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Continuous Glucose Monitoring of Hospitalized Patients with Diabetes: A Pilot Study to Establish Evidence

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Background and Significance

About 25-30% of the hospitalized patients have diabetes mellitus(1). Maintaining target glucose levels of patients with diabetes is critical to both acute and chronic effects of Type 1 and Type 2 diabetes. Inpatient glycemic variability has shown to have worse patient outcomes (2). Negative inpatient outcomes include increased risk of infection, worsening infection, poor wound healing, acute delirium, and increased length of stay for those with hyperglycemia. Hypoglycemia occurs frequently in hospitalized patients contributing to a higher mortality rate (OR 1.07)(3). Inpatient hypoglycemic episodes are predominantly asymptomatic due to decreased hypoglycemic awareness as well as impaired cognition due to acute illness or medications(4). These inpatient risks of poorly controlled glucose levels have shown increased 90-day mortality (2) and decreased overall well-being post hospitalization.

The hospitalization of persons with diabetes mellitus increases the risk of uncontrolled glucose levels for a number of reasons related to both the patient and care provided by the hospital. Patient related factors that present challenges are the patient's underlying illness, steroid use, renal function, NPO status, and erratic eating schedule due to being away from the room for tests. Most importantly, changes associated with self-monitoring and control by the patient in the home setting to one of limited self-care while in the hospital also contributes to poor glycemic control.

Processes for glucose maintenance in the hospital are challenged by hospital staffing patterns which often engage numerous healthcare providers in the overall care of the patient. Thus, glucose control shifts from one of self-management by the patient to one in which unique care providers are responsible for planning and providing meals, checking blood sugar levels and, if needed, administering insulin. The identified risk to poor glucose control during an inpatient stay requires a system level care delivery innovation that addresses challenges presented by both patient and care delivery characteristics.

Systematic continuous glucose monitoring (CGM) is commonly provided as a treatment option to patients with diabetes in ambulatory care settings yet is rarely provided during hospitalization. CGM of inpatients has the potential to be the care delivery innovation that is feasible, cost effective and can improve glucose control, especially by reducing hypoglycemic events. Studies of CGM use in the ICU setting have been found to be helpful for reducing hypoglycemia in some studies while less so in others, however, these studies were performed with earlier generation glucose monitoring devices(5). ICU studies have confirmed accuracy of CGM measurements compared with capillary glucose even in settings with use of vasopressors and large-volume resuscitation. A limited number of studies have evaluated glycemic outcomes in the inpatient non-ICU setting. Studies of non-ICU patients (6-10) are limited by very small sample size, short study duration, and use of older CGM devices. There is, therefore, a critical need to systematically investigate the use of CGM in the inpatient care of patients with diabetes mellitus who are receiving care in a hospital setting that is typical of inpatient care. We propose a randomized clinical trial (RCT) to investigate the efficacy of CGM in the management of glucose levels by clinical staff of two hospital units in Baylor Scott & White Medical Center in Temple, Texas, a flagship hospital of the Baylor Scott & White Health system. The RCT will serve as a pilot study designed to demonstrate the feasibility of using CGM in an inpatient setting. Findings from the study will allow the research team to determine the effect of CGM in managing episodes of hypoglycemia and hyperglycemia during a typical inpatient stay as well as maintaining glucose readings within the target range as much as possible.

The Project Team and Study Feasibility

This innovative study is based on a partnership between a national leader in CGM, the clinical staff of a

