Executive Summary

Hawai'i Pacific Health (HPH) is a not-for-profit health care network of hospitals, clinics, physicians, and care providers dedicated to the mission of improving the health and well-being of the people of Hawai'i and the Pacific Region.

In 2013, Hawai'i Pacific Health (HPH) identified reduction in surgical complications and in length of stay as major areas of focus. As poorly managed blood glucose is a known contributing factor in both areas, Hawai'i Pacific Health identified this clinical area as needing evaluation. We found that multiple glucose management algorithms were being used across the system with varying success, and that although there were national recommendations for improved practices, we had not adopted a number of these. Our initial thought was that insulin dosing algorithms, accessed through our EHR, would solve our problems. We first looked for a vendor solution, and found and selected one. However, we quickly learned that inpatient glycemic management is very complex and that we had many clinical beliefs and practices that needed to be managed and changed. Also, we use data to drive improvement so we had to create a reliable way to measure outcomes, all in addition to the relatively simple changes in insulin ordering that were required.

We implemented EMR order sets to support best practice (both vendor supplied and internally developed), we developed a system-wide hypoglycemia management protocol, we accomplished wireless glucometer integration and we provided a lot of staff and physician education. We experienced the easiest adoption of the provided tools in our critical care units.

In the eighteen months following staggered adoption of the new tools in the HPH critical care units, computer-directed insulin dosing system (CDIDS) utilization increased to greater than 90% of titratable
IV insulin infusions. This was not surprising because the nurses used the system to perform the necessary calculations required for insulin dose adjustment, something that had been their responsibility in the past. We did not see widespread adoption of CDIDS in other parts of our hospitals because the changes required were less about simplified ordering and dosing, and more about complex medication management and clinical workflow changes.

In addition to increased CDIDS utilization for intravenous insulin, 83% of glucose values for patients placed on CDIDS were within the recommended normal glucose range of 70-180 mg/dl, compared to only 59% of glucose values experienced by patients placed on usual care.

**Background Knowledge**

After successfully signing a multi-year contract following a highly contentious negotiation with our largest commercial payer in 2008, HPH was determined to change direction. Our goal was to build a stronger partnership with our payers to avoid a future of repeated win-lose contract negotiations that would ultimately be financially unsustainable for all parties.

In an effort to move forward, we approached our largest commercial payer and suggested that our enterprise-wide, highly integrated EHR (Epic) could be used to drive improvements in care outcome measures and reduce care costs. Our proposal was to ask payers to fund our start-up costs in developing a robust population health program, and we would be accountable to an agreed-to set of outcome performance measures to improve quality and reduce costs. With aligned incentives, it would be a win-win for both parties. Our initial focus would be in chronic disease management and diagnostic screenings. We reached agreement in 2009 and began to develop disease registries, improved order sets, best practice alerts, and a patient outreach program. We achieved rapid success; by the end of the first year, we improved our performance in many areas to 90th percentile benchmarks. This was remarkable given we had started at or below the 50th percentile in most of these metrics.

These results demonstrated we could be successful with a more comprehensive and aggressive goal toward true accountable care across our entire health system – beyond our clinics, to include our hospitals. Our challenge was finding a way to offset the financial losses that our hospitals would inevitably face given the existing fee for service payment structure. Reducing length of stay was identified as one way to do this, and glycemic control was identified as a clinical condition that, if better managed, could help achieve it.

**Local Problem**

Surgical complications bring a heavy burden to patients and to the health care system, increasing long-term disability and death, length of stay (LOS), and total cost of care. The correlation between diabetes status, glucose control, and surgical complications is well-published in the literature, and also supported by our own surgical data. Figure 1 displays the differences in surgical morbidity rates between our diabetic and non-diabetic patient populations in 2013 and 2015. Although the overall rate is decreasing, the difference in complication rates between our diabetic and non-diabetic population is significant. A desire to improve in this area, specifically in our diabetic population, served as the initial fuel to make glycemic control an organizational priority.
Figure 1. Hawai‘i Pacific Health National Surgical Quality Improvement Program (NSQIP) post-operative complication rates for diabetic (blue) and non-diabetic (orange) patients. Data is summarized from all surgical cases performed at Pali Momi Medical Center, Wilcox Memorial Hospital, and Straub Clinic and Hospital during calendar years 2013 and 2015.

