Research Methods

Recovery from Medical Errors:

The Critical Care Nursing Safety Net

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Concern about the extent of accidental injury to patients undergoing medical treatment has increased substantially in the past several years. The Institute of Medicine (IOM) report *To Err Is Human* estimated that medical errors in hospitalized patients result in more than a million injuries and between 44,000–98,000 deaths annually.[1] Despite some controversy surrounding these estimates,[2] preventable adverse events undoubtedly occur frequently. The IOM report found that errors in health care should be seen as the result of complex system failures rather than the fault of individual clinicians. Therefore, efforts toward improving faulty latent system conditions and the defenses to prevent medical errors from harming the patient are more likely to improve safety than blaming responsible individuals.[3,4] The IOM report recommended that effective interdisciplinary teams, such as in critical care units, benefit from team training that includes "attending to one another's safety concerns."[1(p. 173)]

Preventable adverse events and near misses, also known as close calls, in critically ill patients are common and may be life threatening.[5] Nursing surveillance and monitoring activities are essential in critical care units and include ongoing patient assessment and the detection of near misses. In a recent study of intercepted serious errors in critically ill patients, nurses were responsible for 42% of the interceptions.[5] The intensive care unit (ICU) is a complex environment where patients require high-intensity nursing care and often receive high-risk invasive support and therapies.[6] Nurses represent the front line of

Article-at-a-Glance

Background: Safety initiatives have primarily focused on physicians despite the fact that nurses provide the majority of direct inpatient care. Patient surveillance and preventing errors from harming patients represent essential nursing responsibilities but have received relatively little study.

Methods: The study was conducted between July 2003 and July 2004 in a 10-bed academic coronary care unit. Direct observation of nursing care and solicited and institutional incident reports were used to find potential incidents. Two physician reviewers rated incidents as to the presence, preventability, and potential severity of harm of errors and associated factors.

Results: Overall data were collected for 147 days, including 150 hours of direct observation. One hundred forty-two recovered medical errors were found, including 61% (86/142) during direct observations. Most errors (69%; 98/142) were intercepted before reaching the patients. Errors that reached patients included 13% that were mitigated before resulting in harm and 18% that were ameliorated before more severe harm could occur.

Discussion: Protecting patients from the potentially dangerous consequences of medical errors is one of the many ways critical care nurses improve patient safety. Interventions designed to increase the ability of nurses to recover and promptly report errors have the potential to improve patient outcomes.

patient defense[7] and are therefore "uniquely positioned to identity and correct medical errors."[8(p. 196)]

The Eindhoven model for investigating near misses, adopted from chemical industry accident investigations,[9] has been used to describe the nurse's role in identifying, interrupting, and correcting medical errors, collectively termed *recovery*.[8] Recovery from medical errors is often considered routine during nursing care and may go underrecognized and underappreciated by nonnursing staff as well as nurses themselves.[10]

Studying the extent of the nursing contribution to enhancing patient safety is important because the current supply of highly qualified critical care nurses is threatened and maintaining acceptable nurse-patient staffing ratios is increasingly difficult.[11,12] Studying the nurse's role in the recovery of errors may guide future research in understanding the system and individual nursing characteristics that enhance the likelihood of error recovery.[8] Therefore, we conducted a study to assess the incidence and types of errors that were recovered by nurses in a cardiac ICU or coronary care unit (CCU). Recovered medical errors included potentially harmful errors that were intercepted before reaching the patient and errors that reached the patient but were caught before serious harm ensues.

Methods

The data were collected during seven three-week periods between July 2003 and July 2004. After approval of the Institutional Human Subjects Review Board, the study design was presented to the unit nurses at staff meetings. All day-shift staff nurses in the study unit were given the opportunity to participate. Enrolled staff nurses consented to permit direct observation of their ongoing patient care activities. Nonparticipating nurses signed opt-out cards if they did not want ongoing observations to continue when they temporarily assisted patients cared for by participating nurses during the observation sessions.

