Published in final edited form as:

Jt Comm J Qual Patient Saf. 2015 July ; 41(7): 325–336.

Modeling Inpatient Glucose Management Programs on Hospital Infection Control Programs: An Infrastructural Model of Excellence

Nestoras Mathioudakis, MD,

Assistant Professor of Medicine; Associate Director, Inpatient Diabetes Management Service; and Chair, Glucose Steering Committee, Johns Hopkins Hospital and Johns Hopkins University School of Medicine, Baltimore

Peter J. Pronovost, MD, PhD,

Professor of Anesthesiology and Critical Care Medicine; Director, Armstrong Institute for Patient Safety and Quality; Senior Vice President for Patient Safety and Quality, Johns Hopkins Hospital and Johns Hopkins University School of Medicine; and Member, *The Joint Commission Journal on Quality and Patient Safety's* Editorial Advisory Board

Sara E. Cosgrove, MD, MS,

Associate Professor of Medicine and Epidemiology; Director, Antimicrobial Stewardship Program; and Associate Hospital Epidemiologist, Johns Hopkins Hospital and Johns Hopkins University School of Medicine

Daniel Hager, MHA, and

Administrator, Division of Endocrinology, Diabetes and Metabolism, Department of Medicine, Johns Hopkins University School of Medicine

Sherita Hill Golden, MD, MHS

Professor of Medicine and Epidemiology, Johns Hopkins University School of Medicine and Bloomberg School of Public Health; Executive Vice-Chair, Department of Medicine; and Director, Inpatient Diabetes Management Service, Johns Hopkins Hospital

Infection control programs (ICPs) emerged in the United States in the late 1950s in response to nosocomial epidemics of staphylococcal infections.¹ By the early 1970s, the Centers for Disease Control and Prevention (CDC) recommended that hospitals establish ICPs to prevent hospital-acquired infections.² The Joint Commission followed suit shortly thereafter, releasing standards for ICPs as a criterion for hospital accreditation in 1976.^{3*}† It was not until completion of the large-scale SENIC (Study on the Efficacy of Nosocomial

Please address correspondence to Sherita Hill Golden, sahill@jhmi.edu.

*"Infection Control" chapter, Standard 1, "There shall be an active hospital-wide infection control program." In an earlier manual, Standard IV, in the "Environmental Service" chapter, stated, "Responsibility for the control of infection within the hospital, and for the evaluation of the infection potential of the related environment, shall be vested in a multidisciplinary committee of the medical staff." **Source:** Joint Commission on Accreditation of Healthcare Organizations. *Accreditation Manual for Hospitals*, 1970, Updated 1973. Chicago: Joint Commission on Accreditation of Hospitals, 1973.

†As stated in the Overview of the "Infection Prevention and Control" (IC) chapter, "To help reduce the possibility of acquiring and transmitting an infection, hospitals need to establish a systematic infection prevention and control program." **Source:** The Joint Commission. *2015 Comprehensive Accreditation Manual for Hospitals*. Oak Brook, IL: Joint Commission Resources, 2014.

Infection Control) Project in 1983, however, that the efficacy of ICPs was established: nearly one third of health care–associated infections could be prevented by infection control teams integrated into the hospital infrastructure.⁴ In 1986 the Centers for Medicare & Medicaid Services (CMS) included the presence of an ICP in hospitals as a condition of participation in the Medicare program. During the subsequent three decades, several additional studies demonstrated the efficacy and cost-effectiveness of hospital ICPs and of the potential to substantially reduce hospital-acquired infections when infection prevention professionals partner with clinicians.⁵ Among the causes of preventable patient harm, in the United States, health care–associated infections (notably, central line-associated bloodstream infections and catheter-associated urinary tract infections) have the most robust evidence demonstrating that harm has been recently reduced.⁶

Given the dramatic success of ICPs, it might be advantageous to apply the scientific and organizational methodology that formed the basis of these programs to more broadly reduce other types of preventable harm. Despite significant efforts to improve inpatient glucose management during the last decade, harm from hypo- and hyperglycemia (“dysglycemia”) continues unabated and remains far too common.^{7,8} Both infection control and glycemic control face unique challenges in the hospital compared to the ambulatory setting, and inpatient dysglycemia is a perfect example of a preventable harm that could be reduced by applying the ICP paradigm. In this article, we outline parallels in the structure, goals, and functions between ICPs and glucose management programs (GMPs). We then propose that the quality improvement (QI) methodology used by ICPs could serve as an excellent model for QI efforts in hospital-based GMPs.

Current State of Glucose Management Programs

Despite compelling evidence associating dysglycemia with increased morbidity, mortality, and cost,⁹ health care lacks infrastructure and systems to routinely measure and reduce harm from inadequate glycemic control.⁷ In 2004 the American College of Endocrinology and the American Association of Clinical Endocrinologists put forth the first recommendations for inpatient glucose management,¹⁰ followed a year later by the inclusion of the first inpatient-oriented recommendations by the American Diabetes Association (ADA).¹¹ These recommendations were a first step, but they lacked specific organizational and structural recommendations that hospitals could translate into a GMP. Since then, other groups have published recommendations for glycemic control in critical care^{12–14} and non-ICU settings.¹⁵ In July 2006 The Joint Commission began offering hospitals an Advanced Certification in Inpatient Diabetes option that incorporated recommendations by the ADA.^{16,17} The requirements for this certification include the presence of an interdisciplinary team, protocols for glucose monitoring and management, data collection regarding incidence of hypoglycemia, and patient self-management education. Organizations must also use “performance measures relevant to the services provided and populations served” and submit “performance measurement data to The Joint Commission on a routine basis,” but performance measures are not specified.¹⁸ Although this certification is clearly an important advancement in the area of inpatient glucose management, participation is voluntary; 83 hospitals have achieved such certification.¹⁷ Despite the scope of the problem of inpatient glucose management, the only glucose-related measure by which hospitals had recently been

evaluated is the Surgical Care Improvement Project (SCIP) performance measure Cardiac Surgery Patients With Controlled Postoperative Blood Glucose,*¹⁹—which was recently suspended by CMS because it did not reflect current clinical guidelines and could lead to potential negative unintended consequences.²⁰

The current status of GMPs is reminiscent of ICPs in the late 1990s, when few hospitals monitored infection rates and whether a hospital measured infections and had the infrastructure to reduce them was opaque to patients, purchasers, and policy makers. In 2006, 10 years after the Society for Healthcare Epidemiology of America (SHEA) established consensus recommendations on the infrastructure of ICPs,¹ the American College of Endocrinology and the ADA published a consensus statement outlining infrastructure requirements of GMPs.¹⁶ Among the recommendations were the need for administrative support; formation of a multidisciplinary steering committee to promote development of initiatives; assessment of current processes, quality of care, and barriers; development and implementation of interventions (that is, protocols, policies, algorithms); and metrics for evaluation.

