BRIEF REPORT

Improving Insulin Ordering Safely: The Development of an Inpatient Glycemic Control Program

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This report describes a Glycemic Control Program instituted at an academic regional level-one trauma center. Key interventions included: 1) development of a subcutaneous insulin physician order set, 2) use of a real-time data report to identify patients with out-of-range glucoses, and 3) implementation of a clinical intervention team. Over four years 18,087 patients admitted to non-critical care wards met our criteria as dysglycemic patients. In this population, glycemic control interventions were associated with increased basal and decreased sliding scale insulin ordering. No decrease was observed in the percent of patients experiencing hperglycemia. Hypoglycemia did decline after the interventions (4.3% to 3.6%; $p = 0.003$). Distinguishing characteristics of this Glycemic Control Program include the use of real-time data to identify patients with out-of-range glucoses and the employment of a single clinician to cover all non-critical care floors. *Journal of Hospital Medicine* **2009;4:E30–E35.** © *2009 Society of Hospital Medicine.*

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The benefits of glycemic control include decreased patient morbidity, mortality, length of stay, and reduced hospital costs. In 2004, the American College of Endocrinology (ACE) issued glycemic guidelines for non-critical-care units (fasting glucose <110 mg/dL, nonfasting glucose <180 mg/dL).[1] A comprehensive review of inpatient glycemic management called for development and evaluation of inpatient programs and tools.[2] The 2006 ACE/American Diabetes Association (ADA) Statement on Inpatient Diabetes and Glycemic Control identified key components of an inpatient glycemic control program as: (1) solid administrative support; (2) a multidisciplinary committee; (3) assessment of current processes, care, and barriers; (4) development and implementation of order sets, protocols, policies, and educational efforts; and (5) metrics for evaluation.[3]

In 2003, Harborview Medical Center (HMC) formed a multidisciplinary committee to institute a Glycemic Control Program. The early goals were to decrease the use of sliding-scale insulin, increase the appropriate use of basal and prandial insulin, and to avoid hypoglycemia. Here we report our program design and trends in physician insulin ordering from 2003 through 2006.

Patients and Methods

Setting

Seattle's HMC is a 400-bed level-1 regional trauma center managed by the University of Washington. The hospital's mission includes serving at-risk populations. Based on illness, the University HealthSystem Consortium (UHC) assigns HMC the highest predicted mortality among its 131 affiliated hospitals nationwide.[4]

Patients

We included all patients hospitalized in non-critical-care wards—medical, surgical, and psychiatric. Patients were categorized as dysglycemic if they: (1) received subcutaneous insulin or oral diabetic medications; or (2) had any single glucose level outside the normal range of ≥125 mg/dL or <60 mg/dL. Patients not meeting these criteria were
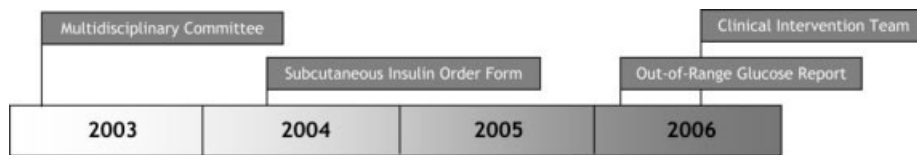
FIGURE 1. Timeline of interventions.

SUBCUTANEOUS INSULIN ORDERS

	Breakfast	Lunch	Dinner	Bedtime
1. Basal Insulin	Give _____ units of: ☐ NPH ☐ Other:	X	X	Give _____ units of: ☐ NPH ☐ Glargine* *Glargine cannot be mixed with other insulin.*

	Breakfast	Lunch	Dinner	Bedtime
2. Prandial Insulin	Give _____ units of: ☐ Lispro(Humalog®) ☐ Regular	Give _____ units of: ☐ Lispro(Humalog®) ☐ Regular	Give _____ units of: ☐ Lispro(Humalog®) ☐ Regular	X

3. Correction Insulin	☐ Lispro(Humalog®) ☐ Regular	☐ Low Dose ☐ Medium Dose ☐ High Dose	☐ Before meals *Add to prandial insulin* ☐ Every 6 hours *If on continuous nutrition*

Correction Insulin Schedule (Do NOT administer at bedtime unless MD order obtained)

Daily total basal and prandial	low dose *< 40 units insulin/day*	medium dose *40-80 units insulin/day*	high dose *> 80 units insulin/day*
Pre-meal BG range			
150-199	1 unit	1 unit	2 unit
200-249	2 units	3 units	4 units
250-299	3 units	5 units	7 units
300-349	4 units	7 units	10 units
>349	5 units and call HO	8 units and call HO	12 units and call HO

Blood Glucose Monitoring
☐ Before meals and at bedtime.
☐ Every 6 hours, if on continuous nutrition.
☐ Additional check at 0300.