Study Site and Population

The study took place in a 10-bed adult coronary care unit (CCU) of a 720-bed tertiary care academic medical center. The CCU has a closed attending model,[13] with hospital-based cardiologists assuming primary patient responsibility in addition to housestaff and cardiology fellows, who provide 24-hour in-house coverage. Medical interns were primarily responsible for entering diagnostic and treatment orders. The usual nurse-to-patient ratio during the CCU's 7 A.M. to 3 P.M. weekday shift was 1:1.25, or 8 registered nurses for 10 patients.

Definitions

Definitions for terms used in the study are provided in Table 1 (page 65). Recovered medical errors—the primary outcome of interest—included intercepted potential adverse events, mitigated potential adverse events, and ameliorated adverse events. Errors with little or no potential for harm, nonintercepted potential adverse events (errors that reached the patient and did not cause harm), and adverse events that were not ameliorated were excluded from analysis. We also excluded from analysis medical errors that were caught by other staff such as physicians and pharmacists.

Data Collection

The primary method of data collection was the direct continuous observation method described by Barker[14] and used in previous critical care safety research studies.[5,15,16] Direct nursing observation sessions were conducted primarily on nonholiday weekdays between 7 A.M. and 3 P.M. and for durations of between two and six hours. Two trained research nurses [K.M.-W., C.F.] with experience in critical care patient safety research collected the data. Observation sessions were scheduled during shifts when at least one participating study CCU nurse was on duty. Depending on patient caseload, one to three nurses were concurrently observed. When more than one nurse was observed during a session, research nurses were instructed to observe one nurse and his/her patients during admissions of new patients, emergency situations, procedures, and bedside discussions with physicians. Participating CCU nurses were instructed to inform the researcher of potential incidents that were missed while concurrently observing a different nurse.

The research observers entered suspected incidents into a semistructured confidential diary and then transferred their findings into standardized data forms. They were instructed to inform the CCU staff of

Table 1. Definitions of Study Terms

Term	Definitions
Medical error*	Failure of a planned action to be completed as intended or the use of a wrong plan to achieve an aim
Recovered medical errors	The primary study outcome of interest and included intercepted potential adverse events, mitigated potential adverse events, and ameliorated adverse events
Adverse event†	Injury due to medical management, rather than underlying disease. In contrast to the Harvard Medical Practice Study definition,‡ prolongation of hospitalization or disability on discharge were not required.
Preventable adverse event	Injury due to a nonintercepted error in medical care
Nonpreventable adverse event	Unavoidable injury due to appropriate medical care
Ameliorated adverse event	Injury due to a medical error that reached the patient but whose subsequent potential severity was significantly reduced as a consequence of later recovering the error before further harm took place
Potential adverse event§	A medical error that had the potential to cause harm but did not
Intercepted potential adverse event	A medical error with the potential to cause harm that was intercepted before reaching the patient
Non-intercepted potential adverse event	A medical error with the potential to cause harm that reached the patient but because of either good fortune, or because the patient had sufficient reserves to buffer the error, did not cause clinically detectable harm. These errors were not considered recovered errors and were excluded.
Mitigated potential adverse event	A medical error with the potential to cause harm that reached the patient but recovered before harm occurred

* Institute of Medicine: *To Err is Human. Building a Safer Health System.* Washington, D.C.: National Academy Press, 1999.

† Forster A.J., et al.: The incidence and severity of adverse events affecting patients after discharge from the hospital. *Ann Intern Med* 138:161–167, Feb. 4, 2003.

‡ Brennan T.A. et al.: Incidence of adverse events and negligence in hospitalized patients. Results of the Harvard Medical Practice Study I. *N Engl J Med* 324:370–376, Feb. 7, 1991.

§ Bates D.W. et al.: Incidence of adverse drug events and potential adverse drug events: Implications for prevention. ADE Prevention Study Group. *JAMA* 274:29–34, Jul. 5, 1995.

potential or ongoing adverse events that were otherwise unrecognized. The research observers were not permitted to assist in patient care except during life-threatening emergencies (for example, cardiac arrest) until other staff arrived at the bedside.

