Implementing patient flow based resource allocation decision support models in hospitals

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Jan M.H. Vissers*

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* Graduate School of Industrial Engineering and Management Science
Eindhoven University of Technology
P.O. Box 513, Paviljoen F16
NL-5600 MB Eindhoven
The Netherlands
Phone: +31.40.472230
Fax: +31.40.464596

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- Case Study Results -

Jan Vissers
National Hospital Institute, Utrecht
and
Eindhoven University of Technology
The Netherlands
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Jan Vissers, National Hospital Institute, Utrecht and
Eindhoven University of Technology, The Netherlands.

Content:

Abstract

This PhD-based research programme on Hospital Capacity Management comprised three parts. First, an analysis was made of the hospital's supply structure, reveiling many shared resources and dependencies between resources. This analysis also showed the need for co-ordinating mechanisms when allocating shared and interdependent resources to avoid structural peaks and troughs in the use of resources and sub-optimisation.
To provide hospitals with tools for co-ordinated allocation of resources, the second part of the research was devoted to the development of a set of decision support computer models. These models were made available to hospitals who considered a re-organisation involving re-allocation of resources, such as an increase of medical staff or a change in the operating theatre time-table or multi-location management in case of a hospital merger.
The last part of the research comprises three case-studies, in which the models are used in a 'controlled' experimental setting in hospitals that are faced by resource management issues within the range of the research programme. Apart from these three cases a reference-case was studied to look at the way hospitals currently deal with these type of resource management issues. The reference-case concerns a hospital that re-organised its operating theatre time-table but did not consider the resource consequences of this re-allocation for other parts of the hospital. Case one is a multi-location hospital where surgical activities of a general surgeons

were to be concentrated in one location. One of the models was used to redesign the surgeons planning while taking into account resource impacts elsewhere in the hospital. Case two concerns a hospital that wanted to improve the use of radiology facilities, focussing on the direct flow of patients from outpatient clinics needing immediate service. Two of the models were used to analyse the x-ray department's workload and to propose changes in the x-ray department's planning and in the clinic schedules of those specialties responsible for the peaks and troughs in the flow of direct patients to the x-ray department. The third case regards a hospital that wants to flexibilise and co-ordinate the allocation of inpatient resources like operating theatre hours, beds and nursing staff. Two of the models were used to project the future need for inpatient resources per specialty and to develop an approach for yearly adjustments in the allocation of the three interdependent resources.

The paper summarises the findings in the first parts of the research and focusses on the use of the models to support decision making in the above-mentioned cases and on the findings of the three case-studies.

1. Introduction

Increased market-orientation and client centredness, improved product line management, more involvement of medical staff in management, improved overall performance of the hospital system, are main challenges to todays hospital management. At the same time hospital resources have become more scarce, because of the limits put to the rising costs of health care expenditures while demand is still growing. This makes allocation of scarce hospital resources to specialties within the hospital -the subject of this paper- a difficult area for managerial decision making but also an interesting topic for research.

In the Netherlands resource management became important since 1983 when the budgeting of hospital expenditures was introduced. The Dutch hospitals are also faced by a bed-reduction programme of the government to reduce the number of beds per 1.000 inhabitants from 5.0 (1974) to 3.4; at the moment the rate is 3.9 (1992). Because of these pressures on the hospital system resources like beds, operating theatres, nursing staff and paramedical staff became increasingly scarce resources that require special attention from the hospital management. Most Western European countries show a similar development, while the U.S.A. health care system is characterised bij relative overcapacity. The influence of the government (or agencies above local hospital management level) versus the hospital management on hospital resources for the Netherlands, the United Kingdom and the U.S.A. is illustrated in table 1.

Resource	Netherlands		United Kingdom		U.S.A.	
	GVMT	MNGT	GVMT	MNGT	GVMT	MNGT
number of beds	+	--	+	--	--	+
number of beds per specialty	--	+	+	±	--	+
specialities	+	--	+	--	+	--
number of specialists	±	+	+	--	--	+
number of operating theatres	±	+	+	±	--	+
number of OT sessions per specialty	--	+	+	±	--	+
number of clinics	±	+	+	±	--	+
number of clinic sessions per specialty	--	+	+	±	--	+

Table 1: Influence on hospital resources by government (GVMT) and hospital management (MNGT) in the Netherlands, United Kingdom and U.S.A. (indications for the present health care system).

From the content of table 1 one can see that the degrees of managerial freedom with respect to hospital resources in the Netherlands outnumber those in the United Kingdom. In the Netherlands the dimensions of the hospital are regulated by the government, while the hospital management can decide about the allocation to specialties; however, the production-volumes of the hospital in terms of admissions, bed-days, day cases and first outpatient visits are yearly agreed upon with local health care insurance organisations. In the United Kingdom there is less local managerial influence on resources due to the role of the Regional and District Health Authorities, which sometimes even decide about allocation of resources to specialties within a hospital. However, the Hospital Trusts within the new health care system will make the local hospital management position much more alike the Dutch situation. The U.S.A. health care system shows the most managerial freedom, including even decisions regarding the dimensions of the hospital; because of the frequent occurrence of overcapacity of resources the internal allocation process draws less managerial attention. However, the recent ideas about a change of the health care system involving more governmental influence will move the hospital management position more towards the situation in Western Europe.

While there are differences, one can say that the (expected) pressure on the hospital system will emphasize the importance of allocation of resources as a core-taste of hospital management. Allocation of resources to specialties and departments is an important tool to create a balance between the demand for services and the provision of hospital services. Decision making in this area requires a combined effort of managers and medical professionals and requires new tools to support decision making. Allocation of hospital resources in this new perspective should not be based on 'historical rights' or on 'best lobbying', but on a profound insight into the primary proces and into the development of patient flows. Hence the reference to the title of this paper 'patient flow based allocation' as an alternative way of allocating hospital resources. The tools needed would enable this patient flow orientation and support decision making in allocating hospital resources with a global perspective on the consequences for the hospital as a whole.
Moreover, these tools should be able to show the perspective for the managers as well as for the professionals, thus feeding the dialoque needed between professionals and managers for improved use of the hospital's scarce resources. The tools used up to now, like computerised planning systems, deal most of the time with a single department (e.q. admission planning, operating theatre scheduling, outpatient appointment scheduling). Moreover, these tools show only the managers perspective and are therefore not inviting to medical professionals to participate in matters regarding the hospital organisation.
This research focusses on one category of tools that can contribute in this respect, namely PC-based models that visualize the relationship between patient flows (demand for services) and the way resources are used to meet demand (supply of services) at management level. These models are of a what-if type and offer decision support to managers and professionals to investigate alternative ways of meeting demand, while visualizing the impacts on the use of resources.
These changes in the allocation of resources occur foremost on the management level of planning: the decision to increase medical staff, the decision to close down a ward or to start a short-stay ward, the decision to change the time-table in the operating theatre department or the outpatient department, etc. That is why this research will concentrate on this level of decision making.

