

PEDIATRICS®

OFFICIAL JOURNAL OF THE AMERICAN ACADEMY OF PEDIATRICS

Voluntary Anonymous Reporting of Medical Errors for Neonatal Intensive Care

Gautham Suresh, Jeffrey D. Horbar, Paul Plsek, James Gray, William H. Edwards, Patricia H. Shiono, Robert Ursprung, Julianne Nickerson, Jerold F. Lucey, Donald Goldmann and for the NICQ2000 and NICQ2002 investigators of the Vermont Oxford Network

Pediatrics 2004;113;1609-1618

DOI: 10.1542/peds.113.6.1609

The online version of this article, along with updated information and services, is located on the World Wide Web at:

<http://www.pediatrics.org/cgi/content/full/113/6/1609>

PEDIATRICS is the official journal of the American Academy of Pediatrics. A monthly publication, it has been published continuously since 1948. PEDIATRICS is owned, published, and trademarked by the American Academy of Pediatrics, 141 Northwest Point Boulevard, Elk Grove Village, Illinois, 60007. Copyright © 2004 by the American Academy of Pediatrics. All rights reserved. Print ISSN: 0031-4005. Online ISSN: 1098-4275.

American Academy of Pediatrics

DEDICATED TO THE HEALTH OF ALL CHILDREN™



Voluntary Anonymous Reporting of Medical Errors for Neonatal Intensive Care

Gautham Suresh, MD*‡; Jeffrey D. Horbar, MD*‡§; Paul Plsek, MS‡||; James Gray, MD‡¶; William H. Edwards, MD‡#; Patricia H. Shiono, PhD‡§; Robert Ursprung, MD‡¶; Julianne Nickerson, MSW‡; Jerold F. Lucey, MD*‡§; and Donald Goldmann, MD‡**, for the NICQ2000 and NICQ2002 investigators of the Vermont Oxford Network

ABSTRACT. *Objectives.* Medical errors cause significant morbidity and mortality in hospitalized patients. Specialty-based, voluntary reporting of medical errors by health care providers is an important strategy that may enhance patient safety. We developed a voluntary, anonymous, Internet-based reporting system for medical errors in neonatal intensive care, evaluated its feasibility, and identified errors that affect high-risk neonates and their families.

Methods. Health professionals ($n = 739$) from 54 hospitals in the Vermont Oxford Network received access to a secure Internet site for anonymous reporting of errors, near-miss errors, and adverse events. Reports used free-text entry in phase 1 (17 months) and a structured form in phase 2 (10 months). The number and types of reported events and factors that contributed to the events were measured.

Results. Of 1230 reports—522 in phase 1 (17 months) and 708 in phase 2 (10 months)—the most frequent event categories were wrong medication, dose, schedule, or infusion rate (including nutritional agents and blood products; 47%); error in administration or method of using a treatment (14%); patient misidentification (11%); other system failure (9%); error or delay in diagnosis (7%); and error in the performance of an operation, procedure, or test (4%). The most frequent contributory factors were failure to follow policy or protocol (47%), inattention (27%), communications problem (22%), error in charting or documentation (13%), distraction (12%), inexperience (10%), labeling error (10%), and poor teamwork (9%). In 24 reports, family members assisted in discovery, contributed to the cause, or themselves were victims of the error. Serious patient harm was reported in 2% and minor harm in 25% of phase 2 events.

Conclusions. Specialty-based, voluntary, anonymous Internet reporting by health care professionals identified a broad range of medical errors in neonatal intensive care and promoted multidisciplinary collaborative learning.

Similar specialty-based systems have the potential to enhance patient safety in a variety of clinical settings. *Pediatrics* 2004;113:1609–1618; *patient safety, medical error, adverse events, medication error, iatrogenic, error reporting, quality improvement, multidisciplinary teams, neonate neonatal intensive care, Internet.*

ABBREVIATIONS. JCAHO, Joint Commission for Accreditation of Healthcare Organizations; NICQ, Neonatal Intensive Care Quality; IP, internet protocol; NICU, neonatal intensive care unit; FMEA, failure mode and effects analysis.

In its landmark report *To Err Is Human*,¹ the Institute of Medicine recommended establishing centralized reporting systems for medical errors and adverse events, with the goal of identifying medical errors, understanding their causes, and making system-wide changes to reduce their frequency. An ideal external reporting system would have the following core features²: centralized collection, collation, and expert analysis of reports of errors, near-misses (close calls), and adverse events from individual health care institutions or providers; confidential or anonymous, nonpunitive reporting; prompt dissemination of warnings (“alerts”) to participating institutions about specific hazards to patient safety; and actionable recommendations to improve systems of care and promote patient safety. In aviation and other high-risk industries, such systems for reporting and feedback have facilitated rapid advances in understanding the factors that contribute to errors and have led to systems improvements that have dramatically improved safety.^{3,4}

There are a number of generally available reporting systems in the United States, but none is fully responsive to the Institute of Medicine’s call for a national voluntary reporting system for all types of serious errors and potentially preventable adverse events. The Sentinel Event system of the Joint Commission for Accreditation of Health care Organizations (JCAHO)⁵ collects reports on events that lead to serious patient harm but does not solicit reports of near misses. Other reporting systems are restricted to specific types of events. For example, the Centers for Disease Control and Prevention’s National Nosocomial Infection Surveillance system⁶ focuses on nosocomial infections. The MedMARx system of the United States Pharmacopeia⁷ and the Institute for

From the *University of Vermont College of Medicine, Burlington, Vermont; ‡Center for Patient Safety in Neonatal Intensive Care, University of Vermont, Burlington, Vermont; §Vermont Oxford Network, Burlington, Vermont; ||Paul E. Plsek and Associates, Inc, Atlanta, Georgia; ¶Beth Israel Deaconess Medical Center, Boston, Massachusetts; #Dartmouth-Hitchcock Medical Center, Lebanon, New Hampshire and; **Children’s Hospital Boston, Boston, Massachusetts.

This work was presented in part at the Pediatric Academic Societies’ annual meeting; Seattle, WA; May 2003.

Received for publication Aug 20, 2003; accepted Oct 23, 2003.

Reprint requests to (G.S.) Department of Pediatrics, Given Bldg, University of Vermont College of Medicine, Burlington, VT 05405. E-mail: gautham.suresh@vtmednet.org
PEDIATRICS (ISSN 0031 4005). Copyright © 2004 by the American Academy of Pediatrics.

Safe Medication Practices system⁸ are restricted to medication errors.

A comprehensive national voluntary reporting system for all types of medical errors and adverse events is likely to be expensive, unwieldy, and technically challenging.² Alternatively, programs tailored to specific segments of the health care system, such as the nascent Patient Safety Reporting System of the Department of Veterans Affairs,⁹ or programs focused on specific medical specialties may be more feasible and acceptable to health care providers. The potential advantages of specialty-based systems include the credibility and commitment of those who run them, the allegiance of reporters to their specialty and its expert opinion leaders, and the direct relevance of reporting and feedback to specialty practice.^{2,10,11} Aggregate data on specialty-specific errors from such systems can serve to raise the awareness of errors in that specialty and provide a stimulus to improve specialty-specific health care delivery systems.

