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Operational Failures and Interruptions in Hospital Nursing

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Objective. To describe the work environment of hospital nurses with particular focus on the performance of work systems supplying information, materials, and equipment for patient care.

Data Sources. Primary observation, semistructured interviews, and surveys of hospital nurses.

Study Design. We sampled a cross-sectional group of six U.S. hospitals to examine the frequency of work system failures and their impact on nurse productivity.

Data Collection. We collected minute-by-minute data on the activities of 11 nurses. In addition, we conducted interviews with six of these nurses using questions related to obstacles to care. Finally, we created and administered two surveys in 48 nursing units, one for nurses and one for managers, asking about the frequency of specific work system failures.

Principal Findings. Nurses we observed experienced an average of 8.4 work system failures per 8-hour shift. The five most frequent types of failures, accounting for 6.4 of these obstacles, involved medications, orders, supplies, staffing, and equipment. Survey questions asking nurses how frequently they experienced these five categories of obstacles yielded similar frequencies. For an average 8-hour shift, the average task time was only 3.1 minutes, and in spite of this, nurses were interrupted mid-task an average of eight times per shift.

Conclusions. Our findings suggest that nurse effectiveness can be increased by creating improvement processes triggered by the occurrence of work system failures, with the goal of reducing future occurrences. Second, given that nursing work is fragmented and unpredictable, designing processes that are robust to interruption can help prevent errors.

Key Words. Nursing work environment, work systems, medical errors

A growing body of evidence suggests more nursing time per patient results in better patient outcomes (Aiken et al. 2002; Kovner et al. 2002; Needleman et al. 2002). Despite this recognition, increasing patient loads (Aiken, Clarke, and Sloane 2001) and a developing nursing shortage (Buerhaus, Staiger, and Auerbach 2000) make it difficult for nurses to spend as much time with their patients as they would like. To date, much of the discussion regarding nursing

time per patient has focused on increasing nurse staffing levels (e.g., Wilson 2004). However, there has been less attention on ensuring that work systems provide supplies, medications, equipment, and information in a timely and accurate fashion. We propose that units lose valuable caregiver time owing to ineffective supply systems, and therefore productive time can be reclaimed by improving work systems. In addition, supply problems interrupt patient care, potentially increasing patient safety risks. We suspect that similar issues affect residents, aids, therapists, and other health care professionals. To explore these propositions, we examined nursing work environments with a particular focus on the systems supplying information, equipment, and materials necessary for patient care. Although specific to nurses, this study may interest other health care professionals who work under similar conditions.

We start by reviewing literature describing the content of nursing work. The 2004 Institute of Medicine report characterized the process for planning and managing nursing work as follows: assess patients, identify desired outcomes for these patients, plan and implement treatments to achieve these outcomes, and re-evaluate patients to ensure that the treatments achieved the intended outcomes. As acknowledged in the report, however, this linear description fails to capture complexities inherent in providing patient care. As a result, many newly graduated nurses find that the practice of nursing differs markedly from what they learned in school, and consequently many new nurses leave the profession (Kramer 1974; Godinez et al. 2001; Roberts, Jones, and Lynn 2004). In addition, nurses lament patients' lack of understanding about the nursing role (Ajiboye 2004). Patients often expect more direct care time from their nurses than is possible, resulting in patient dissatisfaction (Staniszewska and Ahmed 1998). This suggests that a more accurate description of nursing would be valuable for both nursing students as well as the public.

What makes nursing work complex? One source of complexity lies in the continuously changing conditions of patients for whom nurses care (Benner, Hooper-Kyriakidis, and Stannard 1999). As new information about their patients becomes evident, nurses must solve problems in realtime, often changing which problem they are solving, and where in the problem-solving process they are (Taylor 1997). This requires nurses to modify their planned

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sequence of care before they can complete a full cycle from initial assessment to posttreatment evaluation (Taylor 1997). Thus, the nature of patient care requires nurses to move among assessment, planning, implementation, and evaluation in a back-and-forth manner rather than sequentially progressing through the steps to completion.

