Workflow in intensive care unit remote monitoring: A time-and-motion study*

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Objective: **To investigate workflow in intensive care unit remote monitoring, a technology-driven practice that allows critical care specialists to perform proactive and continuous patient care from a remote site.**

Design: **A time-and-motion study.**

Setting: **Facility that remotely monitored 132 beds in nine intensive care units.**

Participants: **Six physicians and seven registered nurses.**

Interventions: **Participants were observed for 47 and 39 hrs, respectively.**

Measurements and Main Results: **Clinicians' workflow was analyzed as goal-oriented tasks and activities. Major variables of interest included the times spent on different types of tasks and activities, the frequencies of accessing various information resources, and the occurrence and management of interruptions in workflow. Physicians spent 70%, 3%, 3%, and 24% of their time on patient monitoring, collaboration, system maintenance, and administrative/social/personal tasks, respectively. For nurses, the time allocations were 46%, 3%, 4%, and 17%, respectively. Nurses spent another 30% of their time maintaining health records. In monitoring patients, physicians spent more percentage times communicating with others than the nurses (13% vs. 7%, $p = .026$) and accessed the in-unit clinical information system more frequently (42 vs. 14 times per hour, $p = .027$), while nurses spent more percentage times monitoring real-time vitals (16% vs. 2%, $p = .012$). Physicians' and nurses' workflows were interrupted at a rate of 2.2 and 7.5 times per hour ($p < .001$), with an average duration of 101 and 45 secs, respectively ($p = .006$). The sources of interruptions were significantly different for physicians and nurses ($p < .001$).**

Conclusions: **Physicians' and nurses' task performance and information utilization reflect the distributed nature of work organization in intensive care unit remote monitoring. Workflow interruption, clinical information system usability, and collaboration with bedside caregivers are the major issues that may affect the quality and efficiency of clinicians' work in this particular critical care setting. (Crit Care Med 2007; 35:2057–2063)**

Key Words: workflow; task analysis; interruption; time-and-motion study; intensive care unit remote monitoring; telemedicine

Intensivist-led multidisciplinary teams in intensive care units (ICUs) have positive effects on preventing adverse events, improving quality, reducing mortality, and optimizing resource utilization (1). However, this intensivist-led practice has been severely hindered by a nationwide shortage of highly trained critical care specialists in the United States (2). ICU remote monitoring was designed to leverage the power of health information technology (HIT) to help intensivists access clinical data and interact with bedside caregivers from a remote site, thereby promoting continuous and proactive patient management in ICUs. It extends critical care specialists' expertise to sites where intensivists are not available and has the potential to drive best practice and evidenced-based medicine as part of a patient safety and quality initiative in concert with the teams at the bedside. A recent study on ICU remote monitoring found that providing around-the-clock remote management of ICU patients by critical care specialists decreased mortality, incidence of complications, and length of stay. The lower incidence of complications also resulted in a considerable reduction in ICU costs (3).

In a typical ICU remote monitoring system, a team of intensivists, critical care nurses, and administrative personnel oversee a large number of ICU patients at multiple hospital sites from a centralized location. Clinicians have access to a clinical information system (CIS) that integrates real-time physiologic, laboratory, and imaging data with current medications and interventions. They can communicate with remote ICU sites through video conferencing and are provided with various decision-support tools in patient management (4). Consequently, clinicians' tasks are centered on continuously monitoring physiologic signs, assimilating large amounts of information, and making prompt clinical decisions. Compared with a regular ICU, the remote monitoring technology allows clinicians to monitor more patients and to promptly identify and address adverse clinical states.

ICU remote monitoring is a new form of critical care practice. Therefore, thor-

***See also p. 2213.**

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Supported, in part, by the Agency for Healthcare Research and Quality through grant 1RO1HS15234. The views expressed here are those of the authors and do not necessarily reflect the policy or position of the funding agency. None of the authors was affiliated with the vendor of the remote monitoring system in any way, and the conduct of the study was independent of the vendor company, financially or otherwise.

The authors have not disclosed any potential conflicts of interest.

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DOI: 10.1097/01.CCM.0000281516.84767.96

ough investigations of how clinicians adapt to the enabling technology are necessary for the technology to meet its full potential. Research on HIT has shown that the functionality of a particular technology has a limited role in determining its success in medical practice. The recent study of the role of computerized physician order entry systems in facilitating medication errors, for example, highlighted the unexpected patient safety and quality outcomes that may occur when clinicians adapt to newly introduced HIT (5). Therefore, designing and implementing HIT are not primarily about the technology but more about the people and the work they do. Factors such as process reengineering, workflow, usability, organizational and social constraints, and change management play major roles in the success, or failure, of HIT (6).

