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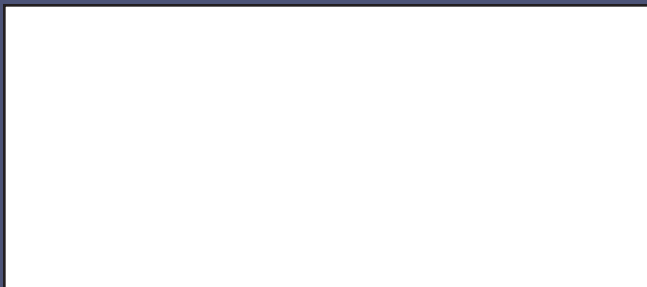
DECISION SUPPORT FOR CPOE

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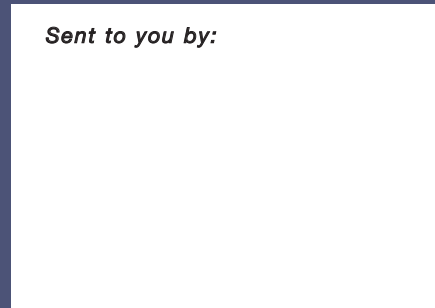
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Effective Use of Medication-Related Decision Support in

CPOE



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By Jane B. Metzger, BA; Emily Welebob, RN, MS; Fran Turisco, BES, MBA; and David C. Classen, MD, MS

If the rollout of computerized physician order entry (CPOE) follows on the heels of other advanced clinical system applications with significant decision support, such as electronic medication administration (eMAR) or clinical documentation, a core team of nurses, physicians, and pharmacists has already learned about the responsibilities and work of applying decision support on a large scale. However, in many hospitals, CPOE is the first advanced clinical application, and clinical decision support (CDS) applied so broadly is new and uncharted territory. Taking full advantage of this new capability to improve medication safety requires mastering each of the areas discussed below.

Build the structure for accomplishing the work of applying clinical decision support.

The logic of clinical decision support tools in CPOE that can guide and critique ordering is eventually applied to every targeted type of physician order. Mindful of what is at stake, hospitals proceed cautiously and deliberately. By now, most hospitals have invested in new group and individual roles and responsibilities to address quality and patient safety overall, and that structure is charged with integrating CDS into the strategy and tactics for improving medication safety (Provonost et al. 2008). Accomplishing this requires clear accountability and new processes to cover some areas such as the work of setting up and testing CDS, as well as ongoing monitoring and updating.

The major tasks of managing CDS tools are listed in Table 1 (pg. 18), along with recommendations and observations from many hospitals visited during development and testing of the evaluation tool and in other CPOE-related research (Metzger & Fortin, 2003; First Consulting Group, 2006). Although staff from the Information Systems Department (IS)—usually one or more physicians or nurse analysts who have mastered the CDS tools—play an important role, physician leaders (and to some extent pharmacists) with responsibility for patient safety own and lead this process.

Hospitals have standing committees such as Patient Safety or Medication Safety and often now a patient safety officer or medical director for patient safety for whom CDS in CPOE represents a new safety net to be applied during the ordering process. Strategy and direction for applying CDS comes from these individuals and groups. The group that ends up doing the day-to-day work of applying the CDS toolset to the identified targets includes physicians, clinical analysts who manage advanced clinical applications, and representatives of pharmacy, nursing, and other departments, often under the leadership of the chief medical information officer (CMIO) or patient safety officer.

Fold the Leapfrog order categories into the quality program.

The additional safety net that decision support in CPOE offers should be managed in coordination with that overall medication safety effort. The order categories in the Leapfrog CPOE evaluation provide a useful framework for applying CDS tools in CPOE (Table 2, pg. 19) because they were selected based on

available evidence concerning the frequency and severity of preventable medication errors (Kilbridge et al., 2001).

These categories should be considered along with local knowledge of high-risk situations as priorities and plans for working on CDS are developed.

Become expert in the CDS toolset in the CPOE application.

CPOE includes many features that work in different ways to improve ordering and physician decision-making about orders (Metzger & Turisco, 2001; Kuperman & Bobb, 2007). Vendor solutions differ significantly in the scope and design of the toolset and how easy it is to implement and manage. Hospitals purchasing CPOE should consider the design, presentation options, and management of decision support tools as one factor in selecting the right solution for their hospital. In hospitals further down the road with advanced clinical systems, getting to know the details about every function of the toolset is an important step in learning how best to apply them. Especially important is understanding the *limitations* of the current toolset. For what types of problem orders are the tools too rudimentary or lacking altogether? Can rules-based alerting be sufficiently fine-tuned to reduce nuisance alerting to an acceptable level? (Kuperman & Bobb, 2007). Vendors continue to enhance the toolsets, and requests from customer hospitals will likely speed progress.

