Improvement from Front Office to Front Line

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Designing a Patient Surveillance Monitoring System for General Care Units

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“Although designed specifically for introduction of a new monitoring system in the general care setting where none previously existed, the described methods are largely generalizable to a wide variety of systems where patient monitoring is in place to prevent harm.”

—Surveillance Monitoring Management for General Care Units: Strategy, Design, and Implementation (p. 300)
Managing service disruptions is a challenge in every health care environment. When disruptions—planned or unplanned—arise in the normal routine of a clinical system, personnel must adapt their practice to the new environment while striving to provide optimal care under the new circumstances. The management of sudden, significant, and unplanned disruptions generally falls under the umbrella of emergency preparedness and disaster medicine. However, planned changes can be as challenging to address, particularly when they are introduced on a short time horizon. Such changes to capacity, staffing, or process must be managed by those persons remaining within the system.

Change management in health care systems is a complex task with broad literature. Traditional approaches include project management, fishbone diagrams, process maps, and Lean and Six Sigma methods. More recently, and of particular relevance to this case, discrete event simulation (DES)—a computer modeling tool used to build in silico (that is, in a digital computer) testbeds for potential changes in complex systems—has been deployed in health care for research and quality improvement (QI), specifically in surgical suite management. As noted earlier, much of the literature on managing service disruptions, which goes back for decades, focuses on unplanned disasters. We found no examples from the literature of deployment of QI techniques to manage imminent, planned, temporary service disruptions, and we know of no systematic approaches specifically geared toward this type of event. Before this investigation, in our setting, and we presume most others, these circumstances were each managed idiosyncratically, ad hoc, with varying result, either by the affected personnel or hospital administration.

In this article, we describe the use of QI methods to minimize the impact of such necessary, planned disruptions to clinical operations. We present a case study to demonstrate our method for dealing with a temporary, planned service disruption in The Children’s Hospital of Philadelphia’s Cardiac Center’s Cardiac Operative and Imaging Complex (COIC). The service disruption was a planned renovation and upgrade of a multipurpose Case Study in Brief

Managing Disruptions to Patient Flow Capacity: Rapid-Cycle Improvement in a Pediatric Cardiac Procedure Complex

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Managing service disruptions is a challenge in every health care environment. Discrete event simulation (DES)—a computer modeling tool used to build in silico (that is, in a digital computer) testbeds for potential changes in complex systems—has been deployed in health care for research and quality improvement (QI), specifically in surgical suite management. A strategy for managing a 6-week planned service disruption needed to be enacted 12 weeks after the announcement, in late October 2014, of the closure of the Hybrid Suite (operating room/catheterization laboratory) for renovation, at The Children’s Hospital of Philadelphia’s Cardiac Center’s Cardiac Operative and Imaging Complex (COIC).

Methods: A previously developed DES was queried to determine theoretical system throughput capacity during the temporary disruption. On the basis of this analysis, a rapid improvement event (RIE) was enacted to address systemic challenges to meeting demand with diminished capacity. During the RIE, system stakeholders (physicians, nurses, and technicians) engaged with performance improvement personnel to identify potential improvements, test those changes in rapid succession, and then implement successful candidates for the disruption.

Results: First-case start time was 43 minutes earlier during the period of diminished capacity. Turnaround time between cases was reduced by 23 minutes. Length of day increased by 1 hour, in accordance with simulated predictions. System throughput was 138 patients during the disruption, compared with 135 patients during the same period the previous year.

Conclusion: A combination of systems analysis and QI methodologies enabled the Cardiac Center to meet demand during a six-week period of diminished capacity. Planned, temporary service disruptions, which must be managed by clinical personnel, can be addressed proactively with promising results.

Article-at-a-Glance

Background: Managing service disruptions is a challenge in every health care environment. Discrete event simulation (DES)—a computer modeling tool used to build in silico (that is, in a digital computer) testbeds for potential changes in complex systems—has been deployed in health care for research and quality improvement (QI), specifically in surgical suite management. During the RIE, system stakeholders (physicians, nurses, and technicians) engaged with performance improvement personnel to identify potential improvements, test those changes in rapid succession, and then implement successful candidates for the disruption.

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procedure room (the Hybrid Suite) within the COIC. The Hybrid Suite, which can function as an operating room (OR), catheterization laboratory, or both, for a single patient encounter, was to be closed for 6 weeks (January 20, 2015–March 6, 2015). The renovation was announced in late October 2014, providing 12 weeks of lead time to enact a strategy for managing the disruption.

The objectives of the project were (1) to determine what level of throughput could be maintained during the six-week period of diminished capacity and (2) develop and refine a strategy for maximizing throughput. Given that the Hybrid Suite was used as a catheterization laboratory four days per week and an OR only once per week, our performance improvement strategy would center on managing throughput for patients requiring cardiac catheterization.

**Methods**

**SETTING**

The Cardiac Center at The Children's Hospital of Philadelphia consists of the COIC; the Cardiac Intensive Care Unit (CICU); the Cardiac Care Unit (CCU); and the Cardiac Preparatory and Recovery Unit (CPRU), which serves as a pre- and postanesthesia care unit. The COIC is a six-room procedure area consisting of a dedicated magnetic resonance imaging (MRI) machine, two ORs, two cardiac catheter laboratories (cath labs), and the Hybrid Suite. The COIC performs approximately 1,200 cardiac catheterizations, 900 cardiothoracic surgeries, and 950 MRIs annually. This project was determined by The Children's Hospital of Philadelphia Institutional Review Board not to be human subjects research, and thus not subject to its oversight.

**SIMULATION ANALYSIS (OCTOBER 2014)**

A DES (a computer modeling tool used to build in silico), testbeds for potential changes in complex systems) of the Cardiac Center was available as an analytical tool, having been developed for a previous project. The DES was developed in 2014 according to a standardized, four-step process, as described in detail in Day et al. First, the system was decomposed into its basic elements—locations (ORs, cath labs, MRI, inpatient areas), resources (for example, physicians, nurses), and entities (patients). Second, the flow through the system was modeled to identify how entities consume resources at locations, as well as how they proceed from one location to the next. Third, the results of steps 1 and 2 were coded into a commercially available DES engine (MedModel Professional, ProModel Corp, Allentown, Pennsylvania). Fourth, the model was informed with real-world data and validated against fiscal year 2013–2014 (July 2013–June 2014).

This simulation was queried with the simulated Hybrid Suite disabled, and no change in arriving patient volume from historical levels. Data were collected on COIC length of day required to serve this volume; 783 days were simulated for each condition (the Hybrid Suite open as the control, and the Hybrid Suite closed as the experiment), representing 3 years of procedural days. This sample size was chosen to have > 99% power to detect a 30-minute change in means, as well as for ease of simulation. Patient arrivals were independent and based on historical arrival data from fiscal year 2013–2014.

**PROCESS CHANGES (NOVEMBER 2014–JANUARY 2015)**

On the basis of the results of the simulation analysis, and through consultation with performance improvement support, a number of process changes in patient preparation, arrival, and staff work flow were instituted, as follows:

- After length-of-day data were procured from the simulation, a traditional QI team consisting of two physicians [including S.C.N.], a nurse practitioner, four nurses [including V.J., A.P.], a technician, and improvement support [D.M., T.E.D.], was assembled to identify strategies to maximize throughput, during collaborative meetings and brainstorming sessions. The project was organized around The Children's Hospital of Philadelphia Improvement Framework, consisting of a four-step improvement process: Define, Diagnose, Test and Implement, and Sustain, as follows:
  - Defining the problem involved engaging unit leaders to confirm the aims of the project.
  - Diagnosing, which entailed consideration of baseline system performance, identified two potential candidate processes for change—reducing turnaround time and time of first case of the day starts.
  - Serial tests of change for reducing turnaround time were implemented beginning in November 2014 and continued through until the closure of the Hybrid Suite on January 20, 2015. These tests were evaluated using Plan, Do, Study, Act (PDSA) cycles as part of a rapid improvement event (RIE). The RIE was organized and conducted by a collaborative, interdisciplinary group, including cardiac anesthesia, cath lab, CPRU, and QI personnel.
  - Finally, the Sustain phase incorporated the successful interventions identified during the previous step during the closure of the Hybrid Suite (that is, the planned service disruption).

To begin the procedural day earlier, the cath lab team instituted the following changes:

1. If the attending physician assigned to the first case was
unable to start at an earlier time, another practitioner’s patient would begin.

2. “Adult” patients (12 years of age and older) were directed to arrive in the CPRU 30 minutes earlier than preintervention.

3. For first-case starts (7:30 a.m.), the intravenous (IV) team was directed to arrive in the CPRU by 6:30 a.m., after calling ahead to confirm that the patient was available.