Aside from its contribution to surgical complications, poor glucose control during acute medical or surgical illness is independently associated with an increased LOS and total hospitalization cost\(^4\). A 2013 study looking at the association between glucose variability and LOS found that for every 10 mg/dl increase in standard deviation, LOS increases by 4.4\%\(^6\). Our LOS data supports the same trend. Figure 2 displays our 2013 average LOS for our diabetic and non-diabetic patient populations. Diabetic patients have a greater glucose variability, and our own data shows about a 2-day increase in LOS for patients with a diagnosis of diabetes compared to those without a diagnosis of diabetes. Since reduction in LOS was a major initiative for our health system in 2013, it made sense to focus on improved glycemic control.
Upon initial evaluation of the approach to glucose control of our adult inpatient population in 2013, we uncovered multiple different practices regarding glucose management and insulin use across the system. With this amount of variation, it was not surprising to find there was significant room for improvement. A snapshot from October 2013 revealed that 33-43% of all glucose values taken from our adult inpatients were outside of the normal range, defined as 70-180 mg/dl. We thus began our quest for improved glucose management.

**Design and Implementation**

At the end of 2013, a small task force was formed from members of Quality/Patient Safety, IT, and clinical staff. (see Appendix D) The initial approach we took was to find a computer-directed insulin dosing system (CDIDS) that was safe, effective, and offered alignment or integration with our EHR. Important considerations for us were that the product was successfully in use at other sites with the same EHR, and that it was designed for the various patient populations we intended to include (ICU, medical/surgical, high risk obstetric and pediatric inpatients). The CDIDS we selected is a proprietary insulin dosing software that assists with IV and subcutaneous insulin dosing, with the major benefit being the ability to interface with our EHR. We thought that this would be all that was needed for rapid standardization and improvement.

A general project timeline is displayed below. IT was an integral part of the project every step of the way, leading infrastructure design and redesign, wireless glucometer integration, and order set revisions and build.
The intended outcome of the project was to reduce variation in inpatient glucose management across our health system and thereby to improve patient outcomes and reduce costs. This case study features three IT solutions that were essential to our overall glycemic control efforts.

**How Health IT Was Utilized**

There were 3 main health IT initiatives in our glycemic control efforts:

- Implementation of Computer-directed insulin dosing system
- Development of EHR order sets to support basal-bolus subcutaneous insulin dosing
- Wireless glucometer integration

**Implementation of Computer-directed insulin dosing system.** Hawai‘i Pacific Health selected a Computer-directed insulin dosing system as the IT tool to assist us in our glycemic control efforts. We first worked to identify vendor products that might meet our needs. Important considerations for us were that the product was successfully in use at other sites with the same EHR, and that it was designed for the various patient populations we intended to include (ICU, medical/surgical, high risk obstetric and pediatric inpatients). The CDIDS we selected is a proprietary insulin dosing software that assists with IV and subcutaneous insulin dosing, with the major benefit being the ability to interface with our EHR. The software is designed to maintain the patient’s blood glucose at the midpoint of a specified target range.

The initial plan was to simultaneously implement IV and subcutaneous modules at each site over the course of 6-9 months starting in December, 2014. We trained clinicians in how to use the tool prior to go-live at the first two sites. We saw variation in the management approach to training, with mandatory nursing education at one site but not at the other. We had unit based clinical pharmacists at one site but not the other, and saw variation in pharmacist engagement as a result. Physicians were not mandated to be trained, but training opportunities were provided. Shortly after our first go-live at two sites we
encountered significant clinical practice and technical challenges that caused us to abruptly halt the subcutaneous insulin dosing module implementation for a period of six months (“Time Out”, February to July, 2015). A major unexpected benefit of the CDIDS Time Out was an opportunity to evaluate our glycemic management practices compared to evidence based best practices. We uncovered some fundamental issues that needed to be addressed across our system.