To date, there have been only a few descriptions of specialty-based external reporting systems, principally in adult intensive care units.^{12,13} No such system exists for neonatal intensive care. Before widespread development and implementation of error reporting systems by individual specialties commences, the feasibility of such systems and the factors that enhance or impede their success should be studied. As part of the Neonatal Intensive Care Quality (NICQ) Collaborative sponsored by the Vermont Oxford Network, we developed a multi-institutional, voluntary, anonymous, Internet-based reporting system for medical errors in neonatal intensive care, evaluated its feasibility, and identified errors that affect high-risk neonates and their families. In this article, we describe the implementation of this external reporting and feedback system that is safe, is easy to use, and provides actionable data for targeted systems improvement.

METHODS

The Vermont Oxford Network and Network Collaboratives for Quality Improvement

The Vermont Oxford Network is a voluntary group of health professionals who are committed to improving the quality and safety of medical care for newborn infants and their families through a coordinated program of research, education, and quality improvement.^{14,15} The network provides its nearly 400 member hospitals with confidential quarterly and annual comparative performance reports for use in internal audit and quality improvement.¹⁶ In addition, the Vermont Oxford Network has conducted a series of improvement collaboratives that are designed to assist multidisciplinary teams from participating institutions to make measurable improvements in the quality and safety of neonatal intensive care. The collaboratives, through twice-yearly meetings, conference calls, and dedicated e-mail discussion lists, foster 4 key habits: change, evidence-based practice, systems thinking, and collaborative learning.¹⁴ The first 2 collaboratives, titled Neonatal Intensive Care Quality (NICQ) and NICQ 2000, involved 10 and 34 centers, respectively.^{17,18} The network is currently conducting its third collaborative, NICQ 2002, with 48 participating centers. The network has established a web site, www.nicq.org, as the Internet archive for tools and resources for quality improvement for use by members of network collaboratives. Local administrators at participating hospitals assign usernames and passwords for individuals from their hospitals. Access is restricted to Internet protocol

(IP) addresses approved by web administrators at participating hospitals.

Error Reporting in Network Collaboratives

In October 2000, the Internet site www.nicq.org was enhanced to support voluntary anonymous reporting of medical errors and near-miss errors through hypertext markup language forms. Access to the site was password protected and was limited to pre-specified IP addresses at the participating institutions. Overall, 739 health care providers (physicians, nurses, respiratory therapists, pharmacists, and others) from a total of 54 neonatal intensive care units (NICUs) participating in NICQ2000 and NICQ2002 were provided access to the error-reporting site. At the collaborative meetings and via e-mail discussion lists ("listserv"), Vermont Oxford Network faculty encouraged providers to use this web site to report anonymously errors that resulted in harm to the patient as well as near misses. Authorized providers could report events that occur in the NICU, step-down unit, well-infant newborn nursery, delivery room, newborn resuscitation room, mother's hospital room, other hospital inpatient unit, and operating room, as well as events that occur during interhospital transport of newborn infants. In addition to submitting new error reports, they could search, browse, and view all previously posted reports.

Anonymity of error reporters was ensured by not collecting any information about the individual reporting the error, patient, hospital, date, time, or people involved in the event. In addition, the standard Internet Information Server (Microsoft Corp, Redmond, WA) web log was inactivated, ensuring that no record of the IP address of the submitting computer was stored at the central reporting site.

Phase 1 of Error Reporting

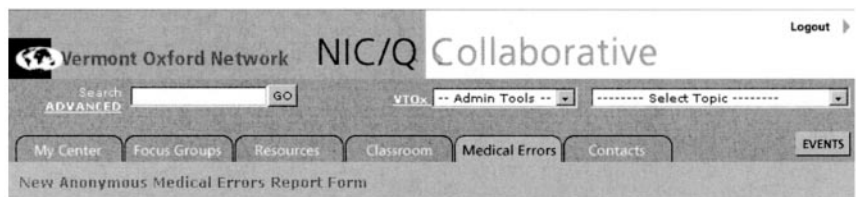
The initial online form, used for error reporting from October 4, 2000, to March 7, 2002 (17 months), contained 4 text boxes labeled Brief Title, Description, Key Words, and References. Each box allowed reporters to type in free text. In addition, reporters were requested to choose keywords relevant to each reported error from a drop-down list. The level of detail contained in the report was left to the reporting individual.

Phase 2 of Error Reporting

A structured online reporting form was introduced on March 8, 2002. The top section of the scroll-down form is shown in Fig 1. This new interface provided several predefined fields for 1) degree of patient harm that resulted from the error, 2) location of the error or near miss, 3) time elapsed between occurrence of the error and submission of the report, 4) categories in which the error would fit, 5) factors that contributed to the event, 6) factors that mitigated the effects of the event, 7) name of the medication if a medication error occurred, and 8) changes implemented to prevent a recurrence of the event. In addition, a text box was provided for feedback and suggestions on how to improve the error reporting system. Responses to fields 1 to 5 in the list above were to be chosen from either a drop-down list or a check box. The available response choices in each of these 5 fields are listed in Appendix 1. Responses to the remaining fields were entered as free text. Reporters had to choose 1 of the following categories to describe the degree of patient harm resulting from the event: event did not have the potential to cause harm, event had the potential to cause harm but did not reach the patient, event reached the patient but did not cause harm, minor harm (increased monitoring, treated with intervention, etc), serious harm (life-threatening, impaired outcome, etc), resulted in death, unknown. This classification was based on the system used for medication errors by the National Coordinating Council for Medication Error Reporting and Prevention.¹⁹

Data and Analysis

We analyzed reports submitted on www.nicq.org between October 4, 2000 (when the error reporting feature was first made available), and January 16, 2003. We identified duplicate reports—which likely resulted from reporters clicking twice in succession on the "submit" button—as pairs of identical reports with consecutive serial numbers and eliminated 1 report from each such pair. We also eliminated reports that were clearly not errors or adverse events. Two reviewers (G.S. and J.G.) separately reviewed all



Brief Title:

Please describe what happened in detail:

Actual or potential harm
 Did the event cause harm: Did the event cause harm - Please Choose One

Where was the patient when the error or near miss occurred?
 Location (A-N): Location (A-N) - Please Choose One

How long ago did the event occur?
 Time Since Event: Time Since Event - Please Choose One

Categories of Errors: Categories of Errors (Check All That Apply)

- Medication Or Drug
- Human Milk
- Enteral Feeding other than Human Milk
- Parenteral Nutrition
- Central Line or Vascular Access
- Infusion or Infiltrate
- Fluid or Electrolyte
- Anaesthesia, Analgesia or Sedation
- Respiratory Care or Ventilator
- Glucose or Insulin
- Monitoring or Alarms
- Radiology or Diagnostic Imaging
- Surgery
- Transportation in or between hospitals
- Transfusion
- Laboratory Testing
- Family or Visitors
- Security
- Patient Misidentification
- Informed Consent
- Resuscitation
- Medical Devices or Equipment