To investigate the characteristics of clinicians' workflow in ICU remote monitoring, we conducted a time-and-motion observational study of critical care specialists working in such a facility over extended periods of time. We were particularly interested in how the enabling technology shaped clinical processes and how physicians and nurses collaborated in this new critical care setting. To our knowledge, the current study is among the very first to investigate the operating performance of the ICU remote monitoring technology. Thus, it complements other studies that focus on the clinical outcomes of this technology and is important in assessing the potential of ICU remote monitoring in critical care.

METHODS

Research Setting. The study was conducted over a 4-wk period between November and December 2005, in an ICU remote monitoring facility affiliated with a large healthcare system located in the Gulf Coast region of the United States. The facility had been using the proprietary eICU technology developed by VISICU (Baltimore, MD) for 21 months and remotely monitored nine ICUs with a total of 132 beds in five of the healthcare system's hospitals at the time of the study. Facility staffing included two intensivists from noon to 7 am Monday through Friday (onsite specialists were present in the ICUs during these time periods) and 24 hrs a day on Saturday and Sunday, and four registered nurses and two administrative technicians 24 hrs a day, 7 days a week. Each intensivist collaborated with two nurses and one technician to monitor half of the ICU beds. The physician's major responsibilities were to direct clinical decisions and patient interventions initiated by the remote monitoring team, attend to patient data presented through the CIS, and document patient management activities. In the meantime, the nurses' main duties were to collect and assess patients' physiologic, psychological, and medical record data; respond to routine, urgent, and emergent situations; and identify and communicate existing or potential patient problems to the physician. The clinicians worked 8- to 12-hr shifts, changing shifts at different times to ensure the continuity of patient management within each team.

Physicians and nurses each used a computer workstation with multiple LCD monitors to manage patient care. The workstations used by intensivists had six monitors; those used by registered nurses had five. Among many functions, the workstation displayed early warning signals on abnormality in a patient's status (Smart Alerts; VISICU) and allowed the clinician to see live video of patients, monitor real-time vitals, and manage clinical information. The computer monitors were stacked vertically in two rows and positioned semicircularly facing the clinician. At the beginning of a shift, the clinician designated each monitor for a specific function.

Participants. Six intensivists and seven registered nurses were selected from a pool of 14 physicians and 19 nurses to participate in the current study. They included the only two full-time physicians working in that facility. The remaining four part-time physicians and the seven nurses (all worked full-time) were randomly selected. Overall, participants' experience with the eICU technology averaged 18 months for physicians (range, 5–30 months, counting one physician's prior experience with the same remote monitoring technology at another healthcare facility) and 12 months for nurses (range, 6–21 months). These were comparable to the experiences of those clinicians not included in the study (averaged at 17 and 11 months for physicians and nurses, respectively).

Before the current study we interviewed ten clinicians and conducted preliminary observations on two physicians and two nurses as part of a larger research project at the same remote monitoring facility. Seven of the 13 current participants were involved in those activities. The broader base of participation, as well as repeated exposure to the research activities, could have helped reduce the obtrusiveness of the current study and mitigate any potential reactive effects.

Apparatus. An electronic data collection tool was specially constructed based on information from the preliminary observations of clinicians' work in the facility (covered physicians' and nurses' complete day and night shifts for approximately 40 hrs). From the results we derived a two-level task hierarchy consisting of tasks and activities. A task was defined as an event with a well-defined clinical, technological, or some other goal. An activity was a concrete action toward achieving that goal. For example, one task that was performed by both physicians and nurses was rounding. In performing this task, a clinician would in turn perform various activities, such as assimilating information, requesting information, communicating with others, and so on. The major tasks and activities uncovered in the preliminary studies were integrated into the data collection tool. They were refined after the current study. The complete listing of tasks and activities is provided in the Results section.

The data collection tool was implemented as a Microsoft Access Form (Microsoft, Redmond, WA) application and installed on a tablet PC (Fig. 1). The information collected included time-stamped tasks and activities, information resources (i.e., artifacts), participants, and sometimes the observer's free-text notes providing additional information relevant to a specific event.

Procedure. Institutional Review Board approval was obtained before the study. Each physician was observed for an entire shift. Among the six physician participants, three were observed during one of their regular dayshifts (noon to 11 pm) and the other three during one of their regular nightshifts (11 pm to 7 am). The total observation time was 49.1 hrs. For the nurses, each was observed for a 6-hr block during a regular 12-hr shift. (Our preliminary studies showed that eICU nurses' role was quite limited in the morning, as there were intensivists at the bedside and no physicians in the remote monitoring facility during this time period. Nurses' workflow also slowed down during late night. Therefore, we decided to observe nurses from noon to midnight in the current study, as this time frame was most representative of the nursing workflow where nurses played an active role in patient management.) Among the seven nurse participants, four were observed during the second half of a dayshift (noon to 6 pm) and the other three during the first half of a nightshift (6 pm to 12 am). The overall observation time for the nurses was 40.5 hrs. Both physicians and nurses were present in the facility throughout the observation sessions. Judging by the numbers and acuities of ICU patients whom the clinicians monitored, the workflows observed during the study sessions were considered typical.