On the clinical side, we discovered that staff and physicians did not have a strong knowledge base in the current principles of glycemic management and effective insulin use. Most of our physicians were still ordering sliding scale insulin as the mainstay of treatment or continuing to use oral hypoglycemic agents even when hyperglycemia was identified. On the nursing side, morning glucose readings were being done at 5:00 am, two hours before breakfast trays were delivered and three hours before insulin was given. Our patients were also being admitted with high Hemoglobin A1c values, a marker of poorly controlled diabetes in the ambulatory setting. This all pointed to a significant need for diabetes and glycemic management education for our staff, physicians, and patients.

Physician education was offered with a focus on updated best practices and an emphasis on the need to manage inpatient hyperglycemia. The use of basal bolus insulin, hypoglycemia management and the internally developed tools available to make updated practices easy for clinicians were addressed. Instruction on how to access and use the CDIDS was also reviewed. Nursing and pharmacy education was also repeated with a heavy emphasis on the clinical side of inpatient glycemic management. Registered Nurse skills fairs, classroom training, staff meetings, daily huddles with pharmacy support to assist the clinical team, and an online learning module were used as venues to deploy the education. There were also facility based teams that worked to improve the timing of glucose testing, insulin administration and meals.

The IV insulin CDIDS was continued throughout, as there were fewer technical issues with implementation, the clinical management was more straightforward, and we found we had fewer longstanding clinical habits that needed to be changed. The IV CDIDS tool also eliminated the need for nurses to do complex calculations for dosing this high risk drug, a significant driver in their adoption of the tool.

**Development of basal-bolus order sets.** As mentioned earlier, prior to our glycemic control efforts sliding scale insulin was the primary dosing method for subcutaneous insulin. Sliding scale is a reactive method of glucose control and not supported by current guidelines. Instead, current guidelines use basal-bolus insulin dosing, which is a proactive strategy aimed to keep blood glucose within a target range throughout the day and night. Basal-bolus regimens include the use of a basal (long-acting) insulin, scheduled meal time bolus doses to account for carbohydrates consumed, and a sliding scale for correction of episodes of hyperglycemia.

Prior to project initiation, our EHR order sets were not structured to support basal-bolus insulin dosing. We thus created order sets to support this method, to assist our clinicians with insulin dosing for those patients who are not candidates for the CDIDS. Appendices A and B show the before and after screenshots of our subcutaneous insulin order sets available for use in Epic. The old order sets were phased out and replaced with the new basal-bolus order sets as each site went live with the CDIDS for subcutaneous insulin. This revamp of our subcutaneous insulin order set is an example of restructuring tools in our EHR to support clinical best practice. We no longer have multiple different insulin order sets that varied based upon physician preference; we have one standard set for use across all four hospitals.
for similar clinical circumstances. These order sets were created by our own IT teams and implemented by us without technical support from the vendor.

**Wireless glucometer integration.** When we first began to introduce changes in glucose management in late 2014, our glucometers were not integrated with our EHR. The workflow using stand-alone glucometers was as follows: Nurse Aide performs the glucose test at the bedside and transcribes the glucose result from the meter into Epic. There was significant potential for error if glucose checks occurred but were not documented (or were documented late), or if values were transcribed incorrectly. Introduction of the CDIDS added another potential failure mode as the algorithm could not provide a correct insulin dose recommendation if the glucose result was not also correctly entered into the CDIDS by the RN. To eliminate these issues, we delayed the reintroduction of the CDIDS for subcutaneous insulin until we had new wirelessly integrated glucometers. Now when glucose checks are performed, results are automatically and wirelessly sent from the device through middleware into Epic, and then into the CDIDS. The transmission of results into subsequent systems occur within one minute, and the process is completed without leaving the patient’s bedside. The workflow was greatly simplified, and the risk of keying errors or missed documentation was eliminated. (see appendix E)

![Figure 3. Medication use process from ordering to administration for IV and subcutaneous insulin at Hawai‘i Pacific Health. Computer-directed insulin dosing system, wireless glucometers, and basal-bolus insulin order sets have been integrated into the workflow.](image)

**Value Derived**

**Process Improvement.** Medication errors are among the most common medical errors. According to “Preventing Medication Errors”\(^9\), a 2006 Institute of Medicine (IOM) report, 400,000 preventable medication-related injuries occur in hospitals each year, resulting in at least $3.5 billion in extra medical costs per year. The IOM report goes on to describe paper-based prescribing as a method associated with high error rates, and recommends implementation of electronic prescribing and other IT solutions to reduce the burden of medication-related errors. In addition, the Institute for Safe Medication Practices (ISMP) identifies insulin, both IV and subcutaneous, as a high alert medication. High alert medications are drugs that bear a heightened risk of causing significant patient harm when used in
error. To mitigate risks associated with this group of drugs, ISMP recommends the application of special safeguards, such as standardizing the ordering and administration of these drugs\textsuperscript{10}.

