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Using Technology to Promote Perinatal Patient Safety

Patricia Robin McCartney

Leaders in health care and national health policy recommend information technology information technology as a strategy to promote patient safety. Technology enables error prevention, surveillance, and analysis. Although there is little research about technology and safety in perinatal care, nurses in the specialty can use current evidence about the electronic health record, decision support systems, and medication safety devices to guide practice. This article includes key issues and general recommendations for the use of information technology to promote patient safety, the most common applications relevant to perinatal care, and strategies for perinatal nurses who implement information technology to promote patient safety. *JOGNN, 35,* 424-431;2006. DOI: 10.1111/J.1552-6909.2006.00059.x

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Technology is strongly endorsed by health care experts as a way to improve patient safety, and expectations for successful implementation are high. Technology can promote a safe environment for nursing practice by reducing negative exposure to risk and liability. Despite these endorsements and expectations, nurses cannot make assumptions about the effectiveness of technology. Information technology (IT) applications can promote a safe environment for patients, but nurses must consciously integrate technology tools into a nursing process framework and seek automation *in* nursing rather than automation *of* nursing. Automated processes are designed to prevent errors, not necessarily to make clinical care easier for the nurse. As the use of technology accelerates, providers grapple with questions about the benefits and limitations of technology.

Is there evidence that technology is effective in promoting perinatal patient safety? Published research on technology and safety is limited. Most studies are nonexperimental and retrospective, and few have been conducted in a perinatal setting. Comparisons between studies are difficult since the studies use different combinations of IT and different error definitions and measures. Traditional paper methods of error reporting result in underreporting of errors, so comparison of error rates before and after implementation of technology may not be accurate. Some studies do support the effects of technology on reducing errors (Bates et al., 1998; Kaushal, Shojania, & Bates, 2003), while other studies raise concerns about a lack of effectiveness and the introduction of new errors or unintended consequences (Bradley, 2005; Koppel et al., 2005; Nebeker, Hoffman, Weir, Bennett, & Hurdle, 2005).

How can perinatal nurses thoughtfully appraise current evidence and implement technology to promote patient safety? This article will highlight general recommendations for the use of IT in promoting patient safety and key issues in using IT to promote safety, review evidence (research and expert consensus) on the most common applications that are relevant in perinatal care, and suggest strategies for perinatal nurses implementing IT to promote patient safety.

Information Technology Recommendations and Initiatives

Leaders in health care, government, and nursing endorse IT as a patient safety solution. The Institute

of Medicine (IOM, 1999, 2001) recommended a number of technology strategies to improve patient safety, including computerized provider (or physician) order entry (CPOE), pharmaceutical software to intercept prescribing errors, bar code medication administration (BCMA), electronic medication administration records, intelligent infusion pumps, and decision support systems (DSSs). The IOM (2001) also set a goal to implement a fully electronic health record (EHR) and eliminate most handwritten data in clinical records within the decade. In response, the U.S. Department of Health and Human Services (2005) identified the effective use of health information technology (HIT) as a national priority, set a goal to establish EHRs in a national health information network, and appointed a National Coordinator for HIT. Federal leaders clearly endorse HIT as an important part of the national patient safety agenda (Clancy, 2005). The Joint Commission on Accreditation of Healthcare Organizations (JCAHO) 2006 National Patient Safety Goals and Related Requirements included "Improve the effectiveness of communication among caregivers" and "Improve the safety of using medications" (JCAHO, 2005). Both goals address risks that IT is designed to reduce.

> The U.S. Department of Health and Human Services identified the effective use of HIT as a national priority.

The American Academy of Nursing (AAN, 2003) initiated the AAN Technology Project, a multiphase project to examine how technology can support safe and effective nursing practice, including a focus on the integrated EHR, decision support, and medication safety technology. An expert panel convened following a recent International Conference in Nursing Informatics to discuss Improving Patient Safety with Technology and published the proceedings as a special issue of the International Journal of Medical Informatics (Marin, 2004). All these activities indicate that IT will expand in perinatal care, and nurses need to be informed to shape the practice.