One of the authors (ZT), who had expertise in behavioral science and was experienced in workflow research in critical care settings, conducted all the observations from behind the participant (facing the workstation). At the beginning of each observation session, the participant was informed of the nature of the study, signed a written informed consent, and was encouraged to perform his or her job duties as normal. The observer initiated the observation by clicking a button on the Access form. The tool automatically recorded the time as the beginning of the observation. The observer then determined the nature of the current task and activity and checked off relevant data fields on the form. As soon as the partic-

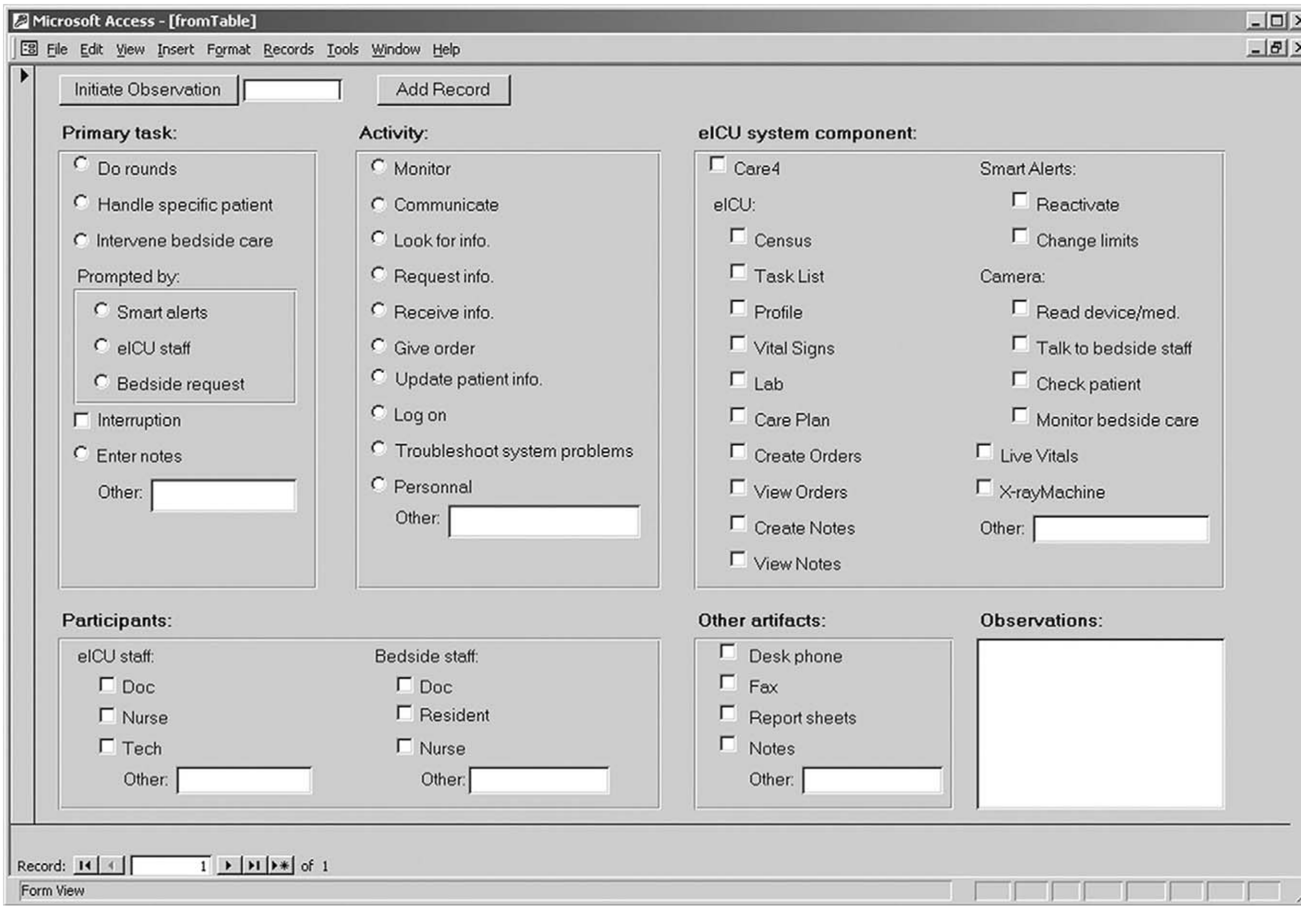

Figure 1. Screenshot of the data collection tool used in the observations.

ipant switched to a different task or activity, the observer clicked the "Add Record" button to conclude the current entry. The tool recorded the time again as the end of the current record and initiated a new record by refreshing the form for the next entry. During the observation, the observer did not initiate any exchange with the clinician so as not to interfere with the clinician's work.