large hospital and the research unit embedded within the inpatient setting. Dr. McNeal, Project Director, has assembled clinical and research teams to lead the implementation of the proposed study. The clinical team, led by Dr. T. McNeal, is composed of experts in endocrinology, inpatient medicine and nursing. The research team is led by Dr. Alan Stevens with support from staff of the BSW Research Institute, Center for Applied Health Research and Clinical Trials groups. The research team has worked with the clinical team to design the proposed study. The clinical team has worked with the clinical support personnel from Dexcom, a leader in the industry of CGM, to secure access to the Dexcom G6 CGM and Dexcom G6 PRO devices. Both the devices are disposable products with an easy-to-use applicator and the Dexcom G6 has the possibility of remote glucose telemetry monitoring. Measurements detected by this sensor are also less affected by acetaminophen than prior sensors were when most other inpatient CGM studies were conducted. Thus, it appears that this device addresses both patient and care delivery challenges that were identified above. EHR data suggests that the two selected inpatient units have a history of providing care to a large number of patients with diabetes. Data provided by BSWH's Center for Applied Health Research (CAHR) show that in 2017 there were over 2000 admissions of patients with diabetes to Baylor Scott & White Medical Center - Temple who received insulin during their stay. These data suggest that the hospital has enough medical patients capable for conducing the study described below.

Study 1: A Pilot Randomized Clinical Trial of CGM

AIM

1) Test the health impact of CGM of inpatients as defined by rates of hypo- and hyperglycemia and the derivative of time in appropriate glucose range. Forty (40) patients will be randomized 1:1 into one of two groups. In the treatment group, patients will receive a Dexcom G6 device and the clinical staff (i.e., nursing and medical staff assigned to the patient's care) will be trained to use readings from the Dexcom G6 for the management of the patient's glucose levels below 100. In the control group, patients will receive a Dexcom G6 PRO device, but the clinical staff (i.e., nursing and medical staff assigned to the patient's care) will not have access to the readings and will provide usual care (four glucose checks per 24 hours and use of insulin or other diabetic agent ordered by the admitting and rounding providers to determine glucose management).

   a. Hypothesis 1: Patients in the treatment group will experience fewer episodes of hypoglycemia as compared to patients in the control group as measured by the Dexcom device readings.

   b. Hypothesis 2: Patients in the treatment group will experience less frequent hyperglycemia events as compared to patients in the control condition as measured by the Dexcom device readings.

Approach

Subject Recruitment & Enrollment Plan: Non-surgical, non-ICU patients with diabetes admitted to BSWMC-Temple who meet the inclusion/exclusion criteria delineated below will be approached for enrollment within 24 hours of admission. Screening and enrollment will be conducted by a research nurse or a Clinical Research Coordinator with consents signed for those wanting to participate.

Inclusion Criteria:

- Patients with Type 1 and Type 2 diabetes.
- Subjects 18 years of age or older with diabetes.
- Subjects willing to avoid using high dose acetaminophen (defined as greater than 4 gm per day)
- Subjects with expected hospital length-of-stay of 2 or more days.

- Subjects willing to wear CGM device.

Exclusion Criteria:

- Female subjects who are pregnant or lactating at the time of enrollment into the study. Females with childbearing potential will be queried about the possibility of pregnancy and a serum pregnancy test will be performed.
- Subjects with greater than 4gm use of Tylenol/24 hr.
- Surgical patients or patients with pre-planned surgery during the study.
- Subjects with acute illness admitted to the ICU or expected to require admission to the ICU.
- Patients who may potentially require IV insulin.
- Patients with skin lesions, severe psoriasis, burns, tattoos, scarring, redness, infection or edema at the application sites that could interfere with device placement or the accuracy of interstitial glucose measurements.
- Patient with a known allergy to medical grade adhesive or isopropyl alcohol used to disinfect skin.
- Patients who have had organ transplant.
- Hematocrit outside specification of the study-assigned blood glucose meter (hematocrit ≤ 30% or ≥ 55%).
- Patients with any severe medical conditions such as end-stage renal disease on dialysis, status post renal transplantation, end-stage liver disease with diffuse anasarca, heart failure on inotropic support, Ejection Fraction (EF) < 15 % or pulmonary disease requiring Non-Invasive Positive Pressure Ventilation (NIPPV) or severe sepsis.
- Any condition for which, in the opinion of the investigators, it would not be in the best interest of the participant.
- Legally protected subjects (under judicial protection, guardianship, or supervision), persons deprived of their liberty, mental or language barriers rendering the subject unable to understand the nature, scope and possible consequences of the study.
- Subjects with active substance abuse.
- Subjects with infaust prognosis.