Key Issues in Using IT to Promote Safety

Technology promotes patient safety through *prevention* of errors and adverse events, *surveillance* that facilitates a rapid response and minimizes harm after an error occurs, and *evaluation* of errors. The goals of adding IT to promote patient safety are promoting accurate communication of data and effective error analysis, while minimizing "workarounds" (overriding the automated system to accomplish a task).

Communication

Effective communication of patient data promotes prevention and surveillance. Information technology enables more complete and timely data documentation, storage, organization, integration, retrieval, and transfer than a paper-based system.

Error Analysis

Electronic databases can facilitate the retrospective analysis of errors and identify more errors than a paper system. Reported errors in labor, delivery, recovery, and postpartum were examined in a secondary analysis of the MedMARx electronic database (an anonymous, Internet-accessible, national medication error–reporting database, based on voluntary reporting). This analysis indicated the majority of reported errors occurred in the administration phase of the five-step "medication use process" (prescribing, documenting-transcribing, dispensing, administering, monitoring response) (Beyea, Kobokovich, Becker, & Hicks, 2004). Although technology-related causes of error (such as dispensing device error, improper pump use, drug distribution system, and computer entry) ranked low in frequency, every setting reported errors involving infusion pumps, including incorrect programming and confusion among multiple medication infusions.

Voluntary error-reporting systems may not fully represent all the errors that actually occur. Computerized devices with an activity log, similar to an airline "flight recorder," can identify medication errors more thoroughly than volunteer reporting. Thus, errors are more visible than in paper format, and consequently a higher rate of errors will be reported (Nebeker, Hoffman, Weir, Bennett, & Hurdle, 2005). Automated devices may also produce new types of errors. One team did identify the potential for new errors in entering, retrieving, and communicating information because computer screens were poorly designed (Ash, Berg, & Coiera, 2004).

Workarounds

When a technology device is inflexible, caregivers develop a "workaround" or alternative approach to override the system and accomplish the desired task. Any workaround or override behavior is an indication that the technology process is not compatible with the human work process. Evaluation of a workaround or override provides an opportunity for improving safety.

Information Technology Applications

Perinatal nurses need to examine evidence about IT safety effectiveness to plan applications with women and newborns. However, few publications exist about experiences with IT in perinatal care. A review of EHRs, DSSs, and medication safety devices offers some background on the advantages, unintended consequences, and challenges for perinatal nurses to consider. Important new terminology and abbreviations are listed in Table 1.

TABLE 1
Acronyms in Information Technology and Patient Safety

ADE	Adverse drug event
ADU	Automated (drug) dispensing unit
AE	Adverse event
BCMA	Bar code medication administration
CPOE	Computerized provider (physician) order entry
CIS	Clinical information system
COW	Computer on wheels
CPR	Computerized patient record
DERS	Drug (dose) error reduction software
DL	Drug library
DSS	Decision support system
EBP	Evidence-based practice
EHR	Electronic health record
EMAR	Electronic medication administration record
FMEA	Failure mode and effects analysis
HIT	Health information technology
IT	Information technology
NDC	National drug code
PADE	Potential adverse drug event
PDA	Personal digital (data) assistant
POC	Point of care
PRBC	Pump readable bar codes

Electronic Health Record

An integrated electronic record can promote patient safety as the framework for processing clinical information and linking various technology applications. The EHR includes the patient's health or medical information linked within a network or clinical information system. The network may include a continuum of care within a single health care organization, from ambulatory prenatal care to inpatient birth, postpartum, and newborn settings. The proposed national health information network will link the EHRs from separate organizations into a larger network, so prenatal data from one agency can be shared with another.

An electronic system can enhance multidisciplinary patient data collection, organization, communication, and sharing. Data, such as an expected delivery date or previous cesarean birth incision type, are entered into the record in real time, at the point of care, and only need to be entered once. The data in the record are legible, organized, and integrated with the entire record. These integrated data are available for multiple providers simultaneously, around the clock, and from different care locations.

The EHR can produce an activity log for error analysis and quality improvement. But an EHR that is not in synch with staff follow-through can have the opposite effect and increase errors. A medication error nearly occurred when a patient's room number was changed on a computer bed listing before the patient was moved into the room (Agency for Healthcare Research and Quality, 2004). When the nurse read the computer medication listing for the new patient, the medication intended for the new patient was brought to the bedside, but the patient in the bed was not the new patient. The previous patient had not yet been moved out of the room.