Enter any other categories of errors that apply:

Fig 1. Top section of the form used for anonymous Internet-based reporting in phase 2.

reports from phases 1 and 2 and classified them into 1 of several mutually exclusive predetermined categories derived from a modification of Leape's classification²⁰ (Table 1). After reviewing the free-text description of each report related to medications, enteral nutrition products, parenteral nutrition products, and blood products, they further subcategorized these reports using a modified version of the stages of the medication system described by Nadzam²¹ and by Kaushal²² into the following subcategories: 1) ordering, 2) transcribing, 3) dispensing, 4) administration, 5) monitoring, 6) wrong medication, and 7) uncertain. Interrater agreement was assessed using the κ statistic. Reports involving a family member were identified using an automated search of the text of

each report for the following terms: "mom," "mother," "dad," "father," "sibling," "brother," "sister," "uncle," "aunt," "grand*," and "family." Reports with 1 or more of these terms were reviewed by W.E. For the analyses described above, reports from phases 1 and 2 were combined. For the following variables, analysis was restricted to phase 2 reports (as they were not consistently reported in the free text used in phase 1): location of the event, the interval between the event and reporting, factors that contributed to the event, and harm category of the event. Data analysis and statistical testing were performed using the Microsoft Excel spreadsheet and the Statistical Analysis Software, version 8.1.

TABLE 1. Classification of Reported Events From Phases 1 and 2

Category	<i>n</i>	%
Errors of diagnosis		
Error or delay in diagnosis	88	7.2
Patient misidentification	30	2.4
Use of inappropriate tests or therapy	5	0.4
Failure to use indicated tests	12	1
Failure to act on results of monitoring or testing	2	0.2
Subtotal	137	11.2
Errors of treatment		
Wrong medication or wrong dose or schedule or infusion rate*	581	47.2
Error in administration or method of using a treatment	176	14.3
Patient misidentification	85	6.9
Error in the performance of an operation, procedure, or test	53	4.3
Avoidable delay in treatment or in responding to an abnormal test	39	3.2
Inappropriate (not indicated) care	15	1.2
Subtotal	949	77.2
Errors of prevention		
Failure to provide prophylactic treatment	0	0
Inadequate monitoring or follow-up treatment	0	0
Patient misidentification	0	0
Subtotal	0	0
Other errors		
Other system failure	84	6.8
Equipment failure	23	1.9
Patient misidentification	21	1.7
Failure of communication	16	1.3
Subtotal	144	11.7
Total	1230	100

* Includes medications, nutritional agents, and blood products.

RESULTS

Of the 1256 reports received during phases 1 and 2 of the study, 26 reports were excluded (22 duplicate reports and 4 reports not related to errors), leaving 1230 reports available for analysis: 522 from phase 1 (17 months) and 708 from phase 2 (10 months). In phase 1, reports varied widely in the level of detail provided, from brief 1-line statements to paragraphs rich in detail. They did not consistently include the occurrence or lack of patient harm with a reported event.

The distribution of reported events from phases 1 and 2 across the 4 major categories and subcategories of the modified Leape's classification²⁰ is shown in Table 1. Illustrative examples of the broad range of reported events from phases 1 and 2 are provided in Table 2. There was a high level of concordance between the 2 reviewers in this classification ($\kappa = .82$). Approximately half (581 [47%]) of all reported events from phases 1 and 2 were related to medications, nutritional agents (breast milk, formula, and parenteral nutrition), or blood products. The distribution of these 581 reports across the stages of the medication system is shown in Table 3. Thirty-one percent of errors occurred at the administration stage, 25% at the dispensing stage, 16% at the ordering stage, and 12% at the transcribing stage. Only 1.4% were errors of drug monitoring. There was a high level of concordance between the 2 reviewers ($\kappa = .98$) for their classifications of the stages. When reports from phases 1 and 2 involving patient misidentification

TABLE 2. Examples of Reported Events From Phases 1 and 2

Errors of diagnosis
Radiograph to assess central venous catheter placement not done until the next day
Abnormal newborn screen result not noted, found 10 days later
Echocardiogram performed on wrong patient
Low blood glucose value not discovered for almost 3 hours
Serum potassium level reported to be 2.8 mEq/L when actually 6.8 mEq/L
Culture of cerebrospinal fluid not ordered, necessitating repeat entry into shunt system
Errors of treatment
Accidental dislodgement of central venous catheters, resulting in blood loss
Catheter malposition leading to complications such as pericardial effusion and liver damage
Tracheal perforation and pneumothorax as a result of excessive insertion depth of endotracheal suction catheter
Preterm infant experienced hypoxia during transport as oxygen tank of ambulance was not turned on
Ventilator malfunction leading to undesirably high or low pressures
Burn to penis from hot Mogen clamp during circumcision
Towel clip placed through infant's finger during procedure
Urethral rupture from inflation of balloon of urinary catheter
Intravenous administration of milk and of oral medications
Intratracheal administration of enteral feeds
Intravenous lipid given through orogastric/nasogastric tube
Hundred-fold overdose of insulin
Administration of fosphenytoin instead of hepatitis B vaccine
Subtherapeutic dose of penicillin for group B Streptococcal infection given for 3 days before discovery
Infusion of total daily intravenous fluids over 1–2 hours
Intravenous administration of lidocaine instead of saline flush
"Stat" blood transfusion took 2.5 hours
Antibiotic given 4 hours after ordering
Delay of >1 hour in obtaining intravenous dextrose to treat hypoglycemia
Medications given to the wrong patient
Infant fed breast milk of wrong mother
Other errors
Consent for a blood transfusion obtained from wrong infant's parent
Infant falls from weighing scale, incubator, and swing
Failure of supply of compressed air throughout NICU
Incubator drawn toward magnetic resonance imaging machine requiring 4 security guards to pull it away

TABLE 3. Reports of Wrong Medication, Dose, Schedule, or Infusion Rate* From Phases 1 and 2, Classified According to Stage

Stage	<i>n</i>	%
Ordering	93	16
Transcribing	70	12
Dispensing	145	25
Administration	181	31.2
Monitoring	8	1.4
Wrong medication	49	8.4
Uncertain	35	6
Total	581	100

* Includes medications, nutritional agents, and blood products.

from the "diagnosis," "treatment," "prevention," and "other" categories in Table 1 were combined, they composed 11.1% ($n = 136$) of all reports.

Of all of the reports in phases 1 and 2, there were 24 in which a parent or family member was involved in the event. In 7 reports, a parent contributed to the occurrence of the error (eg, administering a medication that was not ordered, incorrectly mixing nutrients for feeding). In 8 reports, the family member

was the affected individual (eg, falling as a result of a hazardous condition in the environment, not being informed of a procedure or patient transfer). In 9 reports, a parent was described as either discovering an error or participating in investigating the cause.