The outline of the paper is as follows. First, a summary will be given of the research objectives and the research activities and findings in the previous phases of the study: problem analysis and model development. Next, the implementation strategy and case-study design are described. The emphasis of the paper lies on the different case-studies, reported in paragraph 4-7. The paper concludes with a discussion of the case-study findings.

2. Summary of research objectives, activities and findings previously reported

The objectives of the research on 'Hospital Capacity Management' are to develop: a) an approach, b) tools, and c) insights concerning allocation of scarce hospital resources.
The approach chosen concentrates on the avoidance of structural variations in the need for hospital resources, causing weekly returning peaks and troughs in the use of resources. This is done by visualizing patient flows in the hospital at an aggregate level of planning and the use of resources by these patient flows. To produce this information use is made of decision support computer models that visualize the relationship between patient flows and resources in the hospital and provide decision makers with information on impacts on the use of resources by alternative ways of allocating hospital resources.
Furthermore, this approach focusses on larger changes in the allocation of resources that are critical for the use of resources i.e. 'critical resource incidents'. Examples of 'critical resource incidents' are increase of medical staff, a new operating theatre schedule, closure of a ward, merger of hospitals, etc.

The research objectives are also reflected in the different parts of the research programme conducted:

1. analysis of the hospital's supply structure
2. development of a framework for resource management and development of tools to support decision making on allocation of resources for critical resource incidents
3. case-studies to illustrate the use of the approach and models in concrete settings.

The rest of this paragraph summarises the content and findings of the first two parts of the study; the case-studies will be discussed in more details in subsequent paragraphs.

Analysis of the hospital's supply structure

The supply structure of a hospital is very complex because of the many shared resources and the many dependencies between resources. Key resources we will concentrate upon in this study and which are often shared resources are:

- outpatient department resources (rooms and equipment, personnel)
- diagnostic departments resources (rooms, equipment and personnel in the x-ray departments, laboratory, etc.)
- therapeutic departments resources (rooms, equipment and personnel in the fysiotherapy department, radiotherapy department, etc.)
- operating theatres (rooms and equipment and personnel of this very expensive therapy department)
- nursing resources (beds, personnel in the nursing wards)

Apart from these hospital resources that are allocated to or used by different specialties, we have the specialties resources. This is the time specialists allocate to the different operations they are involved in. A surgical specialist, for example, divides his time over the following operations:

- clinics: to see patients in the outpatient department
- operations: to operate patients in the operating theatre
- diagnostic procedures: to perform diagnostic tests on patients that need physician's attendance (e.q. scopes, etc.)
- ward round: to see patients in the wards, waiting for or recovering from an operation
- non patient-related activities such as administration, meetings, etc.

The specialist can be regarded as a 'multi-functional operator", because he performs different operations, using different resources. To illustrate this feature of the specialist as a critical resource, see figure 1.

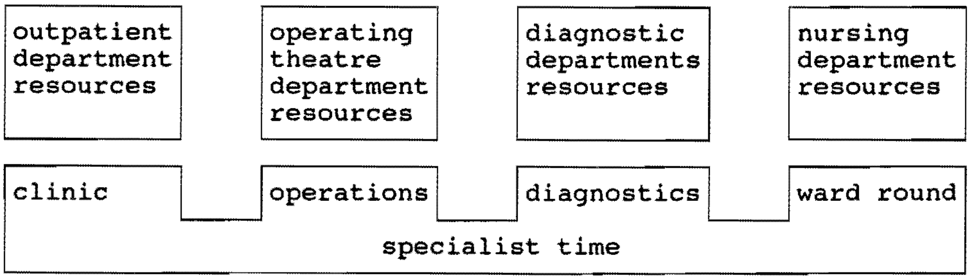

Figure 1: representation of supply structure hospital as an interaction between specialist' time and key resources

This implies that the use of key resources is fully dependent on the availability of the specialist for the activity at hand. For example, when a specialist is not available while the operating theatre personnel is ready, this results in a loss of resources. This dependency applies also for the other departments, but only partially for the nursing department; the nursing process is almost independent from the doctor's availability apart from the ward round.

Next, we will look how this supply structure is being used for production. Production in hospitals for non-urgent cases is organised via sessions. A session comprises a group of patients, requiring the same type of operation and the same type of resources; a session of such a type is being organised at a specific period during the week. A surgeon for example could have regularly a clinic session on Monday morning, a session with vascular operations on Monday afternoon, a general operating theatre session on Tuesday morning, a fracture clinic on Tuesday afternoon, etc. Patients are scheduled for these sessions from a waiting list or at the moment this service is required (e.g. making an appointment for an outpatient visit at the moment of referral by the general practitioner, making an appointment for a day surgery procedure during a visit to the outpatient department, etc.).

The reasons why production in hospitals is organised via sessions is first of all because of the expensive resources used nowadays. Operating theatre hours, for example, are very expensive, involving a room, equipment and various types of surgical personnel. To use this resource efficiently one has to define exactly when specialist and resources are to 'meet' to realise production, not for one patient but for a series of patients. In this way change-over times are minimised, going from one type of operation to another type of operation. Instead of only optimising the doctor's time, the question now is to optimise also the time expensive resources are being used. Another reason why sessions as combinations of doctors and resources during a defined time-interval are being used, is the fact that the same resources need to be shared between different specialists and different specialties. This is again because of the expensiveness of the resources involved. On the other hand, resources are not exchangeable, so that an operating theatre session prepared for a surgeon can not be exchanged with a session for a gynaecologist without changing the configuration of resources needed.
This way of organising production in hospitals using the session mechanism optimtes the use of session hours, but has a number of negative effects, such as:
- It introduces an extra waiting time because sessions are only organised once or twice a week.
- It introduces patterns of workload for other resources required for patients in the next stage of the process.

An operating theatre session causes extra workload for the ward that receives these patients, an outpatient clinic session leads to work in the x-ray department because of the patients referred directly from a session to be seen again by the specialist after having visited in between the x-ray department.
These knock-on effects are typical for the hospital organisation.

- It creates a rigid planning of specialists and resources. Because of the dependency in the system one change of sessions causes a number of changes elsewhere. Fixing the schedule for one specialist is most of the time regarded as the maximum attainable. This makes it difficult to rearrange master schedules, once fixed, even if such a rearrangement would benefit the total use of resources at the level of the hospital.

Ignoring for the time being the extra waiting time introduced, the patterns of workload caused by the use of sessions create the typical pattern of peaks and troughs in the use of resources at the hospital level. This is because the present way of allocating resources does not take into account the overall impact on resources for the hospital as a whole.

To avoid introduction of variations in the need for resources resulting from master schedules around critical resources, i.e. the operating theatre time table, the outpatient department time table and the specialty time table, requires different co-ordinating mechanisms:

a. coordination of the allocations of one resource to specialties sharing the same resource (e.g. beds)
b. coordination of the allocations of different resources to one specialty (capacity load leveling per specialty)
c. coordination of the resource-impacts for resources that are shared by specialties but not allocated to specialties (e.g. x-ray)
d. coordination of specialist-capacity within a specialty (specialty planning restrictions).