A second source of complexity stems from the coordination role that nurses play, ensuring that their patients receive ordered services from other health care workers (e.g., blood tests, radiology tests,and physical therapy) (McCloskey et al. 1996). As an indication of the time nurses spend coordinating care—as opposed to providing patient care—studies find that the average nurse only spends between 31 and 44 percent of her time on direct patient care activities, but between 34 and 49 percent on coordination-related activities (Minyard, Wall, and Turner 1986; Hendrickson, Doddato, and Kovner 1990; Quist 1992; Lundgren and Segesten 2001). Consequently, as nurses conduct their work, they must be continually mindful of what other people are doing (Page 2004). This creates a tightly coupled system (Perrow 1984), increasing the cognitive load on nurses (Beaudoin and Edgar 2003). In summary, factors inherent to caring for patients, such as the need to respond to new information and the need to interact with the larger system of care, increase the complexity of nursing work.

In addition to these unavoidable sources of complexity, care is also complicated by avoidable factors unrelated to patients' conditions. Disruptions in the supply of materials or information have received recent attention. For example, when interviewed about productivity, nurses talked about the negative impact of poorly functioning supply systems (McNeese-Smith 1999; Beaudoin and Edgar 2003). Research shows that nurses frequently experience operational failures (Tucker 2004), which are also called hassles (Beaudoin and Edgar 2003) or glitches (Uhlig et al. 2002). These breakdowns interfere with work, reducing employee effectiveness by increasing the time required to complete tasks. One study of nursing work found that, on average, nurses spend 42 minutes of each 8-hour shift resolving operational failures such as missing medications and broken or missing equipment (Tucker 2004). Other studies estimate that nurses spend from 10 percent (Linden and English 1994) to 25 percent (Miller, Deets, and Miller 1997) of their time looking for other staff members. Operational failures can also cause interruptions, as shown in a study that examined interruptions encountered by one hospital nurse during a 10-hour period. This study found that the nurse was interrupted 43 times, including 10 instances when necessary materials, equipment, or personnel were unavailable (Potter et al. 2004).

For clarity, in this paper we call these workflow problems "operational failures," defined as the inability of the work system to reliably provide information, services, and supplies when, where, and to whom needed (Tucker 2004). Examples of operational failures include the pharmacy inadvertently sending only half of the prescribed dose of a patient's medication, broken or missing equipment, and stocked-out supply items. Furthermore, several articles have illustrated the dire consequences for patients—including medication error, procedures carried out on the wrong patient, and hospital-acquired infection—when health care workers received incomplete or incorrect information, services, and items (Bates 2002; Chassin and Becher 2002; Gerberding 2002; Cleary 2003; Volpp and Grande 2003).

Given these sources of complexity, it is perhaps not surprising that health care organizations have been characterized as complex adaptive systems, where employees face high levels of uncertainty in their daily work (McDaniel and Driebe 2001). Organizational theorists suggest that under such conditions, resilient employees quickly implement positive adaptive behaviors that are matched to the immediate situation (Mallak 1998). Thus, the ability to flexibly respond to challenging situations, using materials at hand, can enable health care employees to function effectively (Weick 1993). Research suggests that experienced nurses are skilled at responding to changing patient conditions (Benner and Tanner 1987; Hansten and Washburn 2000), as well as compensating for operational failures (Tucker and Edmondson 2003).

In this paper, we propose that these two very different sources of complexity warrant different strategies for mitigating potentially negative effects. The first cause is inherent to medical work: new information about a patient becomes evident, triggering a change in caregiver work plans. The inevitability of changing patient conditions suggests that benefits can be gained by designing work to be robust to interruption. The second cause results from faulty work systems: a glitch or error occurs and the caregiver has to compensate for the operational failure. Interruptions due to work system failures are, at least theoretically, avoidable and therefore work systems can be improved to reduce future occurrences. Reducing the time nurses have to spend responding to faulty work systems will allow more time for patient care.

