REVIEW

Society of Hospital Medicine Glycemic Control Task Force Summary: Practical Recommendations for Assessing the Impact of Glycemic Control Efforts

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Data collection, analysis, and presentation are key to the success of any hospital glycemic control initiative. Such efforts enable the management team to track improvements in processes and outcomes, make necessary changes to their quality improvement efforts, justify the provision of necessary time and resources, and share their results with others. Reliable metrics for assessing glycemic control and frequency of hypoglycemia are essential to accomplish these tasks and to assess whether interventions result in more benefit than harm. Hypoglycemia metrics must be especially convincing because fear of hypoglycemia remains a major source of clinical inertia, impeding efforts to improve glucose control.

Currently, there are no official standards or guidelines for formulating metrics on the quality of inpatient glycemic control. This creates several problems. First, different metrics vary in their biases and in their responsiveness to change. Thus, use of a poor metric could lead to either a falsely positive or falsely negative impression that a quality improvement intervention is in fact improving glycemic control. Second, the proliferation of different measures and analytical plans in the research and quality improvement literature make it very difficult for hospitals to compare baseline performance, determine need for improvement, and understand which interventions may be most effective.

A related article in this supplement provides the rationale for improved inpatient glycemic control. That article argues that the current state of inpatient glycemic control, with the frequent occurrence of severe hyperglycemia and irrational insulin ordering, cannot be considered acceptable, especially given the large body of data (albeit largely observational) linking hyperglycemia to negative patient outcomes. However, regardless of whether one is an advocate or skeptic of tighter glucose control in the intensive care unit (ICU) and especially the non-ICU setting, there is no question that standardized, valid, and reliable metrics are needed to compare efforts to improve glycemic control, better understand whether such control actually improves patient care, and closely monitor patient safety.

This article provides a summary of practical suggestions to assess glycemic control, insulin use patterns, and safety (hypoglycemia and severe hyperglycemia). In particular, we discuss the pros and cons of various measurement choices. We conclude with a tiered summary of recommendations for practical metrics

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that we hope will be useful to individual improvement teams. This article is not a consensus statement but rather a starting place that we hope will begin to standardize measurement across institutions and advance the dialogue on this subject. To more definitely address this problem, we call on the American Association of Clinical Endocrinologists (AACE), American Diabetes Association (ADA), Society of Hospital Medicine (SHM), and others to agree on consensus standards regarding metrics for the quality of inpatient glycemic control.

MEASURING GLYCEMIC CONTROL: GLUCOMETRICS

"Glucometrics" may be defined as the systematic analysis of blood glucose (BG) data—a phrase initially coined specifically for the inpatient setting. There are numerous ways to do these analyses, depending on which patients and glucose values are considered, the definitions used for hypoglycemia and hyperglycemia, the unit of measurement (eg, patient, patient-day, individual glucose value), and the measure of control (eg, mean, median, percent of glucose readings within a certain range). We consider each of these dimensions in turn.

Defining the Target Patient Population

The first decision to be made is which patients to include in your analysis. Choices include the following:

1. Patients with a discharge diagnosis of diabetes: this group has face validity and intuitive appeal, is easy to identify retrospectively, and may capture some untested/untreated diabetics, but will miss patients with otherwise undiagnosed diabetes and stress hyperglycemia. It is also subject to the variable accuracy of billing codes.
2. Patients with a certain number of point-of-care (POC) glucose measurements: this group is also easy to identify, easy to measure, and will include patients with hyperglycemia without a previous diagnosis of diabetes, but will miss patients with untested/untreated hyperglycemia. Also, if glucose levels are checked on normoglycemic, nondiabetic patients, these values may "dilute" the overall assessment of glycemic control.
3. Patients treated with insulin in the hospital: this is a good choice if the purpose is mainly drug safety and avoidance of hypoglycemia, but by definition excludes most untreated patients.
4. Patients with 2 or more BG values (laboratory and/or POC) over a certain threshold (eg, >180 mg/dL). This will likely capture more patients with inpatient hyperglycemia, whether or not detected by the medical team, but is subject to wide variations in the frequency and timing of laboratory glucose testing, including whether or not the values are pre-prandial (note that even preprandial POC glucose measurements are not always in fact fasting values).