Monitoring for Adverse Events and Serious Adverse Events: The Principal Investigator is responsible to report all SAE's (serious adverse events) involving participants regardless of whether expected, unexpected, associated, or not associated. SAE's have to be reported to the Institutional Review Board (IRB) with a detailed narrative report within 10 working days after learning of the event. If an SAE is unexpected and definitely or probably related, immediately report to the IRB upon learning of the event (within three business days). All unanticipated adverse device events occurring during the investigation should be reported as soon as possible, no later than 10 business days. All anticipated adverse events will be tracked and will be assessed for frequency. If there is an increase in the number of anticipated adverse events, these events will be reported to the IRB in real time and at the continuing review. The principal investigator will be responsible for determining when these will be reported to the IRB.

Reportable Adverse Events

For this protocol, a reportable adverse event includes any untoward medical occurrence that meets one of the following criteria:

1. A Serious Adverse Event
2. An Adverse Device Effect
3. An Adverse Event occurring in association with a study procedure
4. Hypoglycemia meeting the definition of severe hypoglycemia as defined below
5. Diabetic ketoacidosis (DKA) as defined below (#4) or in the absence of DKA, a hyperglycemic or ketosis event meeting the criteria defined below

Relationship of Adverse Event to Study Device

The study investigator will assess the relationship of any adverse event to be related or unrelated by determining if there is a reasonable possibility that the adverse event may have been caused by the study device.

To ensure consistency of adverse event causality assessments, investigators should apply the following general guideline when determining whether an adverse event is related:

- Yes. There is a plausible temporal relationship between the onset of the adverse event and the study intervention, and the adverse event cannot be readily explained by the participant's clinical state, intercurrent illness, or concomitant therapies; and/or the adverse event follows a known pattern of response to the study intervention; and/or the adverse event abates or resolves upon discontinuation of the study intervention or dose reduction and, if applicable, reappears upon re-challenge.
- No. Evidence exists that the adverse event has an etiology other than the study intervention (e.g., preexisting medical condition, underlying disease, intercurrent illness, or concomitant medication); and/or the adverse event has no plausible temporal relationship to study intervention.

Intensity of Adverse Event

The intensity of an adverse event will be rated on a three-point scale: (1) mild, (2) moderate, or (3) severe. It is emphasized that the term severe is a measure of intensity; thus, a severe adverse event is not necessarily serious. For example, itching for several days may be rated as severe, but may not be clinically serious.

- MILD: Usually transient, requires no special treatment, and does not interfere with the participant's daily activities.
- MODERATE: Usually causes a low level of inconvenience or concern to the participant and may interfere with daily activities but is usually ameliorated by simple therapeutic measures.
- SEVERE: Interrupts a participant's usual daily activities and generally requires systemic therapy or other treatment.

Reportable Device Issues

- All unexpected adverse device events, (UADEs), ADEs, device complaints, and device malfunctions will be reported irrespective of whether an adverse event occurred.

Criteria for Discontinuation of Individual Participants:

Subjects can decide to discontinue entirely from the study at any time for any reason. This is documented as withdrawal of consent. Subjects can also be discontinued from the study or discontinued from the study treatment due to Investigator or Sponsor decision as detailed below.
1. Withdrawal of consent.
2. At the Investigator's discretion in certain situations such as lack of compliance or serious adverse event. (A single severe hypoglycemic event resulting in seizure or LOC or DKA).
3. 2 or more hypoglycemic events based on CGM readings that do not correlate with standard finger stick blood glucose monitor readings.
4. One DKA event or one episode of hyperglycemic, hyperosmolar nonketotic syndrome (HHNS).
5. Skin infection at the site of device insertion that occurs after placement of the device.
6. Transfer of the patient to the ICU or deterioration of medical condition that in the judgment of the principal investigator carries an unacceptable risk for the participant.
7. Skin irritation at the site of device insertion prompting the patient to request removal of the device.