Vendors take different approaches to integrating CDS into CPOE. Some tools reside in the application itself. For example, they may be set in the templates in the order master file or tables controlling the type and level of order

The authors published Part I of this article, "The Leapfrog Group's CPOE Standard and Evaluation Tool," in the July/August issue of *Patient Safety & Quality Healthcare*, which is available at <http://psqh.com/julaug08/cpoe.html>. Preparation for the evaluation is basically doing a good job with medication-related decision support. Part II provides advice about doing that based on what the authors have observed in many visits to hospitals in the course of developing the evaluation tool.

Table 1: Typical Processes for Managing Clinical Decision Support

Processes	Description	Keys to Success
Agenda setting/ targets	<ul style="list-style-type: none"> Individuals and committees request new application of CDS to support specific quality or safety objective. A steering committee reviews and prioritizes requests. Major changes to clinical policy or practice referred to Medical Executive Committee or other group for approval. 	<ul style="list-style-type: none"> Accountability for CDS linked with governance of medical practice (assigned to chief medical officer or other physician leader such as medical director of patient safety). Review and approval by appropriate accountable clinical leader or group. Effective communication and coordination among all individuals and groups.
Setup and testing	<ul style="list-style-type: none"> Analysts in IS setup and test new CDS in development system. One or more physicians may test new CDS on a provisional basis. 	<ul style="list-style-type: none"> Ability to set up and test new tools in other than the operational system. Status tracking (e.g., development, testing, release) and audit trail for CDS tools. Ability to release tools on a limited basis.
Review	<ul style="list-style-type: none"> Steering committee reviews and approves test. May require sign-off of Pharmacy and Therapeutics Committee or department chair. Some hospitals require physician sign-off on personal order sets. 	<ul style="list-style-type: none"> Formal accountability for different targets of CDS tools (medications, disease state).
Disseminate in operational system	<ul style="list-style-type: none"> New order sets available immediately. Batches of new CDS released at regular system updates. CDS addressing major (dangerous or high risk) situations released immediately. Physician community notified of major new CDS in advance and necessary training provided. Collect metrics (baseline if needed) to measure effectiveness. 	<ul style="list-style-type: none"> Effective processes for communicating with physicians about major updates (usually multiple modes are used).
Evaluate and update	<ul style="list-style-type: none"> Responsibility of committee authority. Review each application of CDS periodically to validate currency of clinical content or update as necessary. Monitoring of physician response to implemented CDS (acceptance, override). Physician feedback solicited. Collect metrics on targets of CDS and make changes as appropriate based on findings. 	<ul style="list-style-type: none"> Automated tracking of ownership, clinical research base, and update schedule for each “rule” or type of CDS (e.g., medication checking). Easy mechanisms (two-way) for physicians to provide feedback on form and/or content of CDS. Commitment to respond to each physician suggestion or complaint.

checking against a third-party medication database such as First Data Bank and Multum. However, other tools and the logic or tables that control activation and use may be bundled with the clinical data repository (CDR) or in a separate application (sometimes called the knowledge or rules engine).

Every hospital needs experts who understand the details for the CPOE solution being used. Often the CMIO and a pharmacy or nurse analyst in IS play this role; some hospitals are starting to add a pharmacist informaticist.

Becoming an expert requires not just inventorying all of the specific tools, but also gaining an understanding of what situations they target, how they work, and how to manage them. Table 3 (pg. 20–21) organizes the likely tools and describes how each category of tools applied to CPOE contributes to the goal of improving safety and quality of care. The last category of tools—rules-based surveillance—is strictly speaking not part of CPOE, though often thought of, and implemented in conjunction with CPOE. In fact, rules-based surveillance can be put to use long before CPOE (Classen & Metzger, 2003), and has been shown to speed response to new patient information by notifying

physicians of the need to reevaluate one or more orders (typically involving *medication* orders).

Integrate CDS rollout into CPOE plan.

“When to start applying CDS” and “How quickly to implement it” are two questions with which every hospital wrestles. On the one hand, everyone wants to proceed cautiously and not further complicate the task of getting physicians to enter their orders electronically. On the other hand, getting to “live” CPOE is a multi-year journey and delaying CDS further delays the objective—to improve ordering and patient safety.