Data Analysis. Study-specific events, such as the observer temporarily suspending the observation or a few occasions when a participant spoke to the observer, were discarded before data analysis. This amounted to 1.8 and 1.7 hrs (3.6% and 4.2% of the overall observation times) for physicians and nurses, respectively. As a result, the adjusted total observation time was 47.3 hrs for physicians and 38.8 hrs for nurses. Then each participant's data were analyzed to derive the percentage times spent on performing different types of tasks and activities, the frequencies of accessing different information resources, and the frequency and average duration of interruptions in an individual's workflow.

In conducting inferential statistics, we first examined the effect of experience on workflow by categorizing participants into one of three experience levels based on how long they had been using the remote monitoring technology. There was no evidence suggesting that experience had any significant impact on the percentage times spent on different patient monitoring activities (multivariate $F_{14,2} = 1.355$, $p = .504$) or on the frequencies of accessing different information resources (multivariate $F_{8,8} = 1.550$, $p = .275$). In addition, there was no evidence that experience had any significant effect on the frequency and average duration of interruptions, univariate $F(2,7) = 0.685$, $p = .535$ and $F(2,7) = 0.330$, $p = .729$, respectively.

Based on the results, data from participants of all experience levels were pooled and two multivariate tests, one on times spent on different patient monitoring activities and the other on frequencies of accessing different information resources, were conducted using role (i.e., physicians vs. nurses) as the independent variable. Each multivariate test was followed up with univariate Student's t-tests to examine potential significant difference between physicians and nurses on individual dependent variables. Additionally, two univariate Student's t-tests were conducted to examine the effect of role on frequency and average duration of interruptions. Finally, a 2 (role) $\times$ 4 (source of interruption) chi-square test was conducted to examine if the sources of interruptions for physicians were significantly different from those for nurses.

RESULTS

Tasks and Activities in ICU Remote Monitoring. Clinicians' tasks in ICU remote monitoring fell into five major categories: patient monitoring, collaboration, system maintenance, health records maintenance, and miscellaneous (Table 1).

Patient monitoring was most central to ICU remote monitoring and was conducted in two ways. In the first, general monitoring, a clinician examined the patients in a batch much like an onsite staff would in rounding. The purpose was to gain an overview of all the patients and to identify those in unstable conditions who would need further attention. In the second, focused monitoring, the clinician put a specific patient under close watch, looked for more extensive clinical information, and, if the condition warranted, intervened in bedside care. Clinicians monitored patients independently. (Clinicians did occasionally interact with another staff while monitoring patients, such as to communicate about a patient's condition, request or receive information, and so on. These were considered

Table 1. Categorization of clinicians' tasks in intensive care unit remote monitoring

Task Category	Definition and Specific Tasks
Patient monitoring	A clinician oversees remote patients by using clinical information obtained from various resources General monitoring (i.e., rounding) Focused monitoring (i.e., handling specific patients)
Collaboration	Interactions between two remote monitoring staff with a clinical goal not immediately related to managing a specific patient Shift handover Consultation Mentoring
System maintenance	Tasks related to computer and technology use Workstation preparation System log on/off Troubleshooting system problems
Health records maintenance	Tasks performed by nurses only to keep patients' health records up to date Transcribing admission and progress notes Filling out a paper-based information sheet for each patient
Miscellaneous	Tasks that were of an administrative, social, or personal nature Discussing staffing schedule Socializing with coworkers Personal time