Criteria for stopping the overall study:

1. The IRB will have the responsibility of determining if the overall study should be stopped. Each participant withdrawal (except withdrawal of consent) will be reported to the IRB within 3 days.
2. If an investigational device malfunction results in an SAE and the issue cannot be corrected by a modification to the system or a component of the system or adjustment to protocol procedures, the study will be stopped.
3. In the case of unanticipated adverse device effects (UADEs) related to a severe adverse event, the study will be stopped while the severe adverse event is evaluated and a root cause is determined by the Sponsor.

Randomization:

Patients that meet enrollment eligibility and consent to participate in the RCT will be randomized 1:1 to one of two groups, treatment or control using Research Electronic Data Capture (REDCap). Randomization will be performed by assigning computerized random numbers. Computerized random numbers will be generated by statistical software.

Application of the Dexcom Devices:

Following randomization, the clinical nurse researcher will return to the patient's bedside to apply the Dexcom G6 or Dexcom G6 PRO sensor and transmitter. The sensor can be placed on the upper arm or abdomen. Those in the treatment group will then link the transmitter to the receiver. All clinical nurse researchers assigned to this project will be trained on the application of the device according to Dexcom protocol. The clinical nurse researcher will calibrate the device according to Dexcom protocol.

In some cases, patients will experience care procedures that require the device to be temporarily or permanently removed. If a patient requires a CT, the device will remain in place. If a patient requires an MRI as part of routine evaluation during hospitalization, the CGM device will be removed prior to imaging and a new one will be placed within twelve hours of the patient returning to their patient room on the nursing floor.

Dexcom sensors may be worn up to 10 days. The sensor will only be replaced if it is not providing appropriate readings or as noted above.

Standing Order for All Patients Enrolled in the Study:
Attending and/or consulting physicians will be responsible for writing orders for finger stick glucose measurements on all patients per standard care whether they are in the treatment or control group. Insulin orders will be determined by the patients' home medication history and current clinical status. To avoid investigator bias, orders written by the attending will not be adjusted by the study team with the exception of standing orders for nurse response to CGM readings as detailed below for those patients randomized to the treatment group. Standing orders for blood sugars <100 will allow for administration of glucose replacement in the treatment group based on Dexcom G6 reading.

CGM informed Clinical Care (Treatment Group):
Glucose management of patients in the treatment group will be guided by readings from the Dexcom G6. The Dexcom device will provide interstitial fluid glucose measurements at five-minute intervals used to construct a graph for trending CGM levels as well as an approximate rate of change. Threshold alarm for hypoglycemia will be set with CGM glucose values < 100 mg/dL and system alarm for CGM glucose value < 55 mg/dL. The alarms will be incorporated into the decision protocol for treatment of low blood glucose levels to achieve the stated goal of improved glycemic control and decreased rates of hypoglycemia within the hospital setting.

This requires a detailed protocol of how the devices is to be used in the RCT and that all clinical staff assigned to the patient be trained to follow the protocol (i.e., staff must be trained to use CGM as a patient care tool).

The Dexcom G6 protocol includes the following:

1) The treatment group will have the data displayed with alarms set for glucose measurements of
   A. Threshold alarm CGM glucose < 100 mg/dL
   B. The urgent low soon alert, indicated by 2 downward arrows on the device reading. (Blood sugar of 55 mg/dL in less than 20 minutes)
   C. Urgent low system alarm set at CGM glucose < 55 mg/dL.
2) Definition of target range is CGM glucose 100 -180 mg/dL
3) Definition of hypoglycemia is CGM glucose < 70 mg/dL (2 consecutive CGM readings below threshold)
4) Definition of hyperglycemia is CGM glucose > 300 mg/dL (2 consecutive CGM readings above threshold)
5) Definition of Severe hypoglycemia (see below)

> **Severe Hypoglycemia:** the event required assistance of another person due to altered consciousness, and required another person to actively administer carbohydrate, glucagon, or other resuscitative actions. This means that the subject was impaired cognitively to the point that he/she was unable to treat himself/herself, was unable to verbalize his/her needs, was incoherent, disoriented, and/or combative, or experienced seizure or coma. These episodes may be associated with sufficient neuroglycopenia to induce seizure or coma. If plasma glucose measurements are not available during such an event, neurological recovery attributable to the restoration of plasma glucose to normal is considered sufficient evidence that the event was induced by a low plasma glucose concentration.