Ignoring these coordination-needs results in capacity loss (a-c) or in conflicts with the specialty's planning restrictions because of the 'multi-functional operator-ship' of the specialist.

Development of framework and tools

In the second part of the study a framework for resource management was developed and a set of computer models for resource allocation.
The resource management framework is based on the three-level planning hierarchy according to Anthony (1): strategic planning, management control and operational control.

At the strategic level the hospital has to decide about the amount of resources needed for coping with the present and future demand for care by patients. This is called <u>resource planning</u>.
At the management control level the amount of resources available is fixed. At this level decisions have to be made to allocate resources to specialties, activities or departments. This is called <u>resource allocation</u>.
At the operational level resources are already allocated. At this level decisions are made to use resources for activities. For example, deciding to admit a patient, booking an appointment for an outpatient clinic, etc. This is called <u>resource occupancy planning</u>.
Finally, the day-to-day operations determine how the resources are used in the end. This is because admissions can be delayed, outpatient clinics can be cancelled, etc. This is not planning but operations. This is called <u>operational performance</u>.

This research focuses on the management control level, because this is the level that deals with allocation of resources. However, we will also discuss links with the strategic level and the operational control level.

This is because we can't isolate one level of planning when dealing with real resource management problems. A decision to increase the medical staff of a specialty, for example, involves analysis on different levels:

- operational performance: a growing waiting list and workload per specialist are indicators for a shortage of staff
- operational control: can the efficiency of operations be further improved by adapting procedures and organisation?
- management control: is there a need for more resources (operating theatre hours, clinic hours) to optimise the use of staff hours?
- strategic: how much staff do we need to cope with the expected patient flows from referring general practitioners?

Higher level solutions are necessary if lower level solutions don't helps. Vice versa, lower level solutions are always limited by the boundaries defined by higher level planning.

As already mentioned before we will concentrate in this research on resource allocation. It is important to notice that resource allocation in the context of this research is not a 'lump-sum' allocation to departments or specialties but an allocation to activities of departments and specialties defined by time and place. This is because of the phenomenon of sessions to organise production in hospitals. Because of this, parts of occupancy planning are already incorporated in the procedure for allocation of resources used in hospitals.
The level of efficiency reached in this process of resource allocation determines targets for the workload of resources. These target-workloads are important when you want to calculate the number of resources needed to deal with demand. So this is the link back from resource allocation to resource planning.

Analysing the range of resource management problems at management control level and considering also the complexity of the hospital system, it won't be feasible to develop one integral tool for resource management problems. It seems more feasible to define a comprehensive set of models that deal with well-defined areas of resource management problems.

In this way five areas were defined, covering the following questions:

- 'patient flows and resources'
  What are the impacts on resources needed if there is a change in the flow of patients to the hospital? This change can result from demographic developments or a change of referral policy of general practitioners.
- outpatient capacity management
  Given the demand for outpatient care, how should the supply of resources (sessions of clinics, diagnostic departments, etc.) be balanced with the need of resources by outpatients?
- inpatient capacity management
  Given the demand for inpatient care, how should the supply of resources (operating hours, beds, nurses) be balanced with the need of resources by inpatients?
- x-ray capacity management
  How can the x-ray department's resources be balanced with the need for resources by inpatients, outpatients and GP-patients?
- interface hospital-specialists
  Because specialists are critical resources, an important area of resource management is the interface between the master planning of specialists and the master planning of departments.

Using these areas the following set of decision support models has been developed (see figure 2).

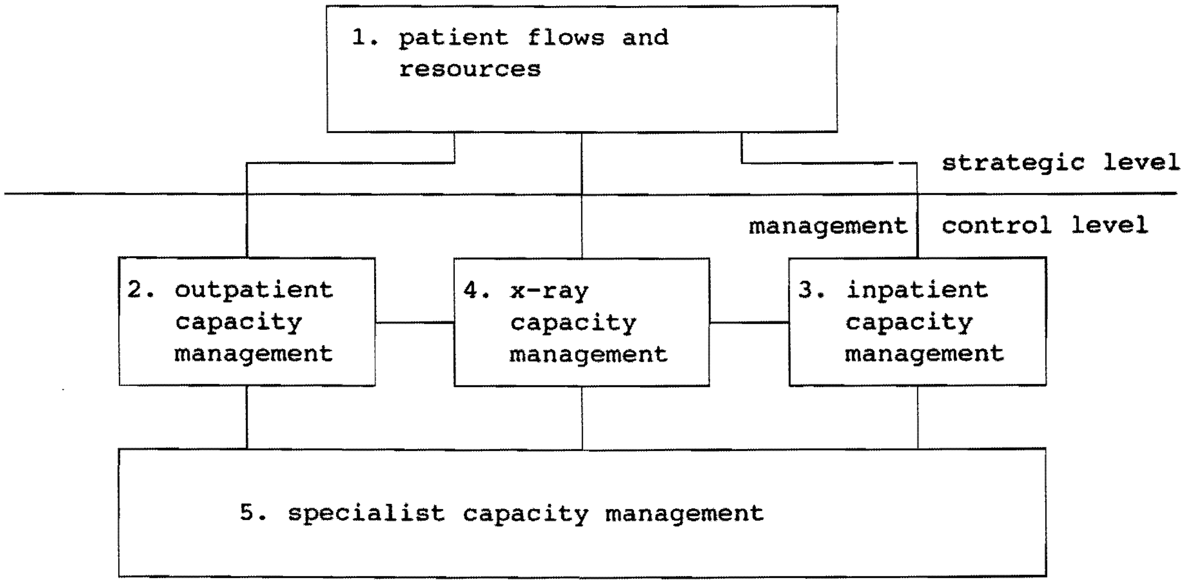

Figure 2: set of models for supporting resource management

The above set of models makes it possible to investigate changes in the patient flow to the hospital and the way care is being provided in the hospital, and the consequences of these changes on resources.
Model 1 deals with resource planning whereas models 2-4 deal with resource allocation. The models are available for hospitals to be used in projects to improve the use of hospital resources. About 30 models have been delivered to Dutch hospitals up to now, English versions of the models are available, and are used in Scotland, Poland, Belgium and Denmark, sometimes as part of a pilot-study. Futher documentation in the models is available (2-5).

3. Implementation strategy and case study design

The third part of this research involves a few case studies meant to illustrate the use of these models in concrete settings. The case studies will furthermore have to shed light on the following questions:
- What is the change in the use of resources?
- To what extent can this change be attributed to the approach followed?
- What other impacts do occur (like improved decision making, increased insight in the hospital as a whole, etc.)?
- Under which conditions can these results be attained?

The case studies selected for this research will use as a common approach:
- problem orientation
  A condition for selection is that a hospital has a real problem with the use of one or more critical resources.
- model support
  A second condition is that the hospital has chosen to use one or two of the models for hospital capacity management developed by the author to tackle the problem.

- participative approach
  A third condition is that the different interest groups will be involved as much as possible in the problem solving approach i.e. by participation in a project team.

