

TOOLS, TECHNOLOGIES, AND INFORMATICS: SUPPORTING GLYCEMIC CONTROL

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ABSTRACT

Objective: To overcome the challenges involved in the adoption and implementation of standards of glycemic control in the inpatient setting.

Methods: Three major barriers to effective glycemic control are examined, and solutions are discussed.

Results: The diabetes care process occurs at several levels of the hospital system, including the community level. Each level must be considered when solutions for glycemic control are determined and implementation planned. Workflow coordination is another challenge; it addresses the end users who provide patient care and use information support. Informatics, or the application of information technology to healthcare, can facilitate system-level and workflow integration efforts to improve glycemic control.

Conclusion: Glycemic control can be achieved through coordinated and facilitated efforts at each level of the hospital system—individual, unit, and hospital-wide. Multidisciplinary team coordination, workflow integration, effective information sharing, and communication are required. (*Endocr Pract.* 2006;12[Suppl 3]:100-107)

Abbreviations:

CDSS = clinical decision support systems; CGM = continuous glucose monitoring; CPOE = computerized physician order entry; EMR = electronic medical record; POCT = point-of-care testing; QC = quality control

INTRODUCTION

Diabetes is a significant public health problem, affecting more than 20 million individuals in the United States (1). Increased hospitalizations and associated costs bur-

den our healthcare system, especially our hospitals, with more than 4.9 million discharges associated with diabetes (2). Glycemic control is an important outcome in the care of people with diabetes, from both a quality-of-life and an economic perspective. Since 2003, national attention has been directed at improving glycemic control in the inpatient setting. Through efforts of the American Association of Clinical Endocrinologists (3) and the American Diabetes Association (4,5), guidelines and standards for improving glycemic control have been promulgated. Implementation of these standards is challenging.

CHALLENGES

This article will address 3 issues that challenge the adoption and implementation of inpatient glycemic standards: the system levels of care, workflow coordination, and the lack of integrated or fragmented information technology support. It will discuss how tools, technologies, and information management strategies support clinicians and systems to improve glycemic control in the hospital. Very little has been published on the integration and evaluation of a system-wide information management approach to glycemic control in the inpatient setting. The literature focuses primarily on protocol development for insulin delivery and quality control (QC) programs for point-of-care testing (POCT). It is the premise of this report that a coordinated systems approach and the increased use of technology can support successful glycemic control and standards implementation in the inpatient setting.

PROBLEMS

Glycemic Control Is a Systems Problem

The “system” referred to herein focuses primarily on the care delivery in the hospital, with the recognition that the patient returns to the community for ongoing care and support. Multiple levels or views of the system exist, depending on one’s perspective: individual, unit or department, hospital, and community. Each level has unique attributes and contributions to the outcome of the patient or person with diabetes. However, at each level, glycemic control is the key outcome of the diabetes care process.

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The diabetes care process occurs at several levels of the system, and each level must be considered when solutions for glycemic control are determined and implemented (Fig. 1). The levels are the individual, the unit or department, the hospital, and the community. Typically, most departments and divisions are designed to accomplish specific tasks related to their mission. However, even in the best systems, fragmented communication exists. Contribution to glycemic control crosses departmental boundaries and multiple disciplines. This creates the demand for a multidisciplinary approach to defining and implementing solutions. These solutions are best determined at each level within the system and integrated across the multiple areas that impact glycemia.

At the individual level, the main focus is the patient and clinician. Most activities in the healthcare transaction occur at this level; for instance, between nurse and patient, between physician and patient, and with ancillary personnel such as a laboratory technician or dietitian. For example, the physician orders the laboratory test that indicates the level of glycemic control for a patient, and determinations are made regarding diagnosis and/or treatment strategies. The nurse administers medication based on the physician order or predetermined protocol. The patient receives

medication and nutrition, and blood glucose measurements continue to be obtained. Most tools and technologies have been developed to support this system level of interaction.