METHODS

We utilized three methods to collect data: direct observation, interviews, and surveys. In 2001, the first author observed 11 different nurses for complete

shifts at six hospitals, recording minute-by-minute information about their work activities—where they were and what they were doing with whom—in a field journal. The mean observation time was 9 hours 51 minutes. After the observation, she wrote up a detailed transcript of the day's events, drawing on the information in the field journal. The transcripts were coded for operational failures by both the first author and an independent researcher until they achieved agreement on identifying operational failures.

The purpose of our observations was to discover if operational failures interfered with nursing work and what actions—if any—nurses took to deal with these glitches. In particular, we wanted to discover if some units used work system failures to trigger system improvement efforts. We therefore focused our study on hospitals with reputations for excellent nursing, as indicated by references from nursing professional societies, or literature citations mentioning excellence in physician-nurse collaboration or nursing staff retention. We deliberately observed a wide span of circumstances to capture variation in nursing tasks and availability of resources. For example, we observed in union and nonunion hospitals, on weekends and nights, and in different units.

Prior to our observation visit, the unit managers selected and asked nurses to participate. These nurses usually had experience training new graduates and had worked at least 2 years on their current unit. From this we derive some confidence that the tactics used and operational failures experienced were not a result of inexperience or unfamiliarity with hospital procedures. Table 1 presents details on the nurses who were observed.

Conducting observations for complete shifts was necessary to quantify the effect that operational failures had on nurses' activities. Operational failures could cause multiple, discontinuous interruptions that might be missed with sampling techniques. In addition, work sampling techniques are not suitable for estimating duration of work activities, only relative frequencies (Burke et al. 2000).

The second phase of data collection, which took place in 2002, involved using a protocol consisting of 31 questions to interview six of the nurses whom we had observed. The other nurses we observed were unavailable because they had changed units or we were unable to gain access to their home phone number through the unit manager. See Table 1 for the list of which nurses were interviewed. The protocol, which was developed after analyzing the observation data, was designed to increase understanding of (a) nurses' general perceptions of operational failures; (b) how they could affect nurses' productivity, and (c) patient care (if at all). Sample questions included "Do you have

Table 1: Characteristics of Nurses Whom We Observed and Their Work Day

	Kristy Redmond	*Fiona Murphy*	*Peggy Watford*	*Kendra Brown*	*Kalila Marple*	*Lois Atwood*	*Leslie Gianni*	*Abby Dickson*	*Blanche Barnett*	*Mallory Norton*	*Norma Garvin*
Experience (years)	3	20	18	17	15	3	25	45	12	7	25
Hospital ID	3	3	4	4	5	7	7	4	4	8	9
Interviewed?	No	Yes	Yes	No	Yes	Yes	Yes	No	No	No	Yes
Type of unit	Med/surg	Med/surg	Ortho/neuro surgery	Ortho/neuro surgery	Oncology/ medical	Oncology/ medical	Oncology/ medical	Maternity	Maternity	Pediatric hem/ oncology	Intensive care unit
Hours observed	17:45–7:20	6:00–18:00	6:45–16:00	7:26–16:20	7:30–19:45	7:00–19:30	7:00–15:00	7:00–15:00	7:00–15:00	7:05–16:16	7:12–18:56
Total hours observed	13 h 34 min	12 h	9 h 15 min	8 h 54 min	12 h 15 min	12 h 30 min	8 h	8 h	8 h	9 h 11 min	6 h 39 min
Shift length	12 h	12 h	8 h	8 h	12 h	12 h	8 h	8 h	8 h	8 h	12 h
Number of patients	3 at start, got 5 more	5, got 1 more	5	5	5, 1 discharged, 1 new admit	6 at start, got 2 more, 2 discharged	5, got 1 more	5	7	2 at start, got 1 more	2
Number of task types	98	106	91	93	85	88	81	72	45	84	93
Number of tasks	293	243	162	223	140	211	151	173	144	216	192
Minutes worked per task	2.8	3.0	3.4	2.4	5.3	3.6	3.2	2.8	3.3	2.6	2.1
Number of switches among patients	108	93	66	74	45	121	57	61	18	40	31
Minutes per switch	7.5	7.7	8.4	7.2	16.3	6.2	8.4	7.9	26.7	13.8	12.9
Number of interruptions	22	10	7	18	5	10	3	4	1	5	0
Number of operational failures	15	12	12	14	11	7	6	12	7	7	7