A significant defect in the infrastructure of GMPs is a lack of clear metrics. Nearly one third of hospitals in the United States have no metric to track the quality of inpatient glycemic management, a sobering statistic considering that the first step in any QI initiative is to define and measure the problem at hand.²¹ Given the varying health status of populations served by health systems, accurate benchmarking of infection rates required development of a clear methodology.²² No doubt, measuring the quality of glucose care is difficult, yet it should be no more difficult than measuring infections, which health care does reasonably well. The challenge in developing glucose metrics is that we do not know what levels of glycemic control are most related to important clinical outcomes. In 2006 Goldberg and colleagues proposed a formal set of performance measures, so-called glucometrics, to facilitate internal and external assessment of inpatient glucose control by hospitals.²³ The Society of Hospital Medicine now offers a Glycemic Control Program, which provides a robust data collection infrastructure for measuring glycemic control and benchmarking.²⁴ As of yet, however, no specific glucometrics have been defined nor endorsed by stakeholder groups such as The Joint Commission or the National Quality Forum,²⁵ or CMS. Standardized glucose performance measures would accelerate efforts to reduce harm from dysglycemia.²¹

Identification of Goals for Inpatient Glucose Management Programs

In QI it is imperative to develop and communicate specific goals and performance measures, ideally both process and outcome measures. Metrics by which ICPs assess their effectiveness include both process (for example, proportion of surgical cases in which appropriate prophylactic antibiotics were given) and outcome measures (rates of surgical site infections every quarter). Similar goals and metrics can be developed for GMPs. We

*The Surgical Care Improvement Project measure (SCIP INF-4), Percent of Cardiac Surgery Patients with Controlled 6 A.M. Postoperative Blood Glucose, was updated in January 2014. At that time, the measure became Cardiac Surgery Patients with Controlled Postoperative Blood Glucose. Description: “Cardiac surgery patients with controlled postoperative blood glucose (less than or equal to 180 mg/dL) in the timeframe of 18 to 24 hours after *Anesthesia End Time*.”

propose that inpatient GMPs partner with patients and family members, as well as other health care stakeholders, to achieve three goals—(1) eliminate preventable harm from hypo- and hyperglycemia, (2) optimize patient outcomes and experience, and (3) eliminate waste in health care.

Goal 1. Eliminate Preventable Harm from Hypo- and Hyperglycemia

The most obvious safety concern in glucose management is the increased risk of hypoglycemia that accompanies efforts to reduce hyperglycemia. The definition of hypoglycemia as a blood glucose < 70 mg/dL is well described and is the threshold for activation of counter-regulatory mechanisms.^{26,27} The harm from hypoglycemia is often severe, the margin for error small, and the time to recover short. In observational studies, hypoglycemia has been associated with increased length of stay (LOS), neurological complications, ischemic events, and mortality.²⁸ One of the challenges in understanding the effects of hypoglycemia in hospitalized patients is the fact that many studies focus only on severe hypoglycemia (that is, blood glucose < 40 or < 50 mg/dL) as a safety factor, while evidence suggests that even lesser degrees of hypoglycemia might have negative clinical consequences through indirect mechanisms.²⁹

Insulin and hypoglycemic drugs rank first among in-hospital-administered medications associated with adverse drug events (ADE).⁸ Among 61,523 patients in the Medicare Patient Safety Monitoring System, ADEs related to hypoglycemic agents (serum glucose 50 mg/dl) in 2010–2011 ranged from 10.0% to 12.6%.⁸ Insulin has therefore been labeled a high-alert medication and is frequently cited as one of the most common medications posing a risk of serious harm and death.³⁰

Most studies in the ICU have shown that hypoglycemia has an independent and dose-dependent effect on mortality, whether or not patients have diabetes.³¹ Although observational studies cannot prove causality, the cardiac and cerebral repercussions of an insufficient fuel source provide practical disincentive against hypoglycemia, particularly in critically ill patients. In addition to a uniform definition of hypoglycemia, a quality of care measure for hypoglycemia must standardize the surveillance for hypoglycemic events (how frequently clinicians measure glucose) and the time to recovery from hypoglycemic events.

Like hypoglycemia, hyperglycemia is associated with excess morbidity, mortality, and prolonged hospital stays in a variety of hospitalized patients and clinical conditions.^{9,32–39} Immune system dysfunction, increased oxidative stress, and endothelial dysfunction are hypothesized as the link between hyperglycemia and outcomes.⁹ The relationship between blood glucose and adverse outcomes appears to take on a U-shaped curve, with both hypo- and hyperglycemia being associated with preventable harm. A longer LOS predisposes the patient to other complications, such as nosocomial infections, deep venous thrombosis, and poor wound healing. As such, quality measures for hyperglycemia could include complications, LOS, and mortality.

Besides hypoglycemia and hyperglycemia, an increasingly recognized indicator of glycemic status is glucose variability.^{40,41} Observational studies suggest that glucose variability is positively associated with mortality in critically ill^{42,43} and non-critically ill⁴⁴ patients;

however, because of heterogeneity in selected indicators of variability, methodological limitations, and possible reporting bias in these studies, the true nature of this association is uncertain.⁴⁵ Furthermore, whether reducing glucose variability improves clinical outcomes in both ambulatory and hospitalized patients remains to be demonstrated. As technologies and therapies evolve, there will likely be increased attention devoted to understanding the effect of glycemic variability on outcomes in hospitalized patients.

Unlike infection control, the purpose of glycemic control is to eliminate consequences that may be several steps “downstream” from glycemia itself. Thus, establishing causation between glycemic control and clinical outcomes in the hospital may not be as clear-cut. For example, although landmark studies in both the ambulatory⁴⁶ and intensive care setting⁴⁷ have shown increased hypoglycemia and mortality rates with intensive insulin therapy, a causative link between hypoglycemia and mortality in these studies could not be definitively made.

Goal 2. Optimize Patient Outcomes and Experience

Glucose mismanagement in the hospital has the potential to negatively influence a patient’s experience by producing distressing symptoms, requiring more frequent blood glucose monitoring and/or insulin injections, escalating level of care (for example, in-hospital diabetic ketoacidosis [DKA]), or causing glycemic-related complications. For patients accustomed to tight outpatient glycemic control, higher (that is, more conservative) inpatient glycemic targets may create the perception of unsatisfactory medical care, and greater transparency about goals of treatment in the hospital versus the outpatient setting may be needed to align patient and clinician expectations.

As patients assume increasing independence in managing their glucose in the hospital (through, for example, self-administered multiple daily injections⁴⁸ or insulin pump management^{49,50}), GMPs will face a challenge in optimizing protocols that standardize care while respecting patient treatment preferences. It is conceivable that with increased individualization of care there may be greater potential for deviation from hospital protocols or policies. Balancing patient safety against patient autonomy will require critical appraisal of glucometric and other outcomes data along with patient satisfaction measures.

Goal 3. Eliminating Waste in Health Care

Nosocomial dysglycemia can increase health care costs by extending LOS and utilization of costly resources. There is mounting evidence that inpatient GMPs are cost-effective by reducing LOS,^{51–54} wound infection rates,⁵³ incidence of catheter-related sepsis,⁵⁴ and readmission rates,⁵² or by increasing correct coding and treatment.⁵² GMPs do not easily lend themselves to a traditional “return on investment” analysis, which often fails to identify and control for confounding variables (for example, case mix). Therefore, collaboration between financial analysis units and biomedical statisticians is needed to scientifically appraise the financial impact of GMPs. As hospital administrators plan and evaluate GMPs, the ability to rigorously demonstrate such clinically and financially relevant outcomes will be crucial to the sustainability of these programs.

Current Evidence Gaps

To develop valid quality measures and reduce preventable harm, clinicians and researchers require a significant corpus of evidence linking improved care process (what clinicians do) to improved outcomes (the results they achieve). The evidence linking interventions to improve glucose control with better clinical outcomes is limited. Early randomized controlled trials (RCTs) in the 1990s demonstrated a benefit of tight glycemic control on morbidity and mortality in surgical ICU patients³¹; however, subsequent RCTs in mixed medical/surgical ICU settings have not been able to replicate these findings.⁵⁵ In fact, the largest of these RCTs showed an unexpected increased risk of mortality with tight control (and increased hypoglycemia rates).⁴⁷ Although there is significant evidence associating hyperglycemia with poor outcomes, there is almost no data showing that reversing hyperglycemia is beneficial in the majority of hospitalized patients. There are also no RCTs of tight glycemic control in non-ICU settings, representing a critical gap in the literature, given that most patients with diabetes are managed in non-ICU settings.