Other considerations include the following:

1. Are there natural patient subgroups that should be measured and analyzed separately because of different guidelines? For example, there probably should be separate/independent inclusion criteria and analyses for critical care and non–critical care units because their glycemic targets and management considerations differ.
2. Which patients should be excluded? For example, if targeting subcutaneous insulin use in general hospitalized patients, one might eliminate those patients who are admitted specifically as the result of a diabetes emergency (eg, diabetic ketoacidosis [DKA] and hyperglycemic hyperosmolar state [HHS]), as their marked and prolonged hyperglycemia will skew BG data. Pregnant women should generally be excluded from broad-based analyses or considered as a discrete category because they have very different targets for BG therapy. Patients with short lengths of stay may be less likely to benefit from tight glucose control and may also be considered for post hoc exclusion. One might also exclude patients with very few evaluable glucose readings (eg, fewer than 5) to ensure that measurement is meaningful for a given patient, keeping in mind that this may also exclude patients with undetected hyperglycemia, as mentioned above. Finally, patients receiving palliative care should also be considered for exclusion if feasible.

Recommendation: Do not limit analyses to only those patients with a diagnosis of diabetes or only those on insulin, which will lead to biased results.

- For non–critical care patients, we recommend a combined approach: adult patients with a diagnosis of diabetes (e. g. using diagnosis-related group [DRG] codes 294 or 295 or International Classification of Diseases 9th edition [ICD9] codes 250.xx) or with hyperglycemia (eg, 2 or more random laboratory and/or point of care (POC) BG values >180

mg/dL or 2 or more fasting BG values >130 mg/dL), excluding patients with DKA or HHS or who are pregnant.
- For critical care units, we recommend either all patients, or patients with at least mild hyperglycemia (eg, 2 random glucose levels >140 mg/dL). Critical care patients with DKA, HHS, and pregnancy should be evaluated separately if possible.

Which Glucose Values to Include and Exclude

To answer this question, we first need to decide which method to use for BG measurement. There are several ways to measure BG, including the type of sample collected (capillary ["fingerstick"], arterial, and venous) and the technique used (central laboratory analyzing plasma, central laboratory analyzing whole blood [eg, from an arterial blood gas sample], glucose meter [usually calibrated to plasma], etc.). The POC (eg, capillary, glucose meter) glucose measurements alone are often preferred in the non-ICU setting because laboratory plasma values generally provide little additional information and typically lower the mean glucose by including redundant fasting values.[1] In critical care units, several different methods are often used together, and each merits inclusion. The inherent differences in calibration between the methods do not generally require separate analyses, especially given the frequency of testing in the ICU setting.

The next question is which values to include in analyses. In some situations, it may be most useful to focus on a certain period of hospitalization, such as the day of a procedure and the next 2 days in assessing the impact of the quality of perioperative care, or the first 14 days of a non–critical care stay to keep outliers for length of stay (LOS) from skewing the data. In the non-ICU setting, it may be reasonable to exclude the first day of hospitalization, as early BG control is impacted by multiple variables beyond direct control of the clinician (eg, glucose control prior to admission, severity of presenting illness) and may not realistically reflect your interventions. (Keep in mind, however, that it may be useful to adjust for the admission glucose value in multivariable models given its importance to clinical outcomes and its strong relationship to subsequent inpatient glucose control.) However, in critical care units, it is reasonable to include the first day's readings in analyses given the high frequency of glucose measurements in this setting and the expectation that glucose control should be achieved within a few hours of starting an intravenous insulin infusion.