certain obstacles that occur repeatedly on your unit? If yes, what are they?"; "Do these obstacles ever cause patients' experiences to be not as good as they could have been?"; and "Is it worth your time to try to prevent obstacles from recurring?" The first author taperecorded and transcribed all interviews. The transcripts were entered into a qualitative data analysis software package (Atlas.ti™) and coded by the A. L. T. The interview data informed our efforts to identify operational failures in our observational transcripts. For instance, we had observed a doctor interrupt a nurse to inform her that he had just written an order for an antibiotic. Originally, we did not consider this as a failure, but instead a sign of good communication, because it ensured that the order was not missed or misunderstood. However, during our interviews, one nurse commented that interruptions during patient care from doctors—especially for unnecessary reasons such as redundantly informing her of a newly written order—were frustrating and demeaning, because she knew to look in the order book for new orders and would do so when the task at hand was completed.

The third phase, conducted in 2002, involved surveying nurses from 48 units in 21 hospitals ($N = 520$) about the number of times they experienced specific work system problems during the last shift they worked. Sample items included, "I started to prepare a patient's medication, but it was missing or incorrect." We also surveyed the managers from these departments, asking them to report on the number of problems (i.e., medication, orders, equipment, and supplies) nurses encountered per shift as well as staff turnover. Collecting data from multiple sources helped mitigate methodological weaknesses of cross-sectional self-report research (Spector 1994).

The overall response rate for the single wave survey mailing was 26 percent, which was comparable to other multiple-hospital surveys conducted by external researchers (i.e., Sorra and Nieva 2004). A robustness test involved comparing reported job satisfaction scores with a similar item on the 2000 U.S. national survey. The comparison shows similar percentages of extremely dissatisfied nurses (6 percent on our survey and 5 percent on the national survey) and extremely or moderately satisfied nurses (64 percent on our survey and 66 percent on the national survey), suggesting that our sample does not contain a disproportionate number of either satisfied or dissatisfied nurses. Finally, in alignment with the national sample, 93 percent of the respondents were women and roughly 60 percent of the sample had worked as a nurse for more than 15 years. The mean number of years as a nurse was 18, and the mean tenure at the hospital was 12 years. Overall, we conclude that our sample does not differ meaningfully from the 2000 U.S. national survey.

RESULTS

Operational Failures

On average, the nurses we observed experienced 8.4 operational failures per 8-hour shift. The most frequent category of failures was medication problems (1.5), followed by medical orders (1.4 per shift), supply issues (including incorrect or missing patient meals) (1.2), problems related to staffing, such as nurses having to do aides' or housecleaning's work (1.2), and broken or missing equipment (1.1). Both nurse and manager survey data on these five categories yielded similar findings. Managers estimated that their nurses, on average, experienced 5.7 operational failures per shift. Nurses reported experiencing an average of 4.5 operational failures during the last shift worked, with the following frequencies: medication (1.2 times per shift), supply items (1.2), equipment issues (0.98), insufficient staffing (0.59), and medical orders (0.54). See Table 2 for the frequencies of failures reported by data source.

Observation of Front Line Care Giving

The nurses we observed faced workload pressure, as evidenced by their staccato pace of work. The average task time was only 3.1 minutes. They switched among patients, on average, every 11 minutes and were interrupted mid-task eight times per shift. On average, the nurses in our dataset worked 45 minutes of unscheduled, unpaid overtime at the end of their shifts. Although such overtime is a well-known phenomenon among health care professionals, it has only recently been studied. Our overtime finding is consistent with another study, in which hospital nurses reported working an average of 69 minutes of unpaid overtime per shift (Rogers et al. 2004).

