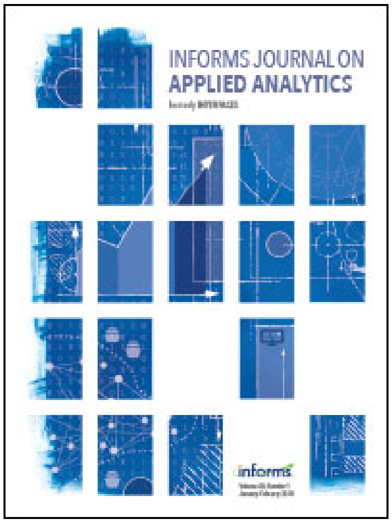

Interfaces

Publication details, including instructions for authors and subscription information:
http://pubsonline.informs.org

Practice Abstracts

Brian T. Denton,

To cite this article:
Brian T. Denton, (2009) Practice Abstracts. Interfaces 39(3):288-290. https://doi.org/10.1287/inte.1080.0426

Interfaces
Vol. 39, No. 3, May–June 2009, pp. 288–290
ISSN 0092-2102 | EISSN 1526-551X | 09 | 3903 | 0288

DOI 10.1287/inte.1080.0426

Practice Abstracts

Brian T. Denton
Edward P. Fitts Department of Industrial and Systems Engineering, North Carolina State University,
Raleigh, North Carolina 27695-7906, bdenton@ncsu.edu

The goal of "Practice Abstracts" is to present interesting, topical, and novel applications of operations research methodology to a wide range of industrial applications. "Practice Abstracts" are intended to provide *Interfaces* readers with short (2–4 page) descriptions of the most relevant aspects of operations research-based projects, in a form that is accessible to academics and practitioners in other organizations. Contributions should be sent for evaluation to the editor of "Practice Abstracts," Brian T. Denton, Edward P. Fitts Department of Industrial and Systems Engineering, 376 Daniels Hall, North Carolina State University, 111 Lampe Drive, Campus Box 7906, Raleigh, North Carolina 27695-7906, bdenton@ncsu.edu.

Key words: health care; scheduling; Pareto analysis.

Improving the Utilization of Catheterization Labs at Scottsdale Healthcare

Scottsdale Healthcare (SHC), located in Scottsdale, Arizona, is a leader in cardiovascular medicine, trauma, radiology, and neurosurgery, and has been recognized for its commitment to nursing excellence. With three hospital locations and approximately 800 beds, it provides emergency, inpatient, and outpatient surgery and diagnostic imaging. SHC had previously implemented lean principles to minimize "waste" in its cardiac catheterization labs (cath labs). However, utilization remained low, and overtime cost and patient waiting times were rising. To address these issues, cath labs teamed with the Center for Productivity, Innovation and Quality at Arizona State University. We analyzed demand patterns using data from the busiest months of the year and used simulation to model the cath labs daily operations at one of its locations. We used parametric analysis on key scheduling decision variables to identify near-optimal scheduling alternatives. We also considered the option of patient rescheduling. Our analysis demonstrated the potential for a reduction of 90 percent in overtime costs and an increase of 25 percent in average utilization. SHC implemented our recommendations and realized significant improvements in utilization, overtime, and patient delay. Furthermore, additional savings are possible when it implements similar recommendations to cath labs in other locations.

Analysis of Current Approach and Methodology for Improvements

Cath labs have high fixed costs, mainly because of facility costs and staff salaries. Scheduling for such valuable and often limited resources is a critical task that hospitals face daily. To address this, we used simulation to model the cath labs patient flow. We collected information on the facility, capacity, patient arrivals, and procedure durations through direct observation, interviews, and analysis of procedure logs. We identified three types of patients: (1) Elective—outpatients requesting a procedure approximately two weeks in advance; (2) Urgent—inpatients whose procedures must be completed within one day of the request; and (3) Emergent—Emergency Department (ED) patients who require immediate processing. Emergent patients are assigned to the next available lab and supersede the case that had been previously scheduled for that time. SHC was using block scheduling, with 120 minutes allocated to each case.

We found three problems with SHC's scheduling approach. First, utilization was low because most cases did not require 120 minutes. Second, patients were experiencing long waiting times. Third, staff often had to work overtime. These problems occurred either because emergent cases arrived randomly or procedure-related variations affected case durations. The hospital did not reschedule patients because rescheduling depends on physician availability; however, it was willing to consider this option and negotiate with the physicians. Therefore, our models included both patient rescheduling and no-rescheduling options, and we compared the outcomes.

Performance Evaluation and Parametric Analysis of Our Recommendations

The facility under study has multiple labs; we developed an initial schedule for elective and urgent cases by allocating time blocks of equal length to all cases, and allocated nonoverlapping breaks for the labs to ensure that at least one lab was operational at all times during the day. We adjusted the schedule in three ways to provide a safety cushion because of the case-duration uncertainty and the arrival of emergent cases. First, for each scheduled case, we allocated a time window that is larger than the historical average of case durations. We also added small buffers to the time allocated to each lunch break to minimize spillover of morning delays to the afternoon schedule. We selected the size of the time windows and buffers after thoroughly analyzing possible sizes. We explain this in detail below. Finally, we added a buffer at the end of the day to accommodate process overflows and decrease the possibility of overtime. We also considered the option of rescheduling inpatients to the end of the day to avoid extreme waits. A patient might be rescheduled if an emergent arrival takes up her or his scheduled block or when the patient has been waiting for "too long" (as determined by the management). To maintain service quality and patient satisfaction, we allowed only one rescheduling per patient.