In this regard, the status of glycemic control programs would be analogous to infection control efforts before the SENIC Project, where there was a dearth of evidence to support infection control practices. Standardization of glucometrics by stakeholder groups such as CMS, NQF, or The Joint Commission would be an important first step to facilitate the design of effective research studies in this area by creating a common language in which researchers can communicate and compare their findings.⁷ Unlike infection control, where the outcomes are dichotomized (that is, infection versus no infection), glycemic control is a continuous metric with unclear targets. In recent years, there has been a shift away from the “one-size-fits-all” target (that is, A1C < 7%) for glycemic control in the outpatient setting, and clinicians are now tailoring A1C targets on the basis of the patient’s age and comorbidities. This practice has not yet been extended to the hospital setting, where professional societies continue to advocate uniform glucose targets; however, targets likely need to be specific to inpatient populations. A study by Egi et al. suggests that the duration and extent of preadmission hyperglycemia should be taken into account when determining glucose targets and rate of correction, with more gradual reductions in patients with chronic hyperglycemia.⁵⁶ Besides specifying inpatient glucose targets, which are likely to change over time as scientific evidence continues to accrue, many variables related to glucose measurement need to be agreed on⁷:

- What should be the source of glucose data? (that is, point-of-care glucose readings and/or serum blood glucose?)
- Which glucometrics model should be used? (that is, patient-day-weighted mean blood glucose? Patient-stay-weighted mean blood glucose?⁵⁷)
- What is the definition of *hypoglycemia* and *hyperglycemia*?

A barrier to appraising the efficacy of GMPs has been the ethical concern of subjecting hospitalized patients to varying degrees of glycemic control in a randomized controlled fashion. PRIDE (Planning Research in Inpatient Diabetes) is a national consortium of researchers and clinicians formed in 2012 to address key issues in inpatient glucose management, propose solutions, and recommend areas in need of further research.⁷ PRIDE

proposes that QI statistical methodologies or multicenter prospective trials be used to evaluate the process, intermediary, clinical, and economic outcomes of GMPs. Ultimately, however, the traditional distinctions between “research” and “clinical practice” may need to be reconsidered for health care systems to effectively learn which interventions reduce patient harm without excessive delays imposed by research oversight.⁵⁸ In addition to uncertain glucose targets, there is also an evidence gap regarding optimal choice of therapy in the hospital. Although insulin has historically been the preferred treatment choice in the hospital, emerging evidence suggests a possible role for incretin-based therapy, which has lower hypoglycemia risk.⁵⁹

Parallels in Functions of Infection Control and Glucose Management Programs

The primary functions of ICPs, as follows and as outlined in Table 1 (pp. 329–330), can be directly applied to GMPs:

- Managing critical data and information
- Setting and recommending policies and procedures to prevent adverse events.
- Intervening directly to prevent adverse outcomes
- Educating and training health care workers and providers

Managing Critical Data and Information

The single-most important factor in improving inpatient glucose control is likely the collection, analysis, and dissemination of glucometrics. The critical data for GMPs are rates of hypoglycemia and hyperglycemia, which as of yet do not have agreed-on definitions. To determine these rates, data sources (also not yet agreed on) include point-of-care and/or serum glucose measurements. After these variables are defined, a glucose dashboard could be created by health care systems by using information technology resources to summarize glucometrics for individual patients, providers, units, hospitals, and health systems. An example of a glucose dashboard, which contains information about glycemic exposure, glycemic control, safety, hypoglycemic management, and benchmarking, is currently available on a subscription basis from the Society for Hospital Medicine.⁶⁰ These glucometrics, as well as those put forth by a group at Yale,²³ are important advancements toward standardization. Other measures of interest, such as rates of DKA, symptomatic hypoglycemia, or insulin use (that is, sliding scale versus basal-bolus), might require additional data sources. In 2013 CMS released a public comment report summarizing the input of key stakeholders on the development of glucose-related measures, which, hopefully, will be addressed and adopted in upcoming CMS metrics.⁶¹

Another important consideration relates to the statistical methodology used in analyzing glucose levels. At a population level, glucose levels do not follow a normal distribution. Despite the fact that most statistical methods assume Gaussian distribution of data, in fact very few studies use approaches to transform glucose data to approximate the normal distribution.^{62–66} There is a need for consensus on how to most appropriately analyze non-

Gaussian distributed glucometric data to make accurate inferences when comparing patient populations.

Setting and Recommending Policies and Procedures to Prevent Adverse Events

Professional society guidelines provide recommendations on the in-hospital diagnosis of diabetes and hyperglycemia, glucose monitoring, glycemic targets, medical nutrition therapy, pharmacological therapy, hypoglycemia management, special clinical situations (for example, enteral or parenteral nutrition, insulin infusions, glucocorticoid-induced hyperglycemia, perioperative glycemic control), and transitions of care.^{15,67} The 2006 American Association of Clinical Endocrinologists/American Diabetes Association Consensus Statement provided more concrete recommendations on infrastructure of GMPs.¹⁶ Although these guidelines can inform the development of hospital policies and procedures, the lack of uniformity among professional society guidelines can create confusion for health care providers and potential patient safety hazards.⁶⁸ Regulatory or accreditation guidelines in this area could help to standardize care among health care systems and eliminate idiosyncratic policies or procedures that do not align with current evidence and best practices.

For both infection control and glycemic control, development of protocols/policies will need to be an iterative process that takes into account constantly evolving therapies. Although the emergence of drug resistance may not have an exact counterpart in glycemic control, new contributory factors to glycemic control in the hospital may emerge as demographics, diabetogenic medical therapies, and comorbidities change with time. GMPs will need to be flexible enough to recognize these factors and to promote shifts in hospital practice in the face of new evidence.

Intervening Directly to Prevent Adverse Outcomes

“Glucose Outbreak” Investigation and Control—As with infection surveillance, unit-based surveillance of glucose data can be used to localize outbreaks of dysglycemia. Such outbreaks depend on treatment offered to the “host,” while the contributory factors behind “spread” likely relate to clustering of unsafe treatment practices (for example, uninformed use of sliding-scale monotherapy, omission of basal insulin for type 1 diabetes). In some institutions, such surveillance practices are already in place and are used to direct consultative resources (that is, diabetes/endocrinology consultation) in “real time.” Glucose-related adverse events and glucose outbreaks should be investigated by personnel trained in diabetes and statistical analysis. To perform an effective root cause analysis of a glucose adverse outcome, glucose management personnel must have unrestricted access to pertinent information, including medical, nursing, and administrative records; glucose and insulin administration data; nutrition information; electronic reporting system reports; and laboratory data. Because glucose management teams will need the authority to direct changes in institutional policies and practices, administrators need to be included in and allocate sufficient resources for the GMP.