Table 2: Average Number of Operational Failures Experienced by Nurses per 8-Hour Shift

	Mean (SD)		
Category of Failure	*Nurse Survey*	*Manager Survey*	*Observer*
(1) Medication	1.2 (0.97)	1.5 (2.3)	1.5 (1.1)
(2) Supply items (including food)	1.2 (1.01)	1.4 (1.7)	1.2 (1.2)
(3) Medical orders	.54 (.55)	1.2 (1.1)	1.4 (1.1)
(4) Equipment	0.98 (.87)	0.80 (1.0)	1.1 (1.0)
(5) Insufficient staffing	0.59 (0.50)	0.80 (1.1)	1.2 (1.1)
Other	Not asked	Not asked	2.0 (0.9)
Total in an average 8-hour shift	4.51	5.7	8.4 (2.4)

In addition to workload pressure, nurses had to complete time-specific procedures for patients, such as administering medications within certain time periods, monitoring vital signs during and after blood transfusions, and preparing patients for procedures (i.e., surgery).

Finally, in addition to the volume of work, nurses managed a wide breadth of responsibilities. Nurses performed, on average, 84 different types of activities. Examples included examining patients, checking medication administration records to determine what medications were due, administering medication and other therapies, removing patient-controlled analgesia pumps, reviewing laboratory results, communicating patient-related information to doctors, educating patients and families, and writing discharge documentation. In addition, nursing work involved cognitive components, such as administering medications that were contingent upon the patient's laboratory test results or vital signs. Table 1 displays details from each observation.

Partitioning, Interweaving, and Reprioritizing Care

We observed that nurses used at least three tactics for managing their time-sensitive, high volume workloads. First, nurses partitioned care for each patient through the shift, rather than performing all tasks for one patient at one time. This tactic stemmed primarily from medical necessity, such as the need to administer medications or to assess vital signs at regular intervals. Second, because most nurses were responsible for multiple patients, nurses had to switch back and forth between different patients' care. We define "interweaving" as providing care for multiple patients in a cyclical fashion, where the caregiver repeatedly switches among patients, as opposed to providing care in a sequential, nonoverlapping manner. To illustrate interweaving, one nurse, Kendra Brown, switched among her five patients 74 times during her 8-hour shift. The longest uninterrupted time spent on behalf of one patient, an elderly woman scheduled to have her remaining leg amputated that day, was 28 minutes.

Third, we noticed that the nurses' had to continually adapt their work plans. They could not definitively sequence work at the shift's start, but instead had to constantly problem solve by adding, subtracting, and reordering tasks as patients' conditions changed and as new information emerged. We termed this problem solving activity "reprioritization." Newly admitted or discharged patients often caused reprioritization as nurses had to fit the new patient—or tasks associated with discharge—into their work load. It also occurred because of changes in existing patient's care plans. For example, Fiona Murphy, a medical/surgical nurse at Hospital 3, was walking to her patient's room to administer a

dose of furosemide, a diuretic, when she saw the patient's doctor in the hallway. Fiona deliberately started a conversation with the doctor to learn his latest thinking regarding the patient's plan of care. The doctor, concerned about the poor condition of the patient's kidneys, gave a verbal order to discontinue the furosemide. Afterwards, Nurse Murphy threw away the syringe containing the medication, commenting, "We just got lucky." We observed similar events at three other hospitals when doctors dynamically cancelled medication that nurses had already prepared and were about to administer.

Two Sources Drive the Use of the Tactics

We found that two very different sources prompted the use of these tactics. Predominantly, demands inherent in medical care necessitated the use of interweaving and reprioritization. Occasionally, however, operational failures drove their use. We observed operational failures cause 18 instances of partitioning—when nurses had to postpone a task until the appropriate supply arrived. We also saw 15 instances of interweaving and eight instances of reprioritization. We classify these instances as avoidable. During her interview, Lois Atwood, an oncology nurse at Hospital 7, commented about an instance of partitioning owing to a failure which delayed a stat medication.

> We had a transfer from the ICU who had cardiac problems and I had to give him some IV cardiac meds, but I had to wait for the pharmacy to put the meds in the automated dispensing system. It took 4 calls to the pharmacy before it got in (one of the medications) and then I had to make 3 more phone calls to get the second one cleared. Nine minutes of phone calls, and then I had to mix them to get them into him the right way. It probably took me between 15 and 20 minutes to get what the doctor wanted in the patient as cardiac meds as a stat order because his heart rate was so bad and blood pressure was high.

