



A model of recovering medical errors in the coronary care unit

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Abstract[^]_^

OBJECTIVE: The purpose of this study was to explore the thoughts, interpersonal processes, and actions used by nurses who had recently intervened to protect coronary care unit (CCU) patients from potential medical errors.

METHODS: The study used semistructured interviews conducted with 18 very experienced CCU nurses in two academic medical centers. Content analysis was used to code and analyze text segments. Core codes were used for developing an empirically derived model.

RESULTS: There were more than 1000 data bits of accounts of involvement in the near-miss events, thought processes and actions surrounding the events, communication strategies used, feelings, outcomes, reflection about the event and consequences, and environment/context in which the events occurred. A three-stage temporally ordered model illustrates the process of recovering medical errors. In stage one, the presence of the evolving clinical scenario and nursing knowledge and expertise plus the CCU context are the antecedents that lead to processes and actions of identification, interruption, and correction of the error in stage two. Outcomes of whether or not the near miss was recovered lead to an adverse event (or not), and reflections on the process and outcome lead to the nurse's feelings about the event in stage three.

CONCLUSIONS: The model can guide nursing administration, practice, education, and research to recognize and value this responsibility, to teach others, and to test strategies to enhance the vital nursing role of recovering near-miss events that leads to safer and better patient care.

Medical errors cause more than one million injuries and between 44,000 and 98,000 deaths annually in hospitalized patients according to the Institute of Medicine report "To Err Is Human."¹ Intensive care units

(ICUs) are sites where the highest rates of medical errors occur.² The Rothschild team³ found 149.7 serious medical errors per 1000 patient-days during a 1-year observational study in two medical ICUs. Although those are striking numbers, had the near misses not been intercepted by others, serious adverse events could have occurred, for example, potentially lethal medication errors or accidental disconnection from needed mechanical ventilation. In a study conducted to learn the effect of reducing interns' work hours on medical errors,⁴ Landrigan and colleagues stated "our data on the high incidence of intercepted serious errors in ICU settings indicate that the ability of other personnel to act as interns' safety net—nurses, pharmacists, and senior medical staff—is very important in preventing injury to patients as a result of interns' errors" (p. 8).

MODELS OF NURSES' PROCESSES SURROUNDING ERRORS AND ERROR RECOVERY[^]

Several models developed from quantitative data, built from interviews around critical incidents, or derived from other disciplines and applied to nursing have been used to provide an understanding of the processes used by nurses who have been involved with errors in health care. For example, the Meurier et al⁵ and McKeon et al⁶ teams both used quantitative data to develop statistical models to understand nurses' causal attributions after an error and organizational factors contributing to violating procedures during medication administration respectively. On the basis of Reason's⁷ Organizational Accident Model, Meurier⁸ also developed a model using written descriptions from 20 structured critical incident reports that were supplemented by interview data from five of the nurses. Although these models are empirically derived and sufficient for providing greater understanding of how people explained their role in errors,⁵ organizational features that may predispose to deviation from procedures as a cause of errors,⁶ and the interaction of latent organizational factors and active specific circumstances on producing a potentially adverse event,⁸ they are focused on nursing errors and not on nurses who recover the error of another.

We located one model, developed by Henneman and Gawlinski,⁹ that illustrates the nursing role in the recovery of medical errors. The Henneman and Gawlinski model is based on the Eindhoven model that was

developed to categorize the root cause of errors in the chemical process industry and then used by transfusion medicine.¹⁰ The model illustrated predisposing factors and the action of nursing recovery (or not) on adverse event outcomes (present or absent).⁹ Henneman and Gawlinski explained their model using hypothetical scenarios of nursing actions to recover medical errors.⁹ Although the model was not helpful in categorizing errors in the emergency department,¹¹ it is suggested⁹ for researchers, administrators, and clinicians to conceptualize the role for nurses in developing interventions to decrease medical errors following the steps of error identification, interruption, and correction. The Henneman and Gawlinski model⁹ was helpful as we reexamined the emerging literature related to near-miss events during our analysis.