The four cases reported further-on in this paper concern one reference-case and three 'real' cases. The reference-case is meant to show the resource-impacts of the approach currently in use for hospital resource allocation, so without making use of model support. The latter approach is followed in the 'real' cases.
The selection of cases was based on a good coverage by the cases of the resource management issues studied and the use of the different models developed.
Table 2 gives an overview of some characteristics of the cases.

Case	Subject	Models used
reference-case	re-organisation OT timetable	(Specialist, Inpatient)
case one	re-organisation general surgery	Specialist
case two	interface X-ray and OPD	X-ray, Specialist
case three	re-organisation inpatient resources	Patient Flows & Resources, Inpatient

Table 2: Overview cases

The next paragraphs will describe the cases in more detail. The description of the cases is by force kept short, because of the limited length of the paper. Moreover, some of the cases are not finished yet. A complete report of the cases will be part of the PhD-thesis, that is to appear in 1994.

4. Reference-case: re-organization the operating theatre time-table without taking notice of knock-on effects in other hospital departments.

This case concerns a hospital with about 275 beds and 15 specialties. In 1990/1991 the board of managing directors decided to ask a management consultancy firm to investigate the functioning of the operating theatre department. One of the problems was that the use of operating theatre resources by specialties was below standards. Based on a detailed analysis of the present use of resources the report of the consultants contained a proposal to change the operating theatre time-table. The present time-table had five morning-sessions each day and four afternoon-sessions with a break of 1.5 hours between morning and afternoon. The allocations per specialty were most of the time on a half-day basis. The new schedule had much more whole-day sessions per specialty with a flexible break of half an hour around noon. The advantage of whole-day allocations is that run-out times of sessions are dealt with within a specialty and that the breaks can be shortened. The report did not mention that the re-organization of the operating theatre's time-table would evoke changes elsewhere in the hospital. The hospital management was interested to see the consequences of the introduction of the new time-table. They agreed to participate in the study on Hospital Capacity Management.

However, because the moment of implementation was so near (March 1992) it wasn't possible to use the models to support the decision making process. In this way a reference-case for the study came into being, in which the models were use to visualize the consequences of a re-organization in one part of the hospital for other parts of the hospital.
In this case - a re-organization of the operating theatre time-table - one can expect changes in the use of resources for inpatient services and in the use of outpatient services (see figure 3).

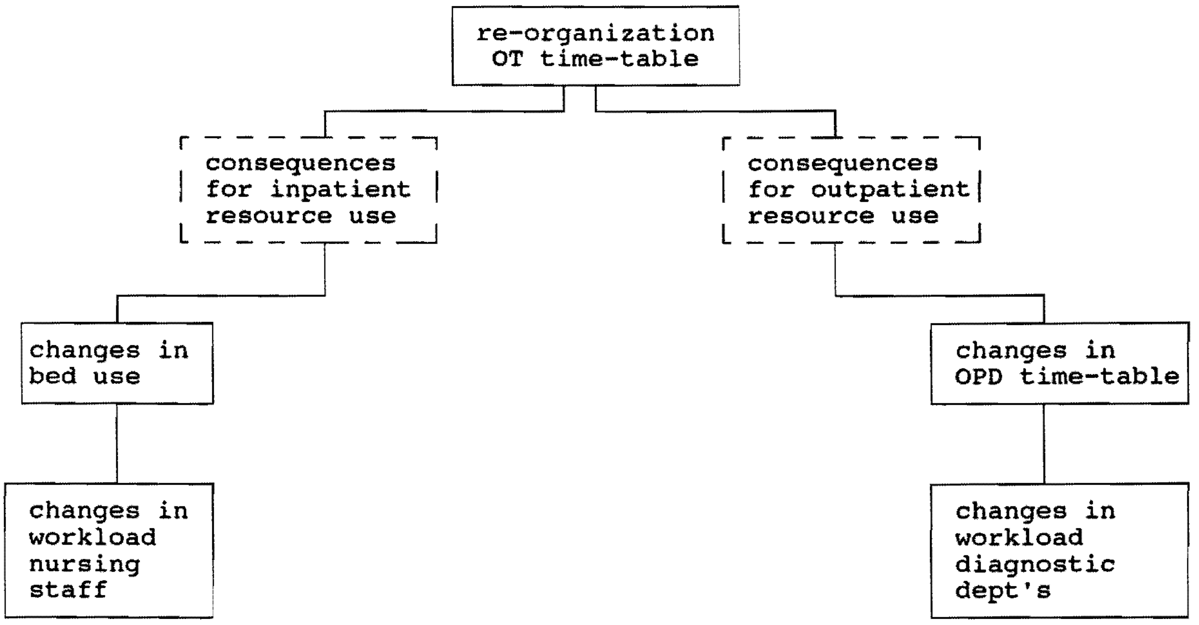

Figure 3: changes in the hospital because of a new operating theatre time-table

The introduction of whole-day allocations for the operating theatres implies a concentration of operating theatre capacity for specialties on certain days of the week, especially for those specialties that don't need operating theatre capacity every day. This concentration of operating theatre capacity will probably introduce structural variations in the need for beds and nursing staff. The new OT time-table will make it necessary to change the clinic hours for those specialists that will have changed operating theatre session times. The changes in the time-table of the Outpatient Department will cause changes in the direct patient flow to diagnostic departments like X-ray and lab.
The Inpatient Capacity Management Model was used to visualize the consequences of the new OT time-table for the inpatient resource use. For 2 comparable periods of 4 weeks before and after the introduction of the new OT time-table data were collected on the admissions to the hospital in this period and on the use of beds and operating theatre time by these patients. Based on these data the model's calculations showed the following results:

- for the hospital as a whole the operating theatre use decreased from 92% to 80% occupancy. The bed occupancy decreased from 88% to 84% while the fluctations stayed at the same level (coefficient of variation : 0.07 - 0.07). The workload for the nursing staff decreased from 79% to 74% occupancy. The number of patients admitted per week was a bit lower (268 - 251).
- While for some specialties the new OT time-table produced positive changes for the inpatient resource use of this specialty, the consequences for gynaecology and orthopaedics were negative. The concentration of operating theatre hours for these specialties had clearly introduced larger variations in the use of beds and nursing staff.

The Specialist Capacity Management Model was used to visualize the consequences for the outpatient resource use. This was done by entering data on the old and the new time-table for the Outpatient Department and by collecting data on the direct referrals from specialty clinics to diagnostic departments. The changes in the outpatient resource use, forced by the new OT time-table, showed according to the model positive results for the hospital as a whole. Apart from a small decrease in the number of clerical staff needed for supporting the clinics sessions (2%) and a small increase in the need for OPD-units (2%), the variations in the flow of patients to diagnostic departments decreased (coefficient of variation: 0.47 - 0.41). However, on some days of the week the X-ray department, for example, was confronted with a change of 30% more or less patients that needed direct service. This must have lead to longer waiting-times for patients, presuming the supply of X-ray services has not been changed.
The reference-case illustrates that a re-organization of an operating theatre time-table produces a number of changes in the use of inpatient and outpatient resources. In this case the consequences of the new OT time-table turned out to be not so bad at all for the hospital as a whole, though some specialties show lower performance in the use of resources due to considerable peaks and troughs in the workload.
However, if this information had been at hand when the new OT time-table was developed one might have come to an even better solution for all specialties concerned.