Failures often impacted other patients by postponing and reducing the time available for their care, as illustrated during an interview with Kalila Marple, an oncology nurse from Hospital 5.

> Sometimes it [an operational failure] has a snowball affect that if you face a huge obstacle in one area with one of your patients, the next thing you know the next patient is paying for that extra time that you had to keep shifting back. It snowballs through your whole care that day. Everyone is affected, not just that one patient.

Frequent Interruptions

Beyond these failures, nurses faced frequent interruptions. The majority (95 percent) of interruptions we observed were due to patient care issues, such as

family member's inquiries regarding their loved one's status. However, about 5 percent stemmed from system glitches, such as redundant pages and messages. For example, in a 9-minute time period when Nurse Kendra Brown was busy preparing and administering pain medication for Patient A, she was informed three times—once in person by another nurse and twice over the intercom—that Patient B needed pain medication. During our interview, Norma Garvin, an intensive care nurse at Hospital 9, commented that interruptions were her greatest source of frustration.

> The interruptions I get on a daily basis [are my greatest source of frustration]. From multiple people, from the docs, from X-rays trying to call to schedule procedures. . . . If I am charging [charge nurse] the interruptions to get new patients, to get patients out, calling the floors multiple times to try to get a bed, calling the house officer to try to get orders, going to our house officer to get them to call their house officer to get orders, multiple iterations there. If I have a patient: interactions with the patient, the family, the doctors. The clerks with questions, they can't read orders. The techs coming looking for something to do, where they need to be directed. Other nurses with questions of not knowing what to do. I mean it is endless.

Nurses often provide care for several patients during one shift, and therefore nurses often have to juggle multiple operational failures or interruptions related to different patients at the same time. For example, we observed Lois Atwood, a nurse at Hospital 7, encounter eight interruptions in the span of 40 minutes while trying to complete three activities: starting a patient's total parenteral nutrition (TPN), hanging a bag of intervenous (IV) medication for another patient, and getting a third patient discharged. To elaborate on one of these examples, at 4:14 PM, she started preparing TPN for a patient, an activity which should have taken a total of 15 minutes. However, she was not able to hang the bag and start the flow of fluid to the patient until 40 minutes later due to two operational failures (she could not find a pump to administer the TPN, and the antimicrobial soap dispenser was empty, but she needed to wash her hands before switching to care for another patient) and six emergent needs from five other patients. Table 3 shows the breakdown of the number of tactic use and interruptions caused from operational failures versus those due to patient care issues.

Work Tactics and Increased Chance of Human Error

The tactics of partitioning, interweaving, and reprioritizing care introduce delays and interruptions in completing work. These increase the likelihood of human error (Reason 1990; Leape 1994) for a variety of reasons. Delays

Table 3: Interruptions Classified by Cause

Type	*Operational Failure Caused Interruption (%)*	*Patient Care Considerations Caused Interruption (%)*	*Total*
1. Partition	18 (35)	34 (65)	52
2. Interweaving	15 (2)	714 (98)	729
3. Reprioritization	8 (9.4)	77 (90.6)	85
4. Interruptions	4 (4.5)	85 (95.5)	89
Total	45 (4.7)	910 (95)	955

between when a plan is formulated and when it is executed can leave one with an incorrect memory of which steps have already been taken (Mandler 1982; Rudolph and Repenning 2002). When the work is restarted, steps may be repeated or omitted. Cook and Woods (1994) refer to the tracking of work duties and their interdependencies as mental bookkeeping. In essence, people mentally manage "stocks" of undone tasks. If this stock increases (because new duties are arriving more quickly than one can complete them), it causes stress, decreasing one's cognitive processing, which can lead to error. This stress occurs even when the tasks are routine (Rudolph and Repenning 2002). In a study directly relevant to health care workers, Flynn et al. (1999) found that pharmacists made more errors when interrupted during medication preparation. The nurses we interviewed also linked interruptions with errors. Norma Garvin, an intensive care nurse at Hospital 9, commented,

> I am in [a patient room] trying to do a medication, priming the IV tubing. The phone rings, the clerk comes and gets me. I stop what I am doing, dial the flow clamp off, hang it over the IV pole, walk out and deal with the phone call. Then someone else comes and asks me, "Can you come and help with whatever." And I totally forget I have this IV that I really haven't hung and haven't given to the patient yet. Until I walk back in the room again—usually pretty quickly—and see the IV hanging there and say "shoot I really need to get that going."