To determine the performance of our approach, we conducted a discrete-event simulation-based parametric analysis. We used time-block length L, patient waiting time before rescheduling W, and lunch buffer B as quantitative factors, and the decision to reschedule patients (or not) as a qualitative factor. The duration of a time-block L is based on percentiles of the historic case duration. The percentiles we used for our analysis ranged from the 55th to the 95th. For the waiting time before rescheduling W, we considered five levels: 30, 40, 50, 60, and 70 percent of the time-block L. Finally, we set the length of the buffer B at 30 and 45 minutes. We developed 120 ($10*5*2=100$ for rescheduling; $10*2=20$ for nonrescheduling) experiments, and evaluated the results based on the total waiting time and the total cost of overtime and underutilization. We calculated overtime cost as (overtime salary $*$ total overtime) and underutilization cost as [$(1-$ utilization$)$ $*$ regular staff salary], and defined patient waiting time as $\max\{0,$ (actual start time $-$ scheduled start time)$\}$. Figure 1 shows the results.

Each point in the graph represents a combination of the three quantitative factors, i.e., L, W, and B. Time-block L ranges from 70 to 100 minutes; the buffer time B is noted in parentheses. It becomes clear that allocating more (less) time per case results in shorter (longer) patient waiting times; however, the cost of underutilization and overtime both increase (decrease). We use Pareto-optimal analysis to optimize both waiting time and cost. On the graph, the ideal solution that minimizes both objectives is the point closest to the origin. However, because we must also consider management concerns, such as target waiting times, we create an *efficiency frontier* by connecting the clusters that are closest to the axes. We omit suboptimal combinations (below the 60th and above the 90th percentiles) for simplicity. The remaining points on the efficient frontier illustrate the basic trade-off between waiting time and cost; thus, management can use this analysis to formulate an educated strategy.

Comparison with Historical Data and Impact

Based on this analysis and discussions with stakeholders, we recommended the allocation of 90 minutes per case and the use of 30-minute buffers. Using historical data for the eight busiest weeks in 2007, we evaluated the performance of our schedule. From an operational perspective, our recommendations would increase the average utilization by 26 percent and dramatically reduce the total overtime from 2,738 minutes to 297 (with rescheduling) or 201 (without rescheduling), a reduction of approximately 90 percent. The

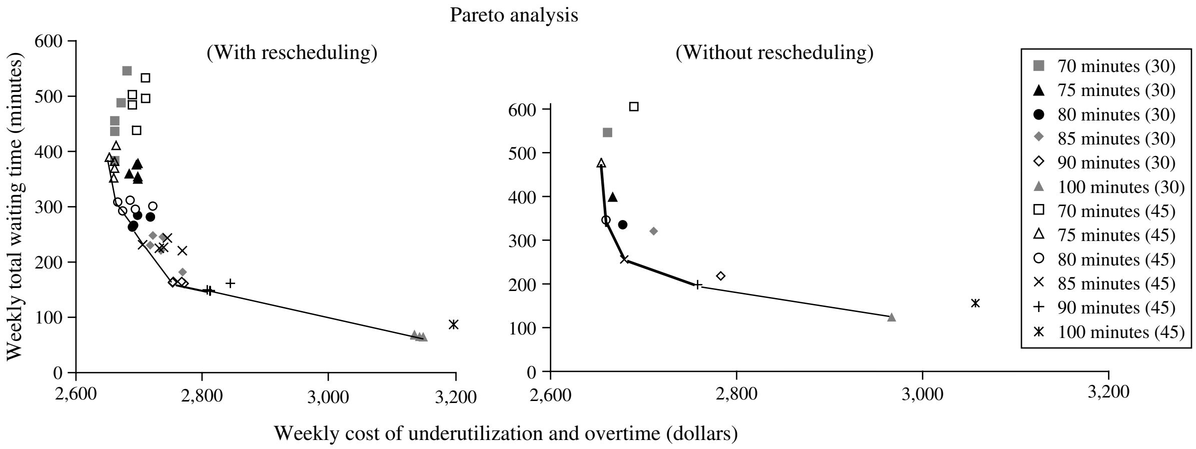

Figure 1: This graph illustrates our analysis of cost vs. waiting time, with and without rescheduling.

annual savings would be $58,263 with rescheduling and $60,036 without rescheduling. In addition, using the proposed parameters, all recorded cases could be completed in fewer days, effectively increasing the available capacity of the labs.

In January 2008, the cath labs at SHC applied our recommendations. Following the implementation, we collected data for the same eight-week period in 2008 and reevaluated the performance. When we compared these two sets of data, we noticed that the average case duration in 2008 was slightly less than in 2007 and that process variation was also less, principally because of a reduction in physician lateness. Hence, utilization improved by 21 percent and overtime decreased by approximately 71 percent. This resulted in actual savings of $5,552 over the eight-week period, and projected annual savings of $36,088. Based on the improvements that SHC realized in 2008, we extended our study to include cath labs in other facilities. Overall, the study indicates that a sensible adjustment of the time allocated to each case and the addition of small buffers to allow for uncertainty and variation can improve performance, reduce cost, and significantly decrease overtime. Furthermore, these findings can be applied to cath labs and other parts of hospital operations that also use block scheduling, allowing them to also achieve significant improvements and cost savings.

Mohan Gopalakrishnan, Srimathy Mohan,
Antonios Printezis
Supply Chain Management Department, W. P. Carey School of Business, Arizona State University, P.O. Box 37100, Phoenix, Arizona 85069 {*mohan@asu.edu, srimathy@asu.edu, printezis@asu.edu*}

Todd LaPorte
Scottsdale Healthcare, 7400 E. Osborn Road, Scottsdale, Arizona 85251, tlaporte@shc.org

Qing Li
Department of Industrial Engineering, Arizona State University, P.O. Box 875906, Tempe, Arizona 85287, qli30@asu.edu