At HPH we were able to implement best practices for titratable insulin infusions across our health system:

- IOM recommendation: Transition away from paper-based protocols to an IT solution
- ISMP recommendation: Standardize ordering and administration of high risk drugs. We were able to move away from multiple paper protocols towards a single, standardized solution.

Prior to the implementation of CDIDS, titratable insulin infusions were managed by paper protocols. The workflow was as follows (BG = blood glucose):

Appendix C displays one example of an insulin infusion paper protocol for the treatment of adult Diabetic Ketoacidosis (DKA) in our health system. Difficulties in performing drug calculations have been found to be a top cause of medication administration errors among nurses\textsuperscript{11}, and the degree of difficulty in the manual calculations required by our DKA paper protocol is evident. Each hour, depending on the current glucose reading, the nurse was required to change the multiplier and recalculate the drip rate using the specified formula. The process increased risk for medication errors involving a high risk drug, and was also very time consuming for the bedside nurse.

With the implementation of the CDIDS, the workflow for initiation and titration of insulin drips was adjusted to (BG = blood glucose):

Screen shots showing the simplified workflow for insulin rate adjustments with the Computer-directed insulin dosing system are shown below. With the introduction of this new software, all manual calculations for the nurse were removed, thus eliminating the risk for medication errors caused by improper calculations at each hour, as well as saving time for the bedside nurse. It was likely that it was this simplification in process that led to the much faster rate of adoption of the IV tool by the ICU clinicians (compared to the much more complex changes required for subcutaneous insulin).
Step 1: Glucose value is wirelessly transmitted from the glucometer into Epic, then from Epic into Computer-directed insulin dosing system. Nurse is required to validate the current glucose value with a single mouse click.

Step 2: Computer-directed insulin dosing system displays recommended insulin infusion rate. Nurse is required to validate the rate change with a single mouse click.

Step 3: Nurse adjusts insulin rate on the infusion pump and documents rate change on the Epic Medication Administration Record (MAR).
Figure 4 below shows increased utilization of the Computer-directed insulin dosing system for titratable insulin drips throughout our health system in the 12 months following implementation at our first site. System wide utilization of the tool has increased to 90% in June, 2016, showing improved adherence to clinical best practice.

![Figure 4](image-url)

Outcomes Improvement. Figures 5-7 below demonstrate improved glycemic control in ICU patients placed on CDIDS versus usual care (paper based protocols). The results include all glucose values across our health system for the time period December, 2014 through June, 2016 (although 2 of our 4 hospitals did not have this system in place until October, 2015).

Hypoglycemia is considered a medical emergency. If severe enough, patients may become unconscious, experience seizures, brain damage, or even death. Repeat episodes of hypoglycemia can also lead to the development of hypoglycemia unawareness, an unsafe condition where the patient is without early warning signs of low blood sugar. In addition, in the hospital setting, hypoglycemia is associated with increased length of stay and mortality. Therefore, one of the goals of glycemic control in any setting is to avoid hypoglycemia. Our initial evaluation revealed that we had variation in how hypoglycemia was managed across settings. We created a standard management approach very early in this effort and the institution adopted it system wide.
results have been encouraging. Figure 5 below shows extremely low rates (<1%) of hypoglycemia in both the CDIDS and usual care patient populations. We were pleased to see that the low rate of hypoglycemia that existed prior to the CDIDS implementation has continued since the tool was introduced.

