How to deal with fluctuations in hospital processes to improve accessibility?
Joustra, P.E.

Citation for published version (APA):

General rights
It is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), other than for strictly personal, individual use, unless the work is under an open content license (like Creative Commons).

Disclaimer/Complaints regulations
If you believe that digital publication of certain material infringes any of your rights or (privacy) interests, please let the Library know, stating your reasons. In case of a legitimate complaint, the Library will make the material inaccessible and/or remove it from the website. Please Ask the Library: http://uba.uva.nl/en/contact, or a letter to: Library of the University of Amsterdam, Secretariat, Singel 425, 1012 WP Amsterdam, The Netherlands. You will be contacted as soon as possible.
Different tollbooths for customers with a pass and customers who want to pay with a credit card or cash

“Trust is earned by many deeds and can be lost with a single deed.”
Socrates
CHAPTER 5

Reducing MRI access times by tackling the appointment-scheduling strategy

J.R.C. van Sambeek
P.E. Joustra
S.F. Das
P.J.M. Bakker
M. Maas

Accepted by BMJ Quality & Safety
CHAPTER 5

Abstract

Background High access times to magnetic resonance imaging (MRI) facilities have a negative impact on quality of care and patient service. Since these resources are both scarce and expensive, utilising the capacity is the most economical way of reducing these access times. As a rule, patient appointments are not scheduled efficiently. Consequently, the most promising way to reduce access times is to optimise the scheduling strategy. The objective of this study was to reduce MRI access times by optimising the scheduling strategy and implement the strategy in practise in an university hospital in the Netherlands.

Assessment of problems The scheduling process was analysed in order to define the improvement potentials and to simulate the process. Computer simulation was used to copy the process and experiment with scheduling strategies in theory. Promising scenarios were defined and run in the simulation model. A new scheduling strategy was designed and implemented based on the simulation results.

Results of assessment The simulation experiments showed that block reduction leads to a maximum decrease in access time of 93%.

Strategies for change Implementing a scheduling strategy with a practically applicable minimum number of blocks resulted in an actual decrease from respectively 36, 22, 28, 9, and 9 to 7, 2, 10, 3, and 1 calendar days, depending on the patient group.

Lessons and messages This study proved that modelling the scheduling process can contribute to optimising the scheduling strategy, which can lead to a reduction in access times to imaging facilities such as MRI scanners.
5.1. Background

Minimising patients’ throughput times in hospitals is a hot item in health care. Central facilities such as diagnostic imaging departments often have a large impact on patients’ throughput times [1]. One of the major bottlenecks in many hospitals is magnetic resonance imaging (MRI). For this reason, access time to MRI facilities is one of the main performance indicators for radiology departments [2]. Capacity is deliberately limited because these facilities are a very expensive resource, and this results in high access times. In order to reduce undesirable access times, one possibility would be to increase the MRI capacity. Another way that is more economical, would be to better utilise the available capacity.

Since an MRI facility is an appointment-based resource, the applied scheduling strategy greatly affects its utilisation. Inappropriate scheduling is common in hospitals [3], something that is often due to scheduling strategies that have developed over time. Partial adjustments to the strategy are usually based on medical reasons, with too little concern for the systems’ performance indicators such as access times and utilisation rate. More attention should be paid to improving MRI appointment scheduling. Because real-time experimentation can have a significant negative impact on patients and costs, modelling is an appropriate technique for coming up with promising improvements in scheduling. Although others have shown that modelling scheduling strategies can support the optimisation of the scheduling process for radiology departments [4-6], they often did not take the different scheduling times for different protocols into account.

An MRI scanning facility in a university hospital has to deal with many types as well as high degrees of variability in the process. The most frequently used modelling techniques (such as analytical models) do not take this variability into account. By contrast, discrete event simulation is more appropriate, because it is a modelling technique that will give very specific quantitative results in situations where variability is important [3, 7, 8]. Although discrete event simulation has been applied within radiology modalities [9], so far it has not been used for complex appointment systems like MRI facilities. The aim of this study was to reduce MRI access times to less than fourteen days by optimising the scheduling strategy and implement the strategy in practice. The objectives of this study were to:

- undertake process analysis of the MRI scan scheduling process;
- to apply computer simulation to test strategies to measure the impact on access times;
- to implement the solution in a ‘real world’ context and to measure the impact of the solution on access times.
The study was performed in a university hospital in the Netherlands, the Academic Medical Center (AMC) in Amsterdam. Annually, 12,000 patients visit this hospital's radiology department for an MRI scan. All MRI outpatients are scheduled for an appointment. Inpatients are excluded from the scope of this study because they are not scheduled but are called when there is an opening. When the study started, MRI access times ranged from 16 days to 36 days, depending on the scanner and the patient category.