The first level of system aggregation occurs at the unit or departmental level. Patients often are grouped on units by service line, by patient population, or by level of acuity. Examples of these are obstetrics, oncology, and critical care. Departments are organized throughout the hospital around key functions such as laboratory and nursing. Currently, the unit or departmental involvement focuses primarily on training and QC of POCT activities. Although it is important to have competent operators and equipment, there is a need to focus on glycemic control at the unit level. Individual patient reports should be aggregated to describe patient population and practice trends for glycemic control on the unit. Many departments are involved in the goal of glycemic control, with each having a function that contributes to the overall goal. Physicians and other clinicians cross departments or divisions during daily patient care. A major challenge is integrating these departmental functions to achieve patient outcomes and to support clinicians at the point-of-service through continuous quality improvement. Hospital departments involved in glycemic control are grouped under “patient care delivery” and “support services”:

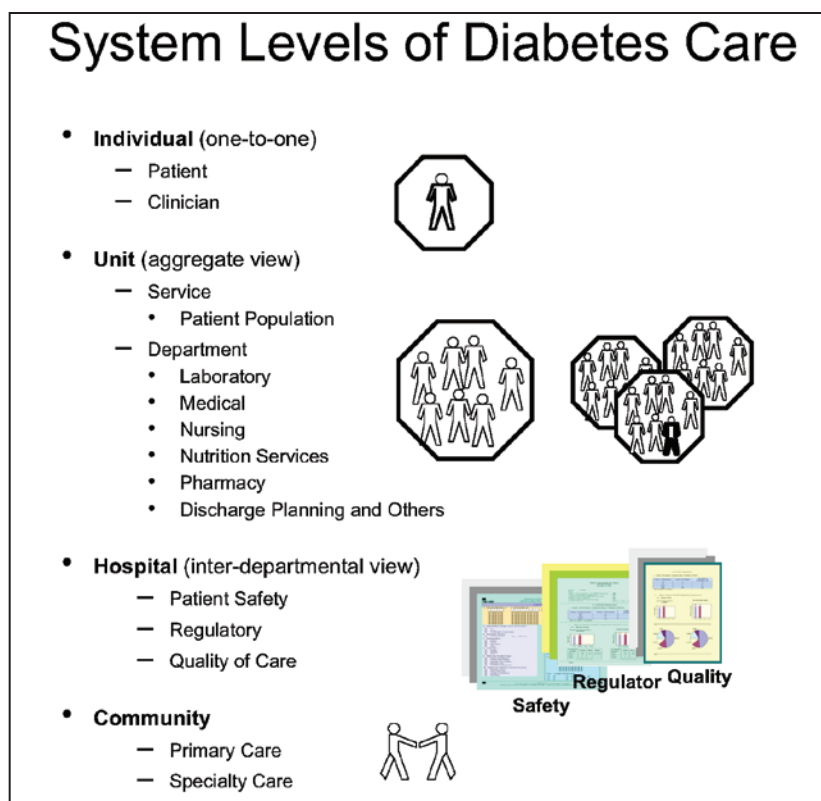


Fig. 1. Illustration of the system levels involved in diabetes care.

Patient Care Delivery

- Nursing
- Medical
- Nutrition services
- Pharmacy
- Discharge planning
- Ancillary departments and others

Support Services

- Laboratory
- Information systems
- Quality
- Others depending on the hospital

Aggregating from the unit or department leads to the hospital-wide inpatient or outpatient point of view. At this level, key outcomes include patient safety, meeting of regulatory requirements, and overall quality of care. Glycemic control is an indicator in each of these areas. The reporting at this level often is cumbersome and requires manual extraction or complex data mining. Utilization of data typically is focused on departmental functions and goals. However, these data have the potential for being used in hospital-wide performance assessment and strategic planning. For instance, a hospital system with 600,000 blood glucose data points annually needs to address not only the individual glucose value but also the impact of diabetes in the health system and community.

A beginning and ending level of the diabetes care process occurs at the community level. Patients come to the hospital from the community, and they return to the community. Health systems have both a direct accountability and an indirect responsibility for diabetes care. Hospitals are *directly* responsible for discharge planning, referrals, and follow-up plans and are *indirectly* responsible for the coordination back into the community with primary care, specialty care, and/or home care.