![Graph showing hypoglycemia rates for ICU patients placed on CDIDS vs. usual care.](image)

**Figure 5.** Hypoglycemia rates for ICU patients placed on Computer-directed insulin dosing system (lavender) vs. usual care (blue) at Hawai’i Pacific Health for the time period 1/1/14-6/30/16. Hypoglycemia rates are presented as % of all glucose readings < 70 mg/dl.

When we looked at normoglycemia and hyperglycemia rates for patients on IV insulin infusions, we found differences in outcomes. Figure 6 displays superior glucose control with CDIDS versus usual care in critically ill patients across our health system. 82.5% of glucose values for patients placed on CDIDS were within the recommended normal glucose range of 70-180 mg/dl, compared to 59.2% of glucose values experienced by patients placed on usual care.

Hyperglycemia management in the hospital has often been considered secondary in importance to the condition that prompted admission. However, a body of literature now supports targeted moderate glucose control in the hospital setting for improved clinical outcomes. Mortality, infection rates, length of stay, and hospitalization costs are all correlated with glucose control. Both hyper- and hypoglycemia among inpatients are associated with adverse short- and long-term outcomes. Increased focus on the details of the clinical management of patients with abnormal glucose values and implementation of the CDIDS has helped us to achieve a better state of glucose management for those patients who required IV insulin infusions to manage their blood glucose, allowing us to provide better care for our sickest
CDIDS in the ICU – Normoglycemia

Figure 6. Normoglycemia rates for ICU patients placed on Computer-directed insulin dosing system (lavender) vs. usual care (blue) at Hawai‘i Pacific Health for the time period 12/1/14-6/30/16. Normoglycemia rates are presented as % of all glucose readings between 70-179 mg/dl.

Following the same trend as Figure 6, Figure 7 shows better glucose control with Computer-directed insulin dosing system versus usual care. 39.8% of all glucose values in the ICU setting were above the recommended limit (Glucose 180 mg/dl) with usual care. With Computer-directed insulin dosing system for intravenous insulin, the hyperglycemia rate is much lower representing just 16.6% of all glucose values.
Figure 7. Hyperglycemia rates for ICU patients placed on Computer-directed insulin dosing system (lavendar) vs. usual care (blue) at Hawai‘i Pacific Health for the time period 12/1/14-6/30/16. Hyperglycemia rates are presented as % of all glucose readings 180 mg/dl or greater.

Although we have had a shorter period of time to evaluate success for our patients who require subcutaneous insulin, we are able to demonstrate more normoglycemic days for patients where the subcutaneous CDIDS product was used. (Figure 8). So far, we have had very disappointing adoption of
the subcutaneous CDIDS tool, at most we have had 20% of potential patients using the tool for insulin dosing.

Figure 8. Comparison of number of normal blood glucose days for patients on CDIDS (lavender) compared to usual care (normalized per 1000 days of each treatment approach).

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We have observed increasing adoption of (non CDIDS) basal-bolus insulin dosing as a result of the focused attention, training and tools that have been provided to our clinicians. We have seen improved clinical practices associated with timing of blood glucose testing, meal delivery, and appropriate documentation of carbohydrate intake and have a much greater shared understanding about optimal inpatient glucose management.

Moving forward, we are committed to tracking and reporting glycemic control measures throughout our facilities to monitor continued improvement and to maintain our focus on this important area. We have adopted many of the Society of Hospital Medicine metrics to be able to measure our progress in a standard way. Our approach to data allows us to provide regular validated reports for clinicians to understand progress toward goals. At regular intervals, the data will be presented to the HPH glycemic control team.
control workgroup, specific hospital glycemic control workgroups, various physician groups, and other relevant stakeholders.

Lessons Learned

Our lessons learned surfaced from our biggest challenges:

- Concomitant rollout of principles of glycemic management and new insulin dosing tools
- Timing of wireless integration of our glucometers
- Technical issues associated with a cloud based product hosted thousands of miles away
- Site ownership and accountability for improved glycemic management

**Concomitant rollout of principles of glycemic management and new insulin dosing tools.** As mentioned earlier, during the initial efforts to introduce the CDIDS we discovered a knowledge gap in glycemic management among our staff and physicians. It was extremely challenging to promote tools with a new approach to glycemic management when the foundation behind the approach was not there. During initial training (2 hours for nurses, 1 hour for pharmacists, physician workshops), there was an assumption that principles of glycemic management were known so only a brief review was provided with the majority of the focus on workflow and how to use the electronic tools. Interrupting implementation of the CDIDS for subcutaneous insulin for six months turned out to be a blessing in disguise as it provided us with much needed time to re-educate our staff and physicians on the foundation of good glycemic management, wirelessly integrate our glucometers, and develop order sets to support basal-bolus insulin dosing in addition to the CDIDS.