Chart abstraction and solicited and voluntary reporting[17] were used to collect suspected incidents in addition to those collected during the direct observation sessions. Chart abstraction[5] included review of all physician and nursing progress notes and consultation reports, and if potential incidents were found, physician orders and test result reports as well.[18] All CCU nurses were permitted and encouraged to report incidents that occurred outside the observation sessions. Formal institutional incident reports and pharmacy incident reports were also reviewed.

Incident Classification

Two physicians independently rated and classified each suspected incident [J.M.R., C.P.L., J.W.C.]. Suspected incidents not rated as recovered errors were excluded. Physician raters judged potential severity using a three-point scale (significant, severe, life-threatening) and preventability using a five-point Likert scale (prevented, definitely preventable, probably preventable, probably not preventable, definitely not preventable) with the

preventability scale collapsed to preventable or not preventable prior to analysis. Rater disagreements were resolved by discussion.

Errors were rated according to the cognitive stage of the task (planning, execution, or surveillance/monitoring) and also classified using the Rasmussen model, later adopted by Reason and Leape.[3,19,20] Errors were categorized into behavioral or performance classes, which included the following:

- Skill-based errors (failures to carry out intended plans of action and commonly known as lapses and slips)
- Rule-based mistakes
- Knowledge-based mistakes

Medical errors were also classified according to clinical activity (prevention, diagnosis, and treatment or procedure), associated individual or systems factors, and organizational factors such as failures in communicating clinical information.[18,21]

Statistical Analysis

Categorical variables were compared using the Fisher's exact test. Comparisons of nonparametric continuous variables were made using the Wilcoxon Rank-Sum test. Comparisons of means of normally distributed continuous variables were made using the Student's *t*-test. Incident rates were compared using the Binomial test. Individual incidents could be associated with multiple systems and/or cognitive stage errors, such that total percentages could exceed 100. Prediscussion interrater judgments were compared for level of agreement using the Kappa (k) statistic for incident classification (k = 0.95) and severity (k = .60).

Results

Patient Population

A total of 300 patients had 311 CCU admissions during the 147-day data collection period. A total of 65 patients with 65 CCU admissions had one or more documented recovered medical errors. Hospital mortality for CCU patients with recovered errors (15/65, 23%) was not significantly different from patients without recovered errors (36/235, 15%). Demographic information is provided for patients with recovered errors detected during direct observation in Table 2 (page 67).

Direct Observation

Among the day-shift CCU nursing staff, 30% (7/23) of nurses agreed to be observed. The observed nurses had a mean age of 47 years, 22 years of total nursing experience, and 14 years of CCU experience. A total of 150 hours of observations were conducted during 50 observation sessions for a mean duration of three hours. Observation sessions included a mean of 2.04 nurses concurrently being observed for a total of 308 observed nurse-hours. The mean nurse-to-patient ratio was 1:1.09.

Clinically Significant Intercepted Recovered Medical Errors

A total of 142 recovered medical errors were found, including 86 (61%) identified during direct observation and 56 (39%) detected by other methods (Table 3, page 68). The mean rate of recovered errors per observation session was 1.7. Most of the errors caused no harm, either because of interception before they reached the patient (69%; 98/142) or mitigated after reaching the patient but before resulting in harm (13%; 18/142). Ameliorated adverse events were corrected before further harm ensued in 18% (26/142) of the caught errors. The potential for new or worsening harm were more often severe or life-threatening (51%). Examples of recovered errors are provided in Table 4 (page 69).

Medication-Related Recovered Medical Errors

Medication errors represented 73% (104/142) of the recovered errors, including 66% (57/86) of the observed errors and 84% (47/56) of errors captured by other means. The most common type of medication errors were wrong dose (17%), wrong medication (15%), duplicate order (15%), omitted medication (12%), wrong route (9%) and wrong patient (8%). The most common medication classes associated with recovered errors were anticoagulants (14%), electrolyte solutions (11%), vasopressors (11%), beta-blockers (6%), antiarrhythmics (5%), and insulins (5%).