Glycemic Control Is a Workflow Problem

Workflow coordination is another challenge that addresses the end users who provide patient care and use information support. Workflow addresses how *tasks* are structured, who performs them, what their relative order is, how they are synchronized, how *information* flows to support the tasks, and how tasks are being *tracked* (6).

Developing guidelines and protocols does not result in improvement of care unless they are successfully integrated into the workflow of the providers and staff. Successful integration requires a systematic observation of the tasks that take place, analysis of the processes that support these tasks, and the modification of processes for efficiency and effectiveness. Following is an example of a workflow analysis; the quote appeared in the electronic community of an organizational specialty practice.

“Our hospital also is having problems with just the *morning insulin dosing*. The clinical nurse assistant (CNA) checks the blood sugars between 5:30 and 6:30 AM and the trays come at 7:15 AM. I have been trying to teach the nurses to give the bolus insulin and the correction dose together, but we are not sure which shift should be held accountable for this. I suppose having the trays come at 8 AM would be a solution, but I think the idea would be met with resistance, as would be the ideas to change the time a shift starts... any ideas?”

The initial effort to “fix the problem” was to reschedule the tray delivery, but other concerns arise as one tries to analyze the work tasks and processes. This “simple” problem takes on a different perspective when viewed from the workflow analysis process:

Our hospital also is having problems with just the *morning insulin dosing*. The CNA checks the blood sugars between 5:30 and 6:30 AM and the trays come at 7:15 AM. **(Problem is defined: Morning insulin dosing)**

I have been trying to teach the nurses to give the bolus insulin and the correction dose together, but we are not sure which shift should be held accountable for this. **(Unit work processes are evaluated and solutions considered. For any new process, staff education will be required.)**

I suppose having the trays come at 8 AM would be a solution, but I think the idea would be met with resistance, as would be the ideas to change the time a shift starts... any ideas? **(At this point, the solution expands across departments and communication, and decision-making will require interdepartmental coordination.)**

In summary, workflow issues increase the complexity of identifying and implementing the most appropriate protocols and procedures. Workflow at the various system levels challenges the coordination of care within the hospital and impacts the overall goal of glycemic control. A systematic approach to the analysis and improvement of workflow issues at the unit and hospital-system levels will support effective and efficient integration of clinician activities for improving glycemic control.

Glycemic Control Is an Information Problem

Information management and technology is a key enabler for integrating the system and activities within each level. Various types of paper and electronic tools, protocols, policies, and procedures exist to support the goal of glycemic control.

Current tools and technologies exist to support decision making at the point of care, with little functionality for the unit or hospital level. Tools that exist today to support

clinicians in their delivery of care include POCT, algorithms, care paths, guidelines, and policies and procedures. However, having the right information at the right time, with appropriate decision support, is critical for safe and effective care. Current systems are not at the sophistication level needed to provide information for timely and appropriate action to control glucose levels.

The following is a case scenario from a pharmacist who was consulted regarding “Why did this patient experience hypoglycemia?”

Case Scenario

The pharmacist arrived on the unit. To gather the data needed for his analysis around the hypoglycemic event, he reported that he had to “thumb through” the paper chart to identify key data points: medication administration, nutrition, and blood glucose values. No integrated view of the patient day or days was presented to this clinician. He synthesized his conclusions based on his random, fragmented review of the chart and other records.

Discussion

Information is critical for timely and appropriate actions to achieve glycemic control (7). In this scenario, the data were not readily organized or available, resulting in the use of valuable staff time and resources to obtain complete (or assumed complete) information for decision making.

At the hospital level, information is critical for meeting patient safety needs, regulatory requirements, risk reduction, and financial sustainability. Hospitals are challenged to develop information infrastructures while supporting day-to-day operations. Technology is a key enabler for integrating systems, workflow, and information for treating, trending, and reporting quality.

