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Destination Bedside

Using Research Findings to Visualize Optimal Unit Layouts and Health Information Technology in Support of Bedside Care

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This study explored the impact of unit design and healthcare information technology (HIT) on nursing workflow and patient-centered care (PCC). Healthcare information technology and unit layout–related predictors of nursing workflow and PCC were measured during a 3-phase study involving questionnaires and work sampling methods. Stepwise multiple linear regressions demonstrated several HIT and unit layout–related factors that impact nursing workflow and PCC.

For over a decade, the Institute of Medicine has been an advocate for change in the healthcare industry.[1,2] It has indicated that timeliness, efficiency, equitability, safety, and effectiveness of care are quality aims that should guide healthcare reform. A sixth and ultimate goal, patient-centered care (PCC), is at the heart of the other aims.

Patient-centered care has been characterized as "provision of care that is respectful and responsive to patient preferences and needs, ensuring that patient values guide clinical decisions."[2] Patient-centered care is being pursued in a variety of ways through advancements in healthcare information technology (HIT), electronic health records (EHRs), and inpatient unit layouts. Emphasizing the importance of such interventions, the American Recovery and Reinvestment Act of 2009 allocated approximately $27 billion to facilitate the adoption of the EHR and related components using a meaningful-use approach.[3] The literature indicates that HIT and related technologies can help prevent medical errors.[4]

The overall aim of the present study was to explore relationships between HIT and unit layout and their impact on nursing workflow and PCC. Decisions on where to place HIT solutions on an inpatient unit and in relation to the patient room may have implications for nursing workflow and PCC. Unfortunately, there is a scarcity of empirical research that demonstrates optimal relationships among HIT, EHR, and unit layouts. Research on the relationships among these is timely, given the growing prevalence of units with private patient rooms and with decentralized nursing station options.[5]

Unit Layout and Clinical Information Systems

Healthcare information technology and unit layout are dormant or latent conditions that may indirectly

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affect nursing workflow and care quality issues related to adverse events.[6,7] Existing research on latent conditions indicates that facility design and equipment and supply failures may be leading contributors to poor patient safety and care delivery inefficiencies.[8] Given these circumstances, a deeper understanding of the challenges and opportunities associated with and between latent conditions such as unit layout and HIT is warranted.

Although the parts of an inpatient unit remain fairly constant, the ideal configuration of patient rooms, nursing stations, corridors, and support core spaces remains a source of debate. A descriptive study including 81 medical-surgical inpatient units concluded that a unit consisting of spokes of patient rooms was an inferior configuration due to low patient visibility and long travel distances.[9] Research comparing radial to rectangular units found that nurses on radial units walk less and spend more time performing patient care activities.[10,11] A retrospective study of an intensive care unit found severely ill patients admitted to rooms not visible from the main nursing station experienced statistically significant higher mortality rates than those patients admitted to rooms in view.[12]

Decentralized nursing stations are immediately inside or outside a patient's room, often with windows for direct patient observation. Accommodations may include medication and supply storage, a hand-washing facility, work surfaces for charting, a computer, and telecommunication devices.[13] Decentralized nursing stations may contribute to decreases in patient falls.[14]

In hospitals, adverse drug events are frequent and a common result of medication errors.[2] Forty-three percent of medication errors may be due to workplace distractions during preparation and dispensing.[15] During medication preparation, major sources of interruptions include other nurses and searches for missing medications and equipment.[16,17] One highly controlled study found that patient rooms with locked medication cabinets had a statistically significant lower medication error rate compared with medication carts.[18] A corroborating study indicated improved efficiencies and fewer interruptions after implementing decentralized medication cabinets at the bedside.[19]

Multiple variables can influence the efficiency and accuracy of information entered into an HIT application. For example, exploratory research of mobile computer technologies or computers-on-wheels versus stationary computers indicated that nurses document more at a computer-on-wheels than a stationary computer during the first hour of data collection.[20] However, the computers-on-wheels were noted by nurses as being clumsy, difficult to push, and inoperable at key locations. Other research has found that bedside computer terminals are associated with a 24.5% decrease in overall nurse documentation time per shift.[21]

Advancements in HIT and unit layout inspire questions on how best to orchestrate HIT with unit layout, nursing workflow, and PCC. There is very little literature specific to relationships between HIT and unit layouts. HIT is advancing at a rate exceeding hospital administrators' ability to adopt and implement it. Furthermore, there is scarcity of research that demonstrates what unit layouts and system configurations are optimal for PCC.