Cognitive Stage of Tasks, Performance Level, Clinical Activity, and Associated Factors

Recovered errors were most commonly related to task execution, such as computerized order entry,

and less often with the planning of actions or monitoring of patients (Table 5, page 70). In addition, most errors involved skill-based performance behaviors such as slips and lapses, rather than knowledge or rule based errors. Clinical activity and associated individual or systems' factors were most often failures to follow protocols of treatments and procedures, failures to take precautions to prevent injury, inadequate monitoring, and reporting or communication failures (Table 6, page 71).

Discussion

We found that during the day shifts in an academic CCU, nurses frequently recovered medical errors, including many that potentially could have resulted in severe or life-threatening harm. Extrapolating our findings to an eight-hour day shift only, slightly more than two potentially harmful medical errors per patient are recovered daily by each CCU nurse, and for a ten-bed CCU, more than 7,300 medical errors are recovered annually.

Recovered errors were most commonly related to the execution of tasks such as procedures or treatment orders and were slips or lapses. In addition, many of the errors involved failures to take precautions, such as not following infection isolation protocols. These errors may be more amenable to recovery than other less visible error types such as diagnostic errors. Nearly three-fourths of the errors were related to medications.

Table 2. Demographics of Coronary Care Unit Patients with Recovered Medical Errors*

Item	Value
Admissions — no.	65
Patients — no.	65
Mean age — no. years (SE)	68 (±1.7)
Male — no. (%)	30 (48)
Caucasian race — no. (%)	47 (77)
Median hospital length of stay — days (IQR)	9.8 (13.5)
Median unit length of stay — days (IQR)	4.4 (7.3)
Died in unit — no. (%)	11 (17)
Died in hospital — no. (%)	15 (23)
Charlson Comorbidity Index (SE)	2.8 (±1.6)
APACHE II score (SE)	19.2 (±8.2)
Admission source — no. (%)	
Emergency Dept.	21 (32)
Transfer from floor or other unit	15 (23)
Other hospital	13 (20)
Catheterization lab	12 (18)
Other	4 (6)
Reason for admission to unit — no. (%)	
Acute coronary syndrome /MI	16 (25)
Ventricular dysrhythmias	7 (11)
Pulmonary edema	4 (6)
Cardiac arrest	3 (5)
Supraventricular dysrhythmias	3 (5)
Cardiogenic shock	2 (3)
Other cardiovascular disease	6 (9)
Sepsis	4 (6)
Acute exacerbation asthma /COPD	2 (3)
Gastrointestinal hemorrhage	2 (3)
Other	16 (25)

* SE, standard error; IQR, interquartile range; APACHE, Acute Physiology and Chronic Health Evaluation; MI, myocardial infarction; COPD, chronic obstructive pulmonary disease.

Recovered errors are important to study because they are more common than errors that result in actual preventable adverse events[22] and can be revealing in learning how to prevent future errors from harming the patient.[23] Recovered errors are instructive as to the weaknesses in a system (errors and inadequate defenses) as well as the strengths of the system (the unplanned informal recovery responses).[24]

Traditionally, physicians have been responsible for most decision making in the care of hospitalized patients. Therefore, most interventions to reduce preventable adverse event rates have focused on physicians. Examples of successful critical care patient safety interventions targeting physicians include computerized order entry,[25] pharmacist participation during physician rounds in critical care units,[26] intensivist staffing of ICUs,[13] and reducing extended intern work shifts during critical care rotations.[16]

Table 3. Recovered Medical Error Classification and Severity

	Method of Event Detection		
	Direct Observation *n* = 86 (%)	Non-Observation Methods* *n* = 56 (%)	Total† *n* = 142 (%)
Classification			
Intercepted potential adverse event	54 (63)	44 (79)	98 (69)
Mitigated potential adverse event	12 (14)	6 (11)	18 (13)
Ameliorated adverse event	20 (23)	6 (11)	26 (18)
Potential Severity			
Life-threatening	5 (6)	5 (9)	10 (7)
Severe	40 (47)	23 (41)	63 (44)
Significant	41 (48)	28 (50)	69 (49)

* Events collected by nonobserved methods were found by solicited reporting and chart abstraction. Formal institutional incident reports and pharmacy incident reports did not result in finding additional events.

