

Do Transient Working Conditions Trigger Medical Errors?

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Abstract

Objective: Organizational factors affecting working conditions for health care workers have received significant attention as latent causes of medical errors. Little is known, however, about the risks associated with transient or changing working conditions. The purpose of this study was to identify specific transient, modifiable working conditions in the hospital environment that serve as triggers for medical errors. **Methods:** A case-crossover design was used to study proximate causes of medical errors. Nursing personnel directly involved in a medical error were interviewed within 2 weeks of the error. Specific attributes of working conditions were assessed at the time immediately preceding the error and at times when no error occurred. Variables examined include subjects' perceptions of work pace, patient census, patient acuity, teamwork, and distractions. Preliminary results are based on 112 interviews completed to date. **Results:** Subjects were more likely to describe their work environment as more hectic and reported increased distractions and feelings of fatigue during the 30 minutes prior to the error occurring as compared with the entire error shift. Subjects were more likely to report missing important patient information, having higher-acuity patients, and experiencing unplanned events on shifts when errors occurred, as compared with shifts when no errors occurred. **Conclusions:** These preliminary results suggest that working conditions immediately preceding the medical error and on the error shift differed from times when no error occurred, suggesting that transient working conditions may contribute to medical errors. Changes to the work environment such as improving the transmission of important patient information may help reduce the occurrence of medical errors.

Introduction

Latent causes of error in health care have received significant attention. Factors such as nurse-to-patient ratio, nurse education, and hospital procedures have been identified as important risk factors for patient safety.¹⁻³ Few attempts, however, have been made to identify whether transient changes in working conditions may precipitate errors or make errors more likely to occur when combined with the latent factors existing at an institution. Traditional cohort or case-control studies are well suited to study the effects of constant or persistent factors that may vary among individuals or across working units, but are not as well suited to the study of risk factors that have significant temporal variability. The study of proximate causes of errors and other sudden-onset events may be

better approached through a case-crossover study, a relatively new methodology designed to answer the question, “Were exposures immediately preceding the case event different from those that typically occur?”⁴

In a case-crossover design, each subject serves as his or her own control, thereby eliminating the problem of confounding by differences among individuals such as job experience, risk-taking behaviors, training, age, and gender. The case-crossover study design allows estimation of the change in risk in the event of interest (for example, a medical error) associated with different temporally variable risk factors. In other words, the frequency of exposure to potential risk factors immediately before the event of interest is compared with the frequency of exposure during control periods when the same subject did not have the event.⁴⁻⁶ This study design seeks to identify triggers, or proximal causes of events, that occur closer in time to the event than other component causes.

Case-crossover studies were first used to study transient risk factors leading to myocardial infarction,⁷⁻⁹ and have subsequently been used to study proximal or transient risk factors for a variety of diseases or events. In addition, case-crossover studies have been proposed and used to study risk factors for occupational injuries.^{6, 10-12} Injuries to workers result from a causal chain of events involving both latent and immediate factors, similar to the chain of events hypothesized for medical errors. Indeed, many risk factors for injury that have been studied in case-crossover studies of injury are also thought to be risk factors for medical errors. For example, transient exposures assessed in previous studies have included cognitive distraction, sleep disturbances, overwork, use of unfamiliar tools or procedures, and rushed work pace. These same risk factors—particularly work hours, shift work, sleep disturbance, and cognitive overload—are also recognized as possible risk factors for medical errors.¹³⁻¹⁸ The close parallels between risk factors for injury and risks for medical error have led us to believe that the case-crossover design is well suited for a study of proximate work environment factors leading to medical error. The case-crossover design allows estimation of the change in the short-term risk of a medical error associated with potential transient risk factors. The aim of this study was to identify specific working conditions that serve as triggers or precipitants for medical errors. Our study was designed to test the hypothesis that working conditions during the time immediately preceding a medical error would differ from working conditions when no error occurred.

Methods

Subjects were nursing personnel (registered nurses, patient care technicians, licensed practical nurses, and nursing assistants) who had direct patient care responsibilities. We recruited subjects from 11 acute care hospitals. The majority of subjects were identified through a systemwide database, with online access at nine of the study sites. As per hospital policy, employees are instructed to report all patient care errors (actual and near-miss errors) through this system. With the assistance of the risk management department, information about this study was

added to the online system. After reading about the study, subjects were asked if they would like to participate. Contact information for subjects who expressed willingness to participate was given to the research team; a member of the research team then contacted the interested individual. Risk managers were asked to inform and recruit subjects from hospitals that did not have the online system in place. To further increase awareness about the study, posters were distributed to individual nursing floors throughout the study hospitals and the hospitals' newspapers published an article about the study. The Institutional Review Boards representing each participating hospital approved this study. To maintain confidentiality, interviews were coded with a unique number and were stored in a locked cabinet in a locked office.