**Timing of wireless glucometer integration.** When we first began to update our glycemic management approaches at Straub Clinic and Hospital and at Pali Momi Medical Center, our glucometers were standalone devices without integration to any system. This lack of integration required the nurses to double document the glucose value in Epic and then into the CDIDS. This was time consuming for the bedside nurse, especially when the patient was on IV insulin infusion requiring 12-24 glucose checks per day. Perhaps more important than the time factor, however, was the opportunity for error. Each manual transcription comes with a risk of transcription error, and we were essentially doubling our error risk by requiring the nurse to transcribe the glucose value twice into two independent systems. In hindsight, the better approach would have been to first move forward with wireless integration of our glucometers, then implement CDIDS. The restart of the subcutaneous insulin dosing module at Straub and at Pali Momi was purposely delayed until integration of the glucometers was accomplished in August 2015. Our other two hospitals, Wilcox Memorial Hospital and Kapi’olani Medical Center for Women and Children, had integrated glucometers in place before CDIDS was implemented there.

**Technical issues associated with a cloud based product hosted thousands of miles away**

Very soon after our initial go-live, our clinicians reported technical problems with freezing episodes. These were significant and interfered with the ability to provide care promptly. This interruption in service was actually the key reason we took a Time Out soon after we started this project. There was a large amount of collaborative detective work that went on during the Time Out period. We did not have complete confidence that the issues were all resolved, so our second attempt to go-live with the subcutaneous product was begun on a single unit. We had reasonable success there, but when we proceeded to a full hospital go-live again there were additional slow-down issues that would have led to a decision to halt the project entirely, but by that time there were physicians at the pilot site who were convinced that care had improved significantly for this patient population and that knowledge encouraged us to continue to move forward.
There were minor issues with workstations that were identified and fixed that helped, but the major issue of unpredictable freezing was not resolved until the vendor worked with us to have a hosted version of the software in our geographic area.

Ownership and accountability. Another challenge we faced was site ownership and accountability for improvement efforts. During go-live the sites became so heavily reliant on the project team, it became difficult for the project team to leave the site. Each hospital required stronger nursing, pharmacy, and physician support within their own walls. While there were efforts made to develop a support structure prior to go-live, the realization of depth of clinical need was not fully appreciated until clinicians had to use the tools to care for patients. Since go-live we have made significant progress and are continuing to build the clinical leadership and support structure at each site such that optimal glycemic control is a priority and an integral part of daily workflow.

We have been able to demonstrate an improvising trend in length of stay (LOS) that is greater for our patients with diabetes compared to the improving trend in LOS for patients without diabetes. (Figure 9)

Figure 9. Comparison of length of stay for patients with and without diabetes in our hospitals.

This improvement has led us to consider additional ways to improve the glycemic control of our diabetes inpatient population as we believe that we have only begun to experience the LOS reduction benefits that can be realized.
**Financial Considerations**

Table 1 displays the financial analysis for improved IV insulin management in the ICU setting. A conservative approach was used: ICU Average Length of Stay (ALOS) impact from IV CDIDS was assumed to be -0.1 days, which was provided by the vendor. The analysis defined a patient as any patient with diabetes, though in reality the need for glycemic control is not limited to known diabetics. Only ICU beds were included in this analysis. Staff training consists of 1-hour ICU nurse training and 30-minute ICU pharmacist training, which is specific to the IV CDIDS.

The model below shows a $420,000 savings from decreased ICU ALOS, which is partially offset by fees and training costs. Net benefit from IV CDIDS utilization in our critical care units is anticipated to bring the health system $240,000 in savings annually.