SETTING BACKGROUND[^]

One of the ICUs in the studies by Rothschild et al³ and Landrigan et al,⁴ a coronary care unit (CCU), was the site for a quantitative follow-up study to examine the incidence and characteristics of near-miss events that CCU nurses intercepted.¹² The Rothschild team directly observed 150 hours of nursing care in the CCU and used anonymous solicited and institutional incident reports to identify near-miss events when nurses intervened to prevent medical errors from harming patients.¹² Some 142 recovered medical errors were identified, of which 98 were intercepted before reaching the patient (prevented), 18 before harming the patient (mitigated), and 26 before severe harm could occur (ameliorated). When those data were extrapolated to one 8-hour day shift for only a 10-bed CCU, approximately two potentially harmful errors are recovered daily per patient with more than 7300 recovered annually.

STUDY AIMS[^]

Quantitative studies^{4,12,13} revealed the magnitude of intercepted errors, but the processes used by nurses who intervened to protect patients from medical errors are less well known. Steps that nurses take to intervene to recover medical errors are illustrated in a model,⁹ but the Henneman and Gawlinski model was not empirically verified and was explained using hypothetical scenarios. Discovering these processes is important to demonstrate the value of and enhance this “invisible role” and to teach the next generation of

CCU nurses who will be taking the place of the current nursing workforce. Therefore, the purpose of this qualitative study was to explore the thoughts, interpersonal processes, and actions used by nurses who had recently intervened to protect CCU patients from potential medical errors. For this study we define errors as mistakes of commission or omission in patient care; near miss as a prevented, mitigated, or ameliorated medical error; and recovery as interception of a near miss.

METHODS[^]

This qualitative study was conducted to follow a quantitative investigation of near-miss events intercepted by CCU nurses.¹² We followed basic content analysis methods¹⁴ to interpret descriptive data obtained from interviews of CCU nurses who had recently intervened to protect a patient from a potential medical error.

Procedures[^]

Institutional review board approval was obtained to interview CCU nurses at two academic medical centers. Nurse managers identified potentially “good informants,” nurses who had both experienced the phenomena and could articulate their experiences.¹⁵ Potential participants were contacted, invited to participate, scheduled for an interview, and asked to be thinking about some near-miss events to share during the interview. Tape-recorded interviews were conducted in a private conference room in the CCU or the general clinical research center.

A semistructured interview guide was used for set questions, but the approach was individualized to guide participants to tell their stories. Notes were taken and used to guide specific follow-up questions. Participants were first asked to describe their role/job in the CCU. Probes, “Tell me some more about ...,” “Help me understand ...,” were used to elicit additional information and to help the participant to start conversing. Then participants were asked the “grand tour question,” “Tell me about being involved in a near-miss event.” If the participant did not start to tell a story about a near-miss event, the interviewer stated, “You might want to start with the one you had in mind when you signed up for this study.” Relevant

probes and follow-up questions were used to elicit additional information and clarification about the event. After participants recalled and described other near-miss events, we asked additional questions about the meaning of the term "near miss," situations when it was difficult to prevent a potential error, learning how to prevent errors, and background data to describe the sample. Participants in later interviews were also asked their opinion of findings to date and on emerging core categories.

Interviews were transcribed verbatim into a word processing package, reviewed/corrected for transcription accuracy and removal/masking of any identifying characteristics of patients or providers, and converted into NVivo for coding and support of qualitative analysis. We used two-person consensus for the analysis. First we open coded text to capture meanings in the data. We then compared codes with each other and performed selective coding to identify core categories. We linked core categories to discover new perspectives from the accounts of participants' experiences [16](#) and examined emerging findings with the recent literature to compare and contrast categories and relationships with the evolving work in this area. Debriefing among researchers, prolonged engagement with the raw data and codes, and use of field and reflective notes established reliability and validity. Validity was also ensured when later participants agreed with core categories and definitions.

We developed the model by relating core categories derived from the data to one another. During data collection/analysis, we reexamined the evolving body of literature related to the topic of near miss and compared our codes, core categories, definitions, and working model with the Henneman and Gawlinski near-miss model, [9](#) in which the term *nursing recovery* is a core category. We concluded that although our data and interpretations did provide empirical support for the Henneman and Gawlinski model, [9](#) that model was insufficient to account for the processes identified in this study.