If feasible to do so with your institution's data capture methods, you may wish to select only the regularly scheduled (before each meal [qAC] and at bedtime [qHS], or every 6 hours [q6h]) glucose readings for inclusion in the summary data of glycemic control in the non-ICU setting, thereby reducing bias caused by repeated measurements around extremes of glycemic excursions. An alternative in the non-ICU setting is to censor glucose readings within 60 minutes of a previous reading.

Recommendation:

- In the non-ICU setting, we recommend first looking at all POC glucose values and if possible repeating the analyses excluding hospital day 1 and hospital day 15 and beyond, and also excluding glucose values measured within 60 minutes of a previous value.
- In critical care units, we recommend evaluating all glucose readings used to guide care.

Units of Analysis

There are several different units of analysis, each with its own advantages and disadvantages:

1. Glucose value: this is the simplest measure and the one with the most statistical power. All glucose values for all patients of interest comprise the denominator. A report might say, for example, that 1% of the 1000 glucose values were <70 mg/dL during a certain period or that the mean of all glucose values collected for the month from patients in non–critical care areas was 160 mg/dL. The potential disadvantages of this approach are that these analyses are less clinically relevant than patient-level analyses and that patients with many glucose readings and long hospitalizations may skew the data.
2. Patient (or the "Patient Stay," [ie, the entire hospitalization]): all patients who are monitored make up the denominator. The numerator may be the percentage of patients with any hypoglycemia during their hospital stay or the percentage of patients achieving a certain mean glucose during their hospitalization, for example. This is inherently more clinically meaningful than using glucose value as a unit of analysis. A major disadvantage is not controlling for LOS effects. For example, a hospitalized patient with a long LOS is much more likely to be characterized as having at

least 1 hypoglycemic value than is a patient with a shorter LOS. Another shortcoming is that this approach does not correct for uneven distribution of testing. A patient's mean glucose might be calculated on the basis of 8 glucose values on the first day of hospitalization, 4 on the second day, and 1 on the third day. Despite all these shortcomings, reporting by patient remains a popular and valid method of presenting glycemic control results, particularly when complemented by other views and refined to control for the number of readings per day.

3. Monitored Patient-Day: The denominator in this setting is the total number of days a patient glucose level is monitored. The benefits of this method have been described and advocated in the literature.[1] As with patient-level analyses, this measure will be more rigorous and meaningful if the BG measures to be evaluated have been standardized. Typical reports might include percentage of monitored days with any hypoglycemia, or percentage of monitored days with all glucose values in the desired range. This unit of analysis may be considered more difficult to generate and to interpret. On the other hand, it is clinically relevant, less biased by LOS effects, and may be considered the most actionable metric by clinicians. This method provides a good balance when presented with data organized by patient.

The following example uses all 3 units of measurement, in this case to determine the rate of hypoglycemia, demonstrating the different but complementary information that each method provides:

In 1 month, 3900 POC glucose measurements were obtained from 286 patients representing 986 monitored patient-days. With hypoglycemia defined as POC BG $\leq$60 mg/dL, the results showed the following:

50 of 3900 measurements (1.4%) were hypoglycemic

22 of 286 patients (7.7%) had $\geq$1 hypoglycemic episodes

40 of 986 monitored days (4.4%) had $\geq$1 hypoglycemic episodes.

The metric based on the number of glucose readings could be considered the least clinically relevant because it is unclear how many patients were affected; moreover, it may be based on variable testing patterns among patients, and could be influenced disproportionately by 1 patient with frequent hypoglycemia, many glucose readings, and/or a long LOS. One could argue that the patient-stay metric is artificially elevated because a single hypoglycemic episode characterizes the entire stay as hypoglycemic. On the other hand, at least it acknowledges the number of patients affected by hypoglycemia. The patient-day unit of analysis likely provides the most balanced view, one that is clinically relevant and measured over a standard period of time, and less biased by LOS and frequency of testing.

One way to express patient-day glycemic control that deserves special mention is the patient-day weighted mean. A mean glucose is calculated for each patient-day, and then the mean is calculated across all patient-days. The advantage of this approach is that it corrects for variation in the number of glucose readings each day; all hospital days are weighted equally.