SOLUTIONS: TOOLS, TECHNOLOGIES, AND INFORMATICS

Problems with system levels, clinician workflow, and availability of information are the challenges to glycemic control. The primary enabler is informatics, or the application of information management and technology to healthcare. Informatics supports the capture of data for interpretation into information that is synthesized and contextualized for knowledge. For an example, see Figure 2; this illustration details a process that uses number 40 as a data point to represent hypoglycemia. Health informatics tools include not only computers but also clinical guidelines, formal medical terminologies, and information and communication systems (8).

Various technology applications exist to support improving glycemic control at the individual, unit, hospital, and community levels. These include the electronic medical record (EMR), computerized physician order

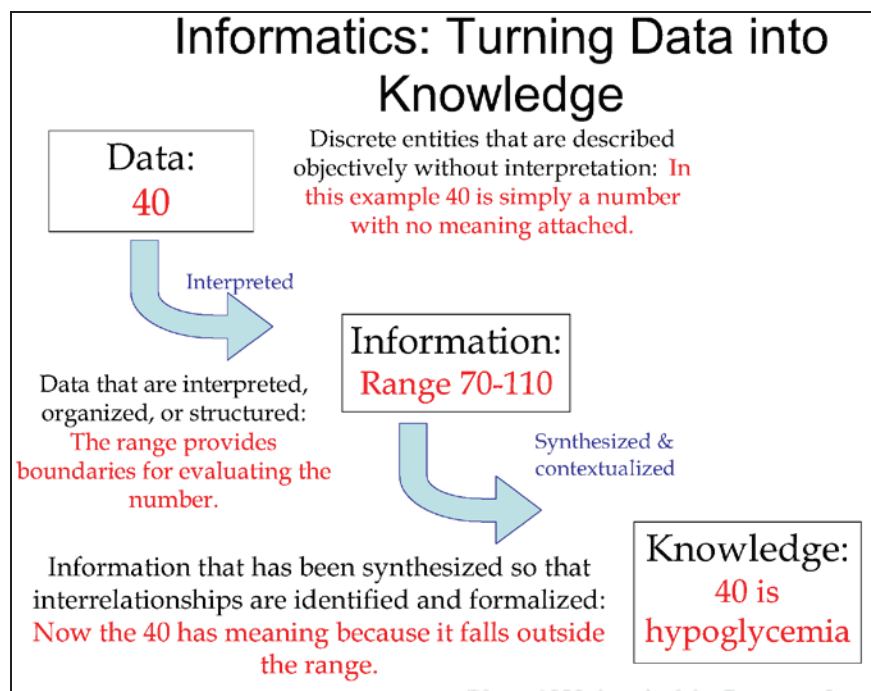


Fig 2. Example of data transformation.

entry (CPOE), POCT, and continuous glucose monitoring (CGM). Tools such as algorithms, protocols, policies and procedures, care maps, and documentation strategies exist to support clinician decision making and action, unit or departmental activity, and hospital-wide risk management. Informatics strategies, when appropriately applied, facilitate an integrated view of glycemic monitoring and management.

Current technologies that support clinician activity in the hospital are evolving rapidly. The EMR is a computer-based patient record that provides the components of a paper medical record such as progress notes, medication administration information, and laboratory results. There are additional benefits such as access of patient data by clinical staff at any defined location, support for automated claims processing with payers, and automated checks for drug and allergy interactions. The CPOE is a newer technology that provides electronic order entry. CPOE systems offer the additional benefit of providing physicians with computer-based aids for decision making, also termed clinical decision support systems (CDSS).

Additional technologies have been designed to specifically support glycemic management in the inpatient setting. For instance, POCT has evolved into a sophisticated tool for information gathering and reporting. Using the point-of-care instrument and connectivity with the laboratory and EMRs, blood glucose data are available to the clinician for evaluation and decision making. Despite significant advancements in equipment technology, many hospitals do not have the level of technology connectivity to support the more sophisticated capabilities of the instruments. Nor are the reports designed and utilized for performance-improvement activities. Most systems facilitate documentation, billing, and aggregating of blood glucose data. A new system, continuous glucose monitoring (CGM), is connected to the patient and provides multiple data points for recognizing blood glucose patterns. CGM supplies real-time data for anticipatory treatment rather than using retrospective data to guide treatment. As CGM becomes more commonly used in the hospital setting, treatment strategies will need to be modified.