Methods

Research Approach and Phases

The present study was conducted in 3 phases using mixed methods. During mixed methods research, qualitative research involving interviews and focus group exercises can complement quantitative research involving questionnaires and behavior observation.[22] One method can compensate for the limitations of the other.

The 1st phase of the study used questionnaires to detect relationships between nursing workflow and patient experience. The RNs' scores on a questionnaire were correlated with their patients' scores on a different questionnaire. Using this approach, the researchers could examine the associations among the unit layout, HIT use, care delivery, nursing workflow, and patient outcomes. Aspects of unit layout, HIT use, care delivery, and nursing workflow that had negative consequences for patient outcomes were not considered patient-centered.

Patients who participated in phase 1 of the study were assigned to rooms based on room availability. Therefore, differences among patients were controlled by a natural instance of random assignment.

The 2nd phase was a work sampling investigation during which the RNs' walking distances, space utilization, HIT use, and frequency of patient care at bedside were monitored. This phase identified whether specific features (ie, unit layout, HIT, and care delivery characteristics) contributed to the frequency and quality of patient care at bedside.

In the 3rd phase of the study, nurses participated in design charrettes where they discussed results from phases 1 and 2. A charrette is a common brainstorming and ideation technique used in architecture to generate visual solutions to a design challenge.[23] This phase enabled the RNs to create sketches of unit and patient room layout with HIT solutions.

Setting

The study site was an academically affiliated teaching hospital located in an urban area of the United States. The hospital has 247 adult inpatient beds with 7 medical-surgical inpatient units, all included in the study. All units had computers-on-wheels and balanced headwalls with identical locations for gasses, outlets, and call buttons on both sides of the patient beds (see Table, Supplemental Digital Content 1; http://links.lww.com/JONA/A68) as well as computerized physician order entry and bar-code medication administration.

Sample

Phase 1 consisted of 109 patients and 89 RNs from the day shift. On average, a participating patient was 62 years of age. On average, a nurse in phase 1 was 35 (SD, 11.19) years old, had 7 (SD, 8.47) years of experience, and cared for 5 (SD, 0.82) patients. On average, a patient in phase 1 was 63 (SD, 15.52) years old. In total, there were 45 pairs of staff and patients. Phase 2 consisted of 111 day- and evening-shift nurses. Of these nurses, 29 used a personal digital assistant (PDA) device and pedometer and completed the questionnaire; 48 only used a PDA, and 34 only filled out a questionnaire. On average, a nurse in phase 2 was 33 (SD, 8.48) years old, had 5.5 (SD, 7.06) years of experience, and cared for 5 (SD, 0.86) patients. Phase 3 consisted of 40 nurses who took part in the charrettes.

Measures

Three self-designed questionnaires were developed for the study. There is a dearth of valid and reliable instruments in the literature specifically assessing the effect of design features on patients and clinicians.

A comprehensive literature review of empirical research of inpatient unit settings was conducted to identify the items for inclusion in the questionnaires. Two rounds of focus groups and work sessions with nursing administration and staff from the participating hospitals were held to refine the questionnaires. To establish content validity, the 1st round involved content experts consisting of 4 nurses, 2 healthcare design architects, and 1 environmental psychologist specializing in research of healthcare design. The 2nd round involved the content experts and additional nursing staff including unit managers. Nursing staff and managers piloted the questionnaires to determine appropriate length and provide additional feedback. Suggestions and recommendations from the content experts and staff were incorporated into the questionnaires. Questions were reversed and scored to prevent response bias by participants.

The 1st questionnaire developed was the Patient and Staff Experience Questionnaire: RN Portion (PSEQ-RNP). The initial version of the PSEQ-RNP consisted of 117 questions. The final version of the PSEQ-RNP consisted of 94 questions. Various subsections addressed characteristics of nurses and their care delivery activities: demographic information and years of work experience, focus and concentration, nurses' perception of patients' cognitive state, aspects of patients and patient care, activities and modes of communication, and space, equipment, and supplies in use for the patients.

The 2nd questionnaire developed was the End of Shift Questionnaire (ESQ). The initial version of the ESQ consisted of 164 questions. The final version of the ESQ resulted in 143 questions. Subsections addressed demographic information and years of work experience, focus and concentration, the care continuum, adverse event occurrence, activities and modes of communication, employee lounge use, team cohesion, and anxiety. Also, the subsections addressed space, equipment, and supplies in use for the patients. A question on the ESQ asked the nurses to record how many steps were taken during a shift.