Subjects were eligible if they had committed a medical error within the past 2 weeks that resulted in no harm or minimal harm to the patient. We defined a medical error as any deviation from an intended action, whether or not it caused harm to the patient. Errors that reached the patient as well as near-miss errors or errors that were caught before they reached the patient were eligible for study inclusion. Errors that resulted in more than minimal harm to the patient were not included in this study. Both medication errors and procedural errors, such as performing the wrong test on a patient, were included in this definition. We believed that the working conditions that contribute to a medical error would be similar regardless of whether the error resulted in a poor patient outcome or no harm to the patient. We also believed that subject recruitment would be simplified, and recall of working conditions less subject to outcome bias, if no-harm or minimal-harm errors were studied.

After obtaining informed consent from each subject, a trained interviewer administered a telephone interview. Subjects were first asked the dates and times of the shift on which the error occurred and the prior shift worked. Subjects were then asked to respond to the statement, "Please tell me about the patient care error." By placing this question at the beginning of the interview, we believe that subjects were able to recall and discuss the circumstances of the error without being sensitized to the specific working conditions being studied.

Following this, subjects were asked about specific attributes of working conditions that existed during three time frames: 30 minutes prior to the error, the entire work shift in which the error occurred, and the last shift worked by the subject prior to the shift on which the error occurred. Working conditions studied included work pace, staffing levels, distractions by other patient care needs, and unfamiliar work practice, work unit, procedures, or equipment. Subjects were asked to rate the degree that these working conditions were present or absent during the specified time frame. Subjects were not asked if they believed that these working conditions directly contributed to the error. Examples of interview questions used to determine the prevalence of potential triggers for errors in each time period are listed in Table 1.

Table 1. Selected questions from the telephone interview

Questions	Accepted responses
1. How distracted would you say you were feeling? 2. How ill would you say you were feeling? 3. How rushed would you say you were feeling? 4. How fatigued would you say you were feeling?	Not at all, a little bit, moderately, quite a bit, extremely
5. How would you describe your work environment?	Very hectic, hectic, moderate, calm, very calm
6. I was missing important information that prevented me from adequately caring for my patient(s). 7. There were enough licensed and unlicensed personnel on the floor to care for patients. 8. There were problems with teamwork or communication among the staff on my unit.	Strongly agree, agree, not sure, disagree, strongly disagree
9. How would you rate the acuity level of your patients?	Very low, low, moderate, high, very high
10. How would you rate your patient assignment?	Very light, light, moderate, heavy, very heavy
11. Did any significant unplanned events happen during your shift? For example, did a patient crash, was there an upset family member, or did a patient leave against medical advice?	
12. Did you, or someone else on your floor that you are aware of, break an accepted policy or protocol? 13. Did you have responsibilities in addition to caring for your patients, for example, were you in charge of orienting another staff member?	Yes, no
14. Please rate the overall quality and thoroughness of the report you received on your patients.*	Very poor, poor, adequate, good, very good

*Respondents were asked to answer this question for two time periods: (a) the shift in which the error occurred, and (b) the last shift they worked prior to the error.

In our analyses, we compared the prevalence of particular potential triggers during the time preceding the error with a time when the error did not occur. Specifically, we compared the working conditions in the 30 minutes preceding the error to working conditions during the entire shift in which the error occurred, and to the prior shift worked. We also compared the entire shift on which the error occurred to the prior shift worked, making the assumption that no error occurred on the prior shift worked. The prevalence of working conditions that could trigger errors was compared during the three time periods using odds ratios (ORs) and 95 percent confidence intervals (CIs); statistical significance was also assessed using McNemar's test for two related samples.¹⁹

Results

These preliminary results are based on the first 112 subjects recruited into the study. The majority of participants were registered nurses (84 percent), with 63 percent of them usually working a 12-hour day shift; the average number of days worked per week was 3. Seventy-nine percent of participants had more than 3 years of work experience in their stated job title; 45 percent of participants had been employed in their current position for more than 3 years. Participants worked on a variety of nursing floors, ranging from general medicine to critical care. Eighty-nine percent of participants were female; their mean age was 41 years. Forty-one percent of subjects held a bachelor's degree, 30 percent held an associate's degree, 7 percent held a master's degree, 1 percent held a doctorate degree, and 22 percent reported "other" for their education level.