Informatics features that will enhance the support of glycemia include data standards, interoperability, and connectivity, which will support data and information sharing across different healthcare entities. With chronic disease, information systems must support population-based assessment strategies and allow for multiple data input capabilities including web-based, touch screen, and telephony with interactive voice response. Such features will facilitate improvements in patient safety, quality, and cost-effectiveness. Patient safety is improved through electronic patient and clinician identification, POCT user authorization, and critical values notification. Quality care is enhanced through data trending and reporting on patient and provider outcomes. Financial benefits accrued to the hospital include

improved charge capture through POCT, improved productivity, and organizational efficiency.

The levels, the functions, operator competency, QC, tools and technologies, and desired features are presented in Table 1. The table depicts an example of the interaction of all stakeholders and their contributions to glycemic control—obviously a complex endeavor requiring system-wide communication and resolution. Interdisciplinary work groups or steering committees that work closely with information technology departments are necessary to achieve this goal.

Integrating technology between the individual, the unit/department, and the hospital-wide environment provides information at the point of service for decision making for patient care. Unit-level and hospital-wide reports facilitate practice improvement and lead to improved quality of care. Some of these reports include:

Patient view: Historical glycemic data and trending

Provider view: Treatment algorithm deployment

Unit view: Protocol adherence

POCT training, protocol adherence, and quality

Hospital view: Regulatory, safety, and POCT quality

Technology offers solutions for glycemic control; however, barriers to adoption exist. In the United States, health information technology adoption remains in its infancy. Adoption remains limited because of various concerns, including organizational issues such as cost of systems and productivity lost during transition from paper-based systems to computer-based systems. The lack of data standards to support connectivity between disparate systems and the lack of interoperability between different data sources impacts the usefulness of the system for the clinician (9). Such limitations often negatively impact workflow and increase resistance to adoption (10).

CONCLUSION

This article details the key challenges for effective information delivery to support glycemic control in the hospital inpatient setting. A multidisciplinary, system-wide approach to integrating tested tools and technologies will promote improved outcomes for people with diabetes. The increasing chronic disease epidemic and the changing dynamics in healthcare create a critical demand for technology as an enabler for improving care (11).

Further research and evaluation must be completed to develop greater systems-level technology support for glycemic control and other aspects of chronic disease care. Technology holds the promise of supporting redesign of care delivery methods. In addition to glycemic control, technology offers solutions to improving transition of the patient to the community and care coordination in the community. Currently, support efforts for glycemic control in

Table 1
Perspective: Stakeholder Contributions to Glycemic Control and Point-of-Care Testing (POCT) for Capillary Blood Glucose (BG)*