Decision Support System

An automated DSS is software in the computerized clinical system that provides information to plan safe care. Information might include evidence-based standards and guidelines, protocols and procedures, rules and recommendations for care, drug reference and calculation tools, and links to a library database, digital textbook, or Internet reference. Decision support systems bring standardized, evidence-based practice resources to the point of care and promote patient safety (Bakken, Cimino, & Hripcsak, 2004).

The software can prompt the user for individual patient data to tailor the plan of care. The systems can trigger reminders for the user to initiate standard care (including preventive care such as antepartum Rh immunoglobulin or intrapartum group B *Streptococcus* prophylaxis), alert the user about risks (allergies, critical laboratory values, such as low platelet count), and facilitate a rapid response.

Decision support can be embedded in the system, so information is automatically presented to the user, rather than requiring the user to actively seek the information. Programs that automatically present information are referred to as "push" technology that "pushes" suggestions to the clinician (Ball, Weaver, & Abbott, 2003). The IOM (1999, 2004) recommends avoiding reliance on memory and promotes using computers to establish forcing functions (forces the right action) and constraints (makes the wrong action hard to do). A systematic review of 100 controlled trials of DSS confirmed an improvement in provider performance (using diagnostic, reminder, disease management, and drug dosing or prescribing systems) but inconsistent improvement in patient outcomes (Gage et al., 2005). The improved performance was associated with components of the system that automatically prompted users to access information (push) compared with components that required users to activate the system (pull).

Wireless devices (such as a handheld, tablet, laptop, or cell phone computer) can integrate the EHR with decision support. Surveillance of care and documentation in the record can be done at the point of care or remotely, while accessing or being prompted by decision support information. The nurse can enter assessments and interventions promptly, before moving on to care for another patient. Providers can review clinical data and enter orders directly into the patient record and medication order system without delay.

Jenkins, Hewitt, and Bakken (2006) monitored the interventions of women's health nurse practitioner students through the analysis of personal digital assistants (PDA) activity logs. Handheld computers combined with a cellular phone were used to notify the clinician about critical laboratory values and enable a rapid response to an adverse event (Bates & Gawande, 2003). Nursing students can use PDAs to retrieve patient safety–related information at the point of care, including a pharmacy database, evidence-based guidelines, and guides for assessment and diagnostic tests (Bakken et al., 2004).

Medication Safety

Medication safety devices are designed to reduce errors in all five stages of the medication use process (prescribing, documenting-transcribing, dispensing, administering, monitoring response). Although these devices are recommended and supported with some research data, nurses must recognize the device limitations and challenges.

The automated drug-dispensing unit (ADU), a computerized cabinet of stock medications located on the patient unit, is the most widely used of the medication IT devices. The ADU provides rapid medication access and tracking from the point of order entry to removal from the cabinet, thereby promoting safety in the phases of documenting-transcribing, dispensing, and administering. But the ADU can be vulnerable to many unsafe medication behaviors. As nurses have become more experienced with ADUs and the potential risks, useful strategies to eliminate unsafe behaviors and prevent errors can be found in the nursing literature. Table 2 summarizes key points to promote safety in the use of ADU.

Misuse of the override function, an example of a workaround to complete a task, is repeatedly identified as a serious risk because the safeguard of the pharmacist review is bypassed. A careful analysis of the failure to be able to access an ADU in an emergency room identified unexpected vulnerabilities and served to educate the users to anticipate and correct vulnerabilities (Perry, Wears, & Cook, 2005). In one review of ADU errors, the most frequent error type was an improper dose, the most frequent cause of error was the drug distribution unit (stocked incorrectly), and the most frequent medication phase of the error was dispensing (stocking) (U.S. Pharmacopeia, 2004). Because errors seem to cluster around stocking, nurses must double-check all medications when removed from the device.

Many experts recommend combining bar coding with the ADU to improve the accuracy of stocking. In an effort to promote use of BCMA, the U.S. Food and Drug Administration now requires manufacturers to place the bar code for the National Drug Code number (which uniquely identifies the drug) on packaging for most prescription drugs (U.S. Food and Drug Administration, 2004).