Some of the most basic, but powerful, CDS tools are features of the order templates for each orderable item, which make up the order master file and determine the content, arrangement, and order-specific rules in the displays physicians use to enter their orders. Basic functions such as these are used to configure the system for the hospital and users, and common sense dictates employing them from the start.

Groups of pre-defined orders—in the form of order sets for specific clinical situations (i.e., admission, diagnosis) and commonly used orders (or departmental or personal “favorites”)—are also fairly basic CDS tools, which most hos-

Table 2: Medication Order Categories in the Leapfrog CPOE Evaluation

Order Category	Description	Examples
Therapeutic duplication	Medication with therapeutic overlap with another new or active order; may be same drug, within drug class, or involve components of combination products	Codeine AND Tylenol #3
Single and cumulative dose limits	Medication with a specified dose that exceeds recommended dose ranges or that will result in a cumulative dose that exceeds recommended ranges	Ten-fold excess dose of Methotrexate
Allergies and cross-allergies	Medication for which patient allergy has been documented or allergy to other drug in same category has been documented	Penicillin prescribed for patient with documented Penicillin allergy.
Contraindicated route of administration	Order specifying a route of administration (e.g., oral, intramuscular, intravenous) not appropriate for the identified medication	Tylenol to be administered intravenously.
Drug-drug and drug-food interactions	Medication that results in known, dangerous interaction when administered in combination with a different medication in a new or existing order for the patient or results in an interaction in combination with a food or food group	Digoxin AND Quinidine
Contraindication/dose limits based on patient diagnosis	Medication either contraindicated based on patient diagnosis or diagnosis affects appropriate dosing	Nonspecific beta blocker in patient with asthma
Contraindication dose limits based on patient age and weight	Medication either contraindicated for this patient based on age and weight or for which age and weight must be considered in appropriate dosing	Adult dose of antibiotic in a newborn
Contraindication/dose limits based on laboratory studies	Medication either contraindicated for this patient based on laboratory studies or for which relevant laboratory results must be considered in appropriate dosing	Normal adult dose regimen of renally-eliminated medication in patient with elevated creatinine
Contraindication/dose limits based on radiology studies	Medication contraindicated for this patient based on interaction with contrast medium in recent or ordered radiology study	Medication prescribed known to interact with iodine to be used as contrast medium in ordered head CT exam.
Corollary	Intervention that requires an associated or secondary order to meet the standard of care	Prompt to order drug levels when ordering aminoglycoside.
Cost of care	Test that duplicates a service within a timeframe in which there is typically minimal benefits from repeating the test	Repeat test for Digoxin level within 2 hours.

pitals stress at initial “go-live.” Aside from ensuring that orders are complete and appropriate, pre-defined orders and order groups also contribute to physician acceptance because they speed order entry significantly.

Groups and individuals charged with system configuration and set-up invest a great deal of time and effort to make CPOE quick (“speed is everything”) and easy to learn and use (Bates et al., 2003). In one large Veterans Administration hospital where significant resources were devoted to set-up, the effort yielded 667 order dialogs, 5,982 preconfigured (quick) orders, and 513 order sets organized in 703 order menus (e.g., for admission for a particular diagnosis). Project leaders reported that the investment paid off in both physician adoption and immediate curtailing of many common errors in ordering (Payne et al., 2003).

Beyond order set-up to encourage appropriate dosing and discourage inappropriate routes of administration and order sets, many hospitals move more slowly with other decision support to guide and critique medication ordering. Drug-allergy, drug-drug interaction, and sometimes therapeutic overlap checking are typically the first types of

order screening employed. Unfortunately, as demonstrated in a recent study, these types of medication errors only account for a small percentage of the preventable medication adverse events (4%, 2%, and 1%, respectively; Adams et al., 2008). The tools for addressing medication errors that account for more adverse events, such as renal status (19%), drug-lab (27%), and drug-age (9%) checking are more difficult to implement given the CDS tools in some vendor solutions (Adams et al., 2008). Teams in some hospitals address these with software customizations. Another look at the potential impact of CPOE concluded that “advanced clinical decision support features” are needed to address 50% of clinically significant prescribing errors (Bobb et al., 2004). Clearly more work remains for both hospitals and vendors to advance CDS tools and their use.

Be sure to deliver value.