Of the errors that subjects reported to us, 91 percent were related to medication administration and 9 percent involved medical procedures. The most frequent type of medication error was giving the wrong dose of medication to the patient (32 percent). Other types of medication errors included wrong medication (12 percent), wrong patient (20 percent), missed dose (10 percent), wrong route (6 percent), intravenous pump errors (5 percent), and near misses (6 percent). Seventy-eight percent of subjects formally documented their error via the hospital voluntary-based reporting system.

Responses to the interview questions (Table 1) revealed differences in perceptions of working conditions across the three time periods studied. Consistent with the case-crossover methodology, McNemar's test and odds ratios were used to analyze the differences in respondents' perceptions of their working conditions during three time periods: 30 minutes before the error was made, the entire shift during which the error was made, and the shift prior to the one when the error was made. Table 2 presents the percentage of respondents who reported the presence of the specific working condition as being less prevalent, more prevalent, or the same during the 30 minutes before the error as compared with the entire error shift. For example, 30 percent of subjects rated their working environment as being more hectic on the 5-point Likert scale in the 30 minutes before the error was made than during the entire shift in which the error occurred. Twelve percent of subjects reported that their working environment was less hectic in the 30 minutes preceding the error as compared with the entire error shift. Fifty-eight percent of subjects reported that there were no differences in this variable between the time periods. Comparisons of working conditions during the entire error shift to working conditions during the prior shift worked are also presented, as well as comparisons between the 30 minutes prior to the error and the prior shift worked. Table 2 also presents the odds ratios associated with each variable. Using the same example, subjects were 2.6 times more likely to report a more hectic working environment in the 30 minutes before the error compared to the rest of the error shift, 1.9 times as likely to report a more hectic working environment when comparing the error shift to the prior shift, and 4.1 times more

Table 2. Comparisons of working conditions between three time periods: 30 minutes before the error, the entire error shift, and the shift prior to the error shift

Presumed Risk Factor	30 Minutes vs. Error Shift [%*]				Error Shift vs. Prior Shift [%*]				30 Minutes vs. Prior Shift [%*]			
	Less Prevalent	More Prevalent	Same	OR 95%CI**	Less Prevalent	More Prevalent	Same	OR 95%CI**	Less Prevalent	More Prevalent	Same	OR 95%CI**
1. Distracted	7.1	30	63	4.1 1.9-10	11	25	64	2.3 1.1-4.9	10	40	50	3.9 2.0-8.4
2. Feeling Ill	17	3.6	80	0.21 0.052-0.63	7.2	14	78	2.0 0.81-5.4	13	7.2	80	0.57 0.21-1.5
3. Rushed	15	28	57	1.8 0.98-3.5	17	28	54	1.6 0.89-3.0	18	43	38	2.4 1.4-4.2
4. Fatigued	19	8.1	73	0.43 0.17-0.98	16	27	58	1.7 0.91-3.3	20	23	57	1.1 0.61-2.1
5. Hectic	12	30	58	2.6 1.3-5.4	17	33	50	1.9 1.1-3.6	12	48	40	4.1 2.2-8.2
6. Missing Information	11	20	69	1.7 0.78-4.0	8.4	21	70	2.5 1.1-6.6	15	35	50	2.4 1.2-4.8
7. Insufficient Staffing	8.9	7.1	84	0.80 0.27-2.2	19	15	66	0.81 0.40-1.6	22	20	58	0.80 0.47-1.6
8. Problems with Teamwork	11	18	72	1.6 0.73-3.8	11	18	71	1.7 0.78-4.0	12	29	59	2.5 1.2-5.4
9. High Patient Acuity	11	9.8	79	1.0 0.37-2.3	12	29	59	2.4 1.2-5.0	14	29	57	2.1 1.1-4.1
10. Heavy Patient Assignment	11	14	74	1.3 0.59-3.1	19	31	50	1.7 0.92-3.0	17	35	48	2.0 1.1-3.7
11. Occurrence of a Significant Event	19	2.7	78	0.14 0.027-0.48	12	29	59	2.4 1.2-5.2	12	12	74	0.86 0.36-2.0
12. Break in Policy	15	1.9	83	0.12 0.014-0.53	7.5	10	82	1.4 0.50-3.9	15	4.9	80	0.33 0.095-0.96
13. Extra Responsibilities	3	0	97	-	7	14	79	1.9 0.75-5.1	10	14	76	7.5 1.7-68
14. Poor Quality of Report	n/a	n/a	n/a	n/a	5.7	22	73	3.8 1.5-12	n/a	n/a	n/a	n/a

*Percentages are based on number of responses (n ranges from 95 to 112)

**Tests of significance were performed using McNemar's test. Bolded figures are significant (P<.05)

likely to report a more hectic working environment when comparing the 30 minutes before the error to the prior shift worked.