Of the 707 reports in phase 2 in which the location of occurrence of the event was reported, the location was the NICU in 675 (95.5%), the intermediate care or step-down unit in 20 (2.8%), the delivery room in 3 (0.42%), during transport from another hospital in 3 (0.42%), other hospital inpatient unit in 2 (0.28%), the mother's hospital room in 1 (0.14%), and the operating room in 1 (0.14%). Two events were reported to have occurred in other locations, which were not named by reporting individuals. In 1 report, the location field was left blank. No events were reported from the well-infant newborn nursery, the newborn resuscitation room, or the radiology department. No events were reported to have occurred during transport to another hospital or during transport within the hospital.

Among the 686 phase 2 reports that contained the interval between event and reporting, the time

elapsed was >28 days in 346 (50.4%), 8 to 28 days in 144 (21%), 4 to 7 days in 67 (9.8%), 1 to 3 days in 44 (6.4%), 4 to 24 hours in 54 (7.9%), and <4 hours in 31 (4.5%).

Among the 584 (82.5%) phase 2 reports in which at least 1 contributory factor was reported, 1 contributory factor was selected in 216 (37%) reports, 2 contributory factors in 170 (29.1%), 3 factors in 98 (16.8%), and 4 factors in 47 (8%). In 52 (8.9%) reports, 5 to 8 factors were selected per report. In 1 report, 11 factors were selected. Table 4 shows the types of contributory factors that were reported in phase 2. The most frequent contributory factors were failure to follow policy or protocol (47%), inattention (27%), communications problem (22%), error in charting or documentation (13%), distraction (12%), inexperience (10%), labeling error (10%), and poor teamwork (9%).

The degree of harm resulting from the 673 events in which this outcome was reported during phase 2 is shown in Fig 2. Actual harm to the patient occurred in 181 (27%) of the reported events, with minor harm (ie, requirement for increased monitor-

TABLE 4. Factors That Contributed to Events Reported in Phase 2

Factor	No. of Events With Factor Reported	% of All Events (<i>n</i> = 584) in Which Factor Was Reported
Practices		
Failure to follow policy or protocol	273	46.8
Communications problem	131	22.4
Error in charting or documentation	78	13.4
Labeling error	56	9.6
Poor teamwork	50	8.6
Calculation error	40	6.9
Error in computer entry	37	6.3
Nursing handoff or shift change	33	5.7
Inadequate protocol	26	4.5
Lack of supervision	19	3.3
Physician handoff or shift change	12	2.1
Wrong protocol used	9	1.5
Inability to contact needed staff	6	1.0
Inadequate security	2	0.3
Human factors		
Inattention	157	26.9
Distraction	69	11.8
Inexperience	59	10.1
Inadequate training	35	6.0
Fatigue	33	5.7
Stress	26	4.5
Confrontational or intimidating behavior	4	0.7
Staffing		
High patient acuity in unit	40	6.9
High census in unit	23	3.9
Low levels of other professional staff	17	2.9
Low nursing staff levels	13	2.2
Consultant or subspecialist unavailable	7	1.2
Low physician staff levels	5	0.9
Low levels of clerical or support staff	2	0.3
Equipment		
Poor equipment design	29	5.0
Equipment failure	20	3.4
Inadequate equipment maintenance	14	2.4
Unfamiliar equipment	11	1.9
Necessary equipment unavailable	6	1.0
Environment		
Lack of space or room	7	1.2
Unfamiliar environment	5	0.9
Noise	1	0.2
Inadequate lighting	1	0.2

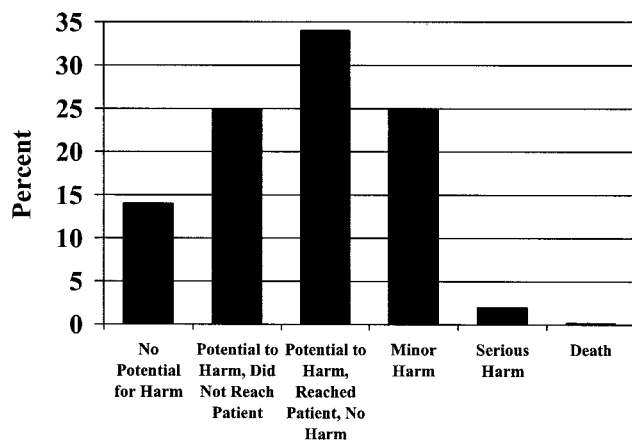


Fig 2. Categories of harm for events reported in phase 2. Outcome of 673 events in which degree of harm was reported. This outcome was not reported in 35 events. Minor harm, which consisted of increased monitoring, treated with intervention, etc, occurred in 167 (25%) events. Serious harm, in which there was a threat to life or an impaired outcome, etc, was reported in 13 (1.9%) events. Death was reported in 1 (0.15%) event. Categories are based on the system used for medication errors by the National Coordinating Council for Medication Error Reporting and Prevention.¹⁹

ing, specific treatment, other interventions) resulting in 167 (25%) cases, serious harm in 13 (1.9%) cases, and death in 1 (0.2%) case.

Periodic structured feedback of collected errors, both through the NICQ 2002 collaborative's e-mail listserv and at biannual meetings, has increased awareness of errors and stimulated numerous patient safety improvement projects. The 739 health professionals (including physicians, nurses, respiratory therapists, pharmacists, and administrators) who had access to this web site represented a broad range of disciplines. Discussion of reported errors has provided a strong impetus for multidisciplinary learning. Multidisciplinary teams for hospitals in the improvement collaborative have prepared 141 poster presentations of case studies on patient safety in their units and shared these at meetings of the collaborative. Teams have presented the results of 43 root-cause analyses, including insulin overdoses, accidental dislodgment of intravenous catheters, administration of wrong medications, falls, breast milk errors, and tracheal perforations. Teams have also used failure mode and effects analysis (FMEA) and hazard analysis and critical control point methods, notably for improving systems for processing and feeding breast milk to infants.

DISCUSSION

Voluntary reporting of medical errors and adverse events is a key component of patient safety efforts, but health care providers may not report such events for fear of being stigmatized, punished by superiors, or exposed to medical-legal liability.^{10,23-25} The success of the Vermont Oxford Network Internet reporting system, NICQ.org, demonstrates that it is possible to overcome such barriers. Health care providers will voluntarily report significant medical errors and adverse events to an external organization using a safe, convenient, specialty-based system—especially

when there is trust in the organization and a strong foundation of multidisciplinary collaborative quality improvement such as that within our network.

