A Workflow Assessment for a Pediatric Intensive Care Unit: A Mixed-Methods Approach

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Abstract

Pediatric Intensive Care Units (PICUs) support the medical needs of children at risk of imminent death resulting from acute illness or injury. Various organizational factors such as staffing, teamwork, patient volume, pressure of work, information technology, and the structure of the PICU may influence patient outcomes and clinician satisfaction. In this paper, we provide a useful framework to assess workflow at a PICU to identify what factors could potentially have a negative impact in the provision of care and investigate best practices. We utilize a mixed-methods research design to evaluate both qualitative and quantitative factors. We conducted a stakeholder analysis and time-motion study to assess workflow issues that impact physician and nurse efficiency and satisfaction in the provision of patient care. In addition, we categorized different tasks into value added and non-value added in order to identify key areas for improvement. Preliminary results indicate that Information Technology (IT) and Electronic Health Record (EHR) systems play an important role in almost every task performed by either nurses or physicians. However, neither IT nor EHR are effectively supporting clinician staff as required. Because of this, the majority of the physicians and nurses agree that information flows need improvement.

Keywords
Healthcare systems, operational efficiency, workflow assessment, mixed-methods, systems engineering

1. Introduction

Pediatric Intensive Care Units (PICUs) support the medical needs of children at risk of imminent death resulting from acute illness or injury. Organizational factors such as staffing, teamwork, patient volume, pressure of work, information technology, and the structure of the PICU may influence patient outcomes and clinician satisfaction [1]. Recently, changes in the provision of care to the critically ill have been implemented including limitations in physician-in-training work hours and the advent of the electronic medical record (EMR) and computerized physician order entry (CPOE), also referred as computerized provider order entry. Despite these significant changes in the provision of care, little exists in the current literature regarding adaptations in the traditional workflow model to account for these changes. With a focus on the physical structure, staffing, daily clinical work and administrative responsibilities, and the impact of EMR documentation and order entry, the purpose of this case study was to assess the current state of workflow in the PICU at Penn State Hershey Children’s Hospital (PSHCH) and to provide recommendations to improve workflow efficiency.

1.1 PICU Structure and Design

Prior to 2013, the PICU at PSHCH was a tertiary care facility with a bed capacity of twelve. Only two of the beds were private rooms while the remaining 10 beds were shared in a common open area. Common open areas are usually characterized by high-visibility whereby the staff caring for the patient has a direct line of sight. In mid-February 2013, the PICU moved to a new family-oriented, state-of-the-art Children’s Hospital that is expanded to 18 beds. However, all beds are located in private rooms, rather than in a common open area. Private rooms are desirable to lower infection rates [2], avoid the spread of contagious diseases, provide more privacy for parents, and additionally, the presence of the family could positively impact children health outcomes [3]. On the other hand, private rooms are usually characterized by low-visibility whereby a direct line of sight among health care providers and the patient cannot be established outside of the patient’s room. Moreover, private rooms may also compromise communication among the health care providers resulting in compromised patient care. Leaf et al. [4] found that critically-ill adults tend to experience higher mortality rates when assigned to intensive care rooms that are poorly
visualized by nursing staff and physicians. Therefore, considering these design factors that would potentially impact the provision of quality of care becomes essential.

1.2 Patient Care Through Rounding

The intensivist is the leader of a multidisciplinary team composed of the nursing staff as well as residents (physicians-in-training), pediatric critical care fellows (physicians who enter a training program in a specialty after completing residency) medical and nursing students, pharmacists, respiratory therapists, social workers, and other medical subspecialists. Each component of the team contributes a unique expertise directed toward the improvement of patient care outcomes, improving efficiency and effectiveness of care, and controlling costs.