Recommendation:

- In non–critical care units, we recommend a combination of patient-day and patient-stay measures.
- In critical care units, it is acceptable to also use glucose reading as the unit of measurement given more frequent and uniform data collection, but it should be complemented by more meaningful patient-day and patient-stay measures.

Measures of Control

In addition to deciding the unit(s) of analysis, another issue concerns which measures of control to use. These could include rates of hypoglycemia and hyperglycemia, percentage of glucose readings within various ranges (eg, $<$70, 70–180, $>$180 mg/dL), mean glucose value, percentage of patient-days during which the mean glucose is within various ranges, or the "in control" rate (ie, when all glucose values are within a certain range).

As with the various units of analysis, each of these measures of control has various advantages and disadvantages. For example, mean glucose is easy to report and understand, but masks extreme values. Percentage of glucose values within a certain range (eg, per patient, averaged across patients) presents a more complete picture but is a little harder to understand and will vary depending on the frequency of glucose monitoring. As mentioned above, this latter problem can be corrected in part by including only certain glucose

values. Percent of glucose values within range may also be less sensitive to change than mean glucose (eg, a glucose that is lowered from 300 mg/dL to 200 mg/dL is still out of range). We recommend choosing a few, but not all, measures of control in order to get a complete picture of glycemic control. Over time one can then refine the measures being used to meet the needs of the glycemic control team and provide data that will drive the performance improvement process.

In critical care and perioperative settings, interest in glycemic control is often more intense around the time of a particular event such as major surgery or after admission to the ICU. Some measures commonly used in performing such analyses are:

1. All values outside a target range within a designated crucial period. For example, the University Healthcare Consortium and other organizations use a simple metric to gauge perioperative glycemic control. They collect the fasting glucose on postoperative days 1 and 2 and then calculate the percentage of postoperative days with any fasting glucose >200 mg/dL. Of course, this is a very liberal target, but it can always be lowered in a stepwise fashion once it is regularly being reached.
2. Three-day blood glucose average. The Portland group uses the mean glucose of each patient for the period that includes the day of coronary artery bypass graft (CABG) surgery and the following 2 days. The 3-day BG average (3-BG) correlates very well with patient outcomes and can serve as a well-defined target.[2] It is likely that use of the 3-BG would work well in other perioperative/trauma settings and could work in the medical ICU as well, with admission to the ICU as the starting point for calculation of the 3-BG.

Hyperglycemic Index

Measuring the hyperglycemic index (HGI) is a validated method of summarizing glycemic control of ICU patients.[3] It is designed to take into account the sometimes uneven distribution of patient testing. Time is plotted on the *x*-axis and glucose values on the *y*-axis. The HGI is calculated the area under the curve of glycemic values but above the upper limit of normal (ie, 110 mg/dL). Glucose values in the normal or hypoglycemic range are not included in the AUC. Mortality correlated well with this glycemic index. However, a recent observational study of glucometrics in patients hospitalized with acute myocardial infarction found that the simple mean of each patient's glucose values over the entire hospitalization was as predictive of in-hospital mortality as the HGI or the time-averaged glucose (AUC for all glucose values).[4] In this study, metrics derived from glucose readings for the entire hospitalization were more predictive than those based on the first 24 or 48 hours or on the admission glucose.

Analyses Describing Change in Glycemic Control Over Time in the Hospital

In the critical care setting, this unit of analysis may be as simple as the mean time to reach the glycemic target on your insulin infusion protocol. On non–critical care wards, it is a bit more challenging to characterize the improvement (or clinical inertia) implied by failure of hyperglycemia to lessen as an inpatient stay progresses. One method is to calculate the mean glucose (or percentage of glucose values in a given range) for each patient on hospital day (HD) 1, and repeat for each HD (up to some reasonable limit, such as 5 or 7 days).