The 3rd questionnaire was the Patient Experience Survey (PES). The initial version of the PES consisted of 118 questions. The final version of the PES consisted of 93 questions. Subsections address characteristics of patients, the patient experience, and patient outcomes: demographics, current room and areas around it, happenings in the room, frequency and intensity of reported pain, experiences with visitors and staff, and experiences with a roommate.

During the 1st phase of the study, participating nurses were asked to fill out the PSEQ-RNP. Patients of participating nurses were also administered the PES. Principal components analysis with varimax rotation was performed on the PES to identify relevant components for statistical analyses. To identify relationships among HIT use, unit layout, and patient safety, the PES component bed-to-bathroom transfer was included. Items that were included in the component ($\alpha = .90$) were "ease of walking on my own to the bathroom," "ease of performing activities inside the bathroom," and "ease of getting in and out of bed to go to the bathroom."

Nurses who participated in phase 2 were asked to complete the ESQ toward the end of each shift and carry a PDA and a pedometer throughout the entire shift. Prior research had utilized the combination of techniques.[24] To convert steps recorded on pedometers to travel distances, a standard conversion rate of 2.6 ft per step was used.[6] Distance and PDA work sampling data were divided by a nurse's shift duration so that data were normalized for statistical analyses.

Procedure

Prior to data collection, the study was approved by the participating institution's human subjects review board. Following approval, the researchers walked the 7 nursing units while taking an inventory of their features including nursing stations, sinks, supplies, equipment, and patient bathroom locations.

During the first phase, the PSEQ-RNP and PES were administered approximately at the same time toward the end of each nurse's shift. Every day for 2 weeks, a research team member arrived on a medical-surgical unit during the day shift and asked the nurses which patients were alert and oriented and capable of filling out a questionnaire. Nurses and their patients who participated in the study participated only once.

The PSEQ-RNP was available to the nurses through a SurveyMonkey software link sent via an e-mail or through an intranet-based home page accessible at computers-on-wheels or computers at nursing stations. The research team member reviewed the contents of an informational letter with each nurse. A consenting nurse was asked to complete the PSEQ-RNP toward the end of his/her shift.

The nurse's eligible patients were approached by the research team member with an informational letter. A consenting patient was asked to fill out a hard copy of the PES. Patients filled out the questionnaire independently of the research team member. Once finished with the questionnaire, the patient placed it in a sealed envelope.

During the 2nd phase, RNs took part in a work sampling study during which each nurse wore a pedometer and carried a PDA device that rang randomly 30 times per 12-hour shift. A participating nurse wore a pedometer and carried a PDA device for only 1 shift. When initially prompted for an ID, the nurses selected a designation that did not reflect their true identity. Each additional query asked about the location and activity of the RN. At the end of their shifts, the nurses filled out the ESQ. On the ESQ, the nurses reported their IDs and the number of steps recorded by their pedometers.

During the 3rd phase, 40 nurses took part in charrettes. Nurses were presented with the research findings and provided a time for review and comment in a focus group format. The nurses were then asked to provide details of an ideal nursing unit and patient room to a sketch artist who helped visualize their ideas.

Results

Phase 1: Patient-Centered

During analyses of phase 1, stepwise multiple linear regression analyses and Pearson pairwise correlations were performed to explore relationships among care delivery, unit layout, HIT use, and the patient experience. Data from the PES and PSEQ-RNP were used in the analyses.

Predictors of Pain Intensity

A stepwise multiple linear regression was performed to identify variables that predicted patients' reported pain intensity. Data from the PES and PSEQ-RNP were used in the analysis. Variables excluded from and included in the final regression model are shown in Table 1. The patient bed-to-bathroom transfer and nurses' reported frequency of documentation at the main nursing station accounted for 16% of the variance in patient pain intensity. The harder it was for patients to perform bed-to-bathroom transfers as reported by the patients, the greater the pain reported by the patients. The more often the nurses reported documentation at the main nursing station, the greater the pain reported by the patients.

Predictors of Patients' Near-Falls

Stepwise multiple linear regression was performed to identify variables that predicted the patients' reported frequency of catching himself/herself from a fall or a near-fall. Data from the PES and PSEQ-RNP were used in the analysis. Variables excluded from and included in the final regression model are shown in Table 2. In total, patient bed-to-bathroom transfers and nurses' reported frequency of documentation at the patients' bedsides accounted for 12% of the variance for near-falls. The patient bed-to-bathroom transfer was a predictor of more reported near-falls. However, the nurses' reported frequency of documentation at the patients' bedsides predicted fewer instances of near-falls.