Definition of severe hyperglycemia/DKA:
Hyperglycemic events are classified as severe hyperglycemia or DKA if the following are present:

- Symptoms such as polyuria, polydipsia, nausea, or vomiting;
- Serum ketones > 1.0 mmol/L or large/moderate urine ketones;
- Either arterial blood pH < 7.30 or venous pH < 7.24 or serum bicarbonate < 15; and treatment provided in a health care facility

Research Blood Glucose Protocol will be followed at all times.

Research Blood Glucose Protocol:

i. If CGM > 180 mg/dL, patient will receive usual care based on attending physician or advanced practice professional orders based on readings from AC and HS finger stick blood glucose readings. In other words, CGM readings will not be used for management of glucose levels > 180 mg/dL. Physicians and Advanced Practice Professionals (APPs – includes nurse practitioners or physician assistants) will be educated on the fact that, to prevent the risk of insulin stacking, CGM glucose values should not be used to bolus insulin or dose insulin. Elevated CGM readings > 180 mg/dL should not be relayed to on-call physicians or APPs by nursing staff. Pharmacy personnel will also be educated to not use CGM readings for dosing of insulin in order to prevent insulin stacking.

ii. If CGM 100-180 mg/dL with arrow direction  : continue usual care

iii. If CGM 100-180 mg/dL with arrow direction  : Recheck CGM in 1 hour; continue usual care

iv. If CGM 100-180 mg/dL with arrow direction  : Recheck CGM in 30 min; continue usual care

v. If CGM 100-180 mg/dL with arrow direction  (double arrow down): Recheck CGM in 15 min; continue usual care

vi. If CGM between 70-100 mg/dL and arrow direction  or  : continue usual care

vii. If CGM between 70-100 mg/dL and arrow direction  (horizontal) Recheck CGM in 30 min and follow research blood glucose protocol

viii. If CGM between 70-100 mg/dL and arrow  : Recheck CGM in 15 min and follow research blood glucose protocol

ix. If CGM between 70-100 mg/dL and arrow direction  (1 arrow down) Administer one of the following options and recheck CGM device 15 minutes after intervention and follow research blood glucose protocol again:
    1. 2 oz. (60 ml) juice
    2. 2 glucose tablets
    3. 1/2 tube glucose gel

4. 12.5 ml D50W IV

x. If CGM between 70-100 mg/dL and arrow direction  (2 arrows down)
Administer one of the following options and recheck CGM device 15 minutes after intervention and follow research blood glucose protocol again:
1. 4 oz. (120 ml) juice
2. 4 glucose tablets
3. 1 tube glucose gel
4. 25 ml D50W IV

xi. If CGM < 70 mg/dL: confirm with finger stick blood glucose and initiate standard of care per hospital hypoglycemia protocol per hospital policy. Resume CGM study research blood glucose protocol after two hours.

Additional standing orders in the Dexcom G6 protocol:

a. Protocol will not encompass changes in basal, pre-meal, or corrective factor insulin ordered by the attending physician.
b. Provide 24-hour CGM printout of glucose monitoring on morning rounds to the physicians caring for patients in the treatment group for their consideration in adjusting the scheduled basal/bolus insulin based on the CGM pattern. Information will also be provided regarding any interventions that were provided to the patient as a result of the research glucose protocol during the prior 24 hours.
c. Review 24-hour CGM printout with patient in the treatment group to outline the effect of food, insulin and any exercise that may have occurred during the past 24 hours on glycemic control.