Setting and sample[^]

The settings were two adult CCUs with an all registered nurse staff in large urban academic medical centers in the same health care system. One of the CCUs was also the site where medical error research previously

cited in this article had been carried out.^{3,4,12} Housestaff were primarily responsible for entering diagnostic and treatment orders under the supervision of cardiology fellows, who provided 24-hour in-house coverage. Hospital-based cardiologists were attending physicians. The units differed in size and housestaff. The 10-bed CCU had interns (first-year residents), and the 16-bed CCU did not have interns.

Eighteen CCU nurses who conversed easily about their nursing practice, were known to have been involved in near-miss events, and agreed to/were available for an interview during working hours constituted the sample. Participants were very experienced (16.6 ± 9.1 years CCU tenure) and well educated (14 had a baccalaureate degree in nursing). All were white, and there was one male. Participants typically cared for one or two patients during their shift, and several had additional responsibilities, such as orienting new staff, being the resource nurse, or being in charge.

RESULTS[^]

Coded interview transcripts yielded more than 1000 data bits of very detailed accounts of involvement in near-miss events, thought processes and actions surrounding the events, communication strategies used, feelings, outcomes, reflection about the event and consequences, and the environment/context in which the near-miss event occurred. Participants applied their knowledge and expertise to the near-miss event as the clinical scenario unfolded or was discovered, determined that action was needed to protect the patient, decided what to do (sometimes with peer consultation), took the action, and followed through.

Many stories included CCU technologies, not as the focus, but rather the environment in which nurse/patient, nurse/physician, and nurse/patient/physician interactions occurred. Intensive, often invasive, and sometimes high-risk diagnostic tests and advanced therapeutics were a part of everyday care of patients.

A three-stage temporally ordered model, "A Model of Recovering Medical Errors in the CCU," illustrates the process of recovering medical errors. In stage one, the presence of the evolving clinical scenario and nursing knowledge and expertise plus the CCU context are the antecedents that lead to processes and actions in

stage two and outcomes in stage three. The nurse uses critical thinking to identify an evolving near-miss or adverse event, acts to interrupt the event, and in his/her advocacy role, as a component of nurse work, corrects the event, leading to the outcome of near-miss recovery. Whether or not the near miss was recovered leads to an adverse event (or not). Reflection on the process and outcome leads to the nurse's feelings about the event. The context of the study environment was described by one of the participants (Fig 1).

Fig 1 Model of Recovering Medical Errors in the CCU.

I've dubbed the patients the sick of the sick. These are acutely ill patients. They're cardiac, their hemodynamics are extraordinarily impaired, they require life support, meaning they need a ventilator to support their respiratory function, oftentimes they need an intraaortic balloon pump to help support their circulatory system. When those two functions are impaired, shortly other systems are impaired, and they need support of their renal function, so we provide renal support—continuous vein-to-vein hemofiltration. These people need a tremendous amount of emotional support, they themselves and their families. Oftentimes these patients are supported with a lot of artificial means. We are responsible for their nutritional needs as well as skin care needs, just the whole basic life for these patients, and that's what we provide here for these people.

Stage one: Antecedents[^]

Participants knew their patients very well—their nursing needs, subtleties, vulnerabilities, the interface between their medical management and current and potential clinical trajectory, and likely consequences if the near miss were not intercepted. By conducting physical examinations; interpreting physiologic data from monitoring devices, laboratory tests, scans, and x-ray films; learning health histories from medical record

data; and being current on prognosis and treatment goals, participants kept abreast of their patients' status. Participants' knowledge and expertise were manifested by clinical skills, ethical comportment, and self-efficacy.

Clinical skills. [^](#)

Clinical skills are the repertoire of knowledge and evidence-based actions carried out proficiently to achieve patient goals. An example is promoting physiologic stability in the presence of competing vascular and cardiac needs.

He came in very dehydrated, had some infection, had this whole sepsis picture, so he has a PA [pulmonary artery] catheter, so we're measuring the right heart pressure and the left heart pressure. He's still on blood pressure medication ... managing his fluid intake as well, because he has a congestive heart failure history. He needs the fluid, but you have to be careful that he doesn't go into pulmonary edema. He had fluid going like 250 an hour [long dialogue/interaction with house staff], so we turned it down to 150 an hour.