5. Case one: Re-organising general surgery in a multi-location setting.

This hospital is a 650 beds hospital system with 16 specialties, operating on 2 locations, about 8 kilometers from apart. There are 8 surgeons attached to the hospital and they form a firm. They have a contract with the hospital, but are not salaried by the hospital (fee for service system). In the beginning of 1992 the decision was taken to concentrate general surgery as much as possible on one location. At that moment 4 surgeons were working on location A and 4 surgeons on location B. A complete concentration on one location, however, was not feasible. The surgeons decided to use location A as a base for all surgeons but to serve location B with 2 surgeons at a rotating basis. This of course had many consequences for the planning of activities for the surgeons. There was a need to design a new master schedule for the surgeons. The surgeons themselves had tried in an earlier stage to develop with some outside support a computer model for this problem but this attempt was not successful. Now the hospital management decided to start a project involving the surgeons and managers of other departments like operating theatres, outpatient department, and nursing wards. This was done because the new schedule of the surgeons would result in further changes for operating theatre planning, outpatient department planning, ward round planning, etc. Because the hospital management knew about the availability of the model 'Specialist Capacity Management' that is designed to support re-organisations of master schedules for specialties and departments they were quite willing to act as case-study. The surgeons also supported the project because of the fast nearing date for concentration (August 1992) and their previous experiences in tackling the problem. A projectteam was established with one of the surgeons as chairman and participation by managers of the departments mentioned before. The project's objective was to redesign the surgeons master schedule and to use this opportunity to look at consequences for resource use in operating theatres, outpatient department, etc.
To summarize the steps taken in the project the following activities took place:
- description of the current schedule of the surgeons using the computer model;
- interviews with each of the surgeons and the department managers concerning the problems with the current schedule and the points of departure and the wishes regarding the future schedule;

- development of a new schedule for the surgeons;
- visualising the resource impacts of the proposed schedule;
- consulting surgeons and departments.

Regular meetings of the projectteam were used to discuss the findings of each step and to decide about next steps. Because of the interview rounds there was much opportunity to participate in the project. This was different from the way this type of changes in schedules were realised in the past, when one was confronted with changes implemented already before the opportunity to discuss problems and alternatives.

Because of the short preparation time it was decided to start with the new schedule developed while there were still opportunities to further optimise resource impacts. Moreover, it was foreseen that in 1993 a new surgeon would start that would need a further adaptation of the schedule. It was decided to use this new moment as an opportunity to optimise the resource impacts and to finish the project. At the moment of writing this paper the second part of the project is still pending. To give some insight into the findings up to now the preliminary schedule is shown (see figure 4) and an example of the resource impacts of this schedule (see figure 5). Also some observations will be given that were crucial for the successful development of the project during the first part.

Schedule: Physicians											
		Monday		Tuesday		Wednesday		Thursday		Friday	
Specialty	SUR	am	pm	am	pm	am	pm	am	pm	am	pm
BOLH	bolhuis	CLIN	OPER	DIAG [2]		CLIN	FREE	OPER	CLIN	CLIN≈	CLIN
ROUS	roussel	OPER	CLIN	CLIN≈	EXT	CLIN≈	OPER	OPER	FREE	DIAG	
SCHO	schouten	CLIN≈	CLIN	OPER	DIAG≈	CLIN	CLIN	OPER	DIAG	OPER	FREE
HAGE	hage	OPER		CLIN≈	CLIN	DIAG≈	OPER	DIAG≈[2]	OPER	CLIN	FREE
HAEF	van haefte	CLIN	DIAG	CLIN		OPER			FREE	CLIN	OPER
HESS	hesselink	DIAG	CLIN	DIAG≈	OPER	FREE	CLIN	OPER	DIAG≈	CLIN	OPER
BOUM	bouma	CLIN≈	MEET	OPER	FREE	DIAG≈	CLIN	DIAG≈	OPER	OPER	
MOLI	molier	CLIN≈			OPER	[2]OPER	FREE	CLIN	DIAG≈[2]	DIAG≈	OPER

Figure 4: preliminary revised physicians schedule

This schedule shows what activities are programmed for each surgeon during the days of the week. This could be operations (OPER), clinics (CLIN), diagnostic sessions (DIAG), ward rounds (WAR) or otherwise like a free afternoon or external activities or regular meetings. If there is more than one activity scheduled within a morning or afternoon this is indicated with a special sign (≈); also non-weekly activities can be indicated ([2]). The activities scheduled in location B are underlined. This preliminary schedule shows that one surgeon is only working in location B while the other surgeons work only for one or two half-days in location B. Figure 5 shows the impact of this schedule for the referrals from outpatient clinics to diagnostic departments.

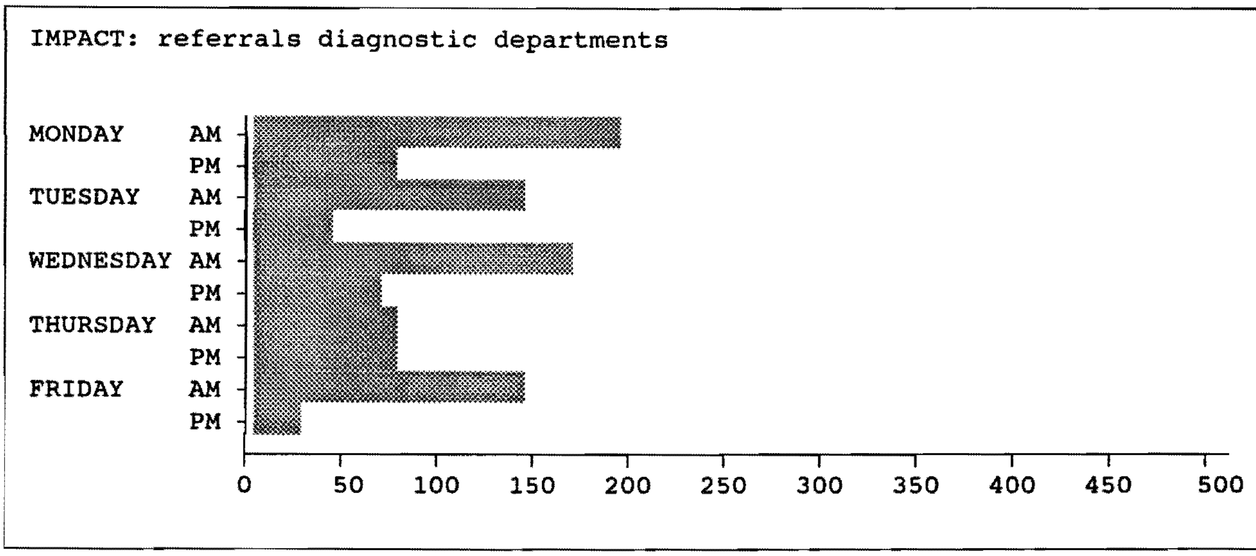

Figure 5: direct referrals from general surgery clinics to diagnostic departments

This shows that the patient flows to diagnostic departments have a number of peaks and troughs that will likely cause problems in the workload of these departments. A better distribution of the clinics of general surgery over the days of the week can contribute in a more balanced workload of diagnostic departments. This will need attention when the second part of the project starts.
The most important observations during this first part of the project were the importance of interview rounds as an efficient and effective way of involvement of the surgeons and the necessity of a structured list of interview results of colleagues'opinions to enable the surgeons to develop their own policy as a group.