In many PICUs including the PICU at PSHCH, a pediatric intensivist is present 24 hours a day. A typical day at the PICU begins with a physician handover (communication regarding patients’ data and progress between healthcare providers), followed by multidisciplinary rounds. Every patient admitted to the PICU is examined by an intensivist. During rounds, each patient’s history, exam, laboratory values, medications, therapies, and responses to interventions or therapies are discussed among the physicians and the bedside nurse. A discussion between other health care providers such as the consultant and the primary surgical team also occurs. This data is synthesized to formulate a unique and timely care plan for each patient. Concurrently, residents, fellows, and students receive education by the intensivist and other faculty subspeciality health care providers. Following rounds, the intensivist is expected to communicate the patient’s progress and plan to his or her family, answer the family’s questions and to assure that the daily plan is implemented.

Throughout the day, the intensivist reassesses each patient’s progress and response to various interventions or therapies. He or she arranges inter-hospital and intra-hospital transfers to and from the PICU. The intensivist is responsible for assessing all admissions. Admissions are often unscheduled and can be admitted at any time throughout the day or night. New admissions are assessed via a history, physical exam, laboratory values, and response to previous medications, interventions, or therapies. The intensivist also leads family meetings and end-of-life discussions including withdraw of life-sustaining therapies, brain death, advanced planning, and organ donation. Finally, the intensivist is responsible for documenting all these efforts in a comprehensive daily note for each patient, a separate note delineating any special activities such as family conferences or procedures, and an admission note on all new patients.

Similarly, the routine daily workflow of the bedside nurse varies to some degree by shift and clinical assignment. In brief, the bedside nurse is responsible for providing all care, verifying and administering all medications and blood products, assuring appropriate functioning of all monitoring equipment, assisting in all procedures, providing emotional support to patients and their families, transporting patients off the unit, and to be available to assist colleagues in times of need. The bedside nurse is also responsible for, at a minimum, an hourly assessment of all organ system functions. In addition, the nurse is responsible for the timely and accurate electronic documentation of these efforts. In the event that the nurse does not have a full assignment, she is required to admit a new patient (planned, unplanned or emergent) and/or to assist with elective procedures and sedations.

In addition to patient care, the intensivist is responsible for teaching concepts of critical care to residents, fellows and medical students. Restrictions in resident work hours may negatively impact residents’ perception of their educational opportunities [5, 6]. Similarly, nurses are responsible for teaching nursing students and graduate nurses. The pediatric intensivist and the critical care nurse, faced with the clinical and technical challenges described above, have found it increasingly difficult to find time to provide education to these trainees.

1.3 Physician and Nurse Staffing

Not all intensive care settings provide equivalent care. Benchmarking with other PICUs across the country, the PICU at PSHCH has one of the highest levels of patient severity of illness based on PRISM3 and PIM2 scores [7]. Both PRISM3 and PIM2 are severity of illness scoring systems developed to predict the intensive care outcomes or mortality of children. Patients with higher PRISM3 or PIM 2 scores are sicker, have a higher predicated risk of death, and are likely to require more care.

The stressful work environment of intensive care can lead to burnout. Burnout can impact the welfare and performance of caregivers, and may lead to a shortage of ICU caregivers in the future. A significant number of ICU physicians and nurses report burnout [8]. Factors which may be associated with increased risk of high stress are
university ICUs, PICUs, the number of beds per unit, and female gender. Risk factors associated with burnout include mortality rate, male gender, and age less than 40 years. The health effects of shift work and extended hours of work include a reduction in quality and quantity of sleep, widespread complaints of fatigue, anxiety, depression, and increased neuroticism, increased evidence of adverse cardiovascular effects (high blood pressure and stroke), possible increased incidence in gastrointestinal disorders, and an increased risk of spontaneous abortion, low birth weight, and prematurity [9].

Specially trained physicians, nurses, respiratory therapists, pharmacists, and social workers staff the PICU. A variety of administrative models have been implemented in various ICUs. Most PICUs operate using an organizational structure in which an intensivist directs a multi-professional team model of care. The PICU at PSHCH utilizes such a model whereby all patients admitted to the PICU receive direct care by a pediatric intensivist. A pediatric intensivist is a physician who trains for six additional years following graduation from medical school; three years in the care of all children and three years focused exclusively on critically ill children. The pediatric intensivist rounds on these patients at a minimum twice daily and provides continuous PICU coverage on a full time basis. In both adults and children, around-the-clock ICU physician staffing is associated with reduced hospital and ICU mortality as well as hospital and ICU lengths of stay (LOS) [10].

Although such specialized and around-the-clock care appears to improve outcomes, it comes at a potential cost to the physician. Moreover, this cost has been compounded over the past ten years by a series of changes invoked by the Accreditation Council for Graduate Medical Education. This council has reduced the number of hours doctors-in-training can work placing more of the non-direct patient care ICU workload (e.g. order entry, documentation, review of normal laboratory results) onto the intensivist. The reduced doctors-in-training work hours has resulted in a perception among both neonatal and pediatric intensivists that their own work hours of providing direct patient care has increased along with increased feelings of fatigue [11]. Additionally, a significant proportion of these physicians believe that their own error rates are likely to increase. Many of the strategies to meet the needs of the ICU workforce including the recruitment of additional intensivists, the recruitment of other advanced care practitioners, the expanding the role of the hospitalist, the enhancement of nursing autonomy, and the enhancement of support with technology have been implemented in the PSHCH PICU.

The ideal model of physician staffing 24/7 has not been clearly defined. Some programs use a traditional model whereby one intensivist staffs the ICU for one week. He or she would be present during the daytime and would take calls from home at night, returning to the ICU as necessary. With shift work staffing, there is 24/7 staffing shared by a pool of intensivists. In such a model, a single intensivist is responsible for all seven day shifts whereas other intensivists cover the night shifts. The PICU at PSHCH uses a hybrid between the traditional and shift work staffing model whereby a single attending covers the unit during the daytime and 4 night shifts while other intensivists cover the PICU the remaining 3 night shifts. This model results in the daytime intensivist working 32 to 36 hour shifts whereas other intensivists cover the night shifts. This model results in the daytime intensivist working 32 to 36 hour shifts every other day. Little is known about how intensivists’ work schedules impact continuity of care, information communicated from physician to physician in the ICU, patient outcomes, or intensivists’ health. In one publication, intensivists doing shift work reported significantly less burnout, better work home balance and less job overload. However, night shift intensivists reported more ambiguity in their work role [12]. In that publication, there was no difference in length of stay, mortality, or patient satisfaction noted when compared to a traditional model of staffing.

For nurses to be eligible to work in the PSHCH PICU they must not only maintain a state nursing license, but they must undergo a period of nursing internship, and maintain pediatric advance life support certification and various competencies. As described above, the PICU at PSHCH utilizes a mode in which all patients admitted to the PICU receive direct care by a pediatric intensivist. Such a model is important to the nursing work flow as the bedside nurse should always have ready access to an easily identifiable physician caring for his/her patient. Nursing care is provided in a similar manner with a charge nurse assigned to oversee the overall running of the unit each shift. Individual patient care is provided by a bedside nurse who is assigned to one or two patients each shift.

The optimal ratio of health care providers to safely and efficiently staff a PICU is largely unknown. According to Pollack et al. [13], the care of more severely ill and injured children in a tertiary care medical center PICU (such as that of the PSHCH PICU) is associated with lower odds of death when compared with care in a non-tertiary care pediatric critical care setting. This contrast raises questions about the staffing and technologic capacities of pediatric critical care resources and how they are distributed across the United States. Not surprisingly, the supply of pediatric intensivists and nurses has been shown to increase with growing numbers of PICU beds. However, when these
results are adjusted for the number of PICU beds, a decrease in pediatric intensivist to bed ratios and nurse to bed ratios has been noted. In one report, the physician to bed ratio was 0.29 and the nurse to patient ratio 2:1 for 13 - 18 bed PICUs [14]. This study was purely descriptive and did not adjust for patient severity of illness, the academic status of the hospital (academic versus community hospital), the sophistication of technologies offered, or the presence of alternative health care providers such as pediatric critical care fellows, advanced care practitioners, hospitalists, or nurse assistants. It is important to note that the staffing ratio of patient to nurse is associated with patient outcomes; the likelihood of adverse events such as unplanned extubations and in-unit mortality has been found to increase with higher patient to nurse and patient acuity to nurse ratios [15, 16].

1.4 Electronic Order Entry and Documentation

Over the past several years, significant changes have occurred in the provision of in-hospital medical care. Perhaps most notable of these changes is the introduction of CPOE and EMR. Despite these significant changes in the provision of care, there is little published regarding adaptations of the traditional workflow model to account for these differences in the delivery of care. These technologies were implemented in a number of ICUs to improve patient safety including the PICU at PSHCH. CPOE is a process of electronic entry of medical practitioner instructions for the treatment of patients. Orders are communicated over a computer network to the medical staff or to the departments (pharmacy, laboratory, or radiology) responsible for fulfilling the order. Theoretically, EMR and CPOE have the potential for improving quality of care while reducing costs [17]. Additionally, CPOE decreases delay in order completion, reduces errors related to illegible handwriting or transcription, allows order entry at point-of-care or off-site, provides error-checking for duplicate or incorrect doses or tests, and simplifies inventory and posting of charges. However, the implementation of CPOE in the PICU has resulted in variable results with respect to patient outcomes including mortality [18, 19]. It clearly has the potential for error, delay, and disruption in nurse to physician communication.

An EMR is a systematic collection of electronic health information about individual patients or populations. It is a record stored in digital format that is theoretically capable of being shared across different health care settings. EMRs may include a range of data such as demographics, medical history, medications, allergies, immunization status, laboratory test results, radiology images, vital signs, nursing assessments, patient notes, procedure notes, and billing information. According to Jacobs [20], the implementation of an EMR with CPOE can have an important effect on medical error detection and reduction in PICUs. However, like any intervention, the use of an EMR may result in unintended consequences. One of the biggest concerns regarding the implementation of CPOE and EMR in the PICU is the speed at which it can be performed. In a PICU that is already facing time restraints related to decreased doctor-in-training staffing and increased demands for documentation, the CPOE and EMR needs to be efficient and user friendly. Currently, there is a paucity of literature delineating the impact of CPOE or EMR on work organization, flow and quality of working life in the care of critically ill patients. The EMR is perceived by physicians as interfering with educational and personal time. Both nurses and physicians perceive the EMR as having a negative effect on patient care [21].

2. Methods

We conducted our case study in the PICU at the PSHCH, which is a tertiary care facility that, at the time of this study, moved to a new facility with a different infrastructure layout and construction. The new facility has a bed capacity of 18 with private room design. In this study, we focus on PICU staff workers that are directly involved with patient care and bedside activities. As discussed below, our mixed-method study design consisted of a stakeholder analysis and two forms of data collection. We collected data using an online survey and time-motion study, where we identified, recorded, and analyzed workflow in the provision of care, focusing on activities conducted by physicians and nurses.

For our qualitative data collection platform, we developed a questionnaire of 10 questions, in which physicians and nurses were asked to provide responses about different dimensions of organizational performance. The survey questions were carefully designed based on typical workflow issues found in the literature, direct observations of the workflow at the PICU, and the stakeholder analysis. The questionnaire was a combination multiple option, Likert’s scale, and open-ended questions. We used an online survey tool (SurveyMonkey) to administer the questionnaire, which was reviewed and validated by the head physicians of the PICU. After the review and modifications, the head of PICU disseminated the online web-link to the questionnaire to all physicians and nurses of the PICU. Responses were recorded on and extracted from the SurveyMonkey website for analysis. At the end of the study, we obtained 20 responses in total, including four from physicians and 16 from nurses, which was a 50% response rate.
For our quantitative data collection tool, we developed and employed a time-motion study for nurse care and multidisciplinary rounding. We first specified the type of tasks that nurses and the rounds could perform during their typical day, which consisted of patient monitoring, collaboration, medication, documentation, transit, supervision, and miscellaneous activities. We assigned these tasks with identification codes from 1 to 7, respectively. In our algorithm, the time and duration were calculated whenever a new task code was entered into the template. We used this time-motion study tool to collect data from one nurse and one physician over an 8-hour shift. The main aim of conducting this sample study was to illustrate the usability of the proposed tool as well as promote its flexibility.

We use descriptive statistics to report results from both the online survey and time-motion study. For the survey, we compare responses of nurses and physicians of their assessments of PICU organizational performance and the satisfaction toward the operations of the current system. We use the time-motion study data to estimate the amount and percentage of time nurses and physicians spent on different activities. A summary of the proposed mixed-methods design is presented in Figure 1.

3. Results and Discussion
In the following section, we provide a summary of the main results obtained from the stakeholder analysis site visits, online survey, and the time-motion sample study.

3.1 Stakeholder Analysis – Initial Site Visit (Old Facility)
During the initial visit to the old PICU facility, we identified some areas of improvement in three main categories: daily operation, layout, and IT system interaction. The site visit served as the starting point to identify those issues that could disappear with the new facility and those that could remain unchanged, such as those related to communication and EHR interaction. We identified potential non-value added tasks through field observation as well as from comments and informal survey from the PICU staff including physicians, residents and nurses.

3.1.1 Daily Operations
During the stakeholder analysis site visit, we identified the main elements (tasks, activities, and barriers) of the workflow for both nurses and physicians. Documentation management, shift changes and information flow, medication management and staffing performance were the main sub-areas analyzed. From the observations made, we found that the IT system was present in all the sub-areas identified. Therefore, the PICU must carefully consider its IT issues since its high implications on clinician’s workflow, efficiency and satisfaction.

3.1.2 Information Technology and Electronic Health Record System
As stated previously, IT and EHR systems play an important role in almost every task performed by both nurses and physicians. According to the field observations made and clinician’s comments, the IT system was not user-friendly, causing dissatisfaction especially when documenting patient’s health. One of the main factors causing non-value added tasks was the lack of flexibility and capabilities to customize interface and output reports. It caused delays in nurses and physician’s daily activities. Nurses have to enter patient’s data in a non-customizable interface system and a huge amount of non-relevant information must be skipped. This issue can potentially cause the nurses to make mistakes when entering the data. On the other hand, physicians and residents are dissatisfied with the non-flexible output reports since they contain many non-useful data and the layout of the reports did not facilitate an easy navigation through it, thus physicians have to spend time erasing irrelevant information and highlighting the important one. In addition, the login system and the lack of integration of it caused non-value added tasks.

3.1.3 PICU Layout and its Impact on Workflow
As in any other industry, the layout design plays an important role in workflow. For this case study, it was very important to understand what would be the impact of the new facility in the daily workflow. The new family-centered PICU facility will have a positive impact in many areas, however travel distances and, therefore, travel time will increase for most of the activities conducted during the day. In the old PICU facility, most of the patients were monitored in a highly visible area, which were connected to open resting and lounge areas. This will no longer be the case for the new PICU facility.

3.2 Online Survey
As previously mentioned, we developed the online survey based on the observations made during the initial site visit and related literature. We distributed the survey among physicians and nurses. It included six main dimensions to further explore the potential areas of workflow improvement. The dimensions covered task identification, satisfaction, IT and EHR perception, non-value added tasks, potential improvements and performance definitions. We received 20 survey responses, which represented more than 50% of the clinician staff of the PICU at the PSHCH.

3.2.1 Information Flow Perception
From the survey results, we discovered that both physicians and nurses believed that the information flow needed improvement. From Figure 2, we observe that 75% of physicians believe that the information flow needs improvement. On the other hand, half of the nurses think that the flow of information needs improvement. We found three recurrent issues to be the main causes of dissatisfaction in information flow: IT system, communication, and coordination. According to the responses provided, the IT system was also having a negative impact on communication and coordination. Some other issues arose directly from the mechanisms to inform and communicate between physicians and nurses. Some believed that although exchange of information can be made directly through the IT system, verbal communication could not be replaced. It was also mentioned in the survey that in the new facility, more clear procedures about who is responsible for each aspect of patient care must be explained. Elimination of redundancy, especially due to IT system interface is another factor that is affecting clinician satisfaction in the flow of information.

3.2.2 Information Technology Satisfaction
As expected from the initial site visit to the old facility, clinician staff was not satisfied with the system interface or with its functionality. Figure 3 shows the responses of physicians and nurses in three main IT categories (System Design, Entering Data, Viewing Data) using a 1–5 Likert scale (1. Very dissatisfied, 2. Dissatisfied, 3. Neutral, 4. Satisfied, 5. Very Satisfied). From the System Design category, we see that doctors are very dissatisfied with each
one of the factors included. The three factors included login issues, password issues and integration issues, which received an average value of 1.25 in a 1-5 Likert scale. On the other hand, nurses appear to be neutral when asked about System Design. The average for login issues was 3.44, 3.06 for password issues, and 2.81 for integration issues. Although nurses have a better opinion of the system design, their average satisfaction is still considered low.

For the second category, Entering Data, physicians were again more dissatisfied than nurses in the three factors: electronic patient notes, entering orders, and entering patient data. Averages for this category are slightly better; however, the averages for those factors are still below 4, which is considered the threshold for satisfactory. The last IT category, Viewing Data, was composed by three factors: viewing patient data, viewing lab values and viewing radiographic studies. In general, no significant difference was found from physician and nurses’ level of satisfaction in this category. On average, Viewing Data had a better perception according to clinicians' view if compared with the other two categories. Nevertheless, the satisfaction values fluctuated from 2.5 and 3.5, which are still below the threshold for satisfaction purposes.

From an open-ended question related to the IT system, we received valuable comments and recommendations to improve the design. The elimination of multiple-clicks appears to be a main concern for clinician staff; this non-value added task could be reduced or eliminated with a friendlier interface design that decreases mental burden. Elimination of the automatic closing out of PowerChart (a multi-entity EMR) was also suggested. Thus, a balance between the benefit of assuring patient confidentiality and clinician efficiency must be considered. Non-value added activities such as having to login multiple times during the day and having to remember multiple passwords were also important causes of dissatisfaction with the IT system. Another common cause mentioned frequently by clinicians was that the system froze too often; thus, valuable time is lost every day causing not only clinician dissatisfaction but also reducing clinician performance.

![Figure 3. IT Satisfaction for Physicians and Nurses](image)

### 3.2.3 Measuring Work Performance

One of the interesting questions included in the survey was: How do you measure work performance? What metrics could be applied to show that you are doing a good job? Usually work performance can be measured in many different fields, which are sometimes conflicting. According to the responses received, most of the work performance should be measured in terms of clinical/patient outcomes. They use National markers to measure work performance, such as Virtual PICU (standardized mortality ratios, length of stay, severity of illness, readmission rates), hospital acquired infections, unplanned extubations, and job satisfaction/turnover. Additionally, efficiency and good use of time was also mentioned as key metrics to evaluate work performance. Some other interesting answers, such as patient’s family satisfaction, patient safety and job satisfaction, must also be considered. According to some clinicians, the best way to know if they are doing a good job is by receiving co-worker recognition and family-recognition. As a consequence, not only measurable metrics must be considered when assessing work performance.

### 3.3 Time-Motion Study Template and Sample Study

In parallel with the collection of the surveys, we conducted a second site visit to the new PICU facility. The main objective of the visit was to test the time-motion study template that we developed to identify where the nurses and physicians spend their time. For statistical validity, a larger sample size is required. We recommend using a stratified random sampling method to obtain 10 block samples and estimate the sample size needed to statistically validate the results. Figure 4 shows the actual template generated in Microsoft Excel. We created an initial list of
Munoz, Bastian & Ventura (2014) activities and sub-activities based on the literature review and the physicians’ feedback. Our time-motion study template is extremely user-friendly. Physicians or nurses can add or remove activities from the initial list without affecting the fully functionality of the template. Calculations are made automatically; the analyst using the template is only required to enter activity ID in the correspondent cell, but all other associated cells are updated automatically (time stamp, duration, id name). Another important feature of the template is that reports are also automated. A pie chart and bar chart is delivered to identify the percentage and time spent on each activity.

![Figure 4. Time-Motion Study Template](image)

Figures 5 and 6 provide an example of what the report looks like. We cannot make general conclusions from these graphs since they are based on only one sample – one-day visit. Therefore, they are used to illustrate the delivered output. It is highly recommended to collect more data in order to obtain a clearer understanding of the workflow for physicians and nurses in terms of time spent on daily activities. As a consequence, critical activities and non-value added tasks can be identified, and therefore, managerial action plans can be generated to remove or decrease the non-value added as well as generate procedures to properly conduct critical activities. Finally, we can obtain and process invaluable information to have an impact not only in clinician efficiency but also in clinician satisfaction.

![Figure 5. Activity Report – One nurse one day sample](image)

OBS: An emergency occurred during the afternoon.

![Figure 6. Activity Report – One physician one day sample](image)
5. Conclusions and Recommendations

The IT and EHR systems at the PICU both play an important role in nearly every task performed by either nurses or physicians, so there are various areas for improvement. The IT system is not very user-friendly, which has caused dissatisfaction to nurses and physicians with respect to documenting the patient’s health. Some recommendations to improve the IT system of the PICU are the following:

- Develop a more user-friendly interface design that is easier to navigate.
- Minimize the number of “clicks” needed to go through multiple patient assessments.
- Create an integrated IT system where all data entry systems is located within the same program.
- Develop customizable, standard patient reports where only relevant information is documented.
- Utilize one login/password, such as a biometric fingerprint or smart card, to streamline the login process.
- Eliminate the automatic closing out of PowerChart, which occurs frequently in the PICU.
- Streamline the process to graph or view data and find lab results/cultures.

As indicated earlier, survey results show how 75% of physicians and 50% of nurses believe that the information flow needs to be improved. The dissatisfaction in information flow is found within the IT system, communication, and coordination. Thus, recommendations to improve the information flow of the PICU include the following:

- Establish clearer procedures about who is responsible for each aspect of patient care.
- Develop a mechanism for tracking patient arrivals and departures to ensure patients are adequately evaluated.
- Utilize phones and/or group text messaging to eliminate people walking around to find people.
- Build a computer-generated situational awareness tool for improved nurse/physician resource utilization.
- Augment central supply areas with more staff to expedite medical equipment delivery upon ordering.
- Ensure nurse participation on rounds and improve internal communication among clinical staff.

Based on some of the open-ended survey responses, some suggestions to remove unnecessary process tasks include:

- In order for nurses to have more patient care time, hire ancillary staff to perform tasks such as, stocking carts, emptying the linens and trash, preparing rooms for admissions, tracking supplies, and cleaning equipment.
- As patient charting can be very redundant and reduces patient care time from the clinical staff, develop and deploy a standardized report that eliminates double charting and enables more patient care time.

5.1 Implications for Healthcare Management Engineers

The majority of the workflow issues and barriers identified in this case study are also present in most of the PICUs across the United States. Although the PSHCH has been ranked as one of the nation’s best children’s hospitals in five specialties (cancer, urology, orthopedics, neurology, and neurosurgery), there are still various areas of improvement. Undoubtedly, the new state-of-the-art facility will facilitate the provision of care in various aspects. However, special emphasis should be put on identifying the factors that could affect communication and coordination, especially those related to the use of EMR and CPOE.

From the proposed methodology, we obtained valuable insights by using a mixed-methods approach, which incorporated both qualitative and quantitative analyses to provide a better, broader, and systematic assessment of the workflow. This is the major take-away for practicing healthcare management engineers who are continually exposed to issues concerning operations management in healthcare facilities, such as the PICU. From this case study, we provide healthcare management engineers with a useful framework consisting of a stakeholder analysis, online questionnaire, and time-motion study tool to assess workflow issues that impacted physician and nurse efficiency and satisfaction at a PICU. Further, we demonstrated a practical method for identifying organizational factors negatively affecting the provision of care, patient outcomes, and clinician satisfaction. Finally, healthcare management engineers can employ this mixed-methods approach as a means of process improvement by assessing and categorizing different tasks into both value added and non-value added.

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