This study provides data on the broad range of medical errors and adverse events in neonatal intensive care. Our experience suggests that medical errors are a major problem in neonatal intensive care, as they are in other areas of health care. Of the reported errors, 27% resulted in harm to the patient. Errors occurred in a wide variety of domains, such as medications, diagnostic testing, medical or surgical procedures, respiratory therapy, the environment of care, patient identification, nursing care, and physician-patient communication (Tables 1 and 2). A number of reported errors pertained to the safety goals promulgated recently by the JCAHO,²⁶ specifically the use of high-alert medications, patient identification, and communication among caregivers. Approximately half of all reports involved medications, nutritional products, or blood products, exceeding rates published previously from pediatric²⁷ and adult^{12,28-30} ICUs in which 12% to 44% of reports involved medication errors. Previous studies that were restricted to medication errors^{22,31-33} documented a high frequency of such errors in NICUs, and a prospective pediatric study using active error detection methods found that the most serious errors occurred significantly more often in the NICU than on other wards.²²

The Agency for Healthcare Research and Quality and the American Academy of Pediatrics encourage parents to be actively involved in error prevention in both ambulatory care and inpatient settings.³⁴ Our findings demonstrate that family members of a hospitalized neonate not only can help discover errors but also can contribute to the cause of the error or themselves be victims of the error. Additional research is required to understand how best to involve families in efforts to enhance the safety of medical care for their hospitalized infants.

In addition to identifying errors and adverse events, in phase 2, we attempted to identify the factors that contributed to their occurrence. Forty-seven percent of reports were associated with a failure to follow a policy or protocol, 27% with inattention, 22% with a communication problem, and 12% with distraction. In contrast, problems in communication, orientation/training, and patient assessment were the 3 most frequent root causes of sentinel events reported to JCAHO.³⁵ We recognize that voluntary reports can provide only a glimpse into the complex cause of error, but our findings suggest that merely issuing new policies or protocols will not improve patient safety in neonatal intensive care. Instead, greater success may result from system-wide improvements that decrease inattention, miscommunication, distraction, and other contributory human factors. These principles are implicit in contemporary "systems" approaches to understanding error and improving safety,³⁶⁻³⁹ including root-cause analysis,⁴⁰ FMEA,⁴¹ hazard analysis and critical control point,⁴² and crew resource management.^{43,44} Surprising, nurse understaffing was infrequently (2%) reported as a contributory factor, although several

studies have discovered an association between high patient–nurse ratios and adverse patient outcomes.^{45–51}

Our study was limited in several ways. First, because reporting was voluntary, the frequency of events reported does not represent the true incidence of errors in participating NICU. All voluntary systems are likely to suffer from incomplete ascertainment and selective reporting. Prospective active surveillance systems, of which the National Nosocomial Infections Surveillance System⁶ is a good model, are required to determine the true incidence of adverse events. Although such systems are critical for understanding the epidemiology of adverse events, they are labor intensive and not well suited for capturing errors that are not documented in medical records or cannot be inferred from laboratory or pharmacy data. Second, we suspect that the intensity and comprehensiveness of local investigation of errors varied widely, and the reliability with which contributing factors were identified probably varied as well. In future versions of our reporting system, we will ascertain whether contributing factors were identified through formal root-cause analysis. Finally, we were unable to identify the number of reports submitted by individual NICUs or by members by professional discipline because reporting was fully anonymous. This is a disadvantage of anonymous reporting, as is the inability to contact reporting individuals for details of a reported event.¹

Several benefits of multi-institutional specialty-based voluntary reporting systems such as the Vermont Oxford Network system are evident. They can identify errors that are rare in individual institutions but occur in multiple institutions. For example, on www.nicq.org, there were several reports of intravenous infusion of solutions intended for enteral use—a systems problem that can be prevented by designing enteral tubing and syringes that cannot be connected to intravenous tubing (a so-called “physical constraint”). Multi-institutional specialty-based reporting systems also can identify patterns of errors that are unique to that specialty. For example, there were multiple reports of infants’ being fed breast milk from the wrong mother and of infants actually or nearly falling from an incubator, weighing scale, or swing while being cared for in the NICU.

According to Leape,² successful reporting systems are nonpunitive, confidential, and independent; provide expert analysis and timely feedback; and are systems oriented and responsive. The Vermont Oxford Network reporting system already adheres at least partially to all of these criteria. An expert faculty analyzes reported events and provides feedback and recommendations to all participating NICUs by e-mail and at the collaborative’s biannual meetings. The next step in the development of nicq.org is to transform it from a reporting system to a real-time learning system. Individuals who report errors will receive immediate electronic feedback on the web site and direct links to case studies of similar errors, prevention tips, and patient safety resources such as root-cause analysis and FMEA tools and human factors checklists. The long-term vision is that shared

learning among the universe of NICUs will enhance patient safety.

CONCLUSIONS

We have successfully developed and implemented a simple, anonymous, voluntary, Internet-based reporting system for medical errors in neonatal intensive care. We speculate that similar voluntary reporting systems have the potential to enhance patient safety in a wide range of medical and surgical specialties.

APPENDIX 1: LISTS OF RESPONSE CHOICES FOR CATEGORY OF HARM, LOCATION OF EVENT, TIME SINCE EVENT, AND CATEGORIES OF ERROR IN THE WWW.NICQ.ORG INTERNET REPORTING FORM USED IN PHASE 2

Actual or potential harm: did the event cause harm (please choose one):

1. No, event did not have the potential to cause harm
2. No, event had potential to cause harm but did not reach patient
3. No, event reached patient but did not cause harm
4. Yes, minor harm (increased monitoring, treated with intervention, etc)
5. Yes, serious harm (life-threatening, impaired outcome, etc)
6. Yes, resulted in death
7. Unknown

Where was the patient when the error or near miss occurred? Location (please choose one):

1. Neonatal intensive care unit
2. Intermediate care or step-down unit
3. Well-infant newborn nursery
4. Delivery room
5. Newborn resuscitation room
6. Mother’s hospital room
7. Other hospital inpatient unit
8. During transport from another hospital
9. During transport to another hospital
10. During transport within your hospital
11. Operating room
12. Radiology department
13. Other

How long ago did the event occur? Time since event (please choose one):

1. <4 hours
2. 4 to <24 hours
3. 1 to 3 days
4. 4 to 7 days
5. 8 to 28 days
6. >28 days
7. Unknown

Categories of errors (check all that apply)

- Medication or drug
- Breast milk
- Enteral feeding other than breast milk
- Parenteral nutrition
- Central line or vascular access
- Infusion or infiltrate
- Fluid or electrolyte

- Anesthesia, analgesia, or sedation
- Respiratory care or ventilator
- Glucose or insulin
- Monitoring or alarms
- Radiology or diagnostic imaging
- Surgery
- Transportation in or between hospitals
- Transfusion
- Laboratory testing
- Family or visitors
- Security
- Patient misidentification
- Informed consent
- Resuscitation
- Medical devices or equipment
- Enter any other categories of errors that apply

Factors that contributed to the event (check all that apply)

Environment

- Inadequate lighting
- Lack of space or room
- Noise
- Unfamiliar environment

Equipment

- Equipment failure
- Inadequate equipment maintenance
- Necessary equipment unavailable
- Poor equipment design
- Unfamiliar equipment

Human factors

- Confrontational or intimidating behavior
- Distraction
- Fatigue
- Inadequate training
- Inattention
- Inexperience
- Stress