BCMA is designed to prevent medication errors and not to speed up medication administration. With BCMA, the nurse administers medications at the point of care (bedside) by logging into the computer system as the user (possibly by scanning a bar code on the nurse's identification badge), scanning the bar code on the patient identification band to produce a screen with the patient's medications, and finally scanning the bar code on the medication package, which verifies a correct match and subsequently documents the administration in real time on the electronic medication administration record.

TABLE 2
Steps to Promote Safety in Use of ADU

Make certain a pharmacist reviews (double-checks) each new order before removing the new medication from the ADU
Perform another double-check when removing the medication from the drawer (to guard against stocking errors)
Remove only one dose for a single patient at the time that it is needed (do not remove multiple medications for multiple patients at the same time)
Do not store high-alert medications in an ADU
Do not return unused doses to an ADU
Do not place medications with similar names or packages in the same drawer
Use any alerting or reminding functions that are available in the ADU system
Do not use the override function to obtain a medication without an approved order
Limit the override medication list and personnel who can access the override function
Form a multidisciplinary committee to develop clinical criteria for an override (e.g., emergent clinical situation, only medications packaged as "ready to use," no "high alert" medications)
Educate staff on the proper use of the override function
Monitor and analyze override reports carefully to determine the patterns of overrides, including errors

Note. ADU = automated drug-dispensing unit.

Based upon Grissinger and Globus (2004); U.S. Pharmacopeia (2004).

This process incorporates important administration safeguards: Medications are prepared for one patient at a time; the right patient is identified; when the drug is scanned, the match verifies the right dose, route, and time; and the administration is not documented until the medication is about to be given at the point of care, although before the patient actually receives it. The BCMA may include decision support, such as incompatibility or unusual dose alerts, and electronic drug references (drug library).

Some reported disadvantages of BCMA include difficulty of transporting the equipment (a portable computer with the bar code reader is taken to the bedside, such as a laptop, tablet, handheld, or computer on wheels), poorly functioning scanners, and identification bands that do not scan reliably unless the bar code is held flat.

Medication administration errors may occur with bar coding when order changes are not promptly transmitted or deviations from medication routines, such as standard administration times, are necessary. Scanning the patient and medication bar codes documents the actual time of administration and identifies medications not actually given "on time." Because of this feature, the most commonly cited problem with BCMA is the nurses' perceived pressure to scan all medications "on time," a challenge that leads to workarounds. One perinatal nurse described scanning after actual administration of oxytocin infusions and medications self-administered by postpartum mothers, but still concluded that scanning had prevented medication errors on the unit (E. Frager, online communication, July 1, 2005).

In one setting, BCMA implementation produced a sustained decrease in medication administration errors and high acceptance by nurses, although the authors of this report did not clarify how errors were measured (Coyle & Heinen, 2005). A pilot installation of handheld BCMA in a perinatal setting resulted in a 67% decrease in administration errors in the first 4 months of operation (Work, 2005).

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However, when the paper-based medication error rate in dispensing (based on pharmacy incident reports) and administration (based on nursing incident reports) was compared with the automated medication error rate log for dispensing and administration 12 months after BCMA implementation, an 18% increase in error rate was found. The authors attributed the increased rate to more accurate reporting with the automated log (Low & Belcher, 2002).

In an ethnographic study of medication administration before and after implementation of BCMA, Patterson, Cook, and Render (2002) observed that nurses developed workarounds for the real-time documentation of medications, especially during high workload periods, and believed the timeliness of medication documentation was overemphasized in the BCMA system. To enable more efficient medication preparation and administration, the nurses bypassed scanning the identification bar code on the patient by typing the identification number into the computer rather than wheeling the computer into the patient's room, scanning duplicate identification bands housed in a central location, or "batch" scanning medications for multiple patients before administration.

Radio frequency identification (RFID) can read identification tags with greater versatility (does not require line of sight) and range (across a room). It is expected to replace bar code scanning. The RFID tags are now used in newborn security systems and could be used for both patient and staff identification (for access to locked units) and tracking (to identify an individual's location).

