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NEONATAL ICU OPERATIONAL ANALYSIS VIA SIMULATION

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1 BACKGROUND AND ANALYSIS

Newark Beth Israel Medical Center is the largest hospital serving the communities of Newark (NJ). It is also home to Children's Hospital of New Jersey (CHoNJ), the state's premier children's health facility. Among the comprehensive pediatric services that it offers, the Neonatal Intensive Care Unit (CHoNJ-NICU) provides specialized care for new born babies with serious health problems.

The patient care processes at NICUs are more challenging and complex than many other healthcare processes because: 1) many patients are premature babies who are usually born before the 37th week, and 2) customers are babies and their anxious parents. CHoNJ-NICU treats the sickest babies in the state. These fragile infants can be premature newborns, or babies with cardiac problems, or other serious or complicated diagnoses. The services required to treat and care for these babies are intensive, and most of the time multi-specialty. A NICU typically involves neonatologists, nurses, physician assistants, resident physicians, therapists, etc. The variety of care providers involved and the complexity of diagnoses and procedures creates difficulties to optimize the efficiency of the workflow. Despite these facts, as well as the typically heavy workload and the limited funds available, CHoNJ-NICU management strives to provide and maintain high quality services. In a mission to further reduce inefficiencies in the system, they partnered with a group of faculty members and Ph.D. students through the Center for Supply Chain Management at Rutgers Business School. The overarching aim of the team is to provide managerial recommendations for NICU operations via data analysis and workflow simulation.

An employee survey was developed and administered by CHoNJ-NICU. The purpose of the survey was to assess employee perceptions of operations, information flows, and performance outcomes in the NICU. Following analysis of the survey data, improvement opportunities were identified. Examples include an opportunity for improving the organization of medical supplies, increasing the number of housekeeping staff for all three shifts, and so forth. Subsequent managerial recommendations were also provided by the team to the CHoNJ-NICU management. For example, implementing a Kanban system could improve the efficiency of the logistical chain of medical supplies. Also, hiring more housekeepers could be a low-cost, high-impact way to improve performance. Because of the importance of maintaining normal operations of the already-busy patient care unit, simulation is an effective tool to validate such findings before implementing these policy changes. We demonstrate the use of simulation in this project by introducing the bottleneck detection and policy change recommendation in CHoNJ-NICU workflow. Due to confidentiality considerations, the numerical results presented in this following context are not real values from CHoNJ-NICU, but the performance improvements shown by simulation are in the same magnitude.

2 WORKFLOW SIMULATION AND CONCLUSIONS

The survey data reflect an openness to change; specifically there is a desire to improve process flows and eliminate waste. Practically speaking, the operations of NICU are very complicated, and thus the team decided to focus on an important but very time-consuming process, which is the rounding process. The purpose of the rounding process is to examine and monitor the patient's status and provide therapy and medication instructions. After multiple site visits and data analysis, the team summarized the rounding process as consisting of three overarching phases: pre-rounding, rounding, and post-rounding. From the perspective of the attending physician (i.e., neonatologists), the pre-rounding phase may consist of reviewing and printing the electronic medical record (EMR) summary, examining the baby, consulting with nurses, and entering orders in the computerized physician order entry system (CPOE). The rounding phase involves exchanging information with physician assistants or residents and maybe nurses in the presence of the baby. The post-rounding phase involves updating the EMR. The greatest challenge and inefficiencies of the rounding process comes from the variation that exists in the sequence and execution of these activities. In other words, each team has their own way of rounding, which can be error-prone and confusing to different participants, especially the residents. Another challenge is the diversity of the team composition. A rounding team may consist of neonatologist alone, neonatologist with one physician assistant (or resident), or neonatologist with two or more physician assistants (or residents).

Based on the observation, data analysis and expert opinions, the team produced a current workflow of the rounding process, and validated their understanding based on 13-days of data recorded by CHoNJ-NICU. The team then recommended a standardized workflow in order to mitigate the risks caused by the diversity of rounding procedures adopted by different teams, and to create a standard operational procedure that NICU care providers can follow. The current and proposed workflows are compared using discrete-event simulation built by the team. Each configuration is simulated for 1000 times.

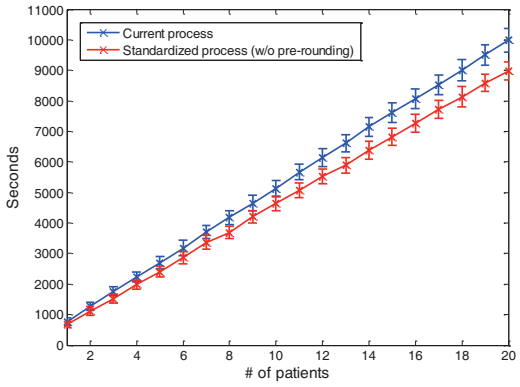

Figure 1: Current vs. standardized processes.

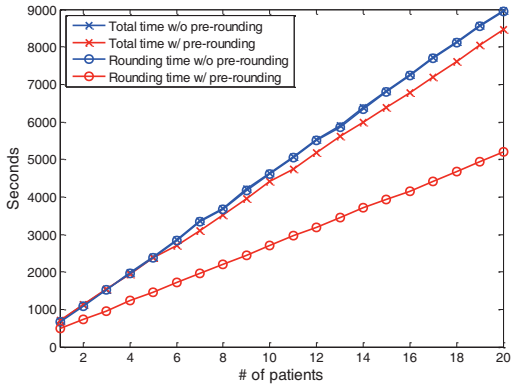

Figure 2: Impacts of pre-rounding.

From Figure 1, it is shown that standardized process (without pre-rounding) saves on average 10.53% of total time spent on rounding process compared with the current process. Meanwhile, the standard deviation of the same measure is reduced by 8.85%. It is also found that with pre-rounding being enforced as a standard procedure, the time savings will be more significant (14.54% on average). The benefits of standardized pre-rounding are further demonstrated in Figure 2. It is shown that when the number of patients are small (e.g., <6), pre-rounding does not have an observable impact on the total rounding time, but as more patients present, the total time decreases. The most significant saving of pre-rounding is that as the neonatologist spends more time collecting information during pre-rounding, the time spent on rounding phase is substantially reduced (by 39.58%). This means that the team, physician assistants or residents participating in the rounding phase, will spend substantially less time. This ought to assist the team in better managing the heavy workload and may positively impact staffing at CHoNJ-NICU.