Usual Care for Glucose Control (Control Group): Patients assigned to the control group and wearing the Dexcom G6 PRO, will receive usual care as ordered by their attending physician. That means, the patient's glucose management will be based on reading from the blood glucose test that are conducted within a 24-hour period, and orders for glucose management will be determined by the attending physician.

Outcome Measures: Impact of CGM on key patient health indicators will be tracked during the enrolled patient's inpatient stay for up to 10 days. Number of events or amount of time will be calculated in consideration by the total time while the patient is hospitalized with an active Dexcom device (i.e., total time in which the Dexcom device is in use will serve at the denominator). Patients with less than 48 hours of Dexcom device reading will be excluded from outcome data analyses. Key outcomes abstracted from the Dexcom device will include:

1) Episodes of hypoglycemia (two consecutive CGM reading above or below threshold)
2) Episodes of hyperglycemia (two consecutive CGM reading above or below threshold)
3) Episodes of severe hypoglycemia
4) Episodes of severe hyperglycemia/DKA
5) Total time spent in the target range of 100-180
6) Number of times that CGM readings would change management of hypoglycemia compared to standard care

Other outcome measures to be collected include:

1) Questionnaires regarding perceptions of use of CGM devices in the inpatient setting to be completed by nurses and physicians
2) Questionnaires about the anticipated experience and actual experience of wearing a CGM device by the patient. To be administrated by a clinical research nurse or research Clinical Research Coordinator immediately prior to application of the device and immediately after removal of the final device applied (i.e., immediately prior to discharge)
3) Length of stay
4) The Diabetes Treatment satisfaction questionnaire–change (DTSQc) at completion of Dexcom data collection (11)

Other variables to be collected and entered in the data analyses include:

1) Patient demographics
2) Medical history
3) Admitting diagnosis
4) Information about home diabetic regimen
5) Most recent hemoglobin A1c found in EHR
6) Length of time since diagnosis of diabetes
7) Any skin irritation at the site of monitor device insertion

Data Analysis: The proposed inpatient health indicators related to glucose management will serve as the study's primary outcomes. The primary outcome measures, number of hypoglycemic events and time in the target range, will be compared between two groups using t-test. Non-parametric test (such as Wilcoxon-Mann-Whitney test) will also be used to examine unadjusted differences in the events between two groups if the distributional assumption of outcome measures does not meet the normality assumption. Other compounding variables such as patient demographics, admitting diagnosis, HbA1c will be adjusted where applicable. Statistical analyses will be conducted using SAS 9.2.

Other outcome measures on patient and provider's experience and perception of using CGM device and Diabetes Treatment Satisfaction Questionnaire-change (DTSQc) also will be analyzed. (See survey questions as stand-alone documents).

Anticipated Challenges: The study team composed of clinical staff and research members is well prepared to carry out the proposed research. There are, however, potential challenges to completing the proposed research. The team is aware of these challenges and will be prepared to address challenges if they emerge. Potential challenges include:

1. Potential adverse effects of the device
   a) Skin irritation, infections, bleeding etc.
   b) Inaccurate sensor value
   c) Error in entering the calibration code from the sensor that would require manual calibration
   d) Patient annoyance due to device alarms

2. Clinical staff adherence to protocol
   a) Nursing staff on the units will be trained in using Dexcom G6 readings for treatment group patients. Specific components that will be addressed include:

- During 2 hr warm up nursing staff will use finger stick blood glucose for dosing decisions.
- In situations when the CGM is not showing a number value or arrow, a finger stick blood glucose reading should be obtained.
- If patient symptoms do not correlate with CGM glucose values or if symptoms are indicative of hypoglycemia or hyperglycemia, a reading from the blood glucose meter will be obtained.
- Patients and caregivers should avoid the use of skin care products coming into contact with the Dexcom G6 device.
- Patients, caregivers, and nurses should be aware that the transmitter and display device should be kept within 20 feet with no obstacles like walls or metal separating the patient location from the device location.
- Patients who receive Tylenol, over the recommended dose of 1000 mg/6 hrs will require a finger stick blood glucose .