Practices

- Calculation error
- Communications problem
- Error in charting or documentation
- Error in computer entry
- Failure to follow policy or protocol
- Inadequate protocol
- Inadequate security
- Labeling error
- Lack of supervision
- Nursing handoff or shift change
- Physician handoff or shift change
- Poor teamwork
- Inability to contact needed staff
- Wrong protocol used

Staffing

- Consultant or subspecialist unavailable
- High census in unit
- High patient acuity in unit
- Low levels of clerical or support staff
- Low levels of other professional staff

- Low nursing staff levels
- Low physician staff levels

APPENDIX 2: NICQ 2000 AND 2002 PARTICIPANTS

Multidisciplinary Teams From Participating Hospitals

- Advocate Lutheran General Hospital, Park Ridge, IL: Jeffrey A. George, DO; Susan K. Okuno-Jones, RN, MA; Diane K. Boyle, RN, MBA; and Kimberly Jenkins, RN
- Baptist Children's Hospital, Miami, FL: Andrew B. Kairalla, MD; Denise Harris, RN, MSN, MBA, CNA; Jacques Rousseau, RN; and Patricia Ahmed, RN, ARNP
- Barbara Bush Children's Hospital at Maine Medical Center, Portland, ME: Heidi G. Towers, BSN, RN; Anne Cormier, RN; and Daniel B. Sobel, MD
- Baylor University Medical Center, Dallas, TX: Pamela S. McKinley, RN; Vance Redfield, MD; Tammy Marnell, RN; and Gloria Allen, RN
- Benefis Healthcare, Great Falls, MT: Evelyn D. Rider, MD; Carlene Turner, RN; Pamela Sowers, RN; and Heather Lilly, RN
- Carle Foundation Hospital, Urbana, IL: William Stratton, MD; Kathey Voelker, CNRP; Stephanie Beever, RN, MS; and Kathy Tredway, RN
- Central Mississippi Medical Center, Jackson, MS: John E. Rawson, MD; Paula Metzger, RNC; Luretha Smith, RNC, CNRP; and Patricia Johnson, RN
- Children's Hospital and Clinics, Minneapolis, MN: Nathaniel R. Payne, MD; Mary Jo Crosby, RNC, MS; and Lisa McGee, RN, MS
- Children's Hospital Medical Center, Akron, OH: Judy Ohlinger, RNC, MSN; Heather Adams, RNC, MSN, CPNP; and Anand Kantak, MD
- Children's Hospital of Illinois at OSF St. Francis Medical Center, Peoria, IL: James Hocker, MD; Howard Cohen, MD; Cheryl Colgan, RN; and Theresa Vaughn, RN;
- Children's Hospital of Orange County, Orange, CA: Sudeep Kukreja, MD; Mindy Morris, MD, CNRP; Karen MacGillivray, RN; and Charlene Keene, BSN
- Children's Hospitals and Clinics, St. Paul, MN: Gabriela Ferski, RN, MPH; Erik Hagen, MD; and Kristine Grupa, RN, BA
- Dartmouth-Hitchcock Medical Center, Lebanon, NH: Caryn S. McCoy, Kimberly D. Knoerlein, Jeffrey K. Low, and Laurie A. Hogden
- DeVos Children's Hospital, Grand Rapids, MI: Amy Atwater, RN, BSN
- Exempla Saint Joseph Hospital, Denver, CO: Alfonso Pantoja, MD; John VanBibber; Diane Johnston; and Susan Jajczyk
- Fairview-University Medical Center, Minneapolis, MN: William Rosen, MD; Marla Mills, BSN, MSN, NNP, CPNP; and Margaret Harder, BSN, MA
- Geisinger Medical Center, Danville, PA: Lauren A. Johnson-Robbins, MD; and Carol Gerber, RN
- Hackensack University Medical Center, Hackensack, NJ: Krystyna W. Toczyłowski RN, MSN; P.

- Santinello, H. Perl, MD; and Cassandra Martin-Walters RN, MSN
- Inova Fairfax Hospital for Children, Falls Church, VA: Claire A. Pagano, BSN, MGA; John North, MD; and Caroline Reich, BSN, MSN
 - Jackson-Madison County General Hospital, Jackson, TN: Donna-Jean B. Walker, MD; Betty Beverly-Brown, RN, MSHA; and Tammy Hardee, RN
 - Joe DiMaggio Children's Hospital, Hollywood, FL: Bella S. Cabrera, MSN, RNC
 - Kaiser Foundation Hospital, Los Angeles, CA: David D. Wirtschafter, MD; Ralph E. Franceschini, MD; Tammy J. Anderson, RNC, MSN; and Shukla Sen, RN, MHA
 - Legacy Emanuel Children's Hospital, Portland, OR: Jamie Rupp, BSN; Tina Rosling, RNC; Elizabeth Liebelt, RN; and Val Newman, MD
 - Lehigh Valley Hospital, Allentown, PA: Ian Gertner, MD; Lynn Peterson, RN, NNP; Janice Mayer, MSW; and Sharon Smetzer, RN
 - Lucile Packard Children's Hospital at Stanford, Palo Alto, CA: Paul J. Sharek, MD, MPH; William Rhine, MD; Hollie Parker-Winzenread, MT, MBA; and Carol Kibler, RN
 - Milton S. Hershey Medical Center, Hershey, PA: Dennis Mujsce, MD; Lois Gates, RN, MSN; Jenny Boettinger, RN, MSN; and Jane Ebersole, RN
 - New Hanover Regional Medical Center, Wilmington, NC: Robert McArtor, MD; Debra McLendon, RN, BSN; LuAnne Davis, RN, BSN; and Deborah Lockey, RN
 - Northside Hospital, Atlanta, GA: Wendy Troyer, MD; Elaine Jacob, RNC, NNP; and Marci Biel, MSN, RNC
 - Oakland Children's Hospital and Research Center at Oakland, Oakland, CA: Richard J. Powers, MD; Nick Mickas, MD; Linda Lefrak, MS; and Teresa Proctor, RN
 - Parkview Hospital, Fort Wayne, IN: Joel Secrest, MD; Laura Michael, RN; Jim Moehring, AS, RRT; and Pat Carteaux, RN
 - Presbyterian St. Luke's Medical Center, Denver, CO: Mark S. Brown, MD; Kelly Gallant; Kay Young; and Connie Rusk
 - Providence St. Vincent Medical Center, Portland, OR: Dana Whitecotton-Brady, RN, BSN; Mara Zabari, RN, MPA-HA; Juanita Stram, RN, BSN; and Cindy Arduza, NNP
 - Rockford Memorial Hospital, Rockford, IL: Patricia Ittmann, DO; Ona Fofah, MD; Pat Fett, RN, CNS; and Ruth Meinhart, RN
 - Sparrow Hospital, Lansing, MI: P. Karna, MD; and Sue Davis, RN
 - St. Barnabas Medical Center, Livingston, NJ: Shyan Sun, MD, DCH; Kamtorn Vangvanichyakorn, MD; Eileen Steffen, RN; and Joyce Major, RN
 - St. John Hospital and Medical Center, Detroit, MI: Renato S. Casabar, MD; Maria L. Duenas, MD; Gayle Novack, RN, CNM; and Ali Rabbani, MD;
 - St. John's Mercy Medical Center, St. Louis, MO: Gary Dreyer, MD; Edward Schwarz, MD; Kelly Burch, PharmD; and Lisa Finley, RN, BS
 - Sunnybrook and Women's College Health Sciences Centre, Toronto, Ontario, Canada: Michael Dunn, MD, FRCPC; Denise Zayack, RN, BA; Maureen Reilly, RRCPC; and Robert Graham, RRCPC
 - The Brooklyn Hospital Center, Brooklyn, NY: Meena LaCorte, MD
 - The Children's Hospital at Bronson, Kalamazoo, MI: Bill Rimmke, MD; Linda Smith, RN; Tish Eaton-Mall, RN; and Mark Storoshenko, RT
 - The Children's Hospital at Providence Alaska, Anchorage, AK: Jack Jacob, MD; Leah Holman, RNC; Kimberly Moore, RNC; and Debra Sims, RNC
 - Vermont Children's Hospital at Fletcher-Allen Health Care, Burlington, VT: NICQ 2002 Collaborative Team
 - Wake Forest University Baptist Medical Center, Winston-Salem, NC: Steven M. Block, MD, BCH; Diane Hudson-Barr, RN, PhD; and Constance Purkey, RN
 - Wesley Medical Center, Wichita, KS: Deanna Kowalski RN
 - Women's Hospital of Greensboro, Greensboro, NC: Roger Saunders, RN, MSN, PNP; Helen Mabe, RN, BSN; Allison DuBuisson, M.Ed; and Tina Hunsucker, RN, MPH, CANNP
 - Woman's Hospital, Baton Rouge, LA: Cliff Richardson, RNC, NNP; Betsy Swett, RNC; Melanie Perkins, RN; and John Dugas, RRT, PPS
 - Yakima Valley Memorial Hospital, Yakima, WA: NICQ 2002 Collaborative Team
- (Seven institutional teams are not listed at their request.)