Quality Improvement Strategies in Hospital Glucose Management—Several QI interventions, the majority of which are multifaceted, have been shown to improve

glucometric outcomes, as summarized in Table 2 (page 332). These strategies include creation of centralized GMPs (often chaired by an endocrinologist or a hospitalist), protocols (for example, DKA management), policies (insulin pump use, hypoglycemia management), computerized order sets (initiating insulin), clinical decision support tools (pocket-card algorithms), prescriber education (Web-based modules, unit-based endocrinology attending on rounds), nursing education (nursing “superuser” program with peer-to-peer education, formal didactic sessions), pharmacist-driven interventions (pharmacist oversight of insulin prescribing), and nutrition interventions (carbohydrate-controlled meals, education of dietitians). The majority of these studies used either “before-after” or cluster-randomized designs to assess the impact of single or multiple interventions on glucometric, clinical, or other outcomes. Among 13 studies that evaluated glucometrics, 5 (~40%) showed reductions in hypoglycemia rates and 9 (~70%) showed reductions in hyperglycemia rates. Among the 9 studies showing a reduction in hyperglycemia rates, there was an accompanying increase in hypoglycemia rates in 2 studies^{69,70} (~20%), a decrease in two studies^{71,72} (~20%), and no change in 5 studies^{73–77} (~60%). Generally, favorable changes in insulin-prescribing practices were demonstrated, with increased use of basal-bolus insulin in place of prolonged use of sliding-scale monotherapy. LOS was reduced in only 1 of 4 studies that reported this outcome.⁷³ Although further studies in this area are needed to clarify the critical components of QI interventions and their effect on hard clinical outcomes, the existing evidence suggests that multicomponent interventions are most likely to simultaneously reduce hypo- and hyperglycemia rates.

Educating and Training Health Care Workers and Providers

Safe and effective inpatient glucose management requires ongoing educational and training programs throughout health care facilities; yet, unlike ICPs, which are mandated to provide ongoing training of staff by accrediting entities, there is no corollary regulatory requirement for training in GMPs. There are several reasons why ongoing education of health care workers in the area of glucose management is needed. First, the processes of care involved in glucose management in the hospital are complex and require the coordination of multiple staff members, including dietary staff, nursing/medical assistants, laboratory technicians, nutritionists, nurses, pharmacists, and prescribers. With technological and pharmaceutical innovations, there will be continuing demands on health care workers to acquire new knowledge and skills in glucose management. Moreover, as scientific evidence continues to accumulate, policies and procedures related to glucose management are likely to change, and there must be mechanisms in place to inform staff and reinforce these changes.

The medical literature is replete with studies highlighting knowledge gaps in inpatient glycemic management among health care providers.^{75,78–87} Educational initiatives in inpatient glycemic control, like those in infection control, should be “simple, clear, and relevant to the policies of the healthcare facility.”^{1(p. 118)} The choice of teaching formats should be based on the learning style of the target audience and commensurate with their level of involvement in glucose management. Educational initiatives should extend to all levels of personnel involved in glucose management. Various educational methods and modalities have been explored, including nursing “superuser” programs, online annual staff updates, online or computer learning modules for providers, case-based training or

simulations, lectures, and direct interaction with experienced clinicians. Most studies of educational interventions have been able to demonstrate clear gains in provider knowledge; however, these gains did not always translate into improved outcomes.⁸⁰

Ongoing monitoring of patient care practices will be helpful to identify areas of continued concern and to evaluate the effectiveness of educational strategies in glucose management. For example, glucose dashboards could be used to inform hospital personnel about problems occurring on their teams or units. This feedback could serve as an educational tool to motivate change in clinical practices.

Personnel Resources

Clinical practice guidelines recommend that hospitals provide administrative support for GMPs,¹⁵ but there are no standards for specific infrastructural requirements according to the size or case mix of a health system population. Adequate personnel and nonpersonnel resources are cited as key components for the success of GMPs.¹⁶

Physician Champion

The importance of a hospital epidemiologist for an effective ICP was established by the SENIC study, in which he or she was often a clinician with training in internal medicine or pediatrics and infectious disease or a pathologist with a primary interest in clinical microbiology.¹ At the time of the SENIC study (1974–1983), most hospital epidemiologists were not formally trained in epidemiology; however, as ICPs evolved in the 1980s and 1990s, training in epidemiology became more widespread. Formal training could be obtained through a course offered by SHEA and the CDC¹; this high level of training and clinical expertise justified financial compensation for the hospital epidemiologist.¹

The corresponding position of the hospital epidemiologist in inpatient glucose management might be dubbed the “Diabetes Health Care Epidemiologist.” Ideally, this would be a clinician with training in internal medicine or endocrinology and significant clinical experience in inpatient glucose management, such as an adult endocrinologist or hospitalist. There is a need for clinicians with dual expertise in inpatient diabetes management and epidemiology or clinical investigation to conduct well-designed research studies assessing the impact of QI initiatives. It is impractical to expect that all glycemic management programs would be spearheaded by a clinician trained in epidemiology; however, a training course could conceivably be offered by a regulatory body or by professional societies, such as the ADA, to ensure that GMP leaders have adequate training to provide oversight in data analysis and study design.

Interventionists

In addition to the hospital epidemiologist, the SENIC study found that an essential component of ICPs was the “infection control practitioner.”¹ This was usually a nurse with a bachelor’s degree or a medical technologist with some training in epidemiology who often supplemented his or her training by taking basic courses offered by professional or health care organizations.¹ In many health care institutions today, the “interventionists” in glucose management are diabetes nurse practitioners (NPs) or physician assistants (PAs). These

highly qualified individuals gain significant clinical experience in the management of hospitalized patients with diabetes or hyperglycemia and can actively intervene independent of physicians if appropriate. In addition to their clinical responsibilities, many NPs are charged with QI tasks, such as participating in hospital glucose safety committees, reviewing electronically reported glucose-related adverse events, or educating staff; however, these important contributions (which often compete with clinical demands) may not be recognized or directly remunerated by hospitals. In this regard, GMPs are in need of direction from regulatory bodies regarding the allocation of personnel time and responsibilities, as some QI responsibilities overseen by advanced practice clinicians could be delegated to a QI nurse.

Place of Glucose Management Programs in the Hospital Administration

Because diabetes is a disease that spans multiple disciplines, it is unclear where GMPs should be situated within the hospital administration hierarchy. At our institution, our GMP falls under the domain of Patient Safety, while at other institutions, GMPs are constituents of Risk Management teams. Regardless of the organizational arrangement, some hierarchy should be in place for GMPs so that the physician champion has the authority to act on glucose outbreaks and so that there is external accountability for the program. Because of their broad patient scope, GMPs should answer to an authority with jurisdiction over the whole hospital and not just individual departments.

Prioritizing GMPs Within Hospital Quality Improvement

During the last decade, there has been a shift in hospital infection prevention and control strategy from a “vertical approach” (active surveillance guiding narrow focus on single pathogen outbreaks) to a “horizontal approach” (universal infection prevention strategies to reduce broad risk of infection regardless of patient condition).⁸⁸ Rather than reacting to outbreaks, it has been shown that it is effective to instead institute proactive horizontal approaches (for example, hand hygiene programs, catheter-associated bloodstream infection programs, daily goals sheets) to preventing them in the first place.⁸⁵ Given the financial and logistical challenges of a vertical approach to infection control, some might argue that a similar horizontal approach should be employed in glycemic control and that many of the analogous components of ICPs may be superfluous or unjustified for GMPs. We acknowledge that proactive strategies, such as standardized order sets, are likely to be more effective than reactive ones, such as targeted education to poorly performing units in glucose control. We also recognize that although further research is needed to determine which of the components of GMPs are necessary, this type of research is difficult to conduct, given the heterogeneity of the components in QI intervention studies for this problem. The GMP components that we have defined represent a current “best-case scenario” on the basis of our own clinical experiences and review of the evidence, but we admit that they are quite likely to change as evidence to support specific strategies continues to accrue.