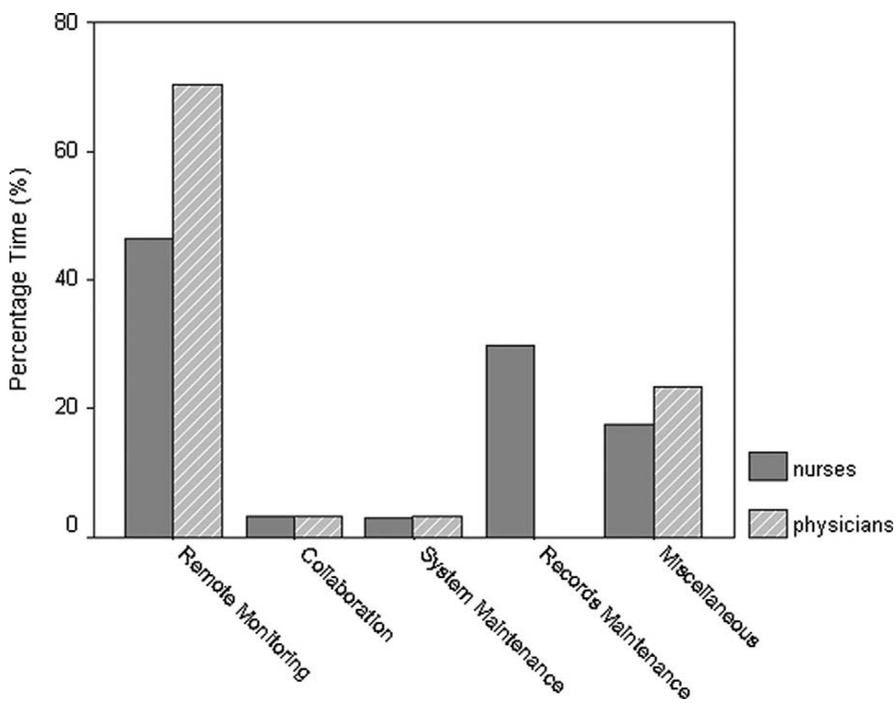

Figure 2. Mean percentage times that physicians and nurses spent on different task categories in intensive care unit remote monitoring.

components of the independent patient monitoring task so as to maintain the integrity of the task hierarchy.) Clinicians also performed some tasks collaboratively, including shift handover, consultation (with peer clinicians), and mentoring (a junior staff). System maintenance tasks stemmed from the technological infrastructure used in ICU remote monitoring. They included workstation preparation, logging on/off clinical applications, and troubleshooting hardware and software problems. Nurses also maintained patients' health records by transcribing bedside admission and progress notes into the CIS and filling out a paper-based information sheet for each patient for quality assurance purpose. Last, there were tasks that were of an administrative, social, or personal nature, such as discussing staffing schedule, socializing with coworkers, and taking a break from work.

Physicians and nurses performed the same types of tasks except for health records maintenance (Fig. 2). On average, physicians spent 70.3 ± 11.8% (mean ± SD) of their time on patient monitoring, 3.3 ± 1.8% on collaboration, 3.1 ± 3.3% on system maintenance, and 23.3 ± 12.9% on miscellaneous tasks. For nurses, the times spent on these four task categories were 45.9 ± 14.6%, 3.4 ± 2.5%, 3.9 ± 5.9%, and 17.6 ± 11.5%, respectively. In addition, the nurses spent 30.3 ± 14.0% of their time on health records maintenance. Further analysis also showed that in monitoring patients, physicians split the time evenly between general and focused monitoring (50.5 ± 9.6% vs. 49.5 ± 9.6%), whereas nurses spent more time on focused monitoring than on rounding (70.4 ± 20.0% vs. 29.6 ± 20.0%).

Patient monitoring, whether general or focused, consisted of a series of activities that a clinician performed to manage remote patient care. There were eight major types of activities: 1) monitor real-time vitals; 2) assimilate clinical information from various resources; 3) request information; 4) receive information; 5) communicate with others about a patient's condition; 6) instruct a junior staff in the remote monitoring facility; 7) intervene in bedside care (by giving orders to bedside caregivers over the phone, a responsibility reserved for physicians only); and, 8) document any measures taken on a specific patient in the CIS. Analysis showed that the most common activity during rounding was assimilating clinical information, whereas in focused monitoring clinicians' activities were more varied. The overall distributions of percentage times that physicians and nurses spent on different activities while monitoring patient are shown in Figure 3. A multivariate test on the percentage times of different activities was conducted using role (physicians vs. nurses) as the independent variable. The results showed that role had an overall significant effect (multivariate $F_{7,5} = 5.661$, $p = .037$). Follow-up Student's t-tests showed that the nurses spent significantly more percentage times monitoring live vitals (15.9 ± 10.9%) than did the physicians (2.1 ± 2.2%) ($t_{11} = 3.026, p = .012$), while the physicians spent significantly more percentage times communicating with others (13.2 ± 5.1%) than did the nurses (7.4 ± 2.8%) ($t_{11} = 2.578, p = .026$).