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<th>SCH</th>
<th>WMH</th>
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| Net Cost                            | $53,625| $(91,294)| $(152,060)| $(40,480)| $(240,208)|
References

4. Umpierrez GE et al. Randomized study of basal bolus insulin therapy in the inpatient management of patients with Type 2 Diabetes (RABBIT 2 Trial). *Diabetes Care* 2007 Sep;30(9):2181-6.
Appendix A

Subcutaneous insulin order set prior to glycemic management efforts at Hawai‘i Pacific Heath. Sections are expanded for intermediate / long-acting insulin (basal), meal time insulin, and insulin apart sliding scale. Each type of insulin (basal, meal time, sliding scale) must be ordered separately. Dose and frequency for basal and meal time insulin are not prepopulated and must be specified by the physician.
Appendix B

Modified subcutaneous insulin order set supporting the best practice of basal-bolus insulin dosing at Hawai‘i Pacific Heath.

Order panel with 0.5 multiplier selected:

Physician selects order panel of his/her choice: weight-based dosing using a multiplier or custom dose

Basal, meal time, and sliding scale doses are prechecked with dose and frequency prepopulated. Physician is only required to select the appropriate order panel (1 click), then sign the orders. Nursing, diet, consult, and hypoglycemia orders are included.
Hawai’i Pacific Health

**Glycemic Control**

- **Insulin aspart 100 UNIT/mL pen (Novolog) High Dose Scale**
  - 2-12 units, QD, W/MEALS AND BEDTIME. Subcutaneous, HIGH DOSE SCALE Correction doses for meal/intermeals checks: Target glucose range: 120-160 BG less than or equal to 70. Treat hyperglycemia per protocol. BG less than or equal to 80. Notify physician to consider reduction in before meal insulin. BG 81-130 no additional insulin required. BG 140-160 4 units insulin aspart. BG 161-180 2 units insulin aspart. BG 181-200 1 unit insulin aspart. BG 201-250 0 units insulin aspart. BG 250-300 1 unit insulin aspart. BG 301-350 2 units insulin aspart. BG 351-400 3 units insulin aspart. BG 401-450 4 units insulin aspart. BG 451-500 5 units insulin aspart. BG 501+ 6 units insulin aspart.

- **Insulin aspart 100 UNIT/mL pen (Novolog) Very High Dose Scale**
  - 3-18 units, QD, W/MEALS AND BEDTIME. Subcutaneous, VERY HIGH DOSE SCALE Correction doses for meal/intermeals checks: Target glucose range: 120-160 BG less than or equal to 70. Treat hyperglycemia per protocol. BG less than or equal to 80. Notify physician to consider reduction in before meal insulin. BG 81-130 no additional insulin required. BG 140-160 3 units insulin aspart. BG 161-180 2 units insulin aspart. BG 181-200 1 unit insulin aspart. BG 201-250 0 units insulin aspart. BG 250-300 1 unit insulin aspart. BG 301-350 2 units insulin aspart. BG 351-400 3 units insulin aspart. BG 401-450 4 units insulin aspart. BG 451-500 5 units insulin aspart. BG 501+ 6 units insulin aspart.

- **Insulin aspart 100 UNIT/mL pen (Novolog) Custom Dose Scale**
  - QD, W/MEALS AND BEDTIME. Subcutaneous, CUSTOM DOSE SCALE Correction doses for meal/intermeals checks: Target glucose range: 120-160 BG less than or equal to 80. Notify physician to consider reduction in before meal insulin. BG less than or equal to 80. Notify physician to consider reduction in before meal insulin.

**Hypoglycemia Protocol**

UNTIL DISCONTINUED

- First occurrence: Today at 0945, if patient responsive: 1. If patient has IV access, give D50W according to scale in D50W order. 2. If patient does not have IV access, give 4 oz. apple or cranberry juice (16g carbohydrates). 3. Recheck BG in 15 minutes. Retreat until BG >70mg/dL. If patient is not responsive: 1. If patient has IV access, give D50W according to scale in D50W order. 2. If patient does not have IV access, give glucagon 1mg IM. 3. Recheck BG in 15 minutes. Retreat until BG >70mg/dL.

**Dextrose**

- Frequency of 4 doses/day exceeds recommended maximum of 3 doses/day

**Glucagon 1 MG Inj**

- 1 mg PRN. Intramuscular. Route, per Hypoglycemia Protocol if patient does not have IV access and is not alert.

