Bi-Criteria Scheduling of an Outpatient Procedure Center

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A rising proportion of surgeries are performed on an outpatient basis. The demand for outpatient surgery typically occurs at the end of a stream of referrals which leads to considerable uncertainty in the type and number of surgeries to be scheduled on a particular day. Surgical services require coordination of many activities including surgical preparation, surgery, and patient recovery. Constructing surgery schedules that result in smooth patient flow is a complicated task due to the dependencies between these activities. The task is further complicated by the fact that the duration of each of these activities can be highly variable. Combining the high volume of activities in an outpatient surgical suite each day with uncertainty in the durations of activities presents challenging scheduling problems for outpatient clinic administrators.

Outpatient procedure clinics typically have multiple operating rooms, with a variety of supporting resources, such as nurses, nurse anesthetists, surgeons, intake rooms, recovery rooms, and various kinds of diagnostic equipment and surgical instrument kits. Surgical procedures occur in three major stages. Intake begins when the patient arrives on the day of surgery to initiate the check-in process and ends with the patient being taken to an operating room. Intra-operative care is defined as the time between when the patient reaches the OR bed and the time they are admitted to the recovery area. Recovery is the time between admission to the recovery area and the time that the patient is discharged from the recovery area. Even for very routine surgery (e.g. endoscopy) the time for intake, surgery, and recovery exhibits considerable uncertainty in duration.

There are a number of performance measures that outpatient clinic administrators may consider in relation to the efficiency of a surgical suite including: OR and recovery room utilization, surgeon and nurse idle time, patient waiting time, and late closure of the surgical suite. These measures are not independent of each other and often are in conflict with each other. For example, patient waiting time is generally negatively correlated with asset utilization...
measures. Thus, the operation of a surgical suite is a multi-criteria problem. Furthermore, high fixed costs and the above mentioned factors combine to make for a highly constrained scheduling environment.

There is an extensive literature devoted to scheduling surgical services and we only include here a partial list of papers closely related to our research. Dexter et al. [1999], Dexter and Marcon [2006], Huschka et al. [2007], and Testi et al. [2007] evaluate scheduling heuristics for multiple ORs using discrete event simulation models. Denton et al. [2006] use a discrete event simulation model for the analysis and design of an endoscopy suite to investigate different surgeon-to-OR allocation scenarios. Lowery [1992], Lowery and Davis [1999], Marcon et al. [2003], and Tyler et al. [2003] use simulation to determine the number of resources (e.g. OR’s and PACU beds) to support a given demand for surgical services. For a more extensive review of the literature on surgery planning and scheduling, the reader is referred to Magerlein and Martin [1978], Blake and Carter [1997], Gupta [2007], Gupta and Denton [2008].

In this presentation we discuss a number of heuristics, including a bi-criteria genetic algorithm, for scheduling a newly designed surgical suite at a major medical facility and evaluate the performance (patient waiting time and staff overtime) of the heuristics through the use of a discrete event simulation model. We discuss the unique design aspects of the suite, provide the details of the heuristics, give an overview of the simulation model, and present numerical results illustrating the trade-offs between the performance measures. In addition to discussing the performance of the heuristics, we also investigate the impact of daily surgical mix on the performance measures.

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References