b) Attending physician on the units will be trained in using Dexcom G6 readings for treatment group patients

3. Recording of CGM data for data analyses

4. Removal and replacement of CGM sensor to accommodate patients receiving MRI.

If, as we assume, CGM is found to be a feasible practice for hospitalized patients, the team is prepared to move CGM into a practice innovation on the two units that participated in the pilot RCT. This will require further development of the RCT protocols into practice guidelines and ongoing training and monitoring of clinical staff implementation of CGM.

Anticipated benefits:

1. Treatment group
    a. Improved glucose control in the target range of 100-180 mg/dL
    b. Decreased severe hypoglycemic events
    c. Decreased severe hyperglycemic events
    d. Improved understanding of the trend of glucose readings over a 24-hour period and how these readings are affected by food, glucose, activity and stress

2. Control group
    a. Realization of the patient's personal contribution to possibly improve medical practices for the larger population of inpatient patients with diabetes
    b. Being allowed the experience of wearing a CGM device which may allow them to determine their personal interest in the use of such a device as an outpatient

Human Subjects:

Risks: The equipment used in magnetic resonance imaging (MRI), or high-frequency electrical heat (diathermy) treatment can potentially damage the Dexcom devices and produce inaccurate readings or prevent alerts, as a result. Therefore, subjects cannot wear the Dexcom devices (sensor, transmitter, receiver, or smart device) during those procedures. Subject in this study who need these procedures will have their CGM device removed prior to the test and replaced within twelve hours thereafter. There is potentially unknown risk to anyone who is pregnant, on dialysis, or critically ill,

as it is unknown how different conditions or medications used by these populations affect performance of the Dexcom sensor. These populations are not included in this study. There is a risk of potential infection at insertion site if the site is not clean and completely dry. There is the potential of scarring or skin irritation if using the same insertion site too often. There is a risk of inaccurate reading of the Dexcom devices due to taking higher than the maximum dose of acetaminophen (e.g. > 1 gram every 6 hours in adults). There is a risk that your personal information may be released outside of the study. Federal Privacy Regulations provide safeguards for privacy, security, and authorized access of your records.

Benefits: There is no monetary compensation to subjects in this study. The results of this study will provide generalizable data in regard to the care of hospitalized patients with diabetes with the use of continuous glucose monitoring (CGM) devices versus without the use of the CGM device. The knowledge and insight gained from this study will potentially change what is currently the standard of care for patients who require glucose monitoring.

Confidentiality: Participation in this study is voluntary. A potential subject's refusal to participate will not affect patient care. Proper precautions are in place to maintain a subject's confidentiality including limiting access to data to only key study personnel of the study and securing data via password-protected devices, locked filing cabinets, behind locked offices.

Informed Consent: Participants of this study will sign an IRB approved consent form. Trained and knowledgeable key study personnel (KSP) of the study will obtain informed consent.

Conflict of Interest Disclosure(s): All KSP will complete conflicts of interest disclosure. At this time, there are no identifiable conflicts to disclose.

Data Retention and/or Data Destruction Plan: All paper data related to the study will be stored securely in a locked file cabinet in a secured room. Any digital data files will be stored in a password protected BSWH maintained network. Access to data will be restricted to listed key study personnel only. Data abstracted for this study will be retained for study recordkeeping purposes and research compliance until the completion of the study. Once the study is closed, research related documents will be stored at the Dallas research Storage facility for an indefinite amount of time.

Subject Withdrawal:
Subjects may choose to withdraw from the study at any time prior to the conclusion of the study. Patients with less 48 hours of Dexcom device readings will be excluded from outcome data analyses.

Reporting adverse events or other significant events: Adverse events will be reported to the IRB accordingly and promptly.