Ethical comportment. [^](#)

Ethical comportment is defined as per Benner 17 as the embodied skilled know-how of relating to others in ways that are respectful and support their concern. Ethical comportment in this study depended on nurse/physician professional relationships and was made visible through communication strategies. Collegial professional relationships developed over time and were stronger with attending physicians, whom most participants had worked with for many years and who valued and trusted their knowledge and patient insights, than with house staff who rotated through the units at 4-week intervals. Communication was typically the first action taken. Participants used strategies of humor, questioning, seizing a teaching moment during rounds, and seeking a private moment. However, when deemed necessary to attempt to rectify a near-miss event, participants “went public” or “went to the top,” invoking the medical hierarchy to protect their patients. Reflection about the discourse surrounding a difficult medication management

regimen for a transplant recipient illustrates ethical comportment.

I think if you approach the residents with a professional demeanor and not come across as you're belittling them or thinking that they did something wrong ... I always come across as well, 'What do you think about this?' and try to get their brain going where mine is instead of just coming right out and saying 'No, I really don't think that's a good idea.' That's what causes conflict. If you are being attacked by a nurse or you are being attacked by a resident because they disagree with something, then obviously you always become on the defensive and that's how problems start. So I always try and make sure that they don't feel like they have to get on the defensive, and I just bring across my opinion in a calm way.

Self-efficacy.[^]

Self efficacy is defined per Bandura [18](#) and means personal beliefs of one's capacity to plan and carry out patterns of behavior that may contain novel, unpredictable, and stressful elements. Participants were confident in their knowledge of the patient and their own expertise, but they also recognized that uncertainty exists in many situations because of patients' overall clinical complexity and the possibility that new medical discoveries or a different philosophical stance on treatment may mean that what participants thought to be a potential medical error may not have been one. Despite not having all the answers, participants still had the confidence to step forward on behalf of the patient, for example, when not knowing a medication ordered during a code.

I was in a code just a few months ago, a horrible code. They wanted me to give TPA [thrombolytic agent] ... I didn't know the front uploading dose. They've changed the dose every few years. So I'm in a room full of people and I'm the code nurse, and I said 'someone needs to find out what the loading dose of TPA is, and the entire room got silent because none of us knew.' So one of the doctors said 'just hang it and start running it and we'll find it out.' I said 'No.' ... When I was 22, I probably would have hung it and then found out. It's better to wait and be safe than it is ... you can't take back what you've done. You can only prevent what you haven't done. At 22, I probably would have done what that physician had said and that would

have been really wrong.

Stage two: Near-miss recovery processes and actions[^]

In stage two, the process of protecting patients emerged as participants applied their critical thinking to clinical scenarios to identify potential errors and followed up by acting in the patient's best interest to interrupt and correct the events. The near-miss recovery process consists of three processes/actions of identify, interrupt, and correct, which are consistent with the Henneman and Gawlinski model.⁹ The three processes/actions occurred so rapidly they were nearly indistinguishable in some stories.

Identify.[^]

Identify means to be prepared and to use critical thinking (those thought process by which nurses make clinical judgments after considering, analyzing, and synthesizing relevant information) to recognize a potential medical error. The categories of being "at the ready" and surveillance-vigilance determined the action of being prepared as participants anticipated outcomes/consequences, performed/interpreted their assessments, and provided extra attention/were more watchful. The critical thinking component of *identify* includes descriptive categories of apply clinical judgment, be the clinical expert, and knows "what should be done." Our definition is aligned with the classic work of Watson and Glaser,¹⁹ and intellectual processes used in applying knowledge of electrolyte management in compromised patients,²⁰ managing complex analgesia administration,²¹ and preventing hyperkalemic emergencies.²²

An example of *identify* is recognizing an incorrect interpretation of the patient's clinical status by neither looking at the proper diagnostic data nor considering the patient's true condition in light of the potent medications required to achieve physiologic status.

