

Background

We consider a surgical department where elective, semi-urgent and urgent patients are treated. The latter patient type needs treatment immediately, which is carried out in a separate emergency OR; semi-urgent patients, who arrive unexpectedly, need surgery within one or two weeks and are treated, just as elective patients, in regular OR time.

Elective patients are canceled to accommodate semi-urgent patients, which is highly undesirable from a patient perspective. Therefore a part of regular OR capacity is dedicated to semi-urgent patients. However, no semi-urgent patients may show up. Since elective patients cannot be planned on such short notice, scarce OR time is not used, which is very undesirable from a financial point of view.

We describe a methodology to handle the uncertainty caused by semi-urgent patients.

Parameter	Value
Weekly arrival rate of semi-urgent surgeries	5.5
P(semi-urgent surgery = 1 slot)	0.53
P(semi-urgent surgery = 2 slots)	0.20
P(semi-urgent surgery = 3 slots)	0.27

Table 1: Parameter values for case study

Methodology

Our methodology consists of three parts, namely:

1. We derive the minimal OR time that should be dedicated to semi-urgent surgeries.
2. We provide a slotted queuing model in discrete time that enables a tradeoff between the number of canceled elective slots (N_c) and the number of unused OR slots (N_e).
3. We come up with a guideline, based on a Markov decision model, for the actual scheduling of one- and two-week semi-urgent surgeries.

Case Study

We present a case study from a neurosurgery department in an academic hospital in the Netherlands. The department has 8 OR days, each OR day is divided in 3 slots of equal length. So per week, the department has 24 slots at its disposal (m). Surgeries take either 1, 2, or 3 slots. The arrival process of semi-urgent slots is modeled as a compound Poisson process. With the parameters as given in Table 1, we find that the minimal amount of OR time to dedicate to semi-urgent surgeries, s_{min} , equals 10 slots per week.

In the queuing model we assign costs to both N_c and N_e . The optimal number of slots to dedicate to semi-urgent surgeries, s^* , is highly dependent on these costs. For example, when we value both components evenly, $s^* = 13$, $E[N_c] = 1.37$, and $E[N_e] = 3.40$ (see Figure 1). Note the high cancellation rate for $s = s_{min}$.

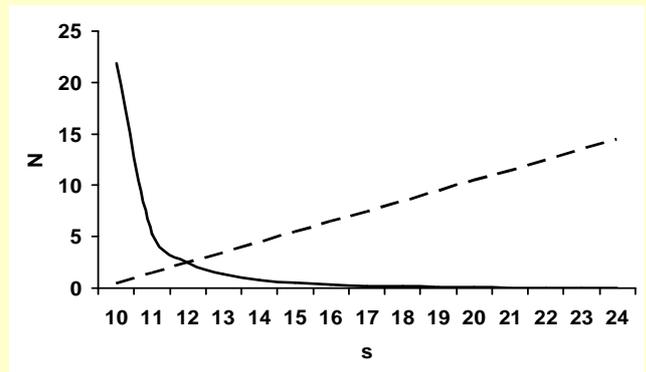


Figure 1: $E[N_c]$ and $E[N_e]$ (interrupted line) for $s = (s_{min}, \dots, m)$

When there is no sufficient room in the OR schedule, it is possible to postpone two-week semi-urgent surgeries for a week. A possible disadvantage of this is that these postponed surgeries, together with the newly arrived one-week semi-urgent surgeries, need more OR time than available (m). Then semi-urgent surgeries are performed in overtime, which is undesirable from a human resource point of view.

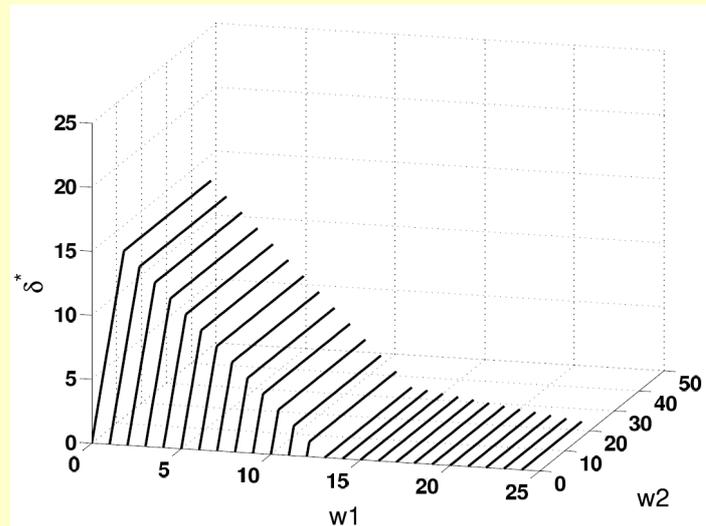


Figure 2: Optimal policy s^* in number of two-week semi-urgent slots to plan this week, for given $w1$ (number of one-week semi-urgent slots waiting) and $w2$ (number of two-week semi-urgent slots waiting) for $s^* = 13$

The Markov decision model provides a guideline that consists of the number of two-week semi-urgent slots to schedule this week.

In Figure 2 the policy obtained for $s^* = 13$ is shown. In this case the policy is straightforward – plan up to s^* and postpone the remaining slots one week.

Discussion & Conclusion

We learn from the case study that focusing on average behavior, in this case allocating the minimal amount of slots (s_{min}) to semi-urgent surgeries, can result in undesirable system outcomes such as the cancellation of many elective patients. With the queuing model we have shown that it is possible to make a trade-off between cancellations and unused OR time. The guideline provided with the Markov decision model substantially simplifies the scheduling task.