Computerized Medication Order Entry

Computerized provider (or physician) order entry allows providers to enter orders directly into the patient record with simultaneous transmission to pharmacy. The software can promote safety by forcing standard dosage and administration formats (e.g., protocols for oxytocin and magnesium sulfate infusions). Any orders outside the standards require deliberate additional operations. The CPOE software can integrate the patient's clinical data (e.g. allergies, age, weight, laboratory results) and medication decision support (standard dosages, dose limits, calculation tools, interactions, contraindications) into the medication order process. Computerized provider (or physician) order entry can monitor laboratory results and identify when results create a contraindication for a given medication (e.g., magnesium level and magnesium sulfate infusion). Advantages of CPOE over paper-based orders include integration with patient data, legible orders, immediate transmission throughout the system, and standardization of dosages, administration times, and abbreviations.

Advantages of CPOE include integration with patient data, legible orders, immediate transmission throughout the system, and standardization of dosages, administration times, and abbreviations.

Bates et al. (1998) found a reduced rate of errors with CPOE when medication errors before and after implementation of a CPOE were compared in a retrospective analysis of incident reports and chart reviews. In another chart review study, prescription errors were compared between the handwritten method and a CPOE with both a drug library and a link to the patient's individual clinical database (Oliven et al., 2005). The CPOE system resulted in significantly fewer errors, especially errors resulting from drug and allergy, disease, or laboratory interactions. Errors in drug ordering and administration decreased according to a prospective chart review of combined use of CPOE and BCMA (Weir, Hoffman, Nebeker, & Hurdle, 2005). Errors in transcription and administration phases decreased in another descriptive study of CPOE and BCMA (Nebeker et al., 2005). The authors suggested that errors in the ordering phase were not reduced because the CPOE did not have decision support software. Koppel et al. (2005) claimed CPOE facilitated "prescription error risks," based on a study including interviews and observations of physicians, pharmacists, informaticists, and nurses. However, Bates (2005) challenged the methodology used in Koppel's study because "perceived risks" or the "likelihood of error" was measured rather than actual errors.

Neonatal intensive-care unit settings may benefit from CPOE implementation. Cordero, Kuehn, Kumar, and Mekhjian (2004) found no medication errors in the 6 months after installation of CPOE interval in a neonatal intensive-care unit, based on a retrospective review of selected drugs (caffeine and gentamicin). Giannone (2005) reported successfully customizing a neonatal CPOE product to calculate weight-based medication infusions for ill neonates but did not identify the effect of the calculation support on error rates.

Smart Pumps

Intelligent infusion pumps could promote medication safety with infusions on labor and delivery units and neonatal intensive-care unit. With standard infusion pumps, reported errors consist of the insertion of the wrong medication syringe and programming an incorrect decimal setting (U.S. Pharmacopeia, 2004). Intelligent infusion pumps contain drug error reduction software for a range of safety functions beyond the standard pump protections, including a link to a decision support drug library, integration with BCMA, and a log report of drug name, concentration, rate, administration times, and alerts.

In one setting, a prospective risk analysis including failure mode and effects analysis predicted a number of potential errors in intravenous drug administration, most commonly administering the wrong dose of a medication because of an error in programming the infusion pump (Adachi & Lodolce, 2005). Based on this risk analysis, the team implemented standardized orders and "smart" infusion pumps with advanced safety software.

Human error may still occur after smart pump implementation. In a cardiac surgical intensive-care unit, Rothschild et al. (2005) compared the medication error rate (near misses and preventable adverse drug events) of infusion pumps with and without decision support software. The smart pumps did not reduce the rate of serious medication errors, but most of the adverse events were associated with human and not device failure. The pump logs revealed that nurses frequently bypassed the drug library because it was optional (25%), administered verbal orders without order documentation (7.7%), and overrode alerts. The authors believed these violations led to the failure to reduce the error rate. As a result of this study, using the drug library was made the default, forced action. In a setting with paper-based provider orders, errors associated with orders, labeling, patient identification, and documentation were more common than pump programming mistakes (Husch et al., 2005). These researchers concluded that smart pumps must be fully integrated with other information systems, such as the EHR, CPOE, BCMA, and pharmacy to effectively reduce errors.