† *p* value not significant for comparisons between incidents collected by direct observation and nonobservation methods.

However, direct patient care for hospitalized patients, especially critically ill patients, is primarily provided by nurses. Decision making for the care of these patients has become increasingly complex, and nurses are taking larger roles in this aspect of care.[27] Patient safety activities of nurses include the monitoring of patient status, performing therapeutic interventions, and integrating patient care to avoid gaps.[10] During patient surveillance, and especially in critical care units,[28] nurses commonly detect early complications and other problems in patient care and often initiate actions to minimize poor patient outcomes.[29] The relationship of hospital-level nurse staff characteristics to patient outcomes is probably in large part due to such patient safety activities. Surgical patients in hospitals with higher proportions of nurses with greater levels of education, greater nursing skill mix, and/or higher nurse-to-patient ratios have lower mortality rates and failure-to-rescue rates.[11,30,31] Hospitals with higher levels of registered staff nurses have lower mortality rates in patients admitted with acute myocardial infarction.[32]

In addition, a number of studies have focused on nursing staffing issues in ICUs. Patients with abdominal aortic surgery who are cared for in ICUs with higher nurse-to-patient ratios have significantly reduced ICU lengths of stay and fewer postoperative pulmonary complications.[33,34] Increased use of pool nurses, as opposed to permanently assigned staff nurses, in a surgical ICU has been associated with an increased rate of primary bloodstream infections.[35] The relationships between critical care nurse staffing and improved patient outcomes may in part result from greater success in recovering medical errors.

Conditions affecting nurses such as increased stress, insufficient training, inadequate supervision, extended work schedules, and heavy patient case loads may influence their capacity for surveillance of potentially harmful medical errors in critical care patients.[34] Extended work hours for staff nurses were reported to be associated with more nursing errors.[36]

In addition to nurse staffing characteristics and working conditions, interactions between critical care nurses and physicians and the nature of their collaboration may also affect patient safety.[37] Many clinicians believe that individuals rather than the system or organization are too often responsible for medical errors.[38] Critical care nurses and physician staffs often have difficulty discussing errors.[39] Poor nurse–physician relationships do not embrace teamwork and are characterized by poor or hierarchal communication and unilateral decision-making by physicians and may lead to unsafe patient care.[40] In contrast, superior critical care units are characterized by a patient-centered culture, strong medical and nursing leadership, effective communication and coordination between nursing and medicine, and open, collaborative approaches to problem solving.[41] Effective interdisciplinary collaboration and teamwork is characterized by clinically competent staff who share mutual trust and respect, share an understanding of goals and roles, communicate well, share decision making responsibilities, and successfully manage conflicts.[27]

How can critical care nurses more successfully recover errors early enough to prevent or reduce patient harm? In a safe organizational culture, all staff are continually

Table 4. Examples of Recovered Medical Errors

Event Type: Intercepted Potential Adverse Event

Severity: Significant

An intern was about to assist a patient who requested to sit up over the side of the bed when the nurse reminded her that it was unsafe to do so. This patient with severe cardiomyopathy and acute renal failure was at that time on continuous venovenous hemofiltration through a femoral dialysis catheter.

Severity: Severe

An intern wrote orders for intravenous normal saline at 100 milliliters per hour on the wrong patient. The patient mistakenly ordered to receive the infusion was on fluid restriction with end-stage renal failure. The nurse intercepted the error before reaching the patient and the infusion order was reordered for the correct patient.

Severity: Life-Threatening

The intern wanted to measure the pulmonary artery (PA) wedge pressure in a patient with an acute myocardial infarction, cardiogenic shock, and worsening hypotension. The intern was intercepted before attempting PA catheter balloon inflation. The nurse recognized an abnormally dampened pressure wave tracing and recommended catheter repositioning. Immediately after pulling the catheter out seven centimeters, the waveform returned to a typical PA waveform and the hypotension resolved.