Conclusion

In the past, hospital epidemiology was limited to the “description and analysis of the occurrence of nosocomial infections.”^{1(p. 120)} More recently, however, there has been a

movement toward application of epidemiology or related statistical methods drawn from industrial process control to areas outside of infection control, leading to the broader concept of “health care epidemiology.” Inpatient GMPs can follow ICPs in adapting and using the theories and tools of continuous QI to focus on improving health care delivery processes for patients with diabetes and hyperglycemia. The interest in measuring health outcomes in recent years confirms the critical role of data collection and analysis in the quality process. There are inherent challenges in measuring glucose-related health outcomes because of difficulties in acquiring and maintaining data in complex health care settings and marked variability of populations and systems that confound comparison between institutions. The goals of a GMP are to reduce LOS, morbidity, and costs; maximize appropriate use of insulin and other treatment modalities; and increase patient satisfaction in hospitalized patients with diabetes or hyperglycemia. Because hyperglycemia is associated with increased risk of infections,^{38,89} improving glucose control in patients with diabetes will likely also have a positive impact in reducing nosocomial infections in this population. Diabetes and prediabetes are growing public health epidemics, so we are likely to continue to see a large number of patients admitted to hospitals with diabetes and hyperglycemia.⁹⁰ Such patients deserve safe and effective glucose management.

References

1. Scheckler WE, et al. Requirements for infrastructure and essential activities of infection control and epidemiology in hospitals: A consensus panel report. Society for Healthcare Epidemiology of America. *Infect Control Hosp Epidemiol*. 1998; 19(2):114–124. [PubMed: 9510112]
2. Feingold DS. Hospital-acquired infections. *N Engl J Med*. 1970 Dec 17; 283(25):1384–1391. [PubMed: 4921308]
3. Joint Commission on Accreditation of Healthcare Organizations. Accreditation Manual for Hospitals, 1976. Chicago: Joint Commission on Accreditation of Hospitals; 1976.
4. Haley RW, et al. The efficacy of infection surveillance and control programs in preventing nosocomial infections in US hospitals. *Am J Epidemiol*. 1985; 121(2):182–205. [PubMed: 4014115]
5. Pronovost P, et al. An intervention to decrease catheter-related bloodstream infections in the ICU. *N Engl J Med*. 2006 Dec 28; 355(26):2725–2732. [PubMed: 17192537]
6. Agency for Healthcare Research and Quality. [Accessed Jun 10, 2015] Interim Update on 2013 Annual Hospital-Acquired Condition Rates and Estimates of Cost Savings and Deaths Averted from 2010 to 2013. <http://www.ahrq.gov/professionals/quality-patient-safety/pfp/interimhacrate2013.pdf>
7. Draznin B, et al. Pathways to quality inpatient management of hyperglycemia and diabetes: A call to action. *Diabetes Care*. 2013; 36(7):1807–1814. [PubMed: 23801791]
8. Wang Y, et al. National trends in patient safety for four common conditions, 2005–2011. *N Engl J Med*. 2014 Jan 23; 370(4):341–351. [PubMed: 24450892]
9. Braithwaite SS, et al. The case for supporting inpatient glycemic control programs now: The evidence and beyond. *J Hosp Med*. 2008; 3(5 Suppl):6–16. [PubMed: 18951385]
10. Garber AJ, et al. American College of Endocrinology position statement on inpatient diabetes and metabolic control. *Endocr Pract*. 2004; 10(Suppl 2):4–9. [PubMed: 15251633]
11. American Diabetes Association. Standards of medical care in diabetes. *Diabetes Care*. 2005; 28(Suppl 1):S4–36. [PubMed: 15618112]
12. Qaseem A, et al. Inpatient glycemic control: Best practice advice from the Clinical Guidelines Committee of the American College of Physicians. *Am J Med Qual*. 2014; 29(2):95–98. [PubMed: 23709472]
13. Jacobi J, et al. Guidelines for the use of an insulin infusion for the management of hyperglycemia in critically ill patients. *Crit Care Med*. 2012; 40(12):3251–3276. [PubMed: 23164767]

14. Dellinger RP, et al. Surviving Sepsis Campaign: International guidelines for management of severe sepsis and septic shock, 2012. *Intensive Care Med.* 2013; 39(2):165–228. [PubMed: 23361625]
15. Umpierrez GE, et al. Management of hyperglycemia in hospitalized patients in non-critical care setting: An Endocrine Society Clinical Practice Guideline. *J Clin Endocrinol Metab.* 2012; 97(1): 16–38. [PubMed: 22223765]
16. American College of Endocrinology and American Diabetes Association consensus statement on inpatient diabetes and glycemic control. *Endocr Pract.* 2006; 12(Suppl 3):4–13. [PubMed: 17357258]
17. The Joint Commission. [Accessed Jun 6, 2015] Advanced Certification in Inpatient Diabetes. http://www.jointcommission.org/certification/inpatient_diabetes.aspx
18. The Joint Commission. 2015 Comprehensive Certification Manual for Disease-Specific Care. Oakbrook Terrace, IL: Joint Commission Resources; 2014.
19. Agency for Healthcare Research and Quality. [Accessed Jun 6, 2015] Measure Summary: Surgical Care Improvement Project: Percent of Cardiac Surgery Patients with Controlled 6 A.M. Postoperative Blood Glucose. <http://www.qualitymeasures.ahrq.gov/content.aspx?id=46451&search=postoperative+glucose>
20. Quality Reporting Center. SCIP-Inf-4 Measure Suspended. Quality Reporting Center Newsletter. 2015; 1(2):2. http://www.qualityreportingcenter.com/wp-content/uploads/2015/02/QRC-Newsletter_Winter2015.pdf.
21. Cook CB, et al. Diabetes and hyperglycemia quality improvement efforts in hospitals in the United States: Current status, practice variation, and barriers to implementation. *Endocr Pract.* 2010; 16(2):219–230. [PubMed: 20061279]
22. Jain R, et al. Veterans Affairs initiative to prevent methicillin-resistant *Staphylococcus aureus* infections. *N Engl J Med.* 2011 Apr 14; 364(15):1419–1430. [PubMed: 21488764]
23. Goldberg PA, et al. “Glucometrics”—Assessing the quality of inpatient glucose management. *Diabetes Technol Ther.* 2006; 8(5):560–569. [PubMed: 17037970]
24. Society of Hospital Medicine. [Accessed Jun 6, 2015] Quality & Innovation: Practical Strategies for Addressing Quality and Safety. https://www.hospitalmedicine.org/Web/Quality_Innovation/Implementation_Toolkits/Glycemic_Control/Web/Quality___Innovation/Implementation_Toolkit/Glycemic/Overview.aspx
25. National Quality Forum. [Accessed Jun 6, 2015] Home page. <http://www.qualityforum.org/Home.aspx>
26. Seaquist ER, et al. Hypoglycemia and diabetes: A report of a workgroup of the American Diabetes Association and the Endocrine Society. *Diabetes Care.* 2013; 36(5):1384–1395. [PubMed: 23589542]
27. Cryer PE, et al. Evaluation and management of adult hypoglycemic disorders: An Endocrine Society Clinical Practice Guideline. *J Clin Endocrinol Metab.* 2009; 94(3):709–728. [PubMed: 19088155]
28. Brodovicz KG, et al. Association between hypoglycemia and inpatient mortality and length of hospital stay in hospitalized, insulin-treated patients. *Curr Med Res Opin.* 2013; 29(2):101–107. [PubMed: 23198978]
29. Dandona P, Chaudhuri A, Dhindsa S. Proinflammatory and prothrombotic effects of hypoglycemia. *Diabetes Care.* 2010; 33(7):1686–1687. [PubMed: 20587729]
30. Cobaugh DJ, et al. Enhancing insulin-use safety in hospitals: Practical recommendations from an ASHP Foundation expert consensus panel. *Am J Health Syst Pharm.* 2013 Aug 15; 70(16):1404–1413. [PubMed: 23903479]
31. Wagstaff AE, Cheung NW. Diabetes and hyperglycemia in the critical care setting: has the evidence for glycemic control vanished? (Or . . . is going away?). *Curr Diab Rep.* 2014; 14(1):444. [PubMed: 24277672]
32. Muhlestein JB, et al. Effect of fasting glucose levels on mortality rate inpatients with and without diabetes mellitus and coronary artery disease undergoing percutaneous coronary intervention. *Am Heart J.* 2003; 146(2):351–358. [PubMed: 12891207]