System level	Stakeholders	Functions	POCT operator competence	POCT quality control	Current tools and technologies	Technology features* desired
Individual	Physician	Orders medication Orders procedures Orders tests Discharges patient	Not applicable	Not applicable	Electronic medical record (EMR) Algorithms Progress notes Order sets Computerized physician order entry (CPOE)	Integrated view of POCT, labs, medication administration, and nutrition intake with clinical decision support systems (CDSS)
	Nurse	Performs test Gives medication Educates patient Provides discharge plan	Trained and certified per hospital policy	Machine and operator competence	Electronic medical record (EMR) BG record Medication administration record Patient education record Progress notes	Integrated view of POCT, labs, medication administration, and nutrition intake with clinical decision support systems (CDSS)
	Dietitian	Reviews BG results Calculates nutritional needs Evaluates medical nutritional therapy	Not applicable	Not applicable	Electronic medical record (EMR) Computational tools Progress notes	Integrated view of POCT, labs, medication administration, and nutrition intake with clinical decision support systems (CDSS)
	Pharmacist	Reviews medication orders Dispenses medication	Not applicable	Not applicable	Electronic medical record (EMR) Order sheet Medication administration record Progress notes	Integrated view of POCT, labs, medication administration, and nutrition intake with clinical decision support systems (CDSS)
Unit and/or Department	Patient	Responds to treatment	Not applicable	Not applicable	BG logbook Insulin pump Continuous glucose monitoring	Personal health record kept at home
	Nursing	Establishes policy for response to critical values (system defined) Training program for operators	Designs and administers: Training and certification plan for operators	Machine quality control (QC) of supplies, Operator competence Lab proficiency testing	Electronic medical record (EMR) Paper charts POCT records Medication administration records Flow sheets Policies Protocols	<i>Clinician view:</i> Integrated view of POCT, medication administration, nutrition intake, and patient education <i>Unit administrator view:</i> Operator competence and BG quality reporting
	Laboratory	Receives test requisition Assures machine QC Performs lab tests Validates critical values Reports results to units in timely manner	Participates in: Policy development Training Monthly reports	Oversees: Regulatory testing Meter/Lab result correlation Operator QC	Laboratory information system (LIS) Laboratory report Quality reports Billing	POCT connectivity with LIS Generates reports to review operator and patient identification, operator recertification, critical value results, appropriate comment-code usage Supports outcome initiatives

Table 1 (Continued)
Perspective: Stakeholder Contributions to Glycemic Control and Point-of-Care Testing (POCT) for Capillary Blood Glucose (BG)*

System level	Stakeholders	Functions	POCT operator competence	POCT quality control	Current tools and technologies	Technology features* desired
	Pharmacy	Reviews: Medication action Bills for POCT	Not applicable	Provides test strips and QC solution	Strip volume usage and QC of supplies Medication usage	Pharmacy activity reporting
	Nutrition Services	Assesses nutrition needs Provides meal plan Delivers food	Not applicable	Not applicable	Diet order tracking by unit	Dietitian/patient ratio for diet assessment and education Patient education supplies
<i>Hospital-Wide Support Services</i>	Information Services	Implements and supports technology Collaborates with end users for system design and training	Operator tracking, bar coding Consults for data management components of BG system	No direct responsibility	Network support of data connectivity functions Network support of data transmission for report development	System-wide approach for data collection, reporting, and evaluation Work with end users to develop reports for practice and outcomes monitoring
	Quality	Reviews reports for: Operator activity Patient safety Clinician performance	Not applicable	Not applicable	Patient, clinician, and operator level reports	Integrated reporting for individual, unit/department, and hospital-wide views
	Risk Management	Reviews reports for: Operator activity Patient safety Clinician performance	Not applicable	Not applicable	Patient, clinician, and operator level reports	Integrated reporting for individual, unit/department, and hospital-wide views
	Hospital Education	Trains staff	Participates in annual recertification	Teaches QC process	User training records New employee ID number	Operator certification integrated into POCT database and staff education record
	Diabetes Education Program	Provides diabetes self-management assessment and education Participates in clinical practice improvement efforts for glycemic control and patient safety issues	Clinical support for training content Co-leads (with Laboratory) policy development and review	Serves as resource for the clinical process with the care team	Patient education progress notes	Integrated view of POCT, labs, medication administration, and nutrition intake Integrated reporting for individual, unit/department, and hospital-wide views
Community	Primary Care Specialty Care Home Care	Provides diabetes management and diabetes self-management education and support	Per office protocol	Per office protocol	Paper charts POCT records Medication administration records Flow sheets Policies Protocols	Integrated view of POCT, labs, medication administration, and nutrition intake; that is, integrated with a personal health record that the patient maintains for continuity of care (Connection between inpatient and community)

*This is not a comprehensive list, but it can be used as a framework for further discussion and development for the inpatient setting.

the community also are being implemented in city, state, and national arenas. Trends include city-wide public-health department mandatory reporting of glucose, state-wide initiatives to improve diabetes care, telemedicine, and the personal health record for patients. Technology will support expanding the reach of the system and the clinician, which also will result in improvement of care.

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