When they're [house staff] reading off their [patient's] vital signs, they'll say their heart rate but they don't read them all. There are 50 heart rates written on the sheet for a 24-hour period if you wrote it every half an hour. Sometimes there's a heart rate of 120, but they happened to miss it and they'll say 'oh the

patient's heart rate is well controlled at 60 to 80.' You'll be like, 'No the patient's heart rate was 120 for 1/2 an hour and he's getting IV Lopressor' [metoprolol].

Interrupt.[^]

Interrupt means action/s to disrupt the evolving scenario and/or to step in to address a potential error.

"Knowing how to intervene" and "being the patient's voice/providing patient or family perspective" were the descriptive categories that formed the *interrupt* category. Nurse/physician communication was usually the first action taken in anticipation of a collaborative decision to rectify the event. But, when participants believed patients' needs for expediency were paramount, they acted on their nursing judgment and took it on themselves to carry out proactive actions. An example of *interrupt* when delay could cause harm was when an intern did not quickly address a patient's mottled and swollen leg.

I interrupted rounds yesterday to get them to come and look at a patient's leg that I was concerned about. I had taken an intern aside and was concerned about this patient's leg because it was swollen, it was mottled, it was swollen from the groin to the foot. And I was worried about compartment syndrome and the intern said, well, 'We'll look at it on rounds.' And then I went back to look at it and I was thinking about it, and we really can't wait so I spoke up in front of rounds to the attending and I said 'You really should come look at this leg.' And they did, they moved on and started immediately calling, send the patient down to CT. So, yes if you have something you really want to bring up, bringing it up in front of everybody is a good way to get attention and maybe getting them to listen to you.

Correct.[^]

Correct means action/s intended to resolve the evolving scenario or redress a potential error to prevent harm or further injury by acting in the patient's best interest despite potential barriers or difficulties. Such actions may be to correct a past or presenting situation or be anticipatory to prevent a future potential error. *Correct* is nurse work of following through and completing necessary actions and was derived from the

descriptive categories of attending the whole person and protecting the patient/safeguarding. There is an advocacy component within *correct*. When nurses acted to correct a potential error, they “attended to the patient versus the doctor” and made the statement “my patient is my patient” operational, even when potentially intimidated. Participants were prepared for “in case,” double-checked as needed, and threw up roadblocks to “block situations.”

Our definition of *correct* is similar to the constitutive pattern of safeguarding that emerged during a study of nursing advocacy during a military operation.²³ An example of preventing a resident from continuing to attempt a central line insertion that could have delayed treatment and risked pneumothorax illustrates the action of *correct*.

Like I said, the senior was there to witness everything [several attempts at inserting a central line], and she agreed with me. I felt bad at first because your adrenaline is going, you're in such a high stress time and I didn't really yell at her [resident], but I just said, 'we really need to stop, she [patient] needs this access immediately.' She kept saying, 'I really think I can get it. I think I can get it.' During those situations, there's no thinking you can get something. You need to know that you can get it and definitely have someone else step in and try.

Stage three: Outcomes[^]

We use the term, *near-miss recovery*, because not all near-miss events are recovered or are not recovered as quickly as participants deemed to be clinically necessary. Participants told stories in which we classified 68 different recovered errors as misdiagnosis, unnecessary delay or not ordering tests or therapeutic interventions/necessary prophylaxis, using incorrect technique, missing coexisting health problems, interpreting clinical signs incorrectly, and medication errors.

Depending on the recovery, presence or no presence of an adverse event, and ease or difficulty of overcoming barriers or communication issues, nurses had positive or negative feelings about the event.

Examples of feelings after not getting physicians to accept that a patient's last line was misplaced led to frustration, whereas being thanked for not giving a wrong drug led to a positive feeling.

That really stuck out in my mind how frustrated I was that I knew that line was not in place. At every level nobody would listen to me, they thought that we had to take the chance [and administer blood through the line, which did pool at the tip]. He came up and thanked me for being prepared and he was upset, but next time he listened.

DISCUSSION[^]_^

The nursing role in recovering medical errors is essential for patient safety in the CCU environment. Critically ill patients with many complex and changing clinical conditions and anticipatory problems typically receive care under the immediate medical direction of a physician in training because of the medical teaching mission of academic medical centers or by a covering physician in community CCUs during weekends and off-shifts.