**Insulin Subcutaneous Basal/Bolus/Correction (0.7 Multiplier - ex. Steroids, Resistant Type 2 DM)**

**Insulin Subcutaneous Basal/Bolus/Correction (Custom Dose)**

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Appendix C

Paper protocol for titratable insulin infusion used in the treatment of adult Diabetic Ketoacidosis (DKA). Prior to Computer-directed insulin dosing system implementation, the protocol was used by the nurse at each hourly glucose check (24 times per day).

DKA INSULIN DRIP ORDERS
Target range = Blood Glucose 140-200
1. Mix insulin drip: 100 units Regular insulin into 100 mL N/S to equal concentration of 1 unit per mL, infuse with compatible maintenance IV or N/S at 10 ml/hr.
2. Start insulin drip on pump at rate determined by this formula:
   \( \text{BG} - 60 \times 0.02 = \text{number of Units of insulin/hour} \)
   \( \text{BG} = \text{current glucose} \)
3. Check BG every hour, then:
   a. Call MD to start infusion containing \( \text{D}_5 \) _____ solution
   b. Increase Multiplier to 0.03
   c. Follow Protocol #5, starting with formula \( \text{BG} - 60 \times 0.03 = \text{number of Units of insulin/hour} \)
4. When BG is < 250:
   a. Decrease by 1 unit per 0.01
   b. Recheck glucose in 15 min.
5. Adjust current multiplier in drip formula #4C above according to the following directions:
   a. Whenever BG is greater than 200 – increase multiplier by 0.01
   b. Whenever BG is within 140-200 – No change in multiplier
   c. Whenever BG is less than 140 – see below #6, #7 or #8

Please note that you must recalculate the insulin dose every hour with the latest BG even if the multiplier doesn't change.
6. For BG 100-139
   a. Decrease multiplier by 0.01
   b. Recheck glucose in 30 min.
7. For BG 81-99
   a. Give D50W by IV push using formula:
      \( \frac{150 - \text{BG}}{0.3} = \text{mL of D50W to be given IV push} \)
   b. Decrease insulin drip multiplier by 0.01 and continue insulin drip, and
   c. Recheck glucose in 15 min.
   d. Continue to repeat above steps until BG >100, then
   e. Resume BG monitoring and insulin drip protocol in order #6 once the BG >139, resume drip at last previous rate.
8. For BG 60-80:
   a. Stop insulin infusion,
   b. Give D50 according to formula:
      \( \frac{100 - \text{BG}}{0.3} = \text{mL of D50W to be given IV push} \)
   c. And check BG in 15 min.
   d. Continue to repeat above steps until BG >100, then
   e. Resume BG monitoring and insulin drip protocol in order #4 once BG >100
9. Monitor for Adverse Hypoglycemic Episodes defined as:
   a. Blood glucose less than 80 mg/dL with or without associated symptoms
   b. Blood glucose less than 65 mg/dL associated with altered mental status, seizure, tachycardiasms, or hemodynamic compromise.
   c. For adverse Hypoglycemic Episodes
      a. Stop insulin infusion, then
      b. Give 50 mL D50@ IV push,
      c. Notify MD.
10. Discontinue IV insulin drip when patient tolerating P.O. feeding and notify M.D. for subcutaneous regular insulin scale. Contact physician for any concerns regarding protocol.

☐ Verbal/Telephone orders read back to physician

Physician Signature ___________________________ Date/Time ___________________________
Appendix E

Initiative #3: Wireless glucometer integration

Prior to integration:
- Nurse aide retrieves patient's BG with glucometer
- Nurse aide transcribes BG value from glucometer into Epic
- Nurse transcribes BG value from Epic into CDIDS
- CDIDS recommends insulin dose based on transcribed BG value

After integration:
- Nurse aide retrieves patient's BG with glucometer
- BG is wirelessly transmitted from glucometer into Epic, then into CDIDS
- CDIDS recommends insulin dose based on transmitted BG value

Advantages:
- Fewer steps
- Less people involved
- Risk of transcription error eliminated
- Less time consuming