If Nutrition is held (i.e. NPO) or severely limited (oral, tube feeding, TPN):
☐ hold prandial insulin.
☐ give one half dose of basal insulin, or
☐ _____ (alternate dose)

☐ Notify HO if prandial insulin has been given AND patient only eats < 25% of meal.

Hypoglycemia orders for BG<60 mg/dL
- If patient can take PO, give 15 grams of fast acting carbohydrate (4oz fruit juice/non diet soda or 8oz nonfat milk.) If patient cannot take PO, give 25mL of Dextrose 50% IV push.
- Recheck finger capillary glucose in 15 minutes and repeat above if BG<80 mg/dL. Notify HO.

PHYSICIAN SIGNATURE	PRINT NAME	PAGER	NPI/UPIN	DATE	TIME

PT.NO

UW Medicine
Harborview Medical Center – UW Medical Center
University of Washington Physicians
Seattle, Washington
SUBCUTANEOUS INSULIN ORDERS

NAME

H2169
H2169

WHITE - MEDICAL RECORD

DOB

HMC2169 REV SEP 07   PMM Item #80184

FIGURE 2. Subcutaneous insulin orders.

Guidelines and Recommendations
Terms

Basal insulin is long acting to imitate normal body response of constant insulin production.
Prandial insulin is rapid acting to imitate normal body response to food intake.
Correction insulin refers to the amount of insulin <u>added</u> to a prescribed prandial dose to adjust for increases in blood sugar. Give at meal times if patient is on an oral diet. Give every 6 hours if on continuous nutrition.
Meal Lag Time refers to the time between when the insulin dose is given and the meal is eaten. Lispro onset is 0 to 15 minutes after injection. Regular onset is 30 minutes after injection.

Type 1 Diabetes

Continue the patient's usual basal insulin dose. Usual daily dose is 0.5 to 0.7 units/kg/day. 50% Basal, 50% Prandial.
Patients require insulin to avoid ketoacidosis.

Type 2 Diabetes

Continue the patient's usual insulin regimen and adjust dose as needed. Usual daily insulin dose is 0.4 to 1 units/kg/day.
Basal/Prandial insulin distribution is patient specific.
If patient is on sulfonylurea oral medication regime, stop oral medication and change to insulin while in hospital for improved ability to titrate, with goal of achieving euglycemia.

Indications for use of insulin infusion:

Type 1 diabetic patient who is NPO (require insulin regardless of blood glucose levels).
Type 2 diabetic patients requiring anesthesia and surgery with glucose levels > 200 mg/dL, or NPO > 24 hr. Withhold oral diabetic medications day of surgery and use "Pre Surgery Diabetic Orders".
Any patient having difficulty with hyperglycemia as a result of a stress response to injury or sepsis, administration of corticosteroids, or continuous nutritional support.

Perioperative or periprocedural:

For patients going to surgery use 'Pre Surgery Diabetic Orders'.
For patients going to procedures use instructions for NPO status on the front of this form.
Metformin should be discontinued if patient is receiving contrast or is NPO. Do not restart until renal function established.

Enteral/ Parenteral Nutrition:
Consult Nutrition. Call 744-4612.
Continuous Tube Feeding:

To avoid hypoglycemia if the enteral feeding is interrupted, the basal insulin dose generally should be no more than 40% of total daily insulin requirement.
Nutritional insulin requirements are met with programmed doses of regular insulin or rapid insulin.
If tube feeding is interrupted for more than 15 minutes, increase the frequency of BG checks, and add D10 at same rate as previous Tube Feeding rate.

Nocturnal tube feeding:

Use NPH or insulin 70/30 to control morning hyperglycemia and add prandial insulin for oral intake during the day.

Bolus Tube Feeding:

Give regular insulin 30 to 45 minutes, or rapid-insulin 0–15 minutes, prior to bolus to control post-bolus Blood Glucose excursions.
Check finger stick Blood Glucose 2 hours after regular insulin or 1 hour after rapid insulin to determine dose adjustments for post-bolus target Blood Glucose < 180 mg/dl.