33. Capes SE, et al. Stress hyperglycaemia and increased risk of death after myocardial infarction in patients with and without diabetes: A systematic overview. *Lancet*. 2000 Mar 4; 355(9206):773–778. [PubMed: 10711923]
34. Furnary AP, Wu Y, Bookin SO. Effect of hyperglycemia and continuous intravenous insulin infusions on outcomes of cardiac surgical procedures: The Portland Diabetic Project. *Endocr Pract*. 2004; 10(Suppl 2):21–33. [PubMed: 15251637]
35. Capes SE, et al. Stress hyperglycemia and prognosis of stroke in nondiabetic and diabetic patients: A systematic overview. *Stroke*. 2001; 32(10):2426–2432. [PubMed: 11588337]
36. McAlister FA, et al. The relation between hyperglycemia and outcomes in 2,471 patients admitted to the hospital with community-acquired pneumonia. *Diabetes Care*. 2005; 28(4):810–815. [PubMed: 15793178]
37. Thomas MC, et al. Early peri-operative glycaemic control and allograft rejection in patients with diabetes mellitus: A pilot study. *Transplantation*. 2001 Oct 15; 72(7):1321–1324. [PubMed: 11602863]
38. Golden SH, et al. Perioperative glycemic control and the risk of infectious complications in a cohort of adults with diabetes. *Diabetes Care*. 1999; 22(9):1408–1414. [PubMed: 10480501]
39. Weiser MA, et al. Relation between the duration of remission and hyperglycemia during induction chemotherapy for acute lymphocytic leukemia with a hyperfractionated cyclophosphamide, vincristine, doxorubicin, and dexamethasone/methotrexate-cytarabine regimen. *Cancer*. 2004 Mar 15; 100(6):1179–1185. [PubMed: 15022284]
40. Braithwaite SS. Glycemic variability in hospitalized patients: Choosing metrics while awaiting the evidence. *Curr Diab Rep*. 2013; 13(1):138–154. [PubMed: 23150242]
41. Hirsch IB. Glycemic variability: It's not just about A1C anymore! *Diabetes Technol Ther*. 2005; 7(5):780–783. [PubMed: 16241882]
42. Egi M, et al. Variability of blood glucose concentration and short-term mortality in critically ill patients. *Anesthesiology*. 2006; 105(2):244–252. [PubMed: 16871057]
43. Krinsley JS. Glycemic variability: A strong independent predictor of mortality in critically ill patients. *Crit Care Med*. 2008; 36(11):3008–3013. [PubMed: 18824908]
44. Mendez CE, et al. Increased glycemic variability is independently associated with length of stay and mortality in noncritically ill hospitalized patients. *Diabetes Care*. 2013; 36(12):4091–4097. [PubMed: 24170754]
45. Eslami S, et al. Glucose variability measures and their effect on mortality: A systematic review. *Intensive Care Med*. 2011; 37(4):583–593. [PubMed: 21279326]
46. Gerstein HC, et al. Action to Control Cardiovascular Risk in Diabetes Study Group. Effects of intensive glucose lowering in type 2 diabetes. *N Engl J Med*. 2008 Jun 12; 358(24):2545–2559. [PubMed: 18539917]
47. Finfer S, et al. NICE-SUGAR Study Investigators. Intensive versus conventional glucose control in critically ill patients. *N Engl J Med*. 2009 Mar 26; 360(13):1283–1297. [PubMed: 19318384]
48. Kennihhan M, et al. Individualization through standardization: Electronic orders for subcutaneous insulin in the hospital. *Endocr Pract*. 2012; 18(6):976–987. [PubMed: 23246685]
49. Nassar AA, et al. Outpatient-to-inpatient transition of insulin pump therapy: Successes and continuing challenges. *J Diabetes Sci Technol*. 2010 Jul 1; 4(4):863–872. [PubMed: 20663450]
50. Bailon RM, et al. Continuous subcutaneous insulin infusion (insulin pump) therapy can be safely used in the hospital in select patients. *Endocr Pract*. 2009; 15(1):24–29. [PubMed: 19211393]
51. Levetan CS, et al. Impact of endocrine and diabetes team consultation on hospital length of stay for patients with diabetes. *Am J Med*. 1995; 99(1):22–28. [PubMed: 7598138]
52. Olson L, Muchmore J, Lawrence CB. The benefits of inpatient diabetes care: Improving quality of care and the bottom line. *Endocr Pract*. 2006; 12(Suppl 3):35–42. [PubMed: 16905515]
53. Furnary AP, et al. Continuous intravenous insulin infusion reduces the incidence of deep sternal wound infection in diabetic patients after cardiac surgical procedures. *Ann Thorac Surg*. 1999; 67(2):352–360. [PubMed: 10197653]
54. Newton CA, Young S. Financial implications of glycemic control: results of an inpatient diabetes management program. *Endocr Pract*. 2006; 12(Suppl 3):43–48. [PubMed: 16905516]

