 28, 565-572. <a href="http://dx.doi.org/10.1016/j.jdiacomp.2014.03.002">http://dx.doi.org/10.1016/j.jdiacomp.2014.03.002</a>	Examination of hypoglycemia in hospitalized patients.	7 RCTs and evaluation of glycemic targets.	Review of RCTs.	A patient-centered approach is the best practice when treating patients and maintaining glycemic control.	Level I	Gaps exist in knowledge regarding treatment of hypoglycemia in the hospitalized patient.	Yes. This study reviews different studies and protocols for treatment.
Clain, J., Ramar, K., & Surani, S. R. (2015, August). Glucose control in critical care. <i>World Journal of Diabetes</i> , 6(9), 1082-1091. <a href="http://dx.doi.org/10.4239/wjd.v6.i9.1082">http://dx.doi.org/10.4239/wjd.v6.i9.1082</a>	A review of changes over the past 15 years regarding glycemic control in the intensive care setting.	Eleven major randomized controlled trials (RTC) investigating the use of intensive insulin therapy or conventional	Review of literature.	The authors found that there was a lack of evidence to support either the intensive or conventional insulin therapy.	Level II	There are too many variables when compare the eleven studies.	Yes. This review of literature was useful in that it compared eleven of the top RCTs and showed

		insulin therapy in the intensive care setting.					how they differ.
Clergeau, A., Parienti, J., Reznik, Y., Clergeau, D., Sequin, A., Valette, X., & Joubert, M. (2017). Impact of a paper-based dynamic insulin infusion protocol on glycemic variability, time in target, and hypoglycemic risk: A stepped wedge trial in medical intensive care unit patients. <i>Diabetes Technology &amp; Therapeutics</i> , 19(2), 115-123. <a href="http://dx.doi.org/10.1089/dia.2016.0314">http://dx.doi.org/10.1089/dia.2016.0314</a>	Assess the efficacy, safety and acceptance of insulin protocols in ICU by the nurse who use them.	131 ICU patients who received continuous intravenous insulin infusion management .	Stepped Wedge study which compared sliding scale insulin protocol and dynamic protocol use in the ICU.	The authors found that the dynamic infusion protocol reduced glycemic variability and the risk of hypoglycemic events.	Level V	The population size is too small to draw robust conclusions.	Yes. This study is beneficial to the proposal scholarly project since it compares two types of insulin protocols.
DeBlock, C. E., Rogiers, P., Jorens, P. G., Schepens, T., Scuffi, C., & Van Gaal, L. F. (2016). A comparison of two insulin infusion protocols in the medical intensive care unit by continuous glucose monitoring. <i>Annals of Intensive Care</i> , 6(115), 1-13. <a href="http://dx.doi.org/10.1186/s13613-016-0214-9">http://dx.doi.org/10.1186/s13613-016-0214-9</a>	To examine the effectiveness of two different insulin infusion protocols in medical intensive care units.	57 Medical Intensive Care Unit patients.	Two prospective RCTs in medical ICUs at two hospitals.	Twenty-two patients were treated with the Leuven protocol while the remaining 35 were treated with the Yale protocol. The authors found no difference in the median glycaemia.	Level II	Only compared two prospective RCT, small sample size could not guarantee the results would be applicable in other areas.	Yes. Although this study only compared two different insulin protocols the information can now be compared to other such studies.

<p>Krieder, K. E., &amp; Lien, L. F. (2015). Transitioning safely from intravenous to subcutaneous insulin. <i>Current Diabetes Reports, 15</i>(23), 1-12.  <a href="http://dx.doi.org/10.1007/s11892-015-0595-4">http://dx.doi.org/10.1007/s11892-015-0595-4</a></p>	<p>Examination of interventions to safely transition patients from an intravenous infusion of insulin to subcutaneous insulin.</p>	<p>Insulin protocols and transition protocols.</p>	<p>Literature Review.</p>	<p>The authors concluded that further research is needed.</p>	<p>Level V</p>	<p>Only reviewed a small sample of a specific type of institutional protocol.</p>	<p>No. There is no specific information provided on the incidence of hypoglycemia.</p>
<p>Kwok, R., Sztal-Mazer, S., Hopkins, R. E., Poole, S. G., Grannell, L., Coutsouvelis, J., &amp; Topliss, D. J. (2017). Evaluation of novorapid infusion as a treatment option in the management of diabetic ketoacidosis. <i>International Medicine Journal, 47</i>, 1317-1320.  <a href="http://dx.doi.org/10.1111/imj.13607">http://dx.doi.org/10.1111/imj.13607</a></p>	<p>Evaluation of the clinical efficacy and safety of two types of insulin for the treatment of diabetic ketoacidosis.</p>	<p>40 patients who were admitted through the emergency department of a tertiary teaching hospital with a diagnosis of DKA.</p>	<p>Retrospective cohort study</p>	<p>The authors concluded that there was significant difference in the use of insulin preparations in the treatment of DKA.</p>	<p>Level IV</p>	<p>Small sample size and study design</p>	<p>Yes. The findings showed that a specific type of insulin had better patient outcomes.</p>
<p>Martin, C., McKinney, Z. J., Hoody, D., &amp; Fish, L. (2016, June). Diabetic ketoacidosis critical care pathway implementation: Incorporation into EMR significantly decreases length of stay. <i>Endocrine Practice, 22</i>(6), 673-678.  <a href="http://dx.doi.org/10.4158/EP151073">http://dx.doi.org/10.4158/EP151073</a>.  OR</p>	<p>Examination of the effectiveness of a critical care pathway for the treatment of diabetic ketoacidosis.</p>	<p>Patients admitted with DKA who were coded with billing codes 250.1 or 250.1x, 387 patients were included.</p>	<p>Retrospective chart review</p>	<p>This study examined length of stay compared with the critical care pathway and found that there was a</p>	<p>Level IV</p>	<p>Prior research is limited on the subject.</p>	<p>Yes. This study reviewed a critical care pathway and implementation of an updated insulin</p>