Distractions and Computers-on-Wheels

Pearson pairwise correlations revealed that nurses who reported frequent use of computer-on-wheels reported more documentation in the hallway ($r = 0.76$, $P < .01$). Conversely, there was a smaller but statistically significant correlation between nurses' reported computer-on-wheels use and documentation at the patient bedside ($r = 0.28$, $P < .05$). Sixty-three nurses reported experiencing distractions while preparing medications. Nurses reported the most distractions while preparing medications at the computers-on-wheels. Figure 1 shows the frequencies of nurses' reported distractions at various locations on the units while preparing medications.

Phase 2: Nurse Work Sampling

During analyses of phase 2 data, stepwise multiple linear regression analyses were used to examine relationships among nurses' characteristics, communication

patterns, walking distances, operational challenges, activities per hour, and locations per hour. Data from the ESQ, PDAs, and pedometers were used in the analyses. Consequently, the researchers were able to identify design and care delivery characteristics that facilitated or hindered nurses' work.

Predictors of Efficient Operations

A series of stepwise multiple linear regressions highlighted the detrimental impact nursing station location can have on a medical-surgical unit's efficiency of operations. Stepwise multiple regression was performed to identify variables that predicted the nurses' walking distance per hour. Variables excluded from and included in the final regression model are shown in Table 3. Documentation at the main nursing station per hour accounted for 6% of variance in the walking distance traveled by nurses per hour. That is, the more the nurses documented at the main nursing station, the more they walked.

Stepwise multiple regression was performed to identify variables that predicted the nurses' number of trips to the patient room per hour. Variables excluded from and included in the final regression model are shown in Table 4. Documentation at the main nursing station per hour was associated with a decreased number of trips to patient rooms by the nurses per hour. The more the nurses documented at the main nursing station, the less often the nurses visited the patients in their rooms.

In total, 44% of the nurses' time at the main nursing station was spent performing documentation. Figure 2 shows the percentages of time spent performing various activities at the nursing station. Only 8.5% of the nurses' time in the patient room was spent assessing the patient, and 3.1% of the nurses' time in the patient room was spent performing documentation. Figure 3 shows the percentages of time spent performing various activities in the patient room.

Nurses' time spent in direct patient care constituted 51.4% of their shift. Patient care activities not performed in the presence of the patients or indirect care activities constituted 8.1% of the nurses' shifts. Figure 4 shows the percentage of time spent performing various activities during a shift. Manual data entry constituted 69% of indirect care activities. Figure 5 illustrates a breakdown of indirect care activities.

Table 1. *Summary of Stepwise Regression Analyses for Variables Predicting Patients' Reported Pain Intensity*

Variable	*B*	SE *B*	*β*
Step 1			
Constant	1.53	0.25	
Bed-to-bathroom transfer	0.32	0.10	0.34[a]
Step 2			
Constant	1.03	0.35	
Bed-to-bathroom transfer	0.31	0.10	0.32[a]
Document at nursing station	0.16	0.08	0.21[b]

Note. $R^2 = 0.11$ for step 1; }{}$\Delta\{R^2 = 0.05$ for step 2 (P's $< .05$).
[a]$P < .01$.
[b]$P < .05$.

Table 2. *Summary of Stepwise Regression Analyses for Variables Predicting Patients' Near-Falls*

Variable	*B*	SE *B*	*β*
Step 1			
Constant	0.86	0.22	
Document at bedside	−0.13	0.06	−0.25[a]
Step 2			
Constant	0.60	0.25	
Document at bedside	−0.13	0.06	−0.25[a]
Bed-to-bathroom transfer	0.12	0.05	0.24[a]

Note. $R^2 = 0.06$ for step 1; }{}$\Delta\{R^2 = 0.06$ for step 2 (P's $< .05$).
[a]$P < .05$.

Distractions and Medication Storage

Medication storage for patients was housed near the units' main nursing stations. A Pearson pairwise correlation revealed that the more trips nurses made to patient medication storage per hour, the more distractions the nurses reported experiencing during medication administration ($r = -0.46$, $P < .01$).

Phase 3: Charrettes

The 40 nurses who took part in the charrettes identified several HIT and unit layout concepts they felt

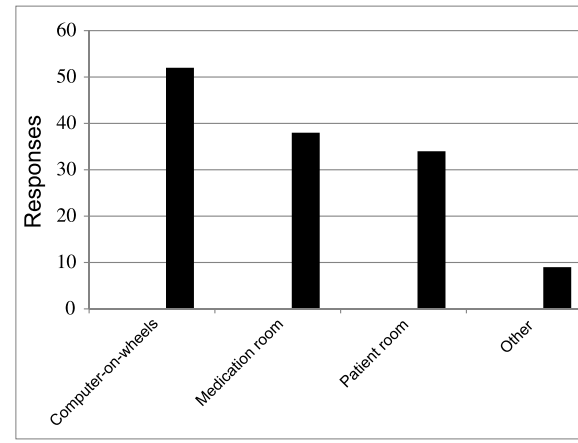

Figure 1. Areas where nurses were distracted while preparing medications. Nurses were permitted to give more than 1 answer.

Table 3. Summary of Stepwise Regression Analyses for Variables Predicting Nurses' Walking Distance Per Hour

Variable	*B*	SE *B*	*β*
Step 1			
Constant	639.76	87.92	
Documentation at nursing station per hour	1,080.16	523.36	0.25[a]

Note. $R^2 = 0.06$ (*P*'s < .05).
[a]*P* < .05.

would bring the nurses closer to the bedside and improve care delivery on a medical-surgical unit. Before each charrette, research findings from phases 1 and 2 were presented during the charrettes. Nurses reacted to the findings with HIT and unit layout concepts dictated to a sketch artist. Table 5 shares the nurses' HIT and unit layout concepts.

See Figure, Supplemental Digital Content 2, which illustrates the nurses' vision of what a patient room informed by the research, their experience, and their mental models could look like, http://links.lww.com/JONA/A73. Favoring a decentralized strategy, the nurses envisioned a patient room with an antechamber or porch accommodating separate staff entry to the room, consults among clinicians, visibility of the patient, visibility of other nurses on the unit, decentralized supplies, decentralized medications, a sink, space for waste and dirty linens, isolation capabilities, and space for a dedicated computer-on-wheels or computer. The latter is consistent with recent recommendations for spaces designed for medication safety zones on units.[25]

Healthcare information technology solutions housed in the porch allow clinicians to work in privacy and concentration out of the hallway for key tasks such as medication preparation and documentation or at the patient bedside in collaboration with the patient and during bedside handoffs. Moreover, clinicians can be responsive to a patient's needs as they have good visibility of the patient, are in close proximity to the patient, and focused on the patient. If necessary, a computer-on-wheels could be housed in the porch and transferred to the patient bedside.

See Figure, Supplemental Digital Content 3, which illustrates the use of a touch-sensitive lighted handrail to assist with fall prevention and pain experienced by patients during bed-to-bathroom transfers, http://links.lww.com/JONA/A74.

The patient room would be a prototype for a same-handed unit configuration wherein all the inpatient beds are oriented in the same direction and do not share a headwall. In a study of a same-handed unit the increased right-sided approach was associated with fewer near-falls as reported by the patients.[26]

The nurses conveyed that their vision could help reinforce an operational model that integrates what has become a fragmented care delivery process. In fragmented processes, nurses do not have the right supplies, equipment, and HIT at the right place and time.

Discussion

This study explored the relationships among several conditions of medical-surgical inpatient units and their impact on nursing workflow and PCC. These conditions included HIT solutions and unit layout. Overall, the research demonstrated that ineffective processes lead to inefficiencies and patient safety risks. Not surprisingly, bed-to-bathroom transfers contributed to patient fall risk and pain intensity. One recent study found that most patient falls over a 2-year period on an orthopedic unit were associated with unassisted, bathroom-related trips during the night shift.[27] The nurses reacted to these results during the charrettes by recommending innovative solutions such as the touch-sensitive lighted handrail that can help prevent patient falls during bed-to-bathroom transfers (See Figure, Supplemental Digital Content 3, http://links.lww.com/JONA/A74).

Optimization of HIT solutions and platforms may improve the patient experience. In this study, computer-on-wheel usage in the hallway exposed the nurses to distractions during care delivery tasks such as documentation and medication preparation. Medication storage at the main nursing station was associated with RN distractions. Overall, information technology and equipment (ie, type and location) may contribute to inefficiencies, patient safety risks, and lower patient satisfaction. Techniques that limit many documentation activities to the vicinity of the patient room may create parameters for mobile technologies. For example, computers-on-wheels and handheld computers could have docking stations, monitors, and power outlets in the vicinity of the patient room or bedside, decreasing distractions for the staff.

Documentation at a traditional main nursing station contributes to inefficiencies, poor patient experience, and patient safety risks. Nurses' documentation at the main nursing station had a detrimental impact on workflow efficiencies by contributing to nurses' increased walking and decreased number of visits to the patient rooms. Moreover, 44% of the nurses' time at the main nursing station was spent performing documentation, 8.5% of the nurses' time in the patient room was spent assessing the patient, and 3.1%

Table 4. *Summary of Stepwise Regression Analyses for Variables Predicting Nurses' Number of Trips to the Patient Room Per Hour*

Variable	*B*	SE *B*	*β*
Step 1			
Constant	0.60	0.05	
Vital signs per hour	1.23	0.26	0.51[a]
Step 2			
Constant	0.52	0.05	
Vital signs per hour	1.27	0.24	0.52[a]
Activities of daily living per hour	0.96	0.24	0.39[a]
Step 3			
Constant	0.33	0.06	
Vital signs per hour	1.64	0.22	0.67[a]
Activities of daily living per hour	1.16	0.21	0.47[a]
Patient assessments per hour	1.07	0.22	0.44[a]
Step 4			
Constant	0.22	0.06	
Vital signs per hour	1.72	0.20	0.70[a]
Activities of daily living per hour	1.22	0.20	0.50[a]
Patient assessments per hour	1.32	0.22	0.54[a]
Patient services per hour	1.00	0.30	0.28[a]
Step 5			
Constant	0.12	0.07	
Vital signs per hour	1.57	0.19	0.64[a]
Activities of daily living per hour	1.35	0.18	0.55[a]
Patient assessments per hour	1.21	0.20	0.50[a]
Patient services per hour	1.12	0.28	0.31[a]
End-of-shift report per hour	0.81	0.23	0.27[a]
Step 6			
Constant	0.04	0.07	
Vital signs per hour	1.27	0.20	0.52[a]
Activities of daily living per hour	1.11	0.18	0.45[a]
Patient assessments per hour	1.36	0.19	0.56[a]
Patient services per hour	1.31	0.27	0.36[a]
End-of-shift report per hour	0.85	0.21	0.28[a]
Give medications per hour	0.72	0.21	0.29[a]
Step 7			
Constant	0.14	0.07	
Vital signs per hour	1.23	0.19	0.50[a]
Activities of daily living per hour	1.09	0.17	0.44[a]
Patient assessments per hour	1.25	0.19	0.52[a]
Patient services per hour	1.31	0.25	0.36[a]
End-of-shift report per hour	0.88	0.20	0.29[a]
Give medications per hour	0.78	0.21	0.31[a]
Documentation at nursing station per hour	−0.28	0.11	−0.17[a]
Step 8			
Constant	0.05	0.08	
Vital signs per hour	1.34	0.19	0.55[a]
Activities of daily living per hour	1.05	0.17	0.42[a]
Patient assessments per hour	1.17	0.18	0.48[a]
Patient services per hour	1.25	0.24	0.34[a]
End-of-shift report per hour	0.88	0.20	0.29[a]
Give medications per hour	0.69	0.20	0.27[a]
Documentation at nursing station per hour	−0.28	0.11	−0.16[a]
Documentation at patient bedside per hour	0.04	0.02	0.16[b]

Note. $R^2 = 0.26$ for step 1; }{}$\Delta\{R^2 = 0.15$ for step 2; }{}$\Delta\{R^2 = 0.16$ for step 3; }{}$\Delta\{R^2 = 0.07$ for step 4; }{}$\Delta\{R^2 = 0.06$ for step 5; }{}$\Delta\{R^2 = 0.04$ for step 6; }{}$\Delta\{R^2 = 0.03$ for step 7; }{}$\Delta\{R^2 = 0.02$ for step 8 (*P*'s < .01).
[a]$P < .01$.
[b]$P < .05$.

of the nurses' time in the patient room was spent performing documentation (Figure 2). A majority of indirect care time was spent manually entering data away from patients. Similar to the present study, an earlier study found that 27.5% of a nurse's shift was spent on documentation, and only 7.2% of a nurse's shift was spent on physical assessment and surveillance of a patient.[24]

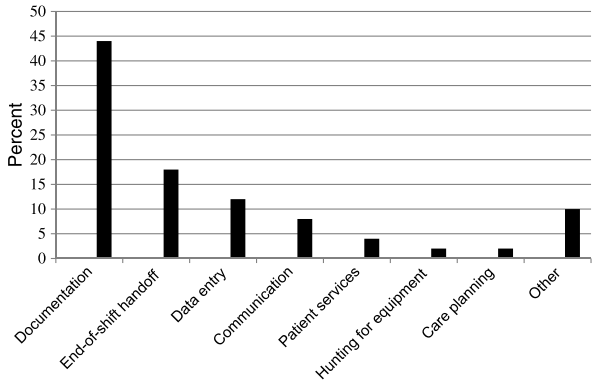

Figure 2. Time spent performing various activities at the nursing station.

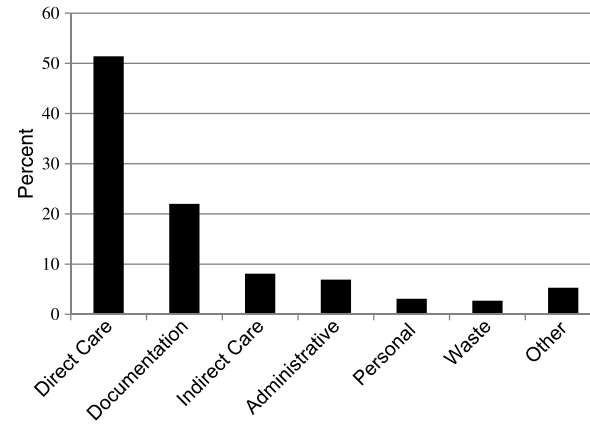

Figure 4. Time spent performing various activities.

A disconcerting finding of this study was that the more often nurses performed documentation at the main nursing station, the greater the pain intensity reported by their patients. In addition, decreased documentation at the patients' bedsides predicted more instances of patients' near-falls.

Implications

This study revealed important relationships among unit layout, nursing workflow, and PCC. These insights can be used for innovations in unit layout and EHR implementations to optimize PCC. For example, nurse executives can use these findings to support decentralized medication solutions at or near the bedside. Decentralized medication solutions could lead to improved efficiencies and PCC by prompting nurses to work in closer proximity to patients. In turn, nurses could be more responsive to their patients' needs. Decentralization and standardization of key equipment and HIT solutions to each patient room would enable nurses to spend less time searching for equipment and information. Integrated HIT solutions (eg, automated vital sign machines) could alleviate manual data entry and increase available time.

When engaged in a new bed tower or renovation project, nurse executives should execute research-based designs and engage staff early in the initiative. Displays of research findings during the charrettes helped nurses target and innovate solutions that may improve efficiencies and PCC on units. The charrette process empowered nurses in their decision making and creativity skills. In this study, the nurses challenged traditional and contemporary design conventions for centralized and decentralized nursing by visualizing an innovative patient room with porch (See Figure, Supplemental Digital Content 2, http://links.lww.com/JONA/A73). The porch serves as a dedicated offstage area within the vicinity of the patient room for HIT, equipment, supplies, and medication. The nurses felt that 12- or 16-room clusters of patient rooms with porches would allow for nurses to concentrate on essential tasks near the patient bedside free from distractions caused by others in the hallway or main nursing station. Strategically placed windows on the porch would allow

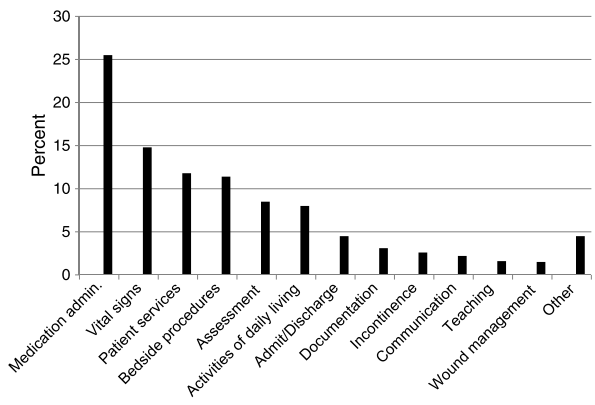

Figure 3. Time spent performing various activities in the patient room.

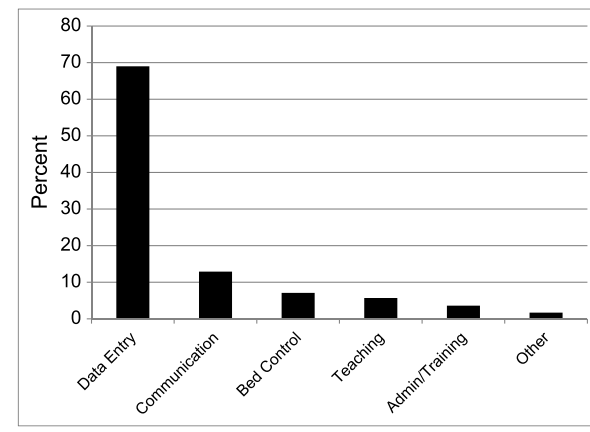

Figure 5. Time spent performing various indirect care activities.