4. A daily team debrief was established to examine first-case start times, and, if later than 7:30 a.m, to identify interventions to prevent delays from happening on subsequent days.

To reduce turnaround time between cases, the following process changes were instituted:

1. Placement of IV in CPRU, given priority over other pre-procedure tasks.

2. One cath lab team member and one anesthesia provider transported patient from CPRU to cath lab (preintervention, two cath lab team members transported patient).

3. A daily team debrief was established to examine turnaround times, and, if prolonged, to identify interventions to prevent delays from happening on subsequent days.

**STATISTICAL ANALYSES**

Mean length-of-day and turnaround times before and after the Hybrid Suite closure were compared using Student’s t-tests, and mean daily start of procedure was reported before and after the Hybrid Suite closure.

**Results**

**Simulation**

The DES model of the COIC predicted that patient volume could be maintained during the disruption, provided that the mean length of day in the COIC was extended from 9.3 ± 2.6 hours (mean ± standard deviation) to 10.3 ± 2.6 hours (p < 0.001), and so long as start of the day was 60 minutes earlier and turnaround times were reduced from the baseline of 55 minutes to 30 minutes. This represents a 10.8% increase in mean length of day to compensate for a 28.6% decrease in available capacity. Process changes were then suggested by the stakeholders, as described in the Methods section of the article.

**Actual Performance**

The mean turnaround time in the two cath labs decreased to 32 ± 12 minutes during the Hybrid Suite closure (January 20, 2015–March 6, 2015) from 55 ± 34 minutes during the baseline period of October 1, 2014, to November 30, 2014, (p < 0.001). The mean starting time in the cath labs during the Hybrid Suite closure was 43 minutes earlier than the baseline period mean time. The mean length of day during the closure period increased, compared with the previous six weeks, by 64 minutes, in accordance with the simulated prediction.

Finally, 138 patients had a cardiac catheterization performed from January 20 through March 6, 2015, compared with 135 for the same period in the previous year, when all rooms were in operation. No overtime hours were required to fulfill demand. There were no complaints registered by patients/families, and all cath lab team members were retained.

**Discussion**

By deploying traditional QI efforts and specialized resources, we were able to maintain patient throughput and manage the length of day in our COIC without increasing staff or using increased overtime. We were able to meet all patient demand, despite reduced throughput capacity, in accordance with our simulated predictions, by beginning our first case almost 45 minutes earlier in the day, by reducing turnaround time between catheter cases by an average of 23 minutes, and by increasing the overall length of day by approximately 1 hour on average.

Comparisons between simulated and real-world interventions, such as those that our team has previously published,13,17 are often challenging because of the difficulty of precisely duplicating simulated interventions in the real world. However, in this case, straightforward comparison of length of day and turnaround times necessary to achieve the desired results were sufficient to provide insights into system capacity and provide direction for disruption management.

Disruptions such as the disruption described in the current study are regular occurrences in any complex system. Managing disruptions is generally done ad hoc and without necessarily planning for lessons learned from one such disruption to the next. However, the existence of a quality and performance improvement structure embedded within the hospital environment affords the opportunity to approach these occurrences with an existing group of methods normally associated with traditional QI, or permanent policy and practice changes. Leveraging these tools proactively, as outlined here, can be valuable in these cases. In addition, institutions that do not have dedicated QI personnel are nevertheless likely staffed with emergency preparedness departments able to address planned disruptions with similar methods. Interdisciplinary, collaborative approaches can be effective in implementing quality and safety initiatives.18

Performing procedures when they are scheduled is a safety and quality issue for patients,19 and delays in performing procedures on time has been identified as a significant driver of patient dissatisfaction.20 Although it can be organizationally
challenging to address planned disruptions proactively, particularly when they occur on a short time horizon, doing so preserves continuity of scheduling, care, staffing, and throughput. Approaches informed by systems-level analysis and rigorous tests of change can enable systems to perform maximally throughout disruptions.

**Limitations**

DES is a tool that necessarily examines a simplified system. As described in the best practices set forth by the Society for Medical Decision Making, simulation models that are insufficiently complex or unvalidated may not provide useful insights. The interventions described herein may not be directly applicable to other facilities undergoing similar planned disruptions. However, the process by which our interventions were identified and implemented should be useful in analogous situations. All simulation-driven QI must receive appropriate provider oversight, as in this case, to ensure the medical appropriateness of potential interventions.

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**References**