55. Wiener RS, Wiener DC, Larson RJ. Benefits and risks of tight glucose control in critically ill adults: A meta-analysis. *JAMA*. 2008 Aug 27; 300(8):933–944. [PubMed: 18728267]
56. Egi M, et al. The interaction of chronic and acute glycemia with mortality in critically ill patients with diabetes. *Crit Care Med*. 2011; 39(1):105–111. [PubMed: 20975552]
57. Munoz M, et al. Implementing and evaluating a multicomponent inpatient diabetes management program: Putting research into practice. *Jt Comm J Qual Patient Saf*. 2012; 38(5):195–206. [PubMed: 22649859]
58. Kass NE, et al. The research-treatment distinction: A problematic approach for determining which activities should have ethical oversight. *Hastings Cent Rep*. 2013; (Spec No):S4–15. [PubMed: 23315895]
59. Umpierrez GE, Schwartz S. Use of incretin-based therapy in hospitalized patients with hyperglycemia. *Endocr Pract*. 2014; 20(9):933–944. [PubMed: 25100362]
60. Maynard G, et al. Design and implementation of a web-based reporting and benchmarking center for inpatient glucometrics. *J Diabetes Sci Technol*. 2014; 8(4):630–640. [PubMed: 24876426]
61. Centers for Medicare & Medicare Services. [Accessed Jun 6, 2015] Special Innovation Project: Maintenance and Development of Medication Measures. Public Comment Summary Report. Nov 13. 2013 <http://www.cms.gov/Medicare/Quality-Initiatives-Patient-Assessment-Instruments/MMS/Downloads/FMQAI-Glycemic-Control-Measures-Public-Comment.pdf>
62. Hoofnagle AN, et al. Use of serum and plasma glucose measurements as a benchmark for improved hospital-wide glycemic control. *Endocr Pract*. 2008; 14(5):556–563. [PubMed: 18753097]
63. Chase JG, et al. A benchmark data set for model-based glycemic control in critical care. *J Diabetes Sci Technol*. 2008; 2(4):584–594. [PubMed: 19885234]
64. Rodbard D. A semilogarithmic scale for glucose provides a balanced view of hyperglycemia and hypoglycemia. *J Diabetes Sci Technol*. 2009 Nov 1; 3(6):1395–1401. [PubMed: 20144394]
65. Rodbard D. Clinical interpretation of indices of quality of glycemic control and glycemic variability. *Postgrad Med*. 2011; 123(4):107–118. [PubMed: 21680995]
66. Saulnier GE, Castro JC, Cook CB. Statistical transformation and the interpretation of inpatient glucose control data. *Endocr Pract*. 2014 Mar 1; 20(3):207–212. [PubMed: 24013995]
67. American Diabetes Association. Standards of medical care in diabetes— 2014. *Diabetes Care*. 2014; 37(Suppl 1):S14–80. [PubMed: 24357209]
68. Mathioudakis N, Golden SH. A comparison of inpatient glucose management guidelines: Implications for patient safety and quality. *Curr Diab Rep*. 2015 Mar. 15(3):13.10.1007/s11892-015-0583-8. [PubMed: 25690724]
69. Baldwin D, et al. Eliminating inpatient sliding-scale insulin: A reeducation project with medical house staff. *Diabetes Care*. 2005; 28(5):1008–1011. [PubMed: 15855558]
70. Hermayer KL, et al. Impact of improvement efforts on glycemic control and hypoglycemia at a university medical center. *J Hosp Med*. 2009; 4(6):331–339. [PubMed: 19670354]
71. Lee J, et al. Indication-based ordering: A new paradigm for glycemic control in hospitalized inpatients. *J Diabetes Sci Technol*. 2008; 2(3):349–356. [PubMed: 19885198]
72. Maynard G, et al. Improved inpatient use of basal insulin, reduced hypoglycemia, and improved glycemic control: Effect of structured subcutaneous insulin orders and an insulin management algorithm. *J Hosp Med*. 2009; 4(1):3–15. [PubMed: 19140173]
73. Schnipper JL, et al. Effects of a subcutaneous insulin protocol, clinical education, and computerized order set on the quality of inpatient management of hyperglycemia: Results of a clinical trial. *J Hosp Med*. 2009; 4(1):16–27. [PubMed: 19140191]
74. Ena J, et al. Long-term improvements in insulin prescribing habits and glycaemic control in medical inpatients associated with the introduction of a standardized educational approach. *Diabetes Res Clin Pract*. 2009; 85(2):159–165. [PubMed: 19520451]
75. Tamler R, et al. Effect of online diabetes training for hospitalists on inpatient glycaemia. *Diabet Med*. 2013; 30(8):994–998. [PubMed: 23398488]
76. Murphy DM, et al. Reducing hyperglycemia hospitalwide: The basal-bolus concept. *Jt Comm J Qual Patient Saf*. 2009; 35(4):216–223. [PubMed: 19435161]

77. Schnipper JL, et al. Effects of a computerized order set on the inpatient management of hyperglycemia: A cluster-randomized controlled trial. *Endocr Pract.* 2010; 16(2):209–218. [PubMed: 20061280]
78. Cheekati V, et al. Perceptions of resident physicians about management of inpatient hyperglycemia in an urban hospital. *J Hosp Med.* 2009; 4(1):E1–8. [PubMed: 19140201]
79. Sperl-Hillen J, et al. Using simulation technology to teach diabetes care management skills to resident physicians. *J Diabetes Sci Technol.* 2013 Sep 1; 7(5):1243–1254. [PubMed: 24124951]
80. Desimone ME, et al. Effect of an educational Inpatient Diabetes Management Program on medical resident knowledge and measures of glycemic control: A randomized controlled trial. *Endocr Pract.* 2012; 18(2):238–249. [PubMed: 22440993]
81. Tamler R, et al. Durability of the effect of online diabetes training for medical residents on knowledge, confidence, and inpatient glycemia. *J Diabetes.* 2012; 4(3):281–290. [PubMed: 22268536]
82. Tamler R, et al. Effect of case-based training for medical residents on confidence, knowledge, and management of inpatient glycemia. *Postgrad Med.* 2011; 123(4):99–106. [PubMed: 21680994]
83. Cook CB, et al. Development of computer-based training to enhance resident physician management of inpatient diabetes. *J Diabetes Sci Technol.* 2009 Nov 1; 3(6):1377–1387. [PubMed: 20144392]
84. Cook CB, et al. Management of inpatient hyperglycemia: Assessing perceptions and barriers to care among resident physicians. *Endocr Pract.* 2007; 13(2):117–124. [PubMed: 17490924]
85. Cook CB, et al. Beliefs about hospital diabetes and perceived barriers to glucose management among inpatient midlevel practitioners. *Diabetes Educ.* 2008; 34(1):75–83. [PubMed: 18267993]
86. Costantini TW, et al. Surgical resident and attending physician attitudes toward glucose control in the surgical patient. *Am Surg.* 2008; 74(10):993–996. [PubMed: 18942630]
87. Bernard AM, et al. What do internal medicine residents need to enhance their diabetes care? *Diabetes Care.* 1999; 22(5):661–666. [PubMed: 10332662]
88. Traa MX, et al. Horizontal infection control strategy decreases methicillin-resistant *Staphylococcus aureus* infection and eliminates bacteremia in a surgical ICU without active surveillance. *Crit Care Med.* 2014; 42(10):2151–2157. [PubMed: 24979485]
89. Murad MH, et al. Glycemic control in non-critically ill hospitalized patients: A systematic review and meta-analysis. *J Clin Endocrinol Metab.* 2012; 97(1):49–58. [PubMed: 22090269]
90. Wallymahmed ME, et al. Hospital in-patients with diabetes: Increasing prevalence and management problems. *Diabet Med.* 2005; 22(1):107–109. [PubMed: 15606701]

Table 1

Comparison Table: Function of Infection Control Programs (ICPs) and Inpatient Glucose Management Programs (GMPs)

	INFECTION CONTROL PROGRAMS	GLUCOSE MANAGEMENT PROGRAMS
Managing Critical Data and Information		
Developing, Implementing, and Monitoring Surveillance	Nosocomial infections and other adverse events	Hypoglycemia and hyperglycemia rates and other adverse events
External Reporting of Event Rates	Clinical performance indicators to assess nosocomial infections, adjusted for case mix, severity of illness, socioeconomic status, and other risk factors	Glucose level on morning following cardiac surgery measure no longer available [†]
	Since 2005, 27 states have enacted laws that require hospitals to report data related to nosocomial infections. The CDC National Healthcare Safety Network (NHSN) is a voluntary national system for the collection of health care–associated incidence and prevention data. [*]	No mandatory reporting requirements, but CMS has metrics under development.
	Expert guidance in indicator selection, oversight of data collection, and analysis of indicators	Indicator selection and benchmark targets will require expertise from endocrinologists and internists with expertise in glucose management.
Setting and Recommending Policies and Procedures to Prevent Adverse Events		
Assuring the Appropriateness and Feasibility of Policies and Procedures	Based on scientifically valid infection prevention and control measures that have a positive impact on process and prevent nosocomial infection	Based on scientifically valid and evidence-based best-practice approaches to safe inpatient glucose management
	Information sources and guidelines: HICPAC, SHEA, and APIC guidelines and regulatory standards from state and local licensing bodies and federal agencies (for example, OSHA, FDA, EPA)	Current professional society clinical practice guidelines for diabetes, but no regulatory or licensing guidelines from government or equivalent agencies yet
Compliance with Regulations, Guidelines, and Accreditation Requirements	Failure to comply with accreditation standards (for example, The Joint Commission) could place patients at greater risk for harm and result in loss of accreditation.	No centralized standards of care for inpatient glucose management but several society guidelines No accreditation requirements related to inpatient glucose management
Intervening Directly to Prevent Adverse Outcomes		
Outbreak Investigation and Control	Health care facilities must have baseline surveillance data on incidence of nosocomial infections to identify outbreaks.	Unit-based surveillance of glycemic patterns to identify areas with higher than expected hypoglycemic and/or hyperglycemic events
	Investigation by personnel trained in infection control, infectious disease epidemiology, and applied statistical analysis	Glucose management personnel: <ul style="list-style-type: none"> • Trained in endocrinology/diabetology and statistical analysis • Evaluation/treatment by mid-level care providers and/or RNs trained and experienced in diabetes management • Diabetes quality improvement team leader
	Direct access to administrative, medical, and nursing personnel with authority to direct changes in institutional policies and practices necessary to achieve immediate control of an outbreak	Same access is needed, with specific access to glucose and insulin administration data, nutrition information, and laboratory data
Educating and Training Health Care Workers and Providers		
Training Techniques Applicable to Adult Learning Styles to Stimulate Behavior Change	Regulatory agencies and accrediting entities (for example, OSHA, The Joint Commission) require ongoing training of staff.	No corollary regulatory requirements for training in inpatient glucose management, but Joint Commission standards address orientation, training, and competency for all staff regardless of job or specialty.