Table 5. Medical-Surgical Inpatient Health Information Technology and Unit Layout Concepts From Charrette Sessions

Level	Design and Operational Parameters	Description
Unit		
	Flooring	Carpet was not preferred because of maintenance and appearance
	Standardization of spaces	Same-handed inpatient units and standardized equipment and supply rooms to improve efficiencies and patient safety
	Pod configurations	May encourage contiguous patient assignments and improve efficiencies
Nursing station		
	Flexible and collaborative layout	Flexible work spaces and computers facilitating private and collaborative, interdisciplinary work and education
	Seating	More seating at nursing station to prevent fatigue and improve collaboration
	Clinical information systems	Advanced electronic medical record capabilities to facilitate interdisciplinary work and care coordination
	Visibility	Enhance visibility of patient rooms and patients using transparent partitions
Patient room		
	Lockable medication cabinet	Decentralized medications to improve efficiency and patient safety
	Smart capabilities	Room automatically accesses patient's clinical information
	Decentralized supplies	Decrease time hunting for linens, saline flushes, insulin, intravenous bags, tubing, alcohol swabs, dressings, and medication cups
	Decentralized equipment	Decrease time hunting for wireless blood pressure cuffs, pulse oximeter, Dinamaps, and thermometers
	Private work surfaces	More work surfaces in the vicinity of the patient room. Screened for care delivery tasks requiring concentration and no distraction
	Seating	Seating options near the patient bedside to improve staff and patient interactions
	Visibility	Enhanced visibility of patients
	Sliding doors	Transparent sliding doors would not obstruct circulation and accessibility
	Handrails	Touch-sensitive lighted handrail that provides patient support and illuminates the path from the bed to the bathroom
	Patient recliner	Facilitates ambulation and activities of daily living
	Task lighting	Better visualization of bedside procedures such as insertion of intravenuous lines

for visibility and connectivity across the unit. In addition, the nurses identified innovative solutions for preventing patient falls such as a touch-sensitive lighted handrail (See Figure, Supplemental Digital Content 3, http://links.lww.com/JONA/A74).

Limitations and Recommendations for Future Research

Although work sampling data were collected during phase 2 of the study, phase 1 was reliant on self-report data from nurses and their patients. The decision to keep phases 1 and 2 distinct was influenced by a desire to simplify study procedures for participants. Future research could combine phases 1 and 2 so patient outcomes could be correlated with the nurses' work sampling data. Future research could involve reprogrammed PDAs to measure the frequency of bed-to-bathroom transfer assists performed by RNs.

Patients who participated in phase 1 of the study were assigned to rooms based on room availability. Therefore, differences among patients were controlled by a natural instance of random assignment. However, the 7 units included in the study were from 1 hospital. Research in other hospitals using similar methods could attest to the generalizability of this study's findings.

Conclusion

This study explored relationships among several conditions of a medical-surgical inpatient unit and their impact on nursing workflow and PCC. These conditions included HIT and unit layout. Patient bed-to-bathroom transfer and nurses' documentation at the main nursing station predicted higher intensities of patients' pain. Patient bed-to-bathroom transfers predicted more near-falls. Nurses' documentation at the bedside predicted fewer near-falls. The use of computers-on-wheels in hallways pulled the nurses away from the patient rooms and exposed the nurses to distractions during essential care delivery tasks.

Documentation at the main nursing station contributed to increased walking distances for nurses and pulled the nurses from patient rooms. Medication storage near the nursing station was associated with more distractions during medication administration.

Overall, the study identified opportunities for integration among unit layout, HIT, and innovative

models of care that may influence nurses to spend more time at the patient bedside. Appropriate type and location of HIT and decentralized documentation, supply, equipment, and medication strategies would help nurses be more responsive to their patients' needs and prevent distractions during essential care delivery tasks. Toward this end, the nurses in this study visualized ideas that integrated HIT, unit layout, nursing workflow, and PCC. These ideas were informed by the research findings. Specifically, the nurses visualized a dedicated offstage area or porch in the vicinity of the patient room for HIT solutions, equipment, supplies, and medication. To ease patients' pain intensity from bed-to-bathroom transfers and prevent near-falls, a touch-sensitive lighted handrail was recommended.

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