Applying CDS effectively requires first that the specific tools used guide practice in the desired direction. As shown in Table 4 (pp. 22–23), the toolset provides a number of options that

Table 3: Clinical Decision Support in CPOE

Category of Clinical Decision Support	Description	Contributions to Safety/Quality	Function of Specific Tools
Basic field edits	Setting of basic parameters for contents entered into individual fields including numeric/text, decimal format, required fields; used to edit information entered such as dosage amounts	<ul style="list-style-type: none"> Reduced errors due to grossly erroneous information in order fields 	<ul style="list-style-type: none"> Order field format checking Required fields Checks for correct data type
Structured orders	Templates for each ordered service that specify data fields to be completed and guide choices with allowable values, defaults, and required fields	<ul style="list-style-type: none"> More complete, actionable orders Reduced errors of omission or commission through field entry appropriate to the type of intervention being ordered (route of administration) and local practice (dosage dispensed in pharmacy, timing of routine blood draws) 	<ul style="list-style-type: none"> Structured orders: route, dose, frequency, duration Required fields Default values Series orders/recurring orders Preset allowable value for route of administration Preset allowable value for available doses Check against hospital formulary Display of cost information
Groups of predefined orders	Pre-defined grouping of orders that can be selected by user as a starting point for patient-specific orders (order set, clinical pathway) or is displayed automatically (corollary order) whenever linked service is being ordered (e.g., a medication order that should be accompanied by an order to test blood levels of the medication to titrate dosing)	<ul style="list-style-type: none"> Reduced errors due to incomplete or erroneous information through use of sets of pre-structured orders with appropriate fields and field contents for each type of intervention being ordered and local practice Increased compliance with recommended care for particular diagnosis, procedure, and/or phase of management (admission, post-op for a given diagnosis or procedure) 	<ul style="list-style-type: none"> Standard order sets and ordering regimens Common order sets Common orders Personal order sets and favorite orders Order sets linked to clinical pathways Order set by diagnosis Corollary/linked orders for adjunct interventions (e.g., monitoring) Vendor-supplied starter sets
Order checking (with or without a reference database)	Checking of medication orders for drug interactions and contraindications (e.g., drug-drug and drug-allergy checking, min-max dose ranges, duplicate and therapeutic overlap checking.) For medications, likely to include the use of an industry reference database. Also checking of non-medication orders to duplicates within specified timeframes.	<ul style="list-style-type: none"> Reduced errors due to flagging of potential contraindications Improved quality due to facilitated access to reference information on medications Reduced ordering of unnecessary duplicate interventions 	<ul style="list-style-type: none"> Drug-drug interaction checking Drug-allergy interaction checking Drug-food interaction checking Drug-disease interaction checking Therapeutic duplication checking—within the same therapy (same drug) Therapeutic duplication checking—within a drug class Therapeutic duplication checking—with components of combination products Single dose limit checking Dose limit checking for each component of a combination product Medication checking of off-formulary items IV incompatibility checking Duplicate order checking Cost-of-care checking Exception documentation for alert overrides

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Table 3: Clinical Decision Support in CPOE (continued)