Information Resources Used in Remote Monitoring. The remote monitor-

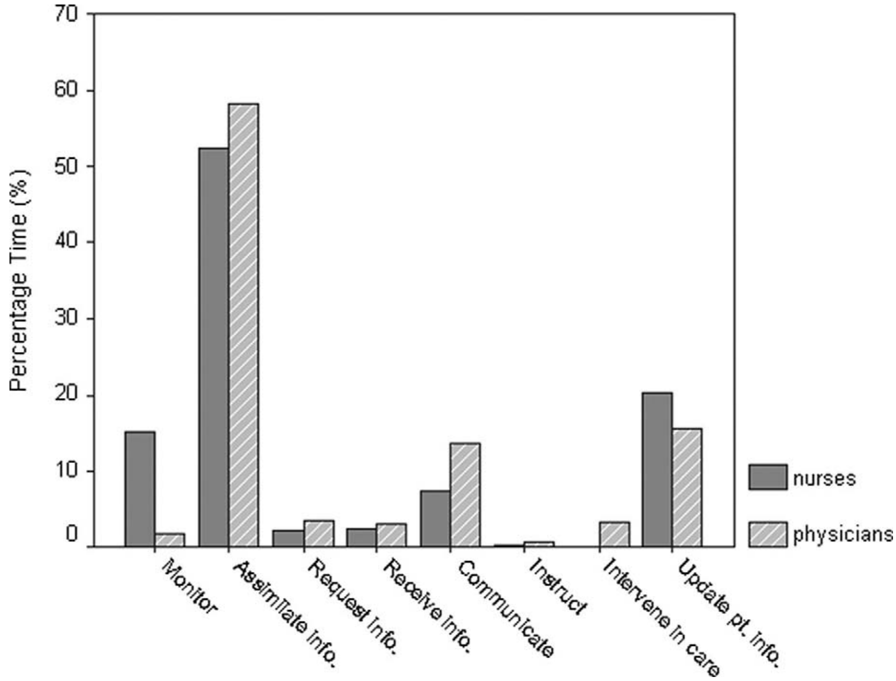

Figure 3. Mean percentage times that physicians and nurses spent on different activities during patient monitoring tasks.

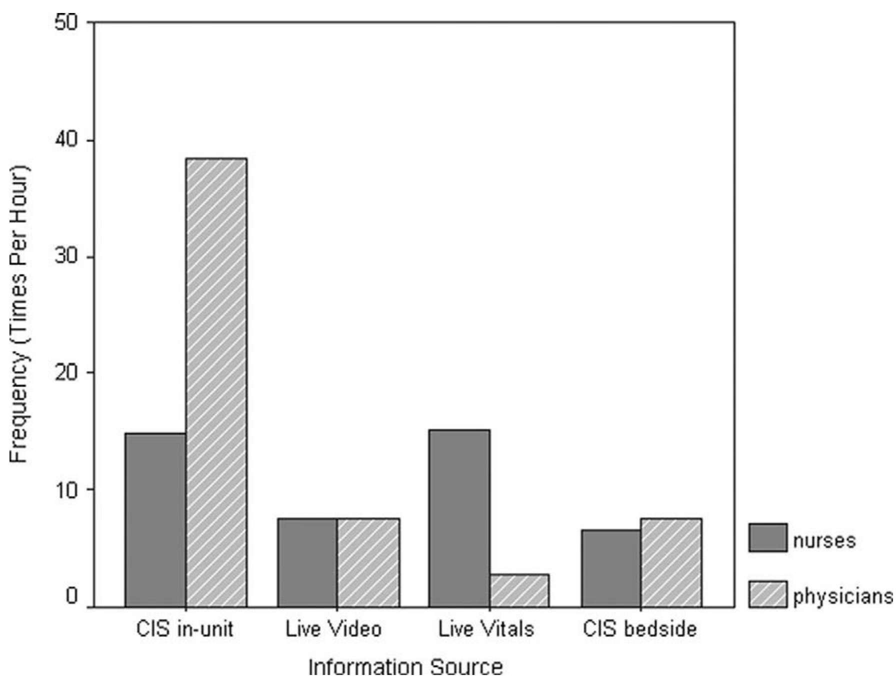

Figure 4. Physicians' and nurses' mean access rate of using different information resources during patient monitoring.

ing system in the facility provided four information resources for clinicians: 1) a primary CIS used in the facility that integrated admission, progress, and procedure notes, as well as other patient data, such as laboratory, microbiology, vital signs, medications, and so on; 2) live video; 3) real-time vitals; and 4) a CIS used at the bedside and accessible to remote monitoring staff. Figure 4 compares physicians' and nurses' access of the four information resources. A multivariate test was conducted on the access rate of all four information resources using role as the independent variable. The results showed that role had an overall significant effect (multivariate $F_{4,8} = 4.538$, $p = .033$). Specifically, the physicians used the primary in-unit CIS at a rate of 42.1 ± 27.0 times per hour, significantly higher than the nurses' access rate of 14.0 ± 10.7 times per hour ($t_{11} = 2.542$, $p = .027$). On the other hand, the nurses accessed patients' real-time vitals at 15.9 ± 8.3 times per hour, significantly more frequently than the physicians did at 3.0 ± 2.4 times per hour ($t_{11} = 3.678$, $p = .004$). Physicians' and nurses' access of live video (8.0 ± 5.9 vs. 7.1 ± 3.8 times per hour) and the bedside CIS (7.2 ± 4.6 vs. 6.5 ± 2.4 times per hour) were not significantly different.

Physicians and nurses also interacted with other staff during patient monitoring. The results showed that the physicians interacted with bedside staff at a rate of 3.4 ± 0.7 times per hour, significantly higher than the nurses did at 2.0 ± 1.2 times per hour ($t_{11} = 2.529$, $p = .028$). Physicians' and nurses' interaction with remote monitoring staff occurred at a rate of 7.3 ± 4.2 and 6.2 ± 2.6 times per hour, respectively. The difference was not statistically significant.