Similarly, returning to interrupted tasks increases cognitive loads because it requires "recovery time," during which details about the previously paused tasked must be summoned for active consideration. This takes times and introduces the risk of one task being confused with another (Speier, Valacich, and Vessey 1999). The negative impact of juggling multiple tasks increases when the tasks are complex (Kahneman 1973; Speier et al. 1999), as is the case with nursing work. Leslie Gianni, a nurse at Hospital 7, commented during our interview,

> It takes time when you have to repeat something, or look at something again, or follow through on something that didn't happen. That takes away a lot of time from patient care. Just the fact of calling to the desk, interrupting the secretary, hunting something down, wondering why something is taking so long, that takes time. You can literally be pulled in four of five different directions all at once. Just to keep track of things and to spend all that time trying to get a task done that would have been pretty simple. It can turn into a nightmare actually.

DISCUSSION

Our study suggests two avenues for improving the nursing work environment. First, our analysis showed that conditions inherent to meeting patient needs make 95 percent of the interweaving and reprioritization unavoidable. Thus, together with nursing management, nurses should try to design nursing processes that minimize negative impacts of interruption. We provide more details in the section below. However, 5 percent of the interruptions stemmed from operational failures, and therefore removing known problems could help prevent avoidable interruptions. System improvement can be accomplished by using failure occurrence to trigger removal of underlying causes, rather than the common approach of relying on people to work around failures (Tucker, Edmondson, and Spear 2002; Spear and Schmidhofer 2005).

When the Tactics Cannot Be Avoided

We recognize that a necessary first step in patient safety is ensuring appropriate patient loads and enabling nurses to exercise control over their practice. Provided that these conditions exist, work system designs can help prevent errors through mistake proofing, which can reduce the negative impact of interruptions. Other industries, such as nuclear power, civil aviation, and aircraft carrier operations, have created mechanisms to help ensure reliable and error-free performance (Weick and Roberts 1993; Weick, Sutcliffe, and Obstfeld 1999). Some health care organizations have been successful in adopting techniques, such as check lists, which are visual management tools that show what work has been performed and what work remains to be performed (Hirano and Talbot 1995). For example, at Johns Hopkins Hospital, an interdisciplinary critical care quality improvement team developed a checklist of best practices for reducing bloodstream infections from central venous catheters (CVC). This checklist was used during insertion and helped ensure that all the steps were properly performed, resulting in elimination of almost all CVC-related bloodstream infections (Berenholtz et al. 2004).

Human factors engineering can also be incorporated into the design of the physical space to make it more difficult for people to commit errors, even if they are interrupted and their chain of thought is broken (Billings 1984; Gosbee 2002, 2004; Grout 2003). For example, in response to medical accidents, anesthesia machines have been redesigned to help prevent inadvertently turning off the flow of oxygen to the patient (Wiklund 2002) or hooking up nitrous oxide instead of oxygen (Ko 2005). These solutions do not add any additional steps in completing work, but make it more difficult to inadvertently make a dangerous mistake (Grout 2003).

In addition to these fail-safe techniques that minimize the negative impact of interruptions, other strategies can be used to prevent interruptions. The Institute of Medicine report, *Keeping Patients Safe* (2004), recommends reducing interruptions nurses encounter during medication preparation by creating a visual signal (e.g., a hat or apron with the words, "Please don't interrupt-preparing medications") that alerts other nurses and patients' families that the nurse should not be interrupted. The report also recommends further reduction of interruptions by filtering messages through a secretary or by providing nurses with enough information to triage their messages, distinguishing between those that need immediate attention and those that can wait to be inserted in the nurse's work so as not to cause disruption (Speier et al. 1999; Page 2004). Similar suggestions have been developed for other professionals, such as engineers (Perlow 1999) and pharmacists (Flynn et al. 1999).