Category of Clinical Decision Support	Description	Contributions to Safety/Quality	Function of Specific Tools
Complex orders with specialized tools	Templates and tools such as dose calculators to guide entry of orders with complex dosing or administration requirements (e.g., taper dosing, sliding scale, alternate day dosing, custom TPN, chemotherapy)	<ul style="list-style-type: none"> • Reduced errors of omission and commission in complex orders • More accurate dosing calculations • Ability to capture broader range of patient orders with CPOE and include them in checking for contraindications 	<ul style="list-style-type: none"> • Complex administration times and dosages for medication orders • Patient-specific dosing and dosage checking • Sliding scale orders • Conditional orders • IVs • Patient-controlled analgesics • Adult TPN ordering • Adult chemotherapy ordering • Pediatric TPN ordering • Pediatric chemotherapy ordering
Order-relevant patient data display	Automatic display of patient information relevant to the intervention being ordered (typically laboratory data to be reviewed before ordering a medication)	<ul style="list-style-type: none"> • Facilitated review of patient information that might influence choice, timing, or dose of medication or other intervention 	<ul style="list-style-type: none"> • Automatic display of relevant patient information for that order
Order-relevant patient data capture	Prompting to verify and/or supply patient-specific information not included in orders, but needed to screen intervention for possible contraindications (e.g., allergy) or to perform necessary calculations (patient weight, body surface area); also includes prompting about clinical appropriateness with documentation of relevant clinical indications	<ul style="list-style-type: none"> • Expanded availability of relevant patient information for decision support (can serve as additional Q/A check on data routinely captured or supply information not captured electronically) • More appropriate use of targeted interventions and capture of relevant information for subsequent review or analysis of clinical appropriateness 	<ul style="list-style-type: none"> • Requirement for weight, height, or other information necessary for dosing • Requirement for allergy documentation • Linked appropriateness criteria requiring physician entry of data
Rules-based prompting and alerts within order entry	Real-time prompting and alerting at the time of order entry, based on explicit rules and a range of patient-specific electronic information. Includes patient-specific dosing (calculator, suggested dose, and/or dosage checking).	<ul style="list-style-type: none"> • Reduced errors of omission and commission in ordering 	<ul style="list-style-type: none"> • Customer-definable rules combining logic (nested “if’s”) and available patient data • User-friendly rule writer • Cumulative dose limit checking • Contraindication/dose limit checking based on patient diagnoses • Contraindication/dose limit checking <ul style="list-style-type: none"> - based on age/weight - based on lab studies - based on procedures • Patient-specific information drives allowable values for specified fields • Facilitated response to recommendation • Context-specific links to clinical knowledge
Rules-based surveillance with alerts outside of order entry	Prompting and alerting to reconsider ordered interventions based on new information regarding patient characteristics or status, with notification outside of electronic order entry	<ul style="list-style-type: none"> • Reduced delays in re-evaluating patient management strategy based on new information about the patient 	<ul style="list-style-type: none"> • Expiring orders alerts • Alerts based on new patient information— allergy or diagnostic test result • External notification • Coverage list • Escalation

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Table 4. Clinical Decision Support Tools to Apply to the Order Categories in the Leapfrog CPOE Evaluation

CDS Tools/Order Categories	Order Edits/ Structured Orders	Groups of Pre-defined Orders	Order Checking with/without Reference Knowledge Base
Therapeutic duplication			✓
Single and cumulative dose limits	✓		✓
Allergies and cross-allergies			✓
Contraindicated route of administration	✓	✓	✓
Drug-drug and drug-food interactions			✓
Contraindication/dose limits based on patient diagnosis		✓	✓
Contraindication/dose limits based on age and weight			✓
Contraindication/dose limits based on laboratory studies			✓
Contraindication/dose limits based on radiology studies			✓
Corollary/linked orders		✓	
Cost of care	✓		✓

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can be used singly or in combination to address each order category in the Leapfrog CPOE evaluation (patient safety experts generally recommend using more than one). It also requires that the guidance be delivered *in a manner acceptable to physicians*.

In keeping with the “speed is everything” caution of many early CPOE adopters (Bates et al., 2003), one dimension to consider when applying decision support tools is to fit within physician workflow so that interruptions and time are minimized. Decision support can be delivered in different forms. The *least* effective (and acceptable) form is a message that pops up and requires a physician response before getting back to order writing. Hence these must be used sparingly, if at all. A much better fit is information displayed alongside or choices pre-screened for appropriateness.

Clinical decision support also can be delivered at different times in the electronic ordering process, as shown in Table 5. The guiding principle with respect to timing of decision support is real-time at the right time.

Also important to physician acceptance is the relevance of CDS-generated advice and information to the current clinical situation (the physician perception of clinical value). Generally, the more the advice or choices are customized to this patient right now, the better (Bates et al., 2003). Moving to more customized decision support as displayed in Table 6 requires both more complex logic (and usually tools) and more comprehensive and up-to-date information about the patient. As hospital teams work on applying CDS, a second guiding principle is to provide tailored or customized advice most of the time. This leads to speedier ordering for physicians, as well as increased physician acceptance.

“Nuisance messages” is the term usually applied to CDS-delivered content the physician considers irrelevant to the situation at hand. (Note that combining information that is *not* useful with a delivery form often viewed as disruptive is especially annoying to physicians!) Because of the importance of minimizing nuisance messages, the team of expert advisors that assisted with development of the Leapfrog CPOE evaluation included detection of nuisance messages as part of the test (Kilbridge et al., 2001).