Interruptions and Workflow Redirections. Clinicians' workflow was frequently interrupted and redirected in ICU remote monitoring. Overall, the physicians had an average of 2.2 ± 1.1 interruptions per hour, while the nurses had 7.5 ± 2.2 interruptions per hour ($t_{11} = 5.239$, $p < .001$). The mean duration of managing an interruption for the physicians and nurses was 100.8 ± 40.7 and 45.2 ± 14.2 secs, respectively ($t_{11} = 3.404$, $p = .006$). The majority of the interruptions were due to the need to attend to specific patients (i.e., focused monitoring). This alone accounted for 77.5% and 87.2% of all the interruptions occurred in the physician and nurse workflow. Other reasons for interruptions included personal matters, consulting another remote monitoring staff, and shift scheduling.

There were four mechanisms through which a clinician's workflow was redirected to managing specific patients: 1) self-initiated interruption; 2) system-generated Smart Alerts; 3) request from another eICU staff; and 4) request from the bedside. Figure 5 shows the relative frequencies of the four interruption mechanisms at work. For the physicians, self-initiated interruptions were the most common (33%), although each of the other three mechanisms also played a sizable role. For the nurses, 80% of the interruptions were

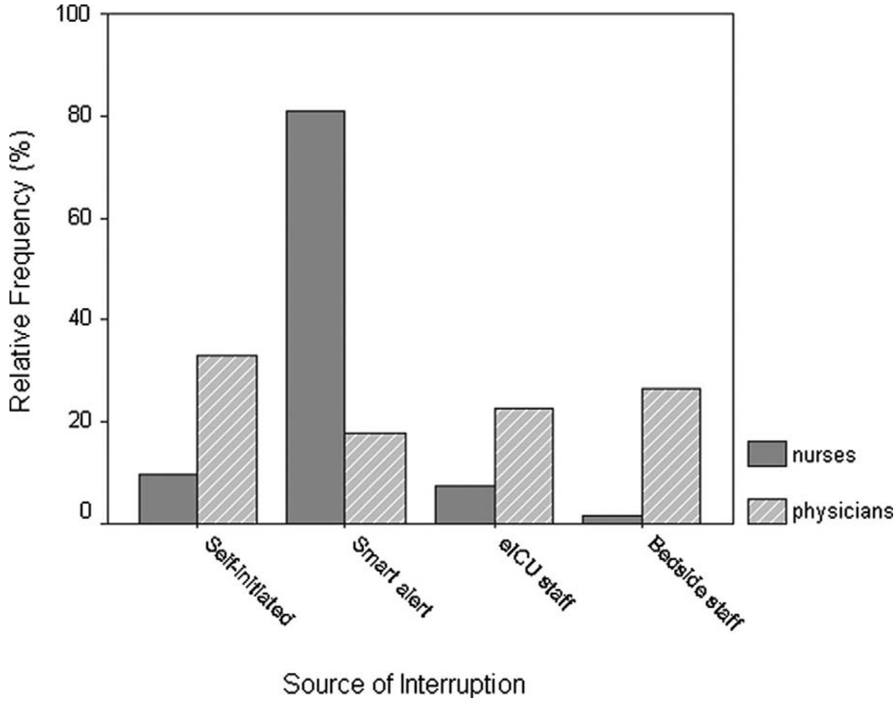

Figure 5. Sources of interruptions when workflow was redirected to managing specific patients.

initiated by Smart Alerts. The difference on source of interruptions between the physicians and nurses was statistically significant (χ^2 (3) $=$ 118.0, $p < .001$).

DISCUSSION

We investigated physician and nurse workflow in ICU remote monitoring and observed three characteristics of clinicians' work in this technology-driven critical care setting. First and foremost, interruptions and workflow redirections were an integral part of ICU remote monitoring, and they affected physicians and nurses in different ways. Nurses were interrupted much more frequently than the physicians (7.5 vs. 2.2 times per hour), whereas physicians spent considerably more time on interrupting tasks than the nurses (100.8 vs. 45.2 secs in average duration). The majority of the interruptions in nurses' workflow were initiated by the embedded technology upon detecting an abnormality in a remote patient's condition. In comparison, most of physicians' workflow redirections were due to the physician's self-initiation or staff request. These results show that, consistent with their respective job expectations, physicians' and nurses' workflows were governed by different mechanisms. Whereas nurse workflow was heavily driven by fluctuations in patients' real-time physiologic status, physician workflow was more autonomous and was affected only when a patient's condition became severe enough to require a physician's attention.

Second, physicians and nurses exhibited different patterns of information processing during patient monitoring. Although both had access to the same information infrastructure, physicians surveyed patient records more extensively, tapping into a broader range of clinical data modules, whereas nurses' use of patient records was limited and much less frequent. In addition, physicians spent more time on communication during patient monitoring and interacted with bedside caregivers more than the nurses did. The fact that physicians spent more time managing an interrupting task provides further support that physicians processed clinical information at a deeper level than the nurses did in remote monitoring.