				decrease in length of stay after implementation of the CCP.			infusion protocol.
Panikar, V., Sosale, A., Agarwal, S., Unnikrishnan, A., Kaira, S., Bhattacharya, A., ... Vadgama, J. (2016, November 12). RSSDI clinical practice recommendations for management of in-hospital hyperglycemia-2016. <i>International Journal of Diabetes Developing Countries</i> , 36(Supplement 1), S1-S21. <a href="http://dx.doi.org/10.1007/s13410-016-0528-z">http://dx.doi.org/10.1007/s13410-016-0528-z</a>	Development of an in-hospital protocol for recognizing hyperglycemia.	Six topic review by executive committee	Executive committee task force review of RCT.	Prevalence of diabetes in hospitalized adults is dependent on the criteria used by the hospital.	Level VII	Limitations include the use of only 1 RCT and expert committee	Yes. The information examined by the executive task force summarized how they use the findings of the RCT.
Soo Hoo, G. W. (2015, November 09). Intravenous insulin therapy. Retrieved from <a href="http://emedicine.medscape.com/article/2049152-overview">http://emedicine.medscape.com/article/2049152-overview</a>	Review of two large RCT to determine the best insulin infusion protocol.	NICE SUGAR study, 6104 patients. RCT of 1200 surgical ICU patients.	Comparison of two RCT and comparison of actual insulin protocols.	20 different insulin infusion protocols are known, however not any one protocol proved to work best for all patients.	Level I	Careful assessment is needed. Nursing input can change outcomes if protocols are not followed. Protocols vary in complexity and	Yes. Although there was variability found among protocols, one common theme is the need for adherence to policies and guidelines.

						instructions.	
Tran, T. T., Pease, A., Wood, A. J., Zajac, J. D., Bellomo, R., & Ekinici, E. I. (2017). Review of evidence for adult diabetic ketoacidosis management protocols. <i>Frontiers in Endocrinology</i> , 8(106), 1-13. <a href="http://dx.doi.org/10.3389/fendo.2017.00106">http://dx.doi.org/10.3389/fendo.2017.00106</a>	Review of evidence from 85 articles on Diabetic Ketoacidosis protocols	85 articles using keywords: diabetic ketoacidosis, diabetes, insulin, rehydration, hypoglycemia, hypokalemia, metabolic acidosis, protocol	Review of evidence	Major deficiencies in evidence were found and affirmed the need for RCT to be used when attempting to use evidence-based practice for improving patient outcomes.	Level VII	This was a narrative review not a systematic review.	Yes. Useful review of further literature, although some of it is very dated.
Van de Vyver, C., Damen, J., Haentjens, C., Ballaux, D., & Bouts, B. (2017). Case report: An exceptional case of diabetic ketoacidosis. <i>Case Reports in Emergency Medicine</i> . <a href="http://dx.doi.org/10.1155/2017/4351620">http://dx.doi.org/10.1155/2017/4351620</a>	Case report of a single patient with rapid deterioration in DKA.	Single patient.	Case report	Rescued via correction of metabolic acidosis, correction of electrolytes.	Level III	Only reviewed one single patients case.	Yes. Useful to review how this patient was treated using the hospital protocol.
Wilinska, M. E., & Hovorka, R. (2014). Glucose control in the intensive care unit by use of continuous glucose monitoring: What level of measurement error is acceptable? <i>Clinical Chemistry</i> , 60(12), 1500-1509. <a href="http://dx.doi.org/10.1373/clinchem.2014.225326">http://dx.doi.org/10.1373/clinchem.2014.225326</a>	Evaluation of three established glucose control protocols for accuracy and	3 glucose control protocols in 56 virtual patients.	Computer simulation evaluation of 3 glucose control protocols	There were varied glucose control between the different protocols rather than with	Level V	Computerized simulation	Yes. Explains the differences between use of protocols and use of measureme

	frequency of glucose monitoring.			continuous glucose monitoring.			nt of glucose.
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Appendix B



March 29, 2019

Liberty University  
1971 University Blvd  
Lynchburg, Virginia 24515

To Whom It May Concern:

Susan Lacey, a DNP student enrolled at Liberty University has been approved to conduct an Evidence Based Practice project, "Infusion Insulin Protocol" at [REDACTED]

This letter of support approves the project as there is no IRB process and it is understood the project will be reviewed through the Liberty University's Institutional Review Board.