6. Case two: smoothing the x-ray department's workload because of walk-in patients from outpatient clinics

The second hospital is a 350 beds hospital with 14 specialties. During a previous investigation into the x-ray department's functioning, analysis of the department's workload and waiting times for patients showed bad results. There was a large flow of outpatients that did not have an appointment made for an x-ray examination, causing peak and troughs in the x-ray department's workload; at these hours the waiting times for these patients increased to unacceptable levels (average waiting time 21 minutes and maximum waits of over 1 hour). Many of these direct patients have to return later-on to the clinic to see the specialist once more; in case of long waiting times in the x-ray department the clinic will probably run over time.
The hospital management decided to start a project, involving the x-ray department and the specialties that have the most direct referrals from their clinics to the x-ray department. The project's objective is to change the x-ray department's planning or to redesign the outpatient department's clinic schedule for these specialties in such a way that their patients referred to the x-ray department will be served without a long wait and that the resulting workload for the x-ray department will show less peaks and troughs. This would involve the use of the model 'X-ray Capacity Management', which is meant to investigate alternative ways of organising the x-ray department's planning, and the model 'Specialist Capacity Management' because of the links between the direct referrals from specialties in the outpatient department and the clinic time-table of these specialties. The hospital was willing to act as a case for the study on Hospital

Capacity Management. They had already purchased the models needed for this project because they wanted to improve the use of resources for the hospital as a whole by improving the management of patient flows on the interfaces between departments. They considered this project as a pilot-study for the hospital to use this approach eventually also for other interfaces in the hospital system.

The project was performed by a student as part of a study for a masters degree(6). The project consisted of two distinct phases. The first phase would be to analyse the x-ray department's workload using the x-ray model and to track down via the specialist model which specialties refer most direct patients to the x-ray department and cause peaks and troughs in the x-ray department's workload. This diagnostic phase was guided by a projectteam consisting of the manager of ambulatory care services, the manager of the x-ray department, the hospital management consultant, the student and the author. In the second part of the project a change-organisation was introduced by installing small working committees for each of the interfaces between the x-ray department and those specialty clinics being most important for the problem studied. These committees consisted of representatives of the specialty clinic (specialist and supporting staff) and of the x-ray department. Based on change literature on 'learning organisations' the meetings offered opportunities for learning on the interface studied, supported by information from the computer models, and to consider alternative ways of matching demand for x-ray services and supply.

The following activities took place during the project:

- description of the present patient flows from wards, outpatient clinics and general practitioners to the x-ray department and of the way these service requests were met by the x-ray department's planning, using the x-ray model;
- analysis of the x-ray department's workload in terms of peak-days and peak-hours, concentrating on the direct examinations;
- analysis of the direct referrals from outpatient clinics, using the specialist model, showing the specialties that are most important for improving the x-ray department's workload and are also confronted with long waiting times for patients that are sent in-between to the x-ray department for a direct examination;
- presentation of the findings of the first phase to the hospital management and representatives of the medical staff, and installment of working committees:
- meetings of the working committees to focus in more detail on the specific interface studied and to brainstorm about possibilities for improvement by adjustments in the x-ray department's planning or by changes in the clinic organisation;
- decision making about solutions to be implemented;
- evaluation of the project approach and outcomes.

This last activity is still underway.

To give an idea about the results of this project up to now, a summary will be given of the findings in both parts of the project. First some results from the diagnostic phase will be shown. Figure 6 shows the occupancy of the technician capacity for small examinations without appointment for the different days of the week. Figure 7 shows for one of the busiest days of the week the occupancy of technician capacity for small examinations without appointment during the hours of the day, and the projected impact for the waiting times during those hours.

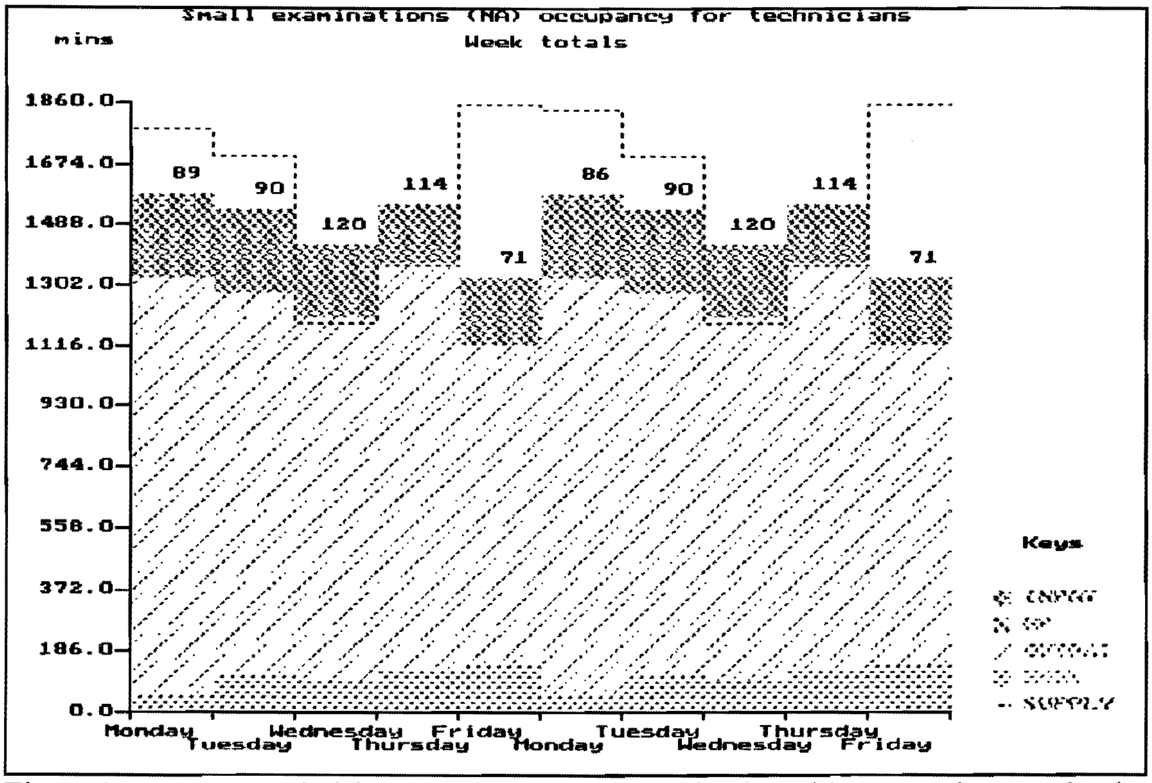

Figure 6: occupancy technician-capacity for small examination without appointment for the days of the week

From figure 6 one can see that Wednesday and Thursday are the busiest days with occupancies of over 100%. The drawn upper line shows the rest-capacity left for small examinations without appointment. The capacity needed for the direct patient flow is shown below (see keys for origin of flow). The technician capacity proved to be the most scarce resource for the x-ray department and not the room capacity or the radiologist capacity. Figure 7 shows for Wednesday that the busiest hours during the day are 9-12 and 14-16. Because there is not enough capacity during the day to cover the peak hours the end of the day shows a considerable build-up of waiting time.