Comparisons of the presumed risk factors between the three time periods revealed that variation exists within and across shifts for specific working conditions. For example, within the error shift, subjects reported feeling significantly more distracted (OR = 4.1, 95% CI = 1.9–10) and reported more hectic conditions (OR = 2.6, 95% CI = 1.3–5.4) in the 30 minutes preceding the error compared to the rest of the error shift. When the same working conditions were compared between the entire error shift and the prior shift worked, subjects were again significantly more likely to report being more distracted (OR = 2.3, 95% CI = 1.1–4.9) and working under more hectic conditions (OR = 1.9, 95% CI = 1.1–3.6).

In contrast, some working conditions were reported to be less prevalent during the 30 minutes preceding the error than on the entire error shift, but were more prevalent on the error shift than the prior shift. Subjects were less likely to report feeling ill (OR = 0.21, 95% CI = 0.052–0.63) or fatigued (OR = 0.43, 95% CI = 0.17–0.98) during the 30 minutes preceding the error compared with the rest of the error shift. Although subjects were more likely to report feeling ill (OR = 2.0, 95% CI = 0.81–5.4) and fatigued (OR = 1.7, 95% CI = 0.91–3.3) on the entire error shift when compared with the prior shift, these ORs were not statistically significant.

Subjects were also asked if a significant unplanned event or break in policy occurred. An example of an unplanned event would be a patient experiencing a sudden clinical deterioration or leaving against medical advice. Overriding the medication administration system in order to give a patient a medication in a timely manner would be a break in policy. These events were less likely to occur during the 30 minutes preceding the error (OR = 0.14, 95% CI = 0.027–0.48 for unplanned event; OR = 0.12, 95% CI = 0.014–0.53 for break in policy); an unplanned event was more likely to occur on the error shift when compared with the prior shift (OR = 2.4, 95% CI = 1.2–5.2).

Some working conditions appear to remain stable within a shift but change between shifts. For instance, when asked the question, “How would you rate the acuity level of your patients?” subjects reported that patient acuity levels were significantly higher on the error shift as compared with the prior shift (OR = 2.4, 95% CI = 1.2–5.0), but reported no change between the 30 minutes preceding the error and the entire error shift (OR = 1.0, 95% CI = 0.37–2.3). This same pattern was seen when subjects were asked to rate the statement, “I was missing important information that prevented me from adequately caring for my patient.” This comparison shows how some working conditions, such as patient acuity or missing information, can differ between shifts while remaining constant across an individual shift.

Minimal differences were seen between the three time periods studied for some variables, including staffing and patient assignment. In addition, small

differences were reported for working on the usual floor, working with unfamiliar equipment, and performing unfamiliar procedures.

Discussion

This study uses a case-crossover design to identify transient working conditions that may precipitate medical errors. This design provides information about the time immediately surrounding the error; but unlike other studies investigating medical errors, this design also provides information about times when an error did not occur. This allows us to compare working conditions between different time periods, in an effort to detect differences and evaluate whether such differences contribute to medical errors.

Our preliminary results show that variation within a shift and across shifts occurs for specific risk factors, and suggests that this variation may play a role in the occurrence of patient care errors. Compared with the rest of the shift, subjects characterized the 30 minutes before the error occurred as being more hectic and reported that they experienced more distractions. When compared with the prior shift worked, the error shift was characterized by hectic and distracting conditions, as well as missing patient information, having higher acuity patients, and the occurrence of significant events.

As reported by Eagle et al.,²⁰ our study suggests that lack of important information contributes to medical errors, as subjects reported that the nursing report was poorer on the error shift and they were more likely to be missing important patient information on the error shift compared with the prior shift. While we did not formally collect data on the type of missing information, subjects reported that their colleagues did not always document completed patient care activities such as medications given. Subjects also stated that patient information was often documented in unusual places, colleagues neglected to pass on new patient information, and staff were not always informed of newly implemented policies and procedures. Our subjects also reported that at times it was not clear who was responsible for certain patient care activities. In an extreme example of this, two nurses thought they were responsible for the same patient, resulting in the patient receiving duplicate doses of medication.

We also found that significant unplanned events were less likely to occur during the 30 minutes preceding the medical error than during the rest of the error shift, though they were more likely to occur on the error shift than the prior shift. The types of events were not routinely collected. However, throughout the interview process, some subjects reported significant events they experienced, and examples included patients deteriorating or requiring emergency services, patients and family members being upset, and preparing for unanticipated procedures. These unexpected, time-consuming events may have contributed to errors by disrupting the nurses' usual routine and adding to their workload.