TPN:

Insulin needs are met with either IV insulin infusion or regular insulin added to the TPN bag directly. Consult Pharmacist.
Use SubQ insulin with caution with TPN. Lack of correlation of insulin peaks and troughs with nutrient delivery may lead to erratic BG control.

HMC2169 REV SEP 07 (BACK)

FIGURE 2. (*Continued*).

classified as euglycemic. Approval was obtained from the University of Washington Human Subjects Review Committee.

Program Description

Since 2003, the multidisciplinary committee—physicians, nurses, pharmacy representatives, and dietary and administrative representatives—has directed the development of the Glycemic Control Program with support from hospital administration and the Department of Quality Improve-ment. Funding for this program has been provided by the hospital based on the prominence of glycemic control among quality and safety measures, a projected decrease in costs, and the high incidence of diabetes in our patient population. Figure 1 outlines the program's key interventions.

First, a Subcutaneous Insulin Order Form was released for elective use in May 2004 (Figure 2). This form incorporated the 3 components of quality insulin ordering (basal, scheduled prandial, and prandial correction dosing) and

provides prompts and education. A Diabetes Nurse Specialist trained nursing staff on the use of the form.

Second, we developed an automated daily data report identifying patients with out-of-range glucose levels defined as having any single glucose readings <60 mg/dL or any 2 readings ≥180 mg/dL within the prior 24 hours. In February 2006, this daily report became available to the clinicians on the committee.

Third, the Glycemic Control Program recruited a full-time clinical Advanced Registered Nurse Practitioner (ARNP) and part-time supervising physician to provide directed intervention and education for patients and medical personnel. Since August 2006, the ARNP has reviewed the out-of-range report daily, performs assessments, refines insulin orders, and educates clinicians. The assessments include chart review (of history and glycemic control), discussion with primary physician and nurse (and often the dietician), and interview of the patient and/or family. This leads to development and implementation of a glycemic control plan. Clinician education is performed both as direct education of the primary physician at the time of intervention and as didactic sessions.

Outcomes
Physician Insulin Ordering
The numbers of patients receiving basal and short-acting insulin were identified from the electronic medication record. Basal insulin included glargine and neutral protamine Hagerdorn (NPH). Short-acting insulin (lispro or regular) could be ordered as scheduled prandial, prandial correction, or sliding scale. The distinction between prandial correction and sliding scale is that correction precedes meals exclusively and is not intended for use without food; in contrast, sliding scale is given regardless of food being consumed and is considered substandard. Quality insulin ordering is defined as having basal, prandial scheduled, and prandial correction doses.

In the electronic record, however, we were unable to distinguish the intent of short-acting insulin orders in the larger data set. Thus, we reviewed a subset of 100 randomly selected charts (25 from each year from 2003 through 2006) to differentiate scheduled prandial, prandial correction, and sliding scale.

Hyperglycemia
Hyperglycemia was defined as glucose ≥180 mg/dL. The proportion of dysglycemic patients with hyperglycemia was calculated daily as the percent of dysglycemic patients with any 2 glucose levels ≥180 mg/dL. Daily values were averaged for quarterly measures.

Hypoglycemia
Hypoglycemia was defined as glucose <60 mg/dL. The proportion of all dysglycemic patients with hypoglycemia was calculated daily as the percent of dysglycemic patients with a single glucose level of <60 mg/dL. Daily values were averaged for quarterly measures.

TABLE 1. Characteristics of the Patient Population

	Dysglycemic	Euglycemic
Number of patients	18,088	26,144
Age (years, mean ± SD)	48.4 ± 20.3	41.3 ± 18.3
Gender, male (%)	64.7	62.7
Ethnicity (%)		
Caucasian	68.2	70.1
African-American/Black	11.0	12.0
Hispanic	6.8	6.2
Native American	1.8	18
Asian	7.9	5.5
Unknown	4.3	4.4
UHC severity of illness index (%)		
Minor	18.3	38.8
Moderate	35.4	40.8
Major	29.5	16.7
Extreme	16.9	3.6
UHC expected LOS (days, mean ± SD)*	7.8 ± 6.9	5.2 ± 4.1
UHC expected mortality (mean ± SD)*	0.06 ± 0.13	0.01 ± 0.06

Abbreviations: LOS, length of stay; SD, standard deviation; UHC, University HealthSystem Consortium.
*UHC LOS and mortality are reported as additional descriptors of severity of illness.

Data Collection
Data were retrieved from electronic medical records, hospital administrative decision support, and risk-adjusted[5] UHC clinical database information. Glucose data were obtained from laboratory records (venous) and nursing data from bedside chemsticks (capillary).