Recommendations:

- In non–critical units, we recommend a limited set of complementary measures, such as the patient-day weighted mean glucose, mean percent of glucose readings per patient that are within a certain range, and percentage of patients whose mean glucose is within a certain range on each hospital day.
- In critical care units, it is often useful to focus measures around a certain critical event such as the 3-day blood glucose average and to use measures such as the HGI that take advantage of more frequent blood glucose testing.

Definitions of Hyperglycemia and Hypoglycemia

Glucometrics outcomes will obviously depend on the thresholds established for hyperglycemia and hypoglycemia. Many centers define hypoglycemia as ≤60 mg/dL, whereas the ADA definition, based on physiologic changes that may take place, defines hypoglycemia (at least in the outpatient setting) as ≤70 mg/dL. Hypoglycemia may be further stratified by severity, with any glucose ≤40 mg/dL, for instance, defined as severe hypoglycemia.

Similarly, the definition of hyperglycemia (and therefore good control) must also be defined. Based on definitions developed by the ADA and AACE, the state of the medical literature, and current understanding of the pathophysiology of hyperglycemia, thresholds for critical care units include 110 mg/dL, 130 mg/dL, and 140 mg/dL, and options in non–critical care units include 130 mg/dL, 140 mg/dL, and 180 mg/dL. Because these thresholds implicitly assume adverse effects when glucose levels are above them, these levels are subject to revision as data become available confirming the benefits and safety of targeted glycemic control in various settings and patient populations.

Introducing optimal BG targets in a stepped fashion over time should also be considered. Furnary et al.[2] have done this in the Portland Project, which tracks glycemic control in cardiac surgery patients receiving intravenous insulin therapy. The initial BG target for this project was <200 mg/dL; it was subsequently lowered stepwise over several years to 150 mg/dL, then to 120 mg/dL, and most recently to 110 mg/dL. This approach allows the safe introduction of targeted glycemic control and promotes acceptance of the concept by physicians and the allied nursing and medical staff.

Recommendations:

- In non–critical care units, it is reasonable to use 40 mg/dL for severe hypoglycemia, 70 mg/dL for hypoglycemia, 130 mg/dL for fasting hyperglycemia, 180 mg/dL for random or postprandial hyperglycemia, and 300 mg/dL for severe hyperglycemia, keeping in mind that these thresholds are arbitrary. In critical care units, values from 110 mg/dL to 140 mg/dL might be better thresholds for hyperglycemia, but it may take time to safely and effectively move an organization toward these lower targets.

Other Considerations Relative to Glucometrics

Yale Glucometrics Website

The Yale Informatics group has put together a Web-based resource (http://glucometrics.med.yale.edu) that describes glucometrics in a manner similar to the discussion here and in an article by group members.[1] The Website allows uploads of deidentified glucose data, with which it can automatically and instantly prepare reports on glucose control. Current reports analyze data by glucose reading, hospital stay, and hospital day, and include means and percent of glucose readings within specified ranges. There is no charge for this service, although the user is asked to provide certain anonymous, general institutional information.

Other Analytic Resources

Commercially available software, such as the RALS system (Medical Automation Systems, Inc., Charlottesville, VA) can gather POC glucose measurements directly from devices and provide real-time reports of glycemic control, stratified by inpatient unit, using user-defined targets for hypoglycemia and hyperglycemia. While they are no substitute for a dedicated, on-site data analyst, such systems can be very useful for smaller hospitals with minimal data or information technology support staff.

APPROACHES TO ANALYSIS: RUN CHARTS

Most conventional clinical trials hold interventions fixed for a period of time and compare results with and without the intervention. For quality improvement studies, this is still a valid way to proceed, especially if studied as a randomized controlled trial. Such methods may be preferred when the clinical question is "Does this type of intervention work in general?" and the desired output is publication in peer-reviewed journals so that others can learn about and adopt the intervention to their own institution. A before and after study with a similar analytic approach may also be valid, although concerns about temporal trends and cointerventions potentially compromise the validity of such studies. This approach again assumes that an intervention is held fixed over time such that it is clear what patients received during each time period.