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Complex Orders with Specialized Tools	Order-Relevant Patient Data Display	Order-Specific Data Capture	Rules –Based Alerts within Order Entry	Rules–Based Surveillance with Alerts Outside of Order Entry
			✓	
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Table 5: Timing of Clinical Decision Support in CPOE

	Timing	Explanation
Least Desirable Timing	Physician has finished writing a series of orders for the patient and attempts to sign them. At this point, he/she is advised of possible issues with the orders.	Disconnected with thought process about ordering and interrupts work flow as the physician must go back to examine details of orders.
Better	Much advice and prompting is delivered as physician is writing orders. A small number of decision support screens are applied as the physician signs orders.	Interrupts thought process and work flow less than the approach above.
Most Desirable Timing	Virtually all rule-generated advice is delivered in real-time as the physician is writing the order through displays and pre-screened choices.	After-the-fact messages are not needed. Physician receives input at the right point in his/her thought process and does not feel interrupted.

Table 6: Customized Decision Support

	CDS Level	Explanation
Generic	<ul style="list-style-type: none"> All orders available for selection. Prompting about medication checking is general—applies to any patient in any clinical situation. 	Information made available to physician does not incorporate any screening related to this patient.
Tailored	<ul style="list-style-type: none"> Order sets for particular diagnosis and situation (admission for patient with a specific condition). Common orders for this clinical department /personal favorites. Prompting about medications or other intervention incorporates a few patient characteristics such as age and sex. 	Tailored to the clinical context in terms of basic dimensions such as type of decision, provider, or patient. Choices for physician to consider have been narrowed.
Customized	<ul style="list-style-type: none"> Choices displayed include designation of those not indicated for this patient based on patient-specific information. Order set highlights recommended options for this patient at this time based on information about patient history and status. 	Focused on the clinical context in accordance with multiple dimensions reflecting patient-specific history and situation, and type of decision.

Constant fine-tuning of decision support is needed to reach and sustain high value of the assistance delivered (a very high “hit rate”). Critical input to that effort comes from system reports on the frequency of CDS firing an alert or delivering a reminder and how often physicians take the advice given (by canceling or changing the order in some way). Hospital teams also actively solicit feedback at staff meetings, during rounds, or sometimes via a feedback button that makes it easy to submit comments or complaints while ordering.

Summing Up

The Leapfrog CPOE standard expects that the CDS tools in CPOE are aggressively applied to avoid potential adverse events that can be detected at ordering. It requires that physicians are entering most orders directly and benefiting from the safety net provided by CDS. Hospitals must work to gain the value available from the CDS toolset. Making effective use of the potential will require a concerted effort. **IPSQH**

Jane Metzger has done research and consulting on bringing computer support to the point of care for the past 36 years. She is a principal in *Emerging Practices*, CSC’s applied research arm. She has completed several studies on the successful adoption of CPOE in community hospitals and on using the clinical decision support tools in CPOE to improve patient safety and quality. She has also developed organizational readiness assessments and other tools that aid in planning for implementation of clinical IT that meets quality improvement objectives, including the development of the Leapfrog CPOE evaluation tool. Metzger may be contacted at jmetzger2@csc.com.

Emily Welebob has worked in leadership roles in clinical nursing, the clinical systems marketplace, and consulting related to clinical systems/EHRs for over 15 years, with a focus on patient safety. For the past 6 years, she was responsible for day-to-day management of the Leapfrog evaluation project in all phases. Welebob has published, lectured, and researched in the areas of clinical informatics and patient safety, including numerous efforts concerning CPOE. She is currently with the Indiana Health Information Exchange. Welebob may be contacted at ewelebob@ihie.com.

Fran Turisco is a principal in CSC *Emerging Practices*. Her more than 25-year career in health information technology includes programming, application implementation and management in delivery organizations, consulting, and research. Turisco’s recent research areas include physician order entry/clinical decision support, mobile computing to support point of care use, planning for emerging technologies, and IT support to clinical research. As a member of the Leapfrog project core team, she was responsible for the development and testing of the Web application for the CPOE evaluation tool and a survey of the CPOE vendor marketplace. Turisco may be contacted at fturisco@csc.com.

David Classen is a partner and chief medical officer at CSC—Healthcare. He is also an associate professor of medicine at the University of Utah and a consultant in infectious diseases at The University of Utah School of Medicine in Salt Lake City, Utah. Classen consults and has authored numerous publications on the use of IT-facilitated process change and decision support and epidemiologic techniques to improve medication safety. Classen serves as a member of advisory and working groups of the Institute of Medicine, Joint Commission, and National Quality Forum. He may be contacted at dclassen@csc.com.

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