Focus on Improving Work System Performance

In contrast to managing unavoidable uses of the three tactics, strategies for reducing avoidable instances focus on improving work systems. For example, an initiative within the University of Pittsburgh Medical Center (UPMC) system, addressed the repetitive problem of not being able to quickly locate the appropriate keys when narcotics had to be dispensed. The nurses figured out how to allow each nurse to carry a key during the shift while still maintaining security. The cost of the solution was minimal and the savings was estimated to be approximately 2,900 nursing hours per year in the 350-bed institution. Another hospital within the UPMC system targeted medication administration as a process for improvement. A series of quick, low-cost redesigns of pharmacy work reduced inventory stock-outs by 85 percent, reduced the overall size of the inventory, and reduced the time required to fill orders (Thompson, Wolf, and Spear 2003). The point of these examples is not to suggest that the solutions developed at UPMC should be copied; their

formulation may be quite site-specific. However, the improvement process employed by UPMC—treating individual operational failures as triggers for process improvement, rather than having health care workers repeatedly work around disruptions—may have some wider benefit.

CONCLUSIONS

This study provides a detailed picture of nursing work, filling an important gap in the literature on the health care work environment. Others have commented on health care's adaptive nature; however, the tactics of partitioning, interweaving, and reprioritization used to achieve flexibility have not been explicitly expressed. Therefore, identifying and defining these tactics bring additional clarity to nursing work—and possibly to other work done in similar conditions, such as the work of physicians and other health care providers. In addition, our observations of the tactics, when combined with existing literature on the effects of delays, distractions, and interruptions on work, suggest that these tactics raise the likelihood of human error, and therefore of harm to patients. Ironically, at the same time, nurses' actions can prevent human error, improve patient outcomes (e.g., Aiken et al. 2002; Kovner et al. 2002), and improve work systems (e.g., Thompson, Wolf, and Spear, 2003; Tucker and Edmondson, 2003). Therefore, understanding which responses improve patient care and which impede care could provide a valuable framework for practitioners and educators.

Limitations and Future Research

The methods used for this paper limit our ability to generalize to a broad range of settings, such as other health care professionals, outpatient procedures, home health care settings, and primary care facilities. Furthermore, observing work can change workers' behavior—either by making workers feel important, motivating higher levels of performance (Roethlisberger and Dickson 1939), or by making them self-conscious, thus preventing typical activities. Finally, we did not design the study to enable us to comment explicitly on the connection between these work tactics and medical errors.

Additional studies could examine other health care professionals or nonhealth care service employees, such as bank tellers, help desk operators, or back-office insurance employees, to compare the rate of operational failures in those work environments. Future studies can include prospective chart review to examine quality of care received by patients in combination with

observation or self-report of the number of times nurses have to interweave care or reprioritize tasks. Such a study might begin to explain the processes through which more nursing care leads to better outcomes (Aiken et al. 2002; Kovner et al. 2002; Cho et al. 2003). Perhaps having fewer patients results in better care in part because of reduced inefficiencies and errors due to reduced partitioning, interweaving and reprioritization. Intervention type studies could shed valuable insight into the effectiveness of specific mechanisms to reduce interruptions, such as messaging systems, by collecting pre- and postimplementation data on the number of interruptions experienced. Finally, explicit efforts to reduce the number of operational failures could be analyzed to study whether they reduce interruptions.

In an article summarizing a policy roundtable on working conditions of the nursing workforce, experts agreed that understanding the context of nursing work was of critical importance to the overall research agenda. They called for future research that better educated nurses for real world practice, communicated nurses' role in patient safety to those outside of nurses, and increased awareness of what is going on at the bedside—what it was actually like to be a nurse (Hope 2004). We expect that this article takes a step in addressing these needs and thus provides a usable stepping stone for improving the nurse work environment through better understanding of its realities.

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