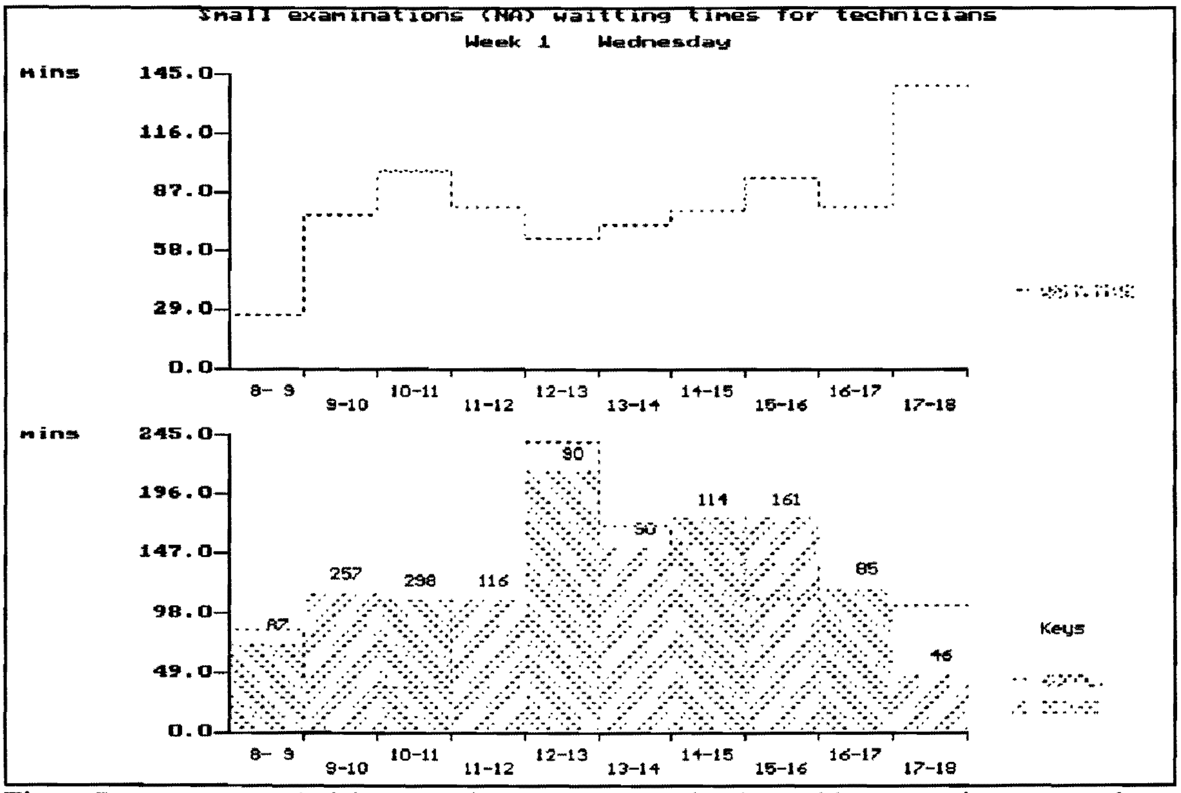

Figure 7: occupancy technician-capacity for small examinations without appointment per hour for Wednesday

Analysis of the outpatient department's time-table and the referrals for direct examinations from clinics showed that general surgery and pulmonology offered the best opportunities for improvement. Figure 8 shows the direct patient flow for small x-ray examinations without appointment as a result of general surgery clinics during the week.

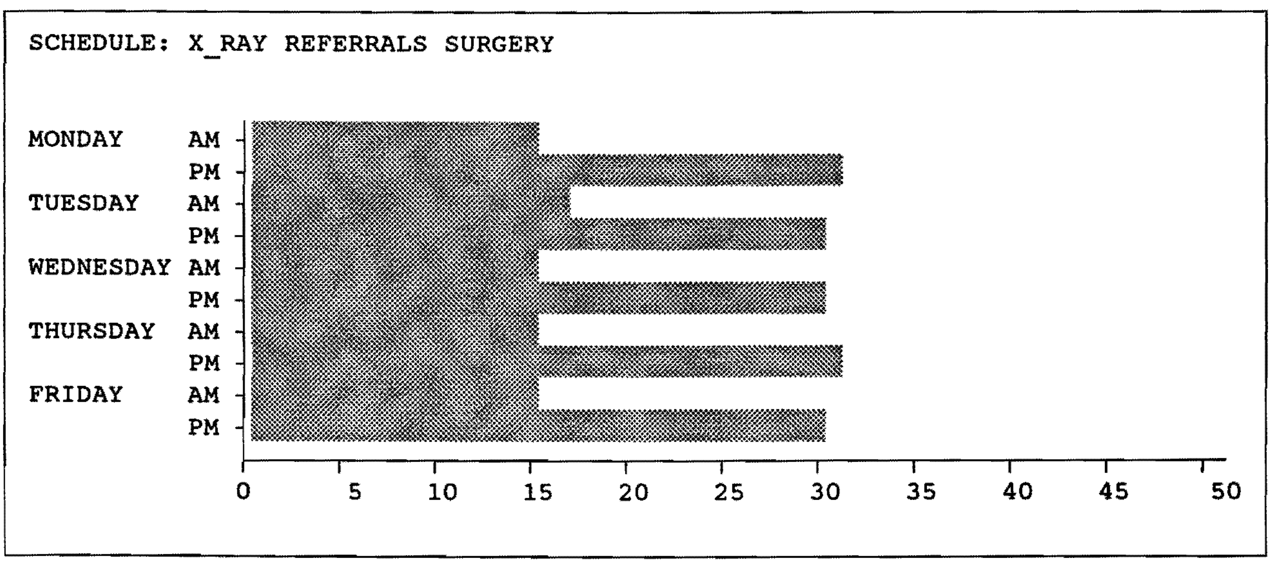

Figure 8: impact referrals from general surgery clinics to the x-ray department

From figure 8 one can see that most referrals are in the afternoon. These patients will probably incur long waiting times at the x-ray department because of the peak in the x-ray department's workload during midday. Something similar was the case with pulmonology, that had clinics every afternoon with approximately 8 direct referrals to the x-ray department.