Understanding the process used by these expert nurse participants can inform nursing practice and education by teaching and role modeling components of the skill set identified in this study. For example, teaching could include strategies to develop skills in making, defending, and justifying judgments by good clinical and ethical reasoning. Ethical comportment [17](#) requires skills in communication and interdisciplinary team work, which are necessary for collaboration, which in turn is associated with better patient outcomes in the ICU setting. [24,25](#) Self-efficacy for recovering near-miss events may be learned in the clinical setting because new nurses view expert nurses as role models and compare themselves with the model. Such vicarious experience is one of the sources of information used to develop self-efficacy beliefs. [18](#) As suggested by Henneman and Gawlinski [9](#) the strategies used by nurses to recover medical errors should be developed into interventions that could also be demonstrated and tested in a simulation laboratory. Because the critical care nursing workforce is aging, [26](#) newer nurses who will be replacing those who retire will need skills to identify, interrupt, and correct potential medical errors.

This study generated new knowledge by extending the body of work in the near-miss area beyond adverse events 3,12 to discover the processes used by nurses who actually recovered medical errors. How participants thought and acted in a collaborative and respectful manner (and when necessary went outside normal communication channels) to protect their patients revealed the voices of expert practitioners. Our data provided both the core categories for building the “Model of Recovering Medical Errors in the CCU” and empirical support (vs the hypothetical scenarios) for the Henneman and Gawlinski model.⁹

As we developed core categories from our codes identified in interview data, we initially had two core categories, critical thinking and advocacy, that depicted the near-miss recovery processes used by nurses. As we compared and contrasted those categories and the codes from which they were derived with the Henneman and Gawlinski 9 steps of identify, interrupt, and correct, we concluded that they were similar. We therefore decided to use the Henneman and Gawlinski 9 labels to depict the recovery process used by nurses in this study. We strongly believe that multiple similar models, but that differ in nomenclature and definitions for core constructs, are not helpful for advancing nursing science.

The “Model of Recovering Medical Errors in the CCU” was developed on the basis of participants in two CCUs, but the degree to which the model can be generalized will be determined as research guided by the model is conducted, for example, what is the effect of acquiring the skills in stage one on recovering medical errors in stage three? A scale to measure self-efficacy for near-miss recovery should be developed for use in future research. Using the self-efficacy scale and previously developed methods to classify incidents in terms of being a medical error or not and degree of seriousness of errors 3,12,27 will allow testing of the “Model of Recovering Medical Errors in the CCU.”

Not recovering a medical error is similar to the quality criterion, failure to rescue,²⁸ when patients die of complications sustained during hospitalization. Although adequately staffed hospitals have better patient outcomes,²⁹ we agree with Clarke and Aiken,³⁰ who suggest that how exactly nurses affect patient safety

should be established. Although this study and resulting model were concerned with recovering medical errors, the “Model of Recovering Medical Errors in the CCU” should be considered to guide such research promoting high-quality care, including rescuing seriously ill patients from potentially lethal complications.

We concur with Affonso and Jeffs [31](#) that the context of near misses associated with care processes should be studied. There should be further explication of the terms: error, near miss, and recovery. Many different definitions, indicators, and measures are used, and this lack of consensus can lead to underrecognition and underreporting of near-miss events.[31](#) We were mindful of this issue of multiple definitions as we reexamined the existing near-miss model [9](#) and grappled with the issue of what on the surface could have been viewed as fitting our data to substantiate the near-miss model when we changed critical thinking and advocacy to identify, interrupt, and correct.

We recognize several potential limitations in this study. Because of the nature of the study, a qualitative investigation with a purposive sample of experienced nurses, the participants were not representative of the general population of CCU nurses, but they were all expert CCU nurses. We believe that our settings were similar to CCUs in other academic medical centers, but they may differ from other CCUs in terms of patient severity and medical teaching mission. We also recognize the issue of potential blurring between what is a quality issue and what universally would be considered an error.

Nonetheless, recovering medical errors is a social process in which individual nurses draw on their knowledge and skill-sets to recover medical errors. This vital role should be recognized and supported.

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