Breaks from policy were significantly more likely to occur on the error shift but not during the 30 minutes prior to the error. Examples of breaks in policy

included failure to verify new medication orders, removing medications from the Pyxis machine before they were entered into the system, and failing to check patients' identification bracelets. Although we asked subjects if there was a break in policy, we did not identify if this directly led to the error. Other studies have cited breaks in policies, such as not reading the patient's identification band, as contributors to errors.^{21, 22} Breaches in policy may lead to errors directly, and in some circumstances may be the result of other working conditions, such as a hectic work environment, time pressures, and distractions.

In our preliminary results, we did not find that subjects' perceptions of patient census and staffing levels differed greatly between the time periods studied. This is in contrast to other studies that have reported that hospital units with lower nurse staffing are more likely to experience an adverse event.^{1, 3, 23} Our study found minimal variation between work shifts in these variables, and thus could not study the direction of any relationship. Similarly, our results did not show any difference in patient acuity within the same shift, though it did fluctuate between different shifts.

Working with unfamiliar equipment, performing unfamiliar procedures, and working in an unfamiliar area have been associated with errors. In our study, the vast majority of our subjects (86 to 98 percent) did not report these working conditions. As most errors in our study were not associated with these variables, we were unable to assess whether they were associated with any increased risk for making a medical error.

Given the nature of this study, we anticipated that nursing personnel might be reluctant to discuss their errors with someone they did not know. Surprisingly, we discovered that nursing personnel wanted to talk about their errors. Our participants told us that they found it therapeutic to talk to someone outside of their work environment and they welcomed the opportunity to share their stories. During the interview process, many of our subjects stated that their motive for participating in the study was to help prevent someone else from making the same error. Most of these were senior nurses, and they believed if they made an error, someone more junior was also likely to make the same error.

Although 79 percent of our subjects had greater than 3 years of work experience, we do not believe that experienced staff members make more errors than their junior colleagues. Rather, we believe that more experienced staff felt more secure in their position and thus felt more comfortable discussing their error and the surrounding circumstances. It is also possible that senior staff understand that many factors are involved in errors and realize that under similar circumstances, anyone can make a mistake.

Data presented here are from the first 112 of 300 planned interviews, and are thus subject to the usual caveats surrounding the interpretation of preliminary data. Since subjects in our study were interviewed after the error occurred, there is the possibility of recall bias in their responses. To minimize the potential impact of recall bias, we interviewed subjects as soon as possible following the error (within 2 weeks of the error). Additionally, we restricted our enrollment criteria to

include only low-harm or near-miss errors. It is likely that individuals committing errors where little or no harm to the patient occurred will experience fewer feelings of guilt and shame, and will have fewer concerns about disciplinary actions and litigation. By focusing on these types of errors, subjects' responses to interview questions are less likely to be biased by their reactions to the event.

To establish trust and to encourage participation, we informed all subjects that the study purpose was to increase our understanding of how working conditions triggered medical errors. Consequently, our recruitment information and consent form may have encouraged subjects to attribute the error to their work environment. To minimize this bias, we restricted our cases to those where no or minimal harm was done to the patient, and subjects were asked to describe the circumstance surrounding their error before we directed their attention to specific working conditions. In addition, we deliberately designed the interview to focus on the presence or degree of specific working conditions during three specific time periods. Subjects were never asked if they thought specific working conditions contributed to their error. Subjects' responses to the open-ended question revealed that 37 percent of subjects held themselves accountable for the error and did not mention the effects of external factors on the error. Therefore we think attribution bias may have been minimized in this study.²⁴

To assess the reliability of our data, we are repeating the interview in a test-retest fashion with a subset of study subjects. We will also assess the validity of our data by comparing the interview data with administrative data on patient acuity, patient census, and staffing levels. Qualitative analysis of responses to open-ended questions may also reveal useful insights into the causes and prevention of patient care errors.

Conclusion

Increased understanding of how transient working conditions contribute to medical errors may suggest new approaches to improving quality of care and patient safety. Our preliminary results suggest that working conditions do differ between error and nonerror shifts, suggesting that transient working conditions contribute to medical errors. Our findings suggest that errors tend to occur on busier, more demanding shifts and when staff report missing important patient information. This suggests the need to train health care workers to recognize that these factors may place them at increased risk for making an error, thereby potentially placing patients at higher risk. Alterations to the work environment, such as improving the transfer of patient information, may also lead to reductions in medical errors and improve patient care.

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