Statistical Analyses
Data were analyzed using SAS 9.1 (SAS Institute, Cary, NC) and SPSS 13.0 (SPSS, Chicago, IL). The mean and standard deviation (SD) for continuous variables and proportions for categorical variables were calculated. Data were examined, plotted, and trended over time. Where applicable, linear regression trend lines were fitted and tested for statistical significance (P value <0.05).

Results
Patients
In total, 44,225 patients were identified from January 1, 2003 through December 31, 2006; 18,087 patients (41%) were classified as dysglycemic as defined by either: (1) receiving insulin or oral diabetic medicine; or (2) having a glucose level ≥125 mg/dL or <60 mg/dL. Characteristics of the population are outlined in Table 1. Both groups shared similar ethnic distributions. Across all 4 years, dysglycemic patients tended to be older and have a higher severity of illness. As an additional descriptor of severity of illness, UHC mean expected length of stay (LOS) and mean expected mortality (risk-adjusted[5]) were higher for dysglycemic patients.

Physician Insulin Ordering
Ordering of both short-acting and basal insulin increased (Figure 3). The ratio of short-acting to basal orders
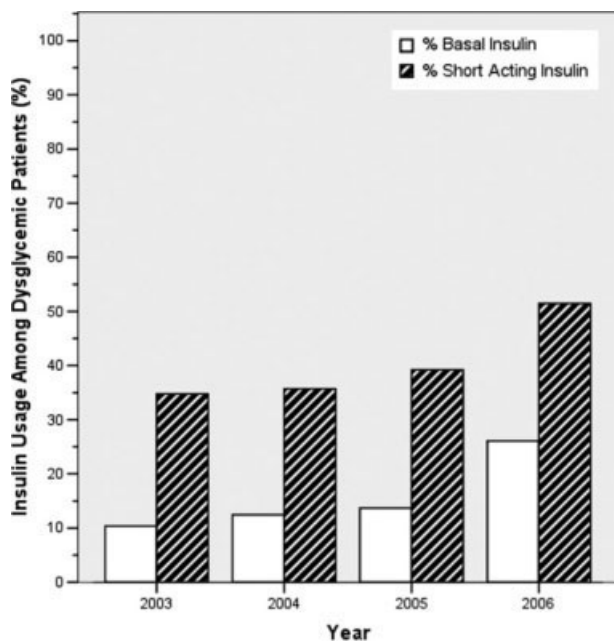
FIGURE 3. Percentage of dysglycemic patients receiving short-acting and basal insulin.

decreased from 3.36 (1668/496) in 2003 to 1.97 (2226/1128) in 2006.

Chart review of the 100 randomly selected dysglycemic patients revealed increased ordering of prandial correction dosing from 8% of patients in 2003 to 32% in 2006. Yet, only 1 patient in 2003 and only 2 in 2006 had scheduled prandial. Ordering of sliding scale insulin fell from 16% in 2003 to 4% in 2006.

Glycemic Control Outcomes

The percentage of dysglycemic patients with hyperglycemia ranged from 19 to 24 without significant decline over the 4 years (Figure 4A). The percentage of hypoglycemic dysglycemic patients was increasing from 2003 to 2004, but in the years following the interventions (2005 through 2006) this declined significantly ($P = 0.003$; Figure 4B). On average, the observed LOS was higher for dysglycemic vs. euglycemic patients (mean $\pm$ SD days: 9.4 $\pm$ 12.2 and 5.8 $\pm$ 8.5, respectively). The mean observed to expected mortality ratio was 0.45 $\pm$ 0.08 and 0.44 $\pm$ 0.17 for the dysglycemic and euglycemic patients, respectively. Over the 4 years no statistically significant change in observed LOS or adjusted mortality was found (data not shown).