If the desired result is improvement at a given institution (the question is "Did we improve care?") then it may be preferable to present results over time using run-charts. In a run chart, the *x*-axis is time and the *y*-axis the desired metric, such as patient-day weighted mean glucose. Points in time when interventions were introduced or modified can be highlighted. Run charts have several advantages over before-and-after summaries: they do not require interventions remaining fixed and are more compatible with continuous quality improvement methods, it is easier to see the effect of different aspects of the interventions as they occur, one can get a quicker picture of whether

something is working, and it is easier to separate out the impact of the intervention from secular trends. Finally, the use of run charts does not imply the absence of statistical rigor. Run charts with statistical process control (SPC) limits[5] can easily convey when the observed time trend is unlikely to be due to chance using prespecified *P* values. (A full discussion of SPC and other methods to study quality improvement interventions is beyond the scope of this article.)

ASSESSING PATTERNS OF INSULIN USE AND ORDER SET UTILIZATION

Besides measuring the impact of quality improvement interventions on glucose control, it is important to measure processes such as proper insulin use. As mentioned in other articles in this supplement, processes are much more sensitive to change than outcomes. Failure to change processes should lead one to make changes to the intervention.

ICU and Perioperative Settings

For ICU and perioperative settings, the major process measure will likely be use of the insulin infusion order set. Designation of BG levels that trigger insulin infusion in these settings should be agreed upon in advance. The number of patients who meet the predefined glycemic criteria would make up the denominator, and the number of patients on the insulin infusion order set would make up the numerator.

Non–Critical Care Units

On non–critical care units, measuring the percentage of subcutaneous insulin regimens that contain a basal insulin is a useful way to monitor the impact of an intervention. A more detailed analysis could examine the percentage of patients on simultaneous basal and nutritional insulin (if applicable). An important measure of clinical inertia is to track the percentage of patients who had changes in their insulin regimens on days after hypoglycemic or hyperglycemic excursions. Another important measure is the frequency with which the standardized order set is being used, analogous to the measure of insulin infusion use in the ICU. A final process measure, indirectly related to insulin use, is the frequency of use of oral diabetes agents, especially by patients for whom their use is contraindicated (eg, patients with congestive heart failure who are on thiazolidinediones and patients with renal insufficiency or receiving intravenous contrast continued on metformin).

OTHER CONSIDERATIONS AND METRICS

Examples of other metrics that can be used to track the success of quality improvement efforts include:

1. Glucose measurement within 8 hours of hospital admission.
2. Glycated hemoglobin (A1C) measurement obtained or available within 30 days of admission to help guide inpatient and especially discharge management.
3. Appropriate glucose testing in patients with diabetes or hyperglycemia (eg, 4 times per day in patients not on insulin infusion protocols, at least until 24 hours of euglycemia is documented).
4. The percentage of patients on insulin with on-time tray delivery.
5. The timing of subcutaneous insulin administration in relation to glucose testing and nutrition delivery.
6. Documentation of carbohydrate intake among patients who are eating.
7. Satisfaction of physicians and nurses with order sets or protocols, using standard surveys.
8. Physician and nurse knowledge, attitudes, and beliefs about insulin administration, fear of hypoglycemia, treatment of hypoglycemia, and glycemic control in the hospital.
9. Patient satisfaction with their diabetes care in the hospital, including the education they received.
10. Nursing and physician education/certification in insulin prescribing, insulin administration, and other diabetes care issues.
11. Patient outcomes strongly associated with glycemic control, (eg, surgical wound infections, ICU LOS, catheter-related bloodstream infections).
12. Appropriate treatment and documentation of hypoglycemia (eg, in accordance with hospital policy).
13. Documentation of severe hypoglycemic events through the hospital's adverse events reporting system (these may actually increase as change comes to the organization and as clinical personnel are more attuned to glycemic control).
14. Root causes of hypoglycemic events, which can be used to understand and prevent future events.