Third, nurses spent considerable time transcribing admission and progress notes written by bedside staff to keep the in-unit CIS up to date. In some of the ICUs, bedside staff entered the notes directly into the system. But in others, there was less motivation to do so. As a result, note transcription became nurses' responsibility in the remote monitoring facility. This took time away from patient monitoring, and the nurses often had to initiate phone calls to request bedside notes. These results show that the collaboration and coordination between the two sites had a direct impact on nurse workflow in remote patient monitoring.

Our findings have a number of practical implications. First, although one of the benefits of ICU remote monitoring lies in the ability to detect and manage patient issues as they occur, frequent interruptions and workflow redirections may have negative consequences on clinicians' other task performance. Research on interruptions in healthcare settings has shown that the time course of managing an interruption could consist of multiple activities before resuming the original task (7), and interruptions increased pharmacists' error rate while filling prescriptions (8). In view of these results, the frequency and duration of interruptions found in the current study are very concerning. We frequently observed that a task could not be resumed because the clinician could not recall what he or she was doing before an interruption. Therefore, it is important to mitigate the negative effect of workflow interruptions. Viable approaches include improving the specificity of system-generated alerts to reduce the number of interruptions as well as providing memory aids to help a clinician return to an interrupted task after a lapse of time.

Second, the fact that both physicians and nurses spent >50% of patient monitoring time accessing and assimilating information from various sources emphasizes the information-intensive nature of remote patient monitoring and the importance of the integrated CIS used in the facility. Particularly, the usability of the system could have a direct impact on clinicians' task performance. For example, because different modules of a patient's health records were displayed on separate, unsynchronized computer monitors, a clinician would need to find a specific patient and bring up the relevant information on each of the five monitors to have an overview of that patient's condition. This process was not only time-consuming but also prone to error. The large number of patients who individual physicians oversaw posed another problem. Although physicians paid more attention to unstable and particularly sick patients, they did maintain oversight of the whole patient population. Physicians surveyed the two types of patients at different time intervals. The user interface of the CIS, however, did not keep track of the surveyed patients. As a result, physicians relied heavily on their own memory to return from time to time to those who particularly needed attention (as in self-initiated interruptions). This is a very unreliable process given that the number of patients being monitored far exceeds human working memory capacity (roughly seven chunks of information) (9). Because this primary CIS plays such a critical role in ICU remote monitoring, improving its usability would have a positive impact on clinicians' task performance.

Third, our results emphasize the importance of collaborating with bedside caregivers in ICU remote monitoring. Physicians and nurses need onsite staff's cooperation to achieve a high level of efficiency. In particular, nurses' workflow in the remote monitoring facility was heavily affected because some of the bedside staff did not enter notes into the CIS. A subtler problem, encountered by both nurses and physicians, was that communication with bedside staff was not always efficient or congenial. For example, a physician who initiated a phone call to the bedside could be left waiting for a prolonged time without any specific explanation. Therefore, optimizing the workflow in ICU remote monitoring is also contingent on the successful coordination of onsite patient care and remote patient monitoring.

The current study has two important constraints. The first is the relatively coarse granularity of analysis afforded by the research methodology. Observation was a practical and efficient way to study workflow in the current setting. However, given the complexity of clinicians' work, it was not sufficient to capture all the performance details, such as detailed interactions with the clinical information system. Therefore, we focused on tasks and activities that emphasize goals instead. The second constraint is that observations of nurses' workflow occurred during the 12 pm to 12 am time period, whereas nursing staffing at the study site was 24 hrs a day. While we feel confident that this time frame fit our research goal better because it was most representative of the nursing workflow where nurses played an active role in remote patient management, the results reported here should be interpreted with this constraint in mind.

CONCLUSION

The enabling technology of ICU remote monitoring has a profound impact on how clinicians deliver critical care. Physicians' and nurses' task performance and information utilization reflected the distributed nature of work organization in remote monitoring. Workflow interruption, software usability, and collaboration with bedside caregivers are the major issues that may affect the quality and efficiency of clinicians' work in this particular critical care setting. These results provide support that integrating advanced information technology in medical practice requires a careful consideration of the clinicians and clinical processes involved.

ACKNOWLEDGMENTS

We thank the anonymous reviewers for their constructive feedback on a previous draft of the manuscript and Dr. Craig Johnson for reviewing the statistical analysis results reported here. We also thank the physicians and nurses who participated in this study and the administrative staff at the study site who helped coordinate the observations.

A working paper titled "A Time-Motion Study of Registered Nurses' Workflow in Intensive Care Unit Remote Monitoring" and containing a small portion of the data reported here was published in the 2006 Proceedings of American Medical Informatics Association Annual Conference.

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