NICQ 2000 AND NICQ 2002 FACULTY AND STAFF

Co-directors

Jeffrey D. Horbar, MD, and Paul Plsek, MS

Facilitators and Consultants

S. Anand, B. Bauman, D. Goldmann, J. Goldsmith, J. Gray, J. Handyside, M. Hill, H. King, N. Leahy-Jacklow, J. Lucey, D. Miller, J. Rogowski, J. Schriefer, P. Shiono, R. Soll, G. Suresh, L. Wojciechowski, M. Abraham, G.R. Baker, G. Cafferata, B. Kuzma-O'Reilly, K. Crompton, E. Lewit, and J. MacDonald

Vermont Oxford Network Staff

Kathy Leahy, RN, NNP, NICQ Project Coordinator; Pam Ford, BA, NICQ Collaborative Assistant; Joseph Carpenter, MS, Director of Technical Operations; and David Mortensen, Internet Engineer.

ACKNOWLEDGMENTS

Supported by grants from the Agency for Healthcare Research and Quality (P20 HS 11583 to Dr Horbar, PI) and the Centers for Disease Control and Prevention (H50/CH121553-01 to Dr Horbar, PI). The development and operation of the NICQ.org Internet site was supported in part by grants from Ross Products Division, Abbott Laboratories, and the David and Lucile Packard Foundation.

REFERENCES

1. Kohn LT, Corrigan JM, Donaldson MS. *To Err is Human. Building a Safer Health System.* Washington, DC: National Academy Press; 2000
2. Leape LL. Reporting of adverse events. *N Engl J Med.* 2002;347:1633-1638
3. Barach P, Small SD. Reporting and preventing medical mishaps: lessons from non-medical near miss reporting systems. *BMJ.* 2000;320:759-763