TABLE 1
SHM-Recommended Metrics

	Non–Critical Care Units		Critical Care Units	
Measurement Issue	**Tier 1 Recommendations**	**Tier 2 Recommendations**	**Tier 1 Recommendations**	**Tier 2 Recommendations**
Patient inclusion and exclusion criteria	All adult patients with POC glucose testing (sampling acceptable). Exclude patients with DKA or HHS or who are pregnant.	All adult patients with diagnosis of diabetes by ICD-9 code* or by glucose testing: random glucose (POC or laboratory) >180 mg/dL × 2 or fasting glucose >130 mg/dL × 2, excluding patients with DKA or HHS or who are pregnant. Additional analysis: exclude patients with <5 evaluable glucose readings, patients with LOS <2 days, or receiving palliative care.	All patients in every critical care unit (sampling acceptable).	Patients with DKA, HHS, or pregnancy in separate analyses. All patients in every critical care unit with random glucose (POC or laboratory) >140 mg/dL × 2.
Glucose reading inclusion and exclusion criteria	All POC glucose values.	Additional analysis: exclude glucose values on hospital day 1 and on hospital day 15 and after. Additional analysis: exclude glucose values measured within 60 minutes of a previous value.	All POC and other glucose values used to guide care.	
Measures of safety	Analysis by patient-day: Percentage of patient-days with 1 or more values <40, <70, and >300 mg/dL.		Analysis by patient-day: Percentage of patient-days with 1 or more values <40, <70, and >300 mg/dL.	
Measures of glucose control	Analysis by patient-day: Percentage of patient-days with mean <140, <180 mg/dL and/or Percentage of patient-days with all values <180 mg/dL. Analysis by patient stay: Percentage of patient stays with mean <140, <180 mg/dL.	Analysis by patient-day: Patient day-weighted mean glucose. † Analysis by patient stay: Mean percentage of glucose readings of each patient <180 mg/dL. ‡ Analysis by hospital day: Percentage of patients with mean glucose readings <140, <180 mg/dL by hospital day (days 1–7).	Analysis by glucose reading: Percentage of readings <110, <140 mg/dL. Analysis by patient-day: Percentage of patient-days with mean <110, <140 mg/dL, and/or Percentage of patient-days with all values <110, <140 mg/dL. Analysis by patient stay:§ 3-day blood glucose average (3-BG) for selected perioperative patients: Percentage of patients with 3-BG <110, <140 mg/dL. Mean time (hours) to reach glycemic target (BG <110 or <140 mg/dL) on insulin infusion.	3-BG as above for all patients in critical care units.‖ Hyperglycemic index for all patients in critical care units (AUC of glucose values above target).
Measures of insulin use	Percentage of patients on any subcutaneous insulin that has a scheduled basal insulin component (glargine, NPH, or detemir).	Percentage of patients with at least 2 POC and/or laboratory glucose readings >180 mg/dL who have a scheduled basal insulin component. Percentage of eating patients with hyperglycemia as defined above with scheduled basal insulin and nutritional insulin. Percentage of patients and patient-days with any changes in insulin orders the day after 2 or more episodes of hypoglycemia or hyperglycemia (ie, <70 or >180 mg/dL).	Percentage of patients with ≥2 POC or laboratory glucose readings >140 mg/dL placed on insulin infusion protocol.	

(*continued*)

TABLE 1
(continued)

	Non–Critical Care Units		Critical Care Units	
Measurement Issue	**Tier 1 Recommendations**	**Tier 2 Recommendations**	**Tier 1 Recommendations**	**Tier 2 Recommendations**
Other process measures	Glucose measured within 8 hours of hospital admission. A1C measurement obtained or available within 30 days of admission.	POC glucose testing at least 4 times a day for all patients with diabetes or hyperglycemia as defined above. Measures of adherence to specific components of management protocol. Appropriateness of hypoglycemia treatment and documentation. Clinical events of severe hypoglycemia reported through the organization's critical events reporting tool. Root causes of hypoglycemia.	Glucose measured within 8 hours of hospital admission. Frequency of BG testing (eg, per protocol if on insulin infusion; every 6–8 hours if not).	Appropriateness of hypoglycemia treatment and documentation. Clinical events of severe hypoglycemia reported through the organization's critical events reporting tool. Root causes of hypoglycemia. Appropriate use of IV-to-SC insulin transition protocol.