Event Type: Mitigated Potential Adverse Event

Severity: Significant

A patient with sepsis, cardiomyopathy, acute renal failure requiring hemodialysis, and anuria has had an indwelling urinary catheter despite no urine output for several days. The nurse informed the intern that the urinary catheter was unnecessary and it was promptly removed.

Severity: Severe

A patient with a history of cardiac tamponade and atrial flutter was admitted for ablation therapy and treated with intravenous heparin. Because of consistently very high partial thromboplastin times (PTT) during the previous day, the heparin infusion dose had been decreasing. The nurse recognized that previous phlebotomies had been drawn from the arm above the heparin infusion site because of lymphedema in the other arm. The nurse requested a test specimen from the radial artery and the PTT was found to be subtherapeutic. The heparin rate was correctly increased to achieve true therapeutic PTT levels.

Severity: Life-Threatening

In a patient treated with intravenous vasopressors for cardiogenic shock, unstable angina, and mitral valve insufficiency, the nurse recognized an incorrect two-day-old order for phenylephrine. The patient was ordered a drug titration range of 10–1,000 micrograms per minute. The order was correctly changed to a maximum of 100 micrograms per minute.

Event Type: Ameliorated Adverse Event

Severity: Significant

In a patient with pulmonary hypertension and atrial flutter requiring ablation therapy, the intern continued to attempt placement of an arterial catheter despite eight previous failed attempts during the previous hour. The nurse insisted that the intern stop and seek assistance by contacting a more experienced physician. A catheter was then successfully placed without difficulty by the cardiology fellow.

Severity: Severe

A patient with recurrent ventricular tachycardia and admitted for ablation therapy became increasingly agitated with delusional behavior. The intern ordered intravenous lorazepam for sedation treatment but it was ineffective. The nurse informed the intern that the patient had been on a lidocaine infusion for two days and suggested discontinuation of the lidocaine instead. Several hours after the lidocaine was stopped, the mental status returned to normal.

Severity: Life-Threatening

A patient with empyema, severe metabolic acidosis, and acute respiratory failure was found by the intern to be suddenly very tachypneic. During his time-consuming patient assessment, the intern was unaware that the patient had been accidentally disconnected from the mechanical ventilator. The nurse returned to the bedside and immediately reattached the endotracheal tube to the ventilator circuit with resolution of the respiratory distress.

vigilant in identifying and resolving safety concerns and are empowered to take necessary actions to prevent an adverse event.[42] Creating a culture to encourage enhanced communication, such as discussing patient safety issues during ICU rounds, may reduce ICU adverse events.[43] In addition, information technology will likely soon help nurses do even better with surveillance and monitoring.[44] Monitoring is inherently a boring routine

Table 5. Cognitive Stage of Tasks and Performance Level of the Recovered Medical Errors

	Method of Event Detection		
	Direct Observation *n* = 86 (%)	Non-Observation Methods* *n* = 56 (%)	Total† *n* = 142 (%)
Cognitive Stage of Task			
Planning	11 (13)	5 (9)	16 (11)
Execution	53 (62)	38 (68)	91 (64)
Surveillance/Monitor	23 (27)	10 (18)	33 (23)
Unable to determine	3 (4)	3 (5)	6 (4)
Performance Stage			
Skill based (slip or lapse)	41 (48)	39 (70)	80 (56)
Rule based	4 (5)	1 (2)	5 (4)
Knowledge based	31 (36)	10 (18)	41 (29)
Unable to determine	10 (12)	7 (13)	17 (11)

* Events collected by nonobservation methods were found by solicited reporting and chart abstraction.

† Cognitive stage and performance level of errors may include more than one category per event, resulting in > 100%. The *p* value was not significant for comparisons between incidents collected by direct observation and nonobserved methods.

activity, and computers can be helpful by taking over some of this function, although nurses will need to identify the signals generated and intervene early before adverse events occur.