5.2 Assessment of problems

The problem was approached by composing a project team containing radiology management, a specialized laboratory worker, the planning staff leader, a radiologist and researchers who are experts in scheduling and patient logistics. The first step was to analyse the scheduling process.

Scheduling takes place manually, by assessing MRI requests on patient category, urgency level, required scanner and scan duration. Appointments are scheduled in the master schedule, in a specific block type, see Figure 5.1. For instance, non-urgent hand scan is scheduled in a light ‘Skeletal’ block. When an appointment cannot be scheduled in the categorical block within urgency request, another block type is allowed.

Six patient groups were differentiated to determine the access time. This was necessary because there was less availability for some groups than for other groups, resulting in different access times. The patient groups were based on whether a radiologist needed to be present during the scan and on the scanner required. Because a radiologist was not present all day long and because some patients had to be scanned on the most advanced scanner, access times were usually different for the various patient groups.

Access time was measured on a weekly basis by a prospective schedule check. To do this, the planning system was searched for potential time slots, and the first day where it was possible to schedule two appointments of a given category was selected. By searching for two successive possibilities, the measurements were not influenced by accidental gaps in the schedule (caused by such things as late cancellations).

The most important bottlenecks that emerged from the process analysis were:

- The high average access times for all patients resulted in a large number of semi-urgent requests. If all patients could be scanned within 2 weeks, it would be unnecessary to categorize as semi-urgent those patients who have to be helped within two or three weeks.

- It emerged that the complexity of the scheduling strategy was caused mainly by the large number of blocks, 78 per week.
Of all appointments, 15% were scheduled outside of their block type, due to the high number of blocks.

The problem analysis led to the assumption that a significant reduction of blocks per week would be the most promising scheduling adjustment to achieve the objective. Since this would be a major change, especially for the influential radiologists, it was desirable to have as much information about the expected change as possible, therefore the project team decided to simulate the process by modelling it.

Due to the complexity of the planning strategy, we selected computer simulation to approach this problem. We used MedModel software. Data was used from the planning system used in the AMC (X/Care, McKesson). This data included all registered appointments from 1 January 2006 to 31 October 2006.

The simulation run was for a period of one year, excluding a four-month start-up period. After building the model, we validated it using actual access times and utilisation rates (extracted from X/Care). The accepted deviation between the actual situation and simulation was 10%.

![Master schedule before intervention](image-url)

**Figure 5.1: Master schedule before intervention**
5.3 Results of assessment

After designing the model and validating the present situation, we defined several interventions in order to study their effect on the access times. Since there were so many blocks, reducing the number of blocks seemed to have the biggest impact. The primary goal of the computer simulation was to analyse and demonstrate the impact of block reduction, and four scenarios were simulated to analyse this:

1. Present situation: 15 different patient categories, 2 urgency levels (semi-urgent and non-urgent);
2. 6 different patient categories, 2 urgency levels;
3. 1 patient category, 2 urgency levels;
4. 1 patient category, 1 urgency level (which means that all patients can be scheduled in any slot during the week).

Table 5.1 demonstrates the relative reduction in access times compared to the present situation, which resulted from the simulation model.

Table 5.1: simulation results

<table>
<thead>
<tr>
<th>Simulation results Scenario</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master schedule</td>
<td>15 categories 2 urgency levels</td>
<td>6 categories 2 urgency levels</td>
<td>1 category 2 urgency levels</td>
<td>1 category equal urgency</td>
</tr>
<tr>
<td>Reduction in average access time</td>
<td>0%</td>
<td>43%</td>
<td>66%</td>
<td>93%</td>
</tr>
</tbody>
</table>

The total capacity per week is equal in every scenario. In scenarios 1 to 3 with both semi-urgent and non-urgent blocks, the proportion of semi-urgent to non-urgent is equal. The table clearly illustrates that the number of blocks greatly influences the expected access time for an average patient: the lower the number of blocks, the lower the access time.

5.4 Strategy for change

5.4.1 Description of new scheduling strategy

The simulation results convinced all stakeholders within the department that it was necessary to reduce the number of blocks. The discussions that followed the presentations of the model’s outcomes resulted in choosing a strategy to implement. This strategy aimed at the absolute minimum number of block types, keeping only the most essential types. A new master schedule was proposed and implemented that contained four different patient categories (regular, stereotactic, cardiology, and anaesthesia). Two categories were allowed to remain because a medical team from
outside the radiology department had to be present during the scans (cardiology, anaesthesia). One category remained because patients had to be scanned right before brain surgery, so it was essential to have a fixed time during the week (stereotactic). All other patient categories were grouped into a new block (“regular”). Fewer semi-urgent blocks were required when the access times dropped to less than two weeks. Initially, the urgent and semi-urgent hours per week remained the same as in the old master schedule. Figure 5.2 shows the new master schedule (an empty block represents the new category of “regular”).