Conclusions

HMC, a safety net hospital with the highest UHC expected mortality of 131 hospitals nationwide, has demonstrated early successes in building its Glycemic Control Program, including: (1) decreased prescription of sliding scale; (2) a marked increase in prescription of basal insulin; and (3) significantly decreasing hypoglycemic events subsequent to the interventions. The decreased sliding scale and increased
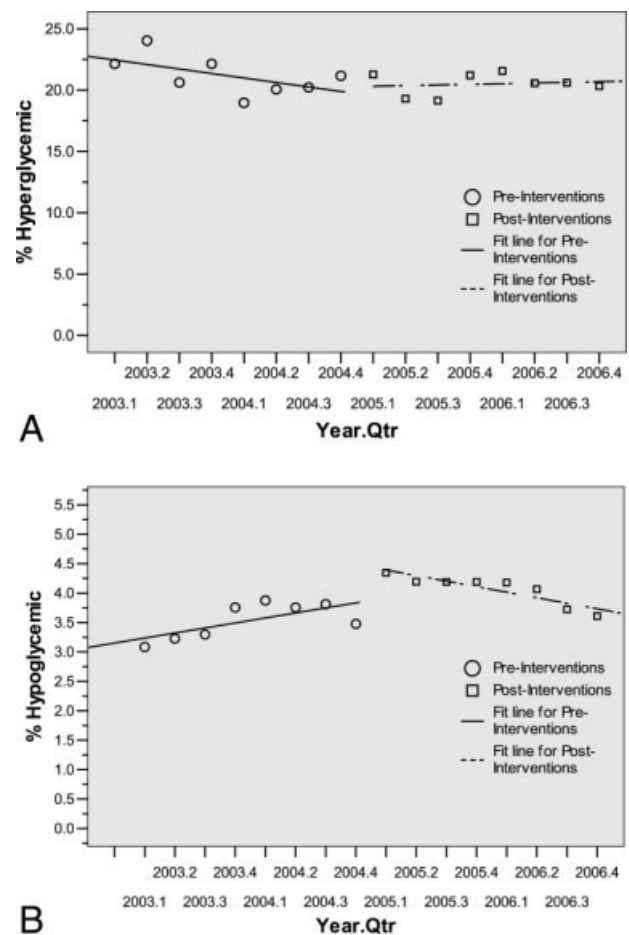
FIGURE 4. (A) Hyperglycemia. Percent of dysglycemic patients with any 2 glucose levels greater than 180 mg/dL in a 24-hour period. (B) Hypoglycemia. Percent of dysglycemic patients with a single glucose level less than 60 mg/dL in a 24-hour period.

overall ordering of insulin could reflect increased awareness brought internationally through the literature and locally through our program. Two distinctive aspects of HMC's Glycemic Control Program, when compared to others,[6–8] include: (1) the daily use of real-time data to identify and target patients with out-of-range glucose levels; and (2) the coverage of all non-critical-care floors with a single clinician.

In 2003 and 2004, the increasing hypoglycemia we observed paralleled the international focus on aggressively treating hyperglycemia in the acute care setting. We observed a significant decrease in hypoglycemia in 2005 and 2006 that could be attributed to the education provided by the Glycemic Control Program and 2 features on the subcutaneous insulin order set: the prominent hypoglycemia protocol and the order "hold prandial insulin if the patient cannot eat." These are similar features identified in a report on preventing hospital hypoglycemia.[9] Additionally, hypoglycemia may have decreased secondary

to the emphasis on not using short-acting insulin at bedtime.

Despite increased and improved insulin ordering, we did not observe a significant change in the percent of dysglycemic patients with 2 glucose levels $\geq$180 mg/dL. In our program patients are identified for intervention after their glucose levels are out-of-range. To better evaluate the impact of our interventions on the glycemic control of each patient, we plan to analyze the glucose levels in the days following identification of patients. Alternatively, we could provide intervention to all patients with dysglycemia rather than waiting for glucoses to be out-of-range. Though this approach would require greater resources than the single clinician we currently employ.

Our early experience highlights areas for future evaluation and intervention. First, the lack of scheduled prandial insulin and that less than one-third of dysglycemic patients have basal insulin ordered underscore a continued need to target quality insulin ordering to include all components—basal, scheduled prandial, and prandial correction. Second, while the daily report is a good rudimentary identification tool for at-risk patients, it offers limited information as to the impact of our clinical intervention. Thus, refined evaluative metrics need be developed to prospectively assess the course of glycemic control for patients.

We acknowledge the limitations of this study. First, our most involved intervention—the addition of the clinical intervention team—came only 6 months before the end of the study period. Second, this is an observational retrospective analysis and cannot distinguish confounders, such as physician preferences and decisions, that not easily quantified or controlled for. Third, our definition of dysglycemic incorporated 41% of non-critical-care patients, possibly reflecting too broad a definition.

In summary, we have described an inpatient Glycemic Control Program that relies on real-time data to identify patients in need of intervention. Early in our program we observed improved insulin ordering quality and decreased rates of hypoglycemia. Future steps include evaluating the impact of our clinical intervention team and further refining glycemic control metrics to prospectively identify patients at risk for hyper- and hypoglycemia.

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