Data collection:
Data will be collected for evaluation purposes and reported only in aggregate. Dexcom data will be compared to historical quality data reports of hypoglycemic events and hyperglycemic events on glucose management. Below is a list of variables that will be collected:

Table 1: Data Collection Variables	
Variable	**Source**
Demographics	
MRN	EPIC
Name (first, last)	EPIC
DOB	EPIC
Gender	EPIC
Race	EPIC
Ethnicity	EPIC
Clinical Outcomes	
Admitting Diagnosis	EPIC
Most recent hemoglobin A1C	EPIC
Length of Stay	EPIC
Episodes of hypoglycemic events	Dexcom
Episodes of hyperglycemic events	Dexcom
Total time spent in the target range of 100-180	Dexcom
# of times that readings would change management of hypo or hyperglycemia compared to standard care	
Glycated hemoglobin levels	EPIC
Survey	
Duration of diabetes	Patient Survey
Information about **home diabetic regimen**	Patient Survey
Perceptions of device use in inpatient setting (comfort with device, preference of finger stick vs. device, feel safer, CGM perceive to prevent hypo/hyperglycemia, CGM assist in staying in a more desirable glucose range, etc.)	Patient Survey
Anticipated experience and actual experience of wearing device (barriers, benefits)	Patient Survey
Patient satisfaction with their diabetes care in the hospital (knowledge of diabetes from clinical team, presentation of care, etc.)	Patient Survey
Clinician feedback (problems encountered with device, preference of having all patients with diabetes/insulin therapy to be on CGM, comfort with protocol/intervention, self-efficacy etc.).	Clinical Staff Survey

Data Collection Details

REDCap is a web-based application for building and managing online surveys and databases. While REDCap can be used to collect virtually any type of data (including 21 CFR Part 11, FISMA, and HIPAA-compliant environments), it is specifically geared to support online or offline data capture for research studies and operations.

Baylor Scott & White Health (BSWH) joined REDCap consortium and received REDCap source code for local installation in 2014. The web server and database server are two separate servers and are in Baylor Scott & White Health (BSWH) data centers located securely as required by institutional policy. Each user has their own account, and their user account will only have access to REDCap projects that they themselves have created or to projects to which other users have granted them access. REDCap implements authentication to validate the identity of end-users that log in to the system. REDCap has a built-in audit trail that automatically logs all user activity and logs all pages viewed by every user, including contextual information (e.g. the project or record being accessed). Whether the activity be

entering data, exporting data, modifying a field, running a report, or add/modifying a user, among a plethora of other activities, REDCap logs all actions.

REDCap allows users to export any and all data from their REDCap projects, supposing they have been given full data export privileges.

REDCap stores its data and all system and project information in various relational database tables (i.e. utilizing foreign keys and indexes) within a single MySQL database, which is an open source RDBMS (relational database management system). All data captured in REDCap is stored on BSWH servers. Therefore, all project data is stored and hosted here at BSWH institution, and no project data is ever transmitted at any time by REDCap from that BSWH to another institution or organization.

Only key study personnel will have access to this information. Any PHI collected during this study will be minimal for the needs of this study and will only be accessed by KSP assigned to this study. PHI records will be obtained using the password protected EHR system of Baylor Scott & White Health.

Data Protection & Confidentiality: * Data will be maintained after the conclusion of the study for six years, after which the data will be removed from REDCap by the PI.

Data Analysis
Descriptive statistics (mean, standard deviations, percentage) will be used to summarize the characteristics (age, gender, race, and ethnicity) of participating patients and clinical outcomes. Exploratory analyses will also be performed to assess relationship between patient's characteristics and experiences/perceptions/satisfaction of using devices collected from survey. Results of data analysis will be reported at aggregate level to improve management of diabetes patients.

Budget
Attached

Timeline for Proposed Study

Study Timeline	Months											
	1	2	3	4	5	6	7	8	9	10	11	12
Study Activities												
Revision of RCT protocols for IRB and FDA approval.												
Training clinical staff												
Patient enrollment												
Data collection and analysis												
Report preparation												

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