![Master schedule after intervention](image)

The new scheduling strategy was implemented on 1 January 2008. This means that patients that were scheduled for an appointment at January first or later were scheduled within the new roster. For a period of three months, the project team evaluated the new situation both quantitatively and qualitatively weekly. To this end, the access times were measured prospectively on a weekly basis until week 20, and during week 36. This was performed at the same way as explained in the process assessment. The qualitative evaluation consisted of weekly meetings were experiences and complaints from the work floor were discussed, and actions to improve were assigned to project members.
5.4.2 Evaluation of new scheduling strategy

Figure 5.3 presents the weekly access times in 2008 compared to the average 2007 access times for the six patient groups. All access times are measured prospectively and expressed in calendar days.

![Figure 5.3: Development of access times after intervention for 6 patient groups](image)

The figure clearly shows better results in 2008 than before the new scheduling strategy was implemented. The access times for the “radiologist” categories dropped from respectively 36, 22, and 28 days in 2007 to 7, 2, and 10 days in September 2008. The access times for less critical patient groups “without radiologist” dropped from 9 and 9 days to 3 and 1 days. During autumn 2008, all access times were well below the two-week performance target.

Right from the start, the increased scheduling flexibility resulted in low access times to MR1 and MR2, and to the early and late time slots of MR3 (“without radiologist”). At the beginning of the new scheduling period the patient group “radiologist MR3” lagged behind the other categories: many scans were only allowed to be scheduled with a radiologist at MR3, which resulted in restricted availability. It turned out that encouraging examination of whether a radiologist was truly necessary had a positive impact on the access time of this category. Within the first 15 weeks, this access time gradually dropped to an acceptable number of days. This can be explained by an increase in the number of scans per week. The scanning production per month increased to some extent, resulting in an increase in scheduled utilisation rate from 70% in 2007 to 80% in 2008.
The category “MR1 without radiologist” came into being in week 5, because until then a radiologist had been present for all scans on MR1 (no early or evening blocks). The sudden decrease of access times for most patient groups was caused by a timely change to the master schedule for 2008. Months before the start of 2008, the planning department was already scheduling appointments that no longer fit into 2007 in the new master schedule for 2008. During the evaluation period no significant change in overtime or cancellations was reported.

5.5 Lessons and messages

After implementing the new scheduling strategy, access times for all relevant patient categories dropped to an acceptable level of fewer than 14 days. This study showed that modelling the scheduling process can contribute to optimising the scheduling strategy, which can lead to a reduction in access times to imaging facilities such as the MRI scanner.

Scheduling techniques and modelling have increasingly proved to be valuable in hospital environments. Computer simulation appeared to have various strengths in the context of this study. First, it was possible to consider various interesting scenarios for evaluation. Second, unpredictable variables such as patient cancellations could be taken into account, which provided results with a high confidence level. Third, because it was possible to satisfactorily visualise the consequences of scenarios, stakeholders relied on the results. The most important added value of the simulation model within this study appeared to be the persuasive power of computer simulation. Although the radiologists in particular were very sceptical about block integration, they were convinced by the numbers that resulted from the simulation.

Differences occur when comparing the simulation results and the actual results after implementation. This is caused by the difference between the experimental master schedules within the simulation model and the actual master schedule after implementation. It was only after seeing the results and becoming convinced that the radiologists started discussing and developing a realistic master schedule with a minimum number of blocks. Many factors were taken into account, such as the number, dispersal, and appropriate time intervals of urgent blocks, non-regular blocks, and spaces that meet the requirements.

When the department learned to work in the new way and the improved performance became apparent, all stakeholders accepted and supported the new scheduling strategy. Over time, minor changes in the roster have been established over time, because of external factors such as changing availability of cardiologists. Fortunately, this has not lead to more blocks. The study confirmed that history-based scheduling can be far from optimal, especially within highly political environments.
CHAPTER 5

such as hospitals. Using scheduling methods from operations management and simulation modelling contribute greatly to radiology performance.

<table>
<thead>
<tr>
<th>Glossary</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access time</td>
<td>The time between the MRI referral and the appointment (in calendar days)</td>
</tr>
<tr>
<td>Patient category</td>
<td>A classification for group appointments based on the type of scan.</td>
</tr>
<tr>
<td>Urgency level</td>
<td>The extent to which an appointment must be scheduled quickly for medical reasons. There are two urgency levels relevant to scheduling: semi-urgent and non-urgent.</td>
</tr>
<tr>
<td>Block type</td>
<td>A classification of time intervals within the weekly master schedule reserved for a specific patient category or a specific urgency level.</td>
</tr>
<tr>
<td>Block</td>
<td>A specific time interval on a given day and MRI scanner within the weekly master schedule reserved for the patients defined in its block type.</td>
</tr>
<tr>
<td>Patient group</td>
<td>A classification for determining access times based on whether a radiologist needed to be present during the scan and the type of MRI scanner required.</td>
</tr>
</tbody>
</table>
References