Strategies for Using IT to Promote Perinatal Patient Safety

Nurses at all levels of the health care organization must take the lead in selecting, implementing, and evaluating IT to promote patient safety. Comprehensive strategies should include the following.

Establish a Team Approach

All stakeholders in the health care organization that will interact with the technology must be involved in selection, implementation, and evaluation of technology. This includes nurses, physicians, pharmacists, informaticists, and vendors. Staff nurses are typically the end users of technology and consequently must be involved in the planning. Nurses can keep the project focus on patient-centered and nursing-sensitive outcomes.

Develop a Well-Planned Strategy for Change

Prepare for resistance to change and initiate measures to support the change process.

Examine Work Processes

Task analysis of both manual and automated work processes is necessary to understand how work is done. Technology alone will not reduce errors; it must fit the way people work. What are the current redundancies or double checks that serve as safeguards? How are discrepancies currently reconciled? How will technology change the way that work is done?

TABLE 3
Internet Resources on Information Technology and Patient Safety

Online newsletters and discussion lists	Agency for Healthcare Research and Quality Patient Safety E-Newsletter: http://www.ahrq.gov/qual/ptsflist.htm National Patient Safety Foundation: http://www.npsf.org/html/l-comm.html Nursing Informatics (nrsing-l): http://mailman.amia.org/mailman/listinfo/nrsing-l Perinatal Nursing (pnatalrn): http://nursing.buffalo.edu/mccartny/perintal.htm
Health information technology site	Health Information and Management System society: An auto-ID virtual tour (including a prenatal through birth experience): http://www.himss.org/ASP/topics_autoid_tour.asp?faid=76&tid=12#

Use Standard Devices Across the Health Care Organization

Multiple technology applications (multiple electronic records, multiple infusion pumps) that are not integrated can cause confusion, increase communication breakdown, and impair access to information. Avoid dual documentation in electronic and paper formats.

Provide Thorough Workforce Education for Technology

The ultimate goal of patient safety must be emphasized, especially when productivity decreases in the beginning of the learning curve. Dedicated resources are needed to provide the time and mentoring needed for transformation of work processes.

Do Not Work Around Ineffective Technology

Workarounds almost always bypass important safeguards and increase the risk of errors. When automated systems fail, fix the process. Analyze system overrides to identify causes and design solutions.

Evaluate the Effect of IT on Safety in the Perinatal Setting

Evidence for practice can come from error analysis, performance improvement projects, and research. Evaluation should occur within the multidisciplinary team. Error analysis must include not only quantitative outcome summaries of error events but examination of processes to identify how and why errors were reduced or generated. Automated activity logs and override reports can be used to identify unintended consequences and risks. Evidence will inform users about the advantages and limitations of the particular technology.

Foster Continuing Education in Nursing Informatics

Communicate IT project outcomes with colleagues through conference presentations and publications. Current and future nurses need to be competent in informatics to actively participate, translate, and lead in multidisciplinary implementation projects. Professional nursing literature on using technology to promote safety is limited; much of the available information is shared through technology conferences, Internet sites, and online discussion lists (Table 3).

Summary

Information technology is repeatedly recommended to promote patient safety, and IT use in perinatal care will only increase. While there is evidence that IT does reduce errors, there is also evidence that IT produces unintended consequences. Challenges remain for perinatal nurses, including integration of the tools into the unique work processes of caring for women and newborns, and ongoing error analysis. Nurses cannot presume that applications will function similarly or reduce errors. Nurses can take an active role in the selection, implementation, and evaluation of IT to promote perinatal patient safety.

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Patricia Robin McCartney, RNC, PhD, FAAN, is a clinical professor at the School of Nursing, University at Buffalo, The State University of New York, and a staff nurse in Labor and Delivery, Sisters Hospital, Buffalo, NY.

Address for correspondence: Patricia Robin McCartney, RNC, PhD, FAAN, School of Nursing, University at Buffalo, The State University of New York, 812 Kimball Tower, 3435 Main Street, Buffalo, NY 14214. E-mail: mccartny@buffalo.edu.