This study has a number of limitations. It was conducted in an academic CCU and may not be generalizable to other critical care units. Most of the errors were committed by housestaff physicians, especially interns who did not have significant CCU or other prior critical care experience. In spite of extensive staff training, observational studies are susceptible to observation bias. The direct observations, conducted during nonholiday weekday shifts, may not reflect the rates of events during evenings, nights or holidays. Nurses who agreed to be observed may have had more CCU experience, medical knowledge, or skills in recognizing and reporting recovered errors to physicians than nurses who did not participate in the study. We did not study what characteristics of nurses may have contributed to recovering and reporting specific errors—knowledge that would be valuable in educating other nurses. Interrater reliability testing of the two research observers was not conducted. The nurse-to-patient ratio in the study CCU may be greater than other units, but at the same time, as a tertiary care referral center, their patients may have been more ill. Finally, we did not measure all medical errors and therefore could not determine how many medical errors slipped through the nurse safety net or the proportion of medical errors recovered by nurses.

Conclusion

In a poststudy interview, one participating nurse expressed nurses' role in patient safety: "We are the first line of defense . . . being a [critical care] nurse is not [just] being good at codes (cardiac arrests), it is being good at preventing them."

Comprehensive patient safety initiatives should include strategies to enhance nursing collaboration and interdisciplinary teamwork and to increase the early identification, interruption, and correction of medical errors—strategies that can be expected to further strengthen the critical care nursing safety net. In addition, greater understanding of the clinical context and processes of care[45] associated with successful interception of medical errors can lead to improved teamwork training and care provided by critical care nurses and physicians. Future ethnographic research is needed to determine the facilitators and barriers to recovering errors, and intervention studies are needed to augment error recovery and improve patient outcomes. Such research can also provide empirically derived content for nursing curriculum and staff education programs.

Finally, with the expected increased burden of a growing critical care population[46] and the shortages in well-trained and experienced critical care nurses,[47] more research is needed to better define optimal and safe nurse-to-patient ratios in CCUs. J

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Table 6. Clinical Activity and Individual or Systems Factors for Recovered Medical Errors

	Method of Event Detection		
	Direct Observation *n* = 86 (%)	Non-Observation Methods* *n* = 56 (%)	Total† *n* = 142 (%)
Prevention	22 (26)	9 (16)	31 (22)
Failure to take precautions to prevent injury	13 (15)	7 (13)	20 (14)
Avoidable delay of treatment	3 (4)	1 (2)	4 (3)
Other	6 (7)	1 (2)	7 (5)
Diagnostic	12 (14)	7 (13)	19 (13)
Avoidable delay in diagnosis	4 (5)	2 (4)	6 (4)
Inadequate patient assessment	3 (4)	2 (4)	5 (4)
Failure to act on results of diagnostic tests	3 (4)	0 (0)	3 (2)
Other	2 (2)	3 (5)	5 (4)
Treatment or Procedure	55 (64)	37 (66)	92 (65)
Failure to follow protocol	32 (37)	29 (52)	61 (43)
Inadequate monitoring system	8 (9)	3 (5)	11 (8)
Use of wrong protocol	4 (5)	2 (4)	6 (4)
Avoidable delay in provision of service	5 (6)	0 (0)	5 (4)
Inadequate reporting or communication	1 (1)	3 (5)	4 (3)
Other	5 (6)	0 (0)	5 (4)
Organizational Factors	10 (12)	7 (13)	17 (12)
Inadequate reporting or communication	5 (6)	3 (5)	8 (6)
Inadequate monitoring system	4 (5)	3 (5)	7 (5)
Other	1 (1)	1 (2)	2 (1)

* Events collected by nonobservation methods were found by solicited reporting and chart abstraction.

† Several clinical activities and systems factors may be associated with recovered medical errors resulting in greater than 100%. The *p* value was not significant for comparisons between incidents collected by direct observation and nonobserved methods.

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