For questions, contact [REDACTED] at the number and/or email below.

Sincerely,

[REDACTED]

[REDACTED]



## Appendix C

Tuesday, May 8, 2018 at 1:23:09 PM Eastern Daylight Time

Page 1 of 1

Subject: Permission to Use The Iowa Model Revised: Evidence-Based Practice to Promote Excellence in Health Care

Date: Thursday, December 28, 2017 at 12:21:04 PM Eastern Standard Time

From: Kimberly Jordan - University of Iowa Hospitals and Clinics

To: Lacey, Susan

You have permission, as requested today, to review and/or reproduce The Iowa Model Revised: Evidence-

Based Prac8ce to Promote Excellence in Health Care. Click the link below to open.

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Citation Iowa Model Collaborative. (2017). Iowa model of evidence-based practice: Revisions and validation. *Worldviews on Evidence-Based Nursing*, 14(3), 175-182. doi:10.1111/wvn.12223

In written material, please add the following statement:

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Completion Date 06-Dec-2016  
Expiration Date 06-Dec-2019  
Record ID 21619065

This is to certify that:

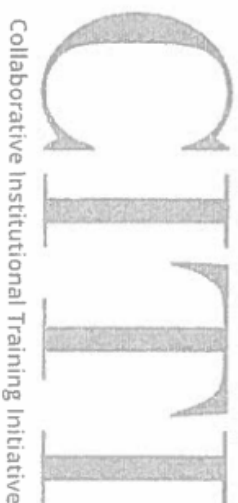
**Susan Lacey**

Has completed the following CITI Program course:

**Social & Behavioral Research - Basic/Refresher** (Curriculum Group)  
**Social & Behavioral Researchers** (Course Learner Group)  
**1 - Basic Course** (Stage)

Under requirements set by:

**Liberty University**



Verify at [www.citiprogram.org/verify/?w86410aa0-2426-43a1-b07a-7073f45c03fd-21619065](http://www.citiprogram.org/verify/?w86410aa0-2426-43a1-b07a-7073f45c03fd-21619065)



Completion Date 12-Oct-2016  
Expiration Date 12-Oct-2019  
Record ID 21123572

This is to certify that:

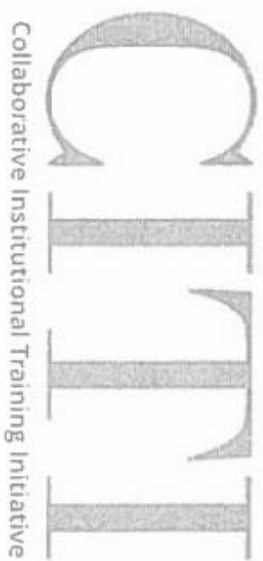
**Susan Lacey**

Has completed the following CITI Program course:

**Biomedical Research - Basic/Refresher** (Curriculum Group)  
**Biomedical & Health Science Researchers** (Course Learner Group)  
**1 - Basic Course** (Stage)

Under requirements set by:

**Liberty University**



Verify at [www.citiprogram.org/verify/?waba7b835-417e-4bc4-82d2-0a96ddd6d5e71-21123572](http://www.citiprogram.org/verify/?waba7b835-417e-4bc4-82d2-0a96ddd6d5e71-21123572)

## Appendix G

June 13, 2018

Susan K. Lacey IRB Exemption 3365.061318: Diabetic Ketoacidosis (DKA) Insulin Infusion Protocol Update Using Evidence-Based Practice: A Quality Improvement Project

Dear Susan K. Lacey,

The Liberty University Institutional Review Board has reviewed your application in accordance with the Office for Human Research Protections (OHRP) and Food and Drug Administration (FDA) regulations and finds your study to be exempt from further IRB review. This means you may begin your research with the data safeguarding methods mentioned in your approved application, and no further IRB oversight is required.

Your study falls under exemption category 46.101(b)(4), which identifies specific situations in which human participants research is exempt from the policy set forth in 45 CFR 46:101(b):

(4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available or if the information is recorded by the investigator in such a manner that subjects cannot be identified, directly or through identifiers linked to the subjects.

Please note that this exemption only applies to your current research application, and any changes to your protocol must be reported to the Liberty IRB for verification of continued exemption status. You may report these changes by submitting a change in protocol form or a new application to the IRB and referencing the above IRB Exemption number.

If you have any questions about this exemption or need assistance in determining whether possible changes to your protocol would change your exemption status, please email us at [irb@liberty.edu](mailto:irb@liberty.edu).

Sincerely,

G. Michele Baker, MA, CIP Administrative Chair of Institutional Research The Graduate School

Liberty University | Training Champions for Christ since 1971