4. Billings CE. Some hopes and concerns regarding medical event-reporting systems: lessons from the NASA Aviation Safety Reporting System. *Arch Pathol Lab Med.* 1998;122:214–215
5. Joint Commission on Accreditation of Healthcare Organizations. Our commitment to patient safety: sentinel event policy. Available at: www.jcaho.org/general+public/patient+safety/patient+safety.htm#two 2003. Accessed April 26, 2003
6. National Nosocomial Infections Surveillance (NNIS) System Report, data summary from January 1992 to June 2002, issued August 2002. *Am J Infect Control.* 2002;30:458–475
7. US Pharmacopeia: Medmarx. Available at: www.medmarx.com//index.jsp. Accessed April 26, 2003
8. The Institute for Safe Medication Practices. The USP-ISMP Medication Errors Reporting Program (MERP). Available at: www.ismp.org/Pages/mederr_usa.html. Accessed April 26, 2003
9. The Patient Safety Reporting System. Available at: psrs.arc.nasa.gov/. Accessed April 26, 2003
10. Cohen MR. Why error reporting systems should be voluntary. *BMJ.* 2000;320:728–729
11. Tunis SR, Hayward RSA, Wilson MC, et al. Internists' attitudes about clinical practice guidelines. *Ann Intern Med.* 1994;120:956–963
12. Beckmann U, West LF, Groombridge GJ, et al. The Australian Incident Monitoring Study in Intensive Care: AIMS-ICU. The development and evaluation of an incident reporting system in intensive care. *Anaesth Intensive Care.* 1996;24:314–319
13. Wu AW, Pronovost P, Morlock L. ICU incident reporting systems. *J Crit Care.* 2002;17:86–94
14. Horbar JD. The Vermont Oxford Network: evidence-based quality improvement for neonatology. *Pediatrics.* 1999;103(suppl):350–359
15. Horbar JD. The Vermont-Oxford Neonatal Network: integrating research and clinical practice to improve the quality of medical care. *Semin Perinatol.* 1995;19:124–131
16. Horbar JD, Carpenter JH, Kenny M. *Annual Database Summary 2001.* Burlington, VT: Vermont Oxford Network; 2002
17. Horbar JD, Rogowski J, Plsek PE, et al. Collaborative quality improvement for neonatal intensive care. *Pediatrics.* 2001;107:14–22
18. Horbar JD, Plsek P, Leahy K. The NIC/Q 2000: establishing habits for improvement in neonatal intensive care units. *Pediatrics.* 2003;111(4). Available at: pediatrics.org/cgi/content/full/111/4/SE1/e397
19. National Coordinating Council for Medication Error Reporting and Prevention. Taxonomy of medication errors © 2001. All rights reserved. Used with permission. Available at: www.nccmerp.org/. Accessed April 26, 2003
20. Leape LL, Lawthers AG, Brennan TA, Johnson WG. Preventing medical injury. *Qual Rev Bull.* 1993;19:144–149
21. Nadzam DM. Development of medication-use indicators by the Joint Commission on Accreditation of Healthcare Organizations. *Am J Hosp Pharm.* 1991;48:1925–1930
22. Kaushal R, Bates DW, Landrigan C, et al. Medication errors and adverse drug events in pediatric inpatients. *JAMA.* 2001;285:2114–2120
23. Lawton R, Parker D. Barriers to incident reporting in a healthcare system. *Qual Saf Health Care.* 2002;11:15–18
24. Leape LL. Why should we report adverse incidents? *J Eval Clin Pract.* 1999;5:1–4
25. Vincent C, Stanhope N, Crowley-Murphy M. Reasons for not reporting adverse incidents: an empirical study. *J Eval Clin Pract.* 1999;5:13–21
26. Joint Commission on Accreditation of Healthcare Organizations. 2003 National patient safety goals. Available at: www.jcaho.org/accredited+organizations/patient+safety/npsg/npsg_03.htm. Accessed April 26, 2003
27. Stambouly JJ, McLaughlin LL, Mandel FS, Boxer RA. Complications of care in a pediatric intensive care unit: a prospective study. *Intensive Care Med.* 1996;22:1098–1104
28. Abramson NS, Wald KS, Grenvik ANA, Robinson D, Snyder JV. Adverse occurrences in intensive care units. *JAMA.* 1980;244:1582–1584
29. Buckley TA, Short TG, Rowbottom YM, Oh TE. Critical incident reporting in the intensive care unit. *Anaesthesia.* 1997;52:403–409
30. Flaatten H, Hevroy O. Errors in the intensive care unit (ICU). Experiences with an anonymous registration. *Acta Anaesthesiol Scand.* 1999;43:614–617
31. Vincer MJ, Murray JM, Yuill A, Allen AC, Evans JR, Stinson DA. Drug errors and incidents in a neonatal intensive care unit. A quality assurance activity. *Am J Dis Child.* 1989;143:737–740
32. Raju TN, Kecskes S, Thornton JP, Perry M, Feldman S. Medication errors in neonatal and paediatric intensive-care units. *Lancet.* 1989;2:374–376
33. Folli HL, Poole RL, Benitz WE, Russo JC. Medication error prevention by clinical pharmacists in two children's hospitals. *Pediatrics.* 1987;79:718–722
34. Agency for healthcare research and quality, American Academy of Pediatrics. 20 Tips to Help Prevent Medical Errors in Children. Available at: www.aHRQ.gov/consumer/20tipkid.htm. Accessed April 26, 2003
35. Joint Commission on Accreditation of Healthcare Organizations. Sentinel event statistics—March 19, 2003. Available at: www.jcaho.org/accredited+organizations/laboratory+services/sentinel+events/sentinel+event+statistics.htm. Accessed April 26, 2003
36. Reason J. *Managing the Risks of Organizational Accidents.* Brookfield, VT: Ashgate Publishing Company; 1997
37. Vincent C, Taylor-Adams S, Stanhope N. Framework for analysing risk and safety in clinical medicine. *BMJ.* 1998;316:1154–1157
38. Vincent C. Understanding and responding to adverse events. *N Engl J Med.* 2003;348:1051–1056
39. Reason J. Human error: models and management. *BMJ.* 2000;320:768–770
40. Joint Commission on Accreditation of Healthcare Organizations. *Root Cause Analysis in Health Care: Tools and Techniques.* 2nd ed. Oakbrook terrace, IL: Joint Commission Resources; 2002
41. Joint Commission on Accreditation of Healthcare Organizations. Failure Mode and Effects Analysis in Health Care. Oakbrook Terrace, IL: Joint Commission Resources; 2002
42. Hulebak KL, Schlosser W. Hazard analysis and critical control point (HACCP) history and conceptual overview. *Risk Anal.* 2002;22:547–552
43. Morey JC, Simon R, Jay GD, et al. Error reduction and performance improvement in the emergency department through formal teamwork training: evaluation results of the MedTeams project. *Health Serv Res.* 2002;37:1553–1581
44. Kosnik LK. The new paradigm of crew resource management: just what is needed to re-engage the stalled collaborative movement? *Jt Comm J Qual Improv.* 2002;28:235–241
45. Archibald LK, Manning ML, Bell LM, Banerjee S, Jarvis WR. Patient density, nurse-to-patient ratio and nosocomial infection risk in a pediatric cardiac intensive care unit. *Pediatr Infect Dis J.* 1997;16:1045–1048
46. Aiken LH, Clarke SP, Sloane DM, Sochalski J, Silber JH. Hospital nurse staffing and patient mortality, nurse burnout, and job dissatisfaction. *JAMA.* 2002;288:1987–1993
47. Pronovost PJ, Dang D, Dorman T, et al. Intensive care unit nurse staffing and the risk for complications after abdominal aortic surgery. *Eff Clin Pract.* 2001;4:199–206
48. Callaghan LA, Cartwright DW, O'Rourke P, Davies MW. Infant to staff ratios and risk of mortality in very low birthweight infants. *Arch Dis Child Fetal Neonatal Ed.* 2003;88:F94–F97
49. Needleman J, Buerhaus P, Mattke S, Stewart M, Zelevinsky K. Nurse-staffing levels and the quality of care in hospitals. *N Engl J Med.* 2002;346:1715–1722
50. Fridkin SK, Pear SM, Williamson TH, Galgiani JN, Jarvis WR. The role of understaffing in central venous catheter-associated bloodstream infections. *Infect Control Hosp Epidemiol.* 1996;17:150–158
51. Jackson M, Chiarello LA, Gaynes RP, Gerberding JL. Nurse staffing and health care-associated infections: proceedings from a working group meeting. *Am J Infect Control.* 2002;30:199–206

Voluntary Anonymous Reporting of Medical Errors for Neonatal Intensive Care
Gautham Suresh, Jeffrey D. Horbar, Paul Plsek, James Gray, William H. Edwards,
Patricia H. Shiono, Robert Ursprung, Julianne Nickerson, Jerold F. Lucey, Donald
Goldmann and for the NICQ2000 and NICQ2002 investigators of the Vermont Oxford
Network

Pediatrics 2004;113;1609-1618

DOI: 10.1542/peds.113.6.1609

Updated Information & Services	including high-resolution figures, can be found at: http://www.pediatrics.org/cgi/content/full/113/6/1609
References	This article cites 37 articles, 17 of which you can access for free at: http://www.pediatrics.org/cgi/content/full/113/6/1609#BIBL
Citations	This article has been cited by 25 HighWire-hosted articles: http://www.pediatrics.org/cgi/content/full/113/6/1609#otherarticles
Subspecialty Collections	This article, along with others on similar topics, appears in the following collection(s): Premature & Newborn http://www.pediatrics.org/cgi/collection/premature_and_newborn
Permissions & Licensing	Information about reproducing this article in parts (figures, tables) or in its entirety can be found online at: http://www.pediatrics.org/misc/Permissions.shtml
Reprints	Information about ordering reprints can be found online: http://www.pediatrics.org/misc/reprints.shtml

American Academy of Pediatrics

DEDICATED TO THE HEALTH OF ALL CHILDREN™