The second part of the project, the change phase, is still underway. The two working committees have been installed recently. The first meeting of each of the committees was devoted to a discussion of the results on the interface between the x-ray department and the outpatient clinics. The participants acknowledged the problems indicated and brought forward possible explanations. It was decided to collect some extra data to get more insight into possible solutions. For pulmonology, for example, the x-ray department thought it would be possible to make a reservation for every afternoon for 8 small examinations without appointment. Pulmonology proposed to send a list of clinic appointments a few days before the clinic was held, indicating the patients that would likely be referred without appointment. In this way an 'unpredictable' patient flow to the x-ray department became a planned flow.

7. Case three: a dynamic approach to capacity planning and allocation for inpatient resources

The third hospital is also a 350 beds hospital, but with 12 specialties. Previous investigations showed inbalances in the use of inpatient resources. One specialty did have a shortage of operating theatre time while the use of beds was below standards, another specialty showed a shortage of beds. Allocation of resources was based on historical 'rights' rather than on real data on use of resources. Up to now it was almost impossible to discuss a re-allocation of resources. However, a number of specialties have asked the hospital management to reconsider the allocation of resources, because they face increasingly problems with too long waiting lists. The hospital management has decided to start a project to reach for more flexibility in the use of resources by developing a yearly revision of the allocation of inpatient resources (beds, theatre time, nursing staff). The project's objective is to develop a dynamic capacity planning and allocation for inpatient resources taking into account developments in the catchment area and technology and a balanced use of use of resources per specialty. This will involve the use of the model 'Patient Flows and Resources' to look at the longer term projection of patient flows and resource needs, and the model 'Inpatient Capacity Management' to look at a balanced use of inpatient resources. Because the hospital served as pilot for the development of the latter model they were familiar with the study on Hospital Capacity Management and very willing to act as case.

The project was performed by another MsC student(7). A projectteam was set up consisting of the hospital management consultant, the head of the planning department, the student and the author. The hospital admission policy committee - an advisory committee with representatives of specialties and managers of inpatient services departments regarding problems and development of admission policy and admission procedures - acted as steering group for the project. The project was divided into three phases dealing with the following questions:

- analysis of the influence of external developments on the patient flows to the hospital at the strategic level of planning, using the patient flow model;
- analysis of the present use of inpatient resources and the relationship between bed capacity, operating theatre capacity and nursing capacity at the management control level of planning, using the inpatient model;
- development of a method to allocate inpatient resources to specialties taking into account a match between the need for resources and the supply of resources and a balanced use of resources.

Regarding external developments changes in the population structure, in the demand for care and in the market-share of the hospital influence the flow of inpatients to the hospital. An increase of 6% in admissions in 5 years time is expected due to population developments in the catchment-area, leading to a 5% increase in the bed-occupancy. The analysis of developments in demand and market-share did not show a trend for the hospital as a whole; some specialties, however, showed over 3 years time decreases or increases of more than 10%. The expected rise of the bed-occupancy to 91% in 1995 can be reduced to the present 85% if the decrease of the length of stay develops as indicated by the specialties consulted.
The analysis of the present use of bed capacity, operating theatre capacity and nursing capacity lead to the following results:

- At hospital level the bed capacity is the bottleneck capacity. The average bed occupancy of 85% is high, leading to 'admission stops' during busy periods.
- The present allocation of beds to specialties deviates strongly from the actual use of beds by some specialties. There are specialties with below 65% occupancy and specialties with above 100% occupancy.
- The operating theatre capacity on hospital level is enough to meet the demand. The average occupancy of this resource is 75%. However, the occupancy on some days is on average much higher than on other days.
- The workload for the nursing staff on hospital level is about 90%. This seems to be OK, compared to the 100% that is used as reference for an optimal nursing workload level. However, there are large variations on ward-level from day to day.
- There is a relation between the use of the three inpatient resources. Bed and nursing resource use are on the same level while the operating theatre resource use level stays behind. This applies as well as to the busy periods in the year as in periods that are considered as average.

The development of the inpatient resource allocation method was triggered by the bottleneck capacity beds. The demand for beds per specialty, using data on actual use of beds, was used as a starting point for bed allocation. The left-over capacity of beds can be used by the hospital management to stimulate those specialties that need to grow according to the overall hospital strategic policy plan. Next, the two other inpatient resources need to be allocated, taking into account a balanced use between the already allocated beds and the operating theatre capacity and nursing capacity.
The presentation of the results of this project and the method proposed for future re-allocations of inpatient resources in different meetings in the hospital found much approval and support. Implementation of this proposal - which did not make part of this project - will be decided upon in the near future. The management of the hospital regards the proposed method an important step forward to a better use of the available hospital capacity.

8. Discussion of case-study findings.

Even though the case-studies are not finished yet, it's possible to discuss the main findings in this third part of the project on 'Hospital Capacity Management'. The evaluation of each of the case-studies that are still under way will provide more material later-on.
As research questions for the case-studies were mentioned in paragraph 3:

- What has changed in the use of resources?
- What is the contribution of the approach used in the case-studies?
- What other impacts to occur?
- Under which conditions can these results be obtained elsewhere?

We will look at each of these questions in more detail.

Change in resource use.
Each of the cases, including the reference-case, looks at a different resource management issue:
- OT time-table re-organisation (reference-case)
- re-organisation general surgery (case one)
- interface x-ray department and outpatient clinics (case two)
- re-allocation plan for inpatient resources (case three).

The correspondence between the cases is that all cases look at a change introduced in one particular subsystem of the hospital and at the consequences of this change for other subsystems within the hospital, creating a global hospital perspective on resource use. In each of the cases considerable resource impacts could be visualized because of the many shared resources and the dependencies between resources. The difference between the cases is that some are linked to a re-organisation (reference-case and case one), another case is not linked to a re-organisation but concerns a subject selected as an opportunity for improved operations (case two) and the last case regards the development of a plan with at this stage no implications for resource use.

Contribution of approach and models.
In each of the cases models were used to visualize resource impacts of the present situation and alternatives considered. The models performed quite well in this respect. They provided information in a comprehensive and easy understandable way - information that would otherwise involve a lot of energy and quantitative insight. They helped to create a shared understanding about the diagnosis of the problem studied. More-over, they brought decision-makers together around the table to discuss alternatives for improvement and not to dispute the correctness of data. However, before reaching this stage in the project it took considerable time, especially from the students, to collect the data needed to produce the information. Because of this, the time left for the change or implementation phase was sometimes short. The perspective of 'learning organisations' was important support for this change phase.

Other impacts.
The different cases show as other impacts:
- improved policy development for the specialty as a whole (case one)
- improved relationship between x-ray department and clinics (case two)
- improved insight into knock-on effects between resources that were up to now controlled separately (case three).

Alle the cases report improved insight into the functioning of the hospital as a whole.

Conditions.
If one uses the same approach to similar problems in other hospitals, there are no further conditions that need to be fulfilled to get to the same results. Even the contribution of the computer models could be substituted by traditional analyses of data; however, this would require more energy and offers less decision support. Projects that are linked to larger re-organisations already accepted offer more opportunities for resource use improvements than projects chosen for quality or efficiency reasons alone.

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