All measures, targets, and recommendations should be individualized to the needs and capabilities of a particular institution.

Abbreviations: DKA, diabetic ketoacidosis; LOS, length of stay; HHS, hyperglycemic hyperosmolar state; POC, point of care (i.e., "finger-stick" glucose meter readings, bedside BG monitoring).

* CD-9CM code 250.xx.

† Mean glucose for each hospital-day, averaged across all hospital days.

‡ Percentage of each patient's glucose readings that are <180 mg/dL, averaged across all patients.

§ For perioperative patients, average glucose on day of procedure and next 2 hospital days.

‖ For nonperioperative patients, average glucose on day of admission to critical care unit and next 2 hospital days.

15. Appropriate transitions from IV to SC insulin regimens, (eg, starting basal insulin prior to discontinuing infusion in patients who have been on an insulin infusion of at least 2 units/hour or who have a known diagnosis of diabetes or A1C >7).

(Survey instruments and other measurement tools are available from the authors upon request.)

SHM GLYCEMIC CONTROL TASK FORCE SUMMARY RECOMMENDATIONS

The SHM Glycemic Control Task Force is working to develop standardized measures of inpatient glucose control and related indicators to track progress of hospital glycemic control initiatives (see the introduction to this supplement for a description of the charge and membership of this task force). The goals of the Task Force's metrics recommendations (Table 1) are several-fold: (1) create a set of measurements that are complete but not overly burdensome; (2) create realistic measures that can be applied to institutions with different data management capabilities; and (3) allow for comparison across institutions for benchmarking purposes, evaluation of quality improvement projects, and reporting of results for formal research studies in this field.

For each domain of glycemic management (glycemic control, safety, and insulin use), the task force chose a set of "best measures." They are presented as two tiers of measurement standards, depending on the capabilities of the institution and the planned uses of the data. Tier 1 includes measures that, although they do take time and resources to collect, are feasible for most institutions. Tier 2 measures are recommended for hospitals with easy manipulation of electronic sources of data and for reporting quality-of-care measures for widespread publication, that is, in the context of a research study. It should be emphasized that these recommendations are only meant as a guide: the actual measures chosen should meet the needs and capabilities of each institution.

We recognize that few data support the recommendations made by this task force, that such data are needed, and that the field of data collection and analysis for hospital glycemic management is rapidly evolving. The hope is to begin the standardization process, promote dialogue in

this field, and eventually reach a consensus in collaboration with the ADA, AACE, and other pertinent stakeholders.

CONCLUSIONS

Like the field of inpatient glycemic management itself, the field of devising metrics to measure the quality of inpatient glycemic control is also in its infancy and quickly evolving. One should not be paralyzed by the lack of consensus regarding measurement—the important point is to pick a few complementary metrics and begin the process. The table of recommendations can hopefully serve as a starting point for many institutions, with a focus on efficacy (glycemic control), safety (hypoglycemia), and process (insulin use patterns). As your institution gains experience with measurement and the field evolves, your metrics will likely change. We recommend keeping all process and outcome data in its raw form so that it can be summarized in different ways over time. It is also important not to wait for the perfect data collection tool before beginning to analyze data: sampling and paper processes are acceptable if automated data collection is not yet possible. Eventually, blood glucose meter readings should be downloaded into a central database that interfaces with hospital data repositories so data can be analyzed in conjunction with patient, service, and unit-level information. Only with a rigorous measurement process can institutions hope to know whether their changes are resulting in improved care for patients.

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