	INFECTION CONTROL PROGRAMS	GLUCOSE MANAGEMENT PROGRAMS
	New scientific innovations in infection control: Using surveillance program data as feedback for staff (for example, reporting surgical site infection rates to individual surgeons reduces nosocomial infection rates)	New scientific innovations in glucose control: <ul style="list-style-type: none"> Nursing superuser program model Clinical topics module for house staff Annual staff update Inpatient glucose dashboard to provide direct feedback to staff
Personnel Resources		
Physician Champion	Hospital epidemiologist: clinician with training in internal medicine or pediatrics and in infectious diseases or pathologists with primary interest in clinical microbiology or sterilization	“Diabetes Health Care Epidemiologist”: endocrinologist or hospitalist trained in internal medicine and diabetes
	Training courses offered by SHEA/CDC	No formal training currently
	Adequate and appropriate compensation for work	Same
Interventionists	Infection control professionals and surveillance personnel <ul style="list-style-type: none"> Most RNs with bachelor’s degree Medical technologists MPH epidemiologists 	Diabetes nurse practitioners (NPs) to see high-risk diabetes patients Diabetes QI nurse to review patient safety net reports to generate consults on at-risk patients, in collaboration with NPs
	Training in infection surveillance and control and epidemiology through basic courses (may obtain Certification in Infection Control by the Certification Board of Infection Control)	No formal training currently
Secretary	Data entry; typing of meeting minutes, policies, and correspondence; meeting organization	Same
Data Analyst	Management and analysis of laboratory and clinical data	Same
Nonpersonnel Support		
Office Support	Sufficient office space to house program members; contiguous space with other QI programs to foster interstaff communication convenient to clinical services under surveillance; standard office equipment.	Same
Computing Support	Software including word processing, spreadsheet, database management, and basic statistical programs; establishment of network to allow single entry, primary-source capture of health care data for efficient handling, analysis, and distribution of data within the institution and throughout the integrated health care system; data backup system.	Same
Audiovisual Support	For educational and presentation activities	Same
Laboratory and Pathology Services	<ul style="list-style-type: none"> Microbiology laboratory reports Adequate pathology services 	<ul style="list-style-type: none"> Quality control for point-of-care glucose testing Timely and accurate reporting of serum blood glucose results

CMS, Centers for Medicare & Medicaid Services; HICPAC, Healthcare Infection Control Practices Advisory Committee; SHEA, Society for Healthcare Epidemiology of America; APIC, Association for Professionals in Infection Control and Epidemiology; OSHA, Occupational Safety and Health Administration; FDA, Food and Drug Administration; EPA, Environmental Protection Agency.

* National Conference of State Legislators. Methicillin-Resistant *Staphylococcus Aureus* (MRSA) and Other Healthcare-Associated Infections. Accessed Jun 10, 2015. <http://www.ncsl.org/research/health/healthcare-associated-infections-homepage.aspx>.

[†]The Surgical Care Improvement Project measure (SCIP INF-4), Percent of Cardiac Surgery Patients with Controlled 6 A.M. Postoperative Blood Glucose, was updated in January 2014. At that time, the measure became Cardiac Surgery Patients with Controlled Postoperative Blood Glucose. Description: “Cardiac surgery patients with controlled postoperative blood glucose (less than or equal to 180 mg/dL) in the timeframe of 18 to 24 hours after *Anesthesia End Time*.” Data collection on this measure was suspended effective July 1, 2014.

OSHA, Occupational Safety and Health Administration; SHEA, Society for Healthcare Epidemiology of America; CDC, Centers for Disease Control and Prevention; QI, quality improvement.

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

Table 2

Interventions: 1, Centralized glucose management program; 2, Policies and/or protocols; 3, Computerized order sets; 4, Clinical decision support tools; 5, Prescriber education; 6, Nursing education; 7, Pharmacist-driven intervention; 8, Nutrition interventions												
Author (year)	Interventions								Outcomes			
	1	2	3	4	5	6	7	8	Hypoglycemia Rates	Hyperglycemia Rates	Insulin Use	Nonglucometric Outcomes
Baldwin ^{66*} (2005)		x			x				↑	↓	↓ use of SSI monotherapy	
Lee ⁶⁸ (2008)	x	x	x	x					↓	↓	↑ use of basal insulin	
Hermayer ⁶⁷ (2009)	x	x		x	x	x		x	↑	↓	↑ use of insulin infusions	
Maynard ⁶⁹ (2009)	x	x	x	x	x	x		x	↓	↓	↓ use of SSI monotherapy	No effect on LOS
Murphy ⁷³ (2009)	x	x	x	x	x	x	x	x	No change	↓		
Schnipper ⁷⁰ (2009)	x	x	x	x	x	x	x		No change	↓ (first 3 days of hospital stay only)	↑ use of scheduled nutritional insulin	↓ LOS
Ena ⁷¹ (2009)		x		x	x				No change	↓	↓ use of SSI ↑ use of BBI	No effect on LOS
Schnipper ⁷⁴ (2010)		x	x	x	x	x			No change	↓	↓ use of SSI monotherapy	No effect on LOS
Selig ⁷ (2010)	x	x				x			Not evaluated	Not evaluated		↑ compliance with hypoglycemia treatment protocol
Curl ⁷⁴ (2010)								x	↓ in carbohydrate-controlled meal plans compared to patient-controlled meal plans	No change		↑ Patient satisfaction with patient-controlled meal plans
Munoz ^{5,5} (2012)	x	x	x	x	x	x	x	x	↓	No change		
Buchko ⁸ (2012)	x	x	x		x	x			↓	No change		↑ Documentation by RN ↑ Compliance with insulin pump policy
Desimone ⁷⁷ (2012)	x	x		x	x				No change	No change		↑ Provider knowledge
Tamler ⁷² (2013)					x				No change	↓		

SSSI, sliding-scale insulin; LOS, length of stay; BBI, basal-bolus insulin.

*
Numbered references can be found in References (p. 336).

[†] Selig PM, Popek V, Peebles KM. Minimizing hypoglycemia in the wake of a tight glycemic control protocol in hospitalized patients. *J Nurs Care Qual.* 2010;25(3): 255-260.

[†]Curtl M, et al. Menu selection, glycaemic control and satisfaction with standard and patient-controlled consistent carbohydrate meal plans in hospitalised patients with diabetes. *Qual Saf Health Care*. 2010;19(4):355–359.

§ Buchko BL, et al. Improving care of patients with insulin pumps during hospitalization: Translating the evidence.

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript