Hospital planning

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HOSPITAL PLANNING: AN OVERVIEW AND AN ILLUSTRATION

The paper will address problems and application-areas of operational research in the hospital sector. Also practical experiences are reported. A distinction will be made between planning at the operational level, the management level and the strategic level. Thus, the applications discussed will range from admission planning and workload-measurement to resource allocation and resource planning.

Apart from this state-of-the-art of hospital planning, the paper also describes one practical application at the strategic level: a decision support model for investigating regional patient flows. This model was developed to help hospital management in decision regarding the amount of resources needed to cope with present and future patient flows facing the hospital.

1. Introduction

From the start of Operational Research in health care, hospital planning has been one of the major application areas.

A number of reasons can be given to explain this "popularity". First of all, hospitals do represent the most obvious and concrete manifestation of health services in a health care system. Second, the costs of hospitals account for about half of health care expenditures in a country. Third, hospitals are extremely complex organizations, for more complex than the average commercial or industrial organization.

This makes hospitals an obvious area for research to improve the effectiveness and efficiency of health services. We expect this also to be true for the future. Although OR-research up to now has produced "solutions" to a number of problems faced by hospitals, there will be always new challenges. In the past most research was concerned with

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1 National Hospital Institute, Utrecht and Eindhoven University of Technology, the Netherlands
improving the performance of one department, mostly on the operational and tactical level. For the future we expect a shift to the strategic level and to improvements in the overall performance of the hospital as a whole.

Also the type of contribution made by OR will change. Traditionally OR-studies aimed at finding optimal solutions, or, in a later period and less ambitious, at finding satisfying solutions. But whatever the quality of the solution, the OR-approach always succeeded in structuring the problem: showing the impact of different variables on the outcomes, the appraisal of outcomes by the decision-makers involved, etc. These strong points of OR, combined with the big developments in computer technology, account for a new type of OR-contribution: decision support models that can visualize the impacts of alternative actions and support the decision making-process. A logical next type of contribution will be OR-models as a tool of change. By focusing the contribution of OR on how to bring about change in an organization, the emphasis is back again on implementation.

The paper will address problems and application-areas of operational research in the hospital sector.

Paragraph 2 introduces in more detail hospital planning: the different levels of planning and the problems at each level in the hospital-organization that can be addressed by OR-studies.

Paragraph 3 presents in a nutshell an overview of OR-application in hospital planning.

More detailed information can be found in the contribution of P.C. O'Kane to the book "Operational Research Applied to Health Services" [1]. The second part of the paper consists out of an illustration of an OR-approach to decide about the amount of resources needed for a hospital to cope with the demand by patients.

2. Hospital planning

Objectives

Any essay on planning should first address the objectives of planning. However, this is one of the most difficult parts of hospital planning, compared with planning in industrial systems. A hospital can not be approached as one system. Rather a hospital can be looked at as a number of subsystems having different objectives. Using a stake-holders approach to the hospital you will see that there are many decision-makers and that there is not one general objective for the
hospital. Of course there exists some overall-objective which is usually expressed in such general terms as "to provide the best care possible for the patients with the available resources". However, this is too vague. Furthermore, it would require agreement of a number of people that have different sub-objectives. These sub-objectives are often in conflict. This makes decision-making in a hospital very difficult. Two examples will illustrate this. For instance, clinic times will usually be arranged to meet the specialist immediate objectives, but the result may be to cause very uneven workloads on medical department like X-ray and laboratory. Thus the specialist’s objectives will be in conflict with the objectives of those responsible for the efficient running of these departments.

Also allocation of resources is a frequent source of conflict. Because the total amount of resources will be always limited, any extra allocation to one unit in the hospital will cause less availability of resources in another part of the hospital. This will result in not meeting the objectives of planning by the unit whose resources are decreased. This shows clearly that decision-making in hospital is difficult and that OR can make a major contribution by showing the underlying structure of the system and the interaction between the subsystems. This may contribute to resolving conflicts between subsystems and to avoiding sub-optimization.

So, instead of using one overall-objective for the hospital, it is better to distinguish between to conflicting categories of planning-objectives:
- department planning: how to optimize the service rendered by the department with the available resources
- patientflow-planning: how to optimize patient-throughput to meet patient-demand.

Allocation of resources forms the link between those categories of planning.

Levels of planning

It is important to distinguish between different levels of planning: strategic, managerial and operational. Planning at the strategic level involves deciding about the amount of resources needed to perform the services set as objectives for the hospital. This is long-term planning with a time-horizon of more than one year. Planning at management level involves decision about the
allocation of resources to the different units to reach the production volumes agreed. This is medium-term planning with a time-horizon of 3 month to one year. This level is also called tactical planning.

Planning at the operational level involves decision about the scheduling of patients to meet service-criteria and to make the best use of resources available. This is short-term planning with a time-horizon of 1 week to 3 month.

The different levels of planning and their relation to services and resources are shown in figure 1.

<table>
<thead>
<tr>
<th>services</th>
<th>resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>strategic</td>
<td></td>
</tr>
<tr>
<td>what services</td>
<td>what resources do we</td>
</tr>
<tr>
<td>we want to offer</td>
<td>need and how many</td>
</tr>
<tr>
<td>management</td>
<td>how to allocate</td>
</tr>
<tr>
<td>how to organise</td>
<td>resources to departments and specialties</td>
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<tr>
<td>services to meet</td>
<td></td>
</tr>
<tr>
<td>service-criteria</td>
<td></td>
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<tr>
<td>and resource criteria</td>
<td></td>
</tr>
<tr>
<td>operational</td>
<td>how to optimize</td>
</tr>
<tr>
<td>how to optimize</td>
<td>short-term adjustment</td>
</tr>
<tr>
<td>day-to-day</td>
<td>of resources in case</td>
</tr>
<tr>
<td>scheduling of</td>
<td>of peak-loads</td>
</tr>
<tr>
<td>services</td>
<td></td>
</tr>
</tbody>
</table>

Figure 1: Levels of planning services and resources in hospitals.

As illustrated in figure 1, there is a hierarchy of planning. Higher levels of planning determine the boundaries for lower levels of planning.

If, for example, there is general shortage of nursing staff, planning tools are limited to management level. Options left to consider are to allocate the available staff according to the workload to the different wards, or to reorganize services to make better use of the available resources, for example by adapting admission-policies.

Problem areas

The above scheme of planning categories already indicates problem areas in hospital planning.
However, to use better labels for identification of problems covered, we will use the following list of application-areas of OR to planning problems in hospital:
1. hospitals, general
2. outpatient scheduling
3. inpatient scheduling
4. nurse staffing
5. support services

This classification is based on an eerie classification of application areas by Stimson and Stimson [2] and Boldy and Clayden [3]. We will discuss the different application-areas in more detail in the next paragraph. Each of the areas contains OR-contributions on strategic, management and operational level. By combining application areas and levels of planning one gets a matrix that can help to identify a single OR-application (see figure 2).

<table>
<thead>
<tr>
<th>application areas</th>
<th>levels of planning</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>strategic</td>
</tr>
<tr>
<td>1. hospitals, general</td>
<td>demand-supply models</td>
</tr>
<tr>
<td></td>
<td>outpatient dept. appointment simulation systems</td>
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<tr>
<td>2. outpatient scheduling</td>
<td>ward simulation</td>
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<tr>
<td></td>
<td>manpower planning</td>
</tr>
<tr>
<td>3. inpatient scheduling</td>
<td>x-ray department</td>
</tr>
<tr>
<td>4. nurse staffing</td>
<td></td>
</tr>
<tr>
<td>5. support services</td>
<td></td>
</tr>
</tbody>
</table>

Figure 2: Overview application areas.

Some examples of planning are mentioned. The reader can fill in other examples known to him or her. Just to illustrate, we will focus on area 4: nurse staffing. Contributions at the strategic level look at the amount of nursing staff need to cope with the demand for care; this is called manpower planning. OR-studies on workload of nursing wards try to identify areas of understaffing, which can lead to other allocation of nursing staff. OR-studies on rota systems try to schedule the available nursing staff on a day-to-day basis taking into account holidays,
study-leaves, etc. Again, these examples illustrate that higher levels (available manpower) set boundaries to lower levels of planning.

3. Overview of applications

This paper does not permit a complete elaboration of projects falling into the application categories mentioned before. Nor does this paper attempt to be complete in this overview of applications. The reader that would like more information is referred to other authors like O’Kane [1], Stimson and Stimson [2], Boldy and Clayden [3] and Luck, Luckman, Smithand Stringer [4], that have produced excellent overview of this kind. Perhaps a bit outdated, they still represent well-documented examples of OR-contributions to hospital planning problems. Rather I will try to describe more qualitatively and sketchy the different application areas and the type of contributions by OR to solving problems in these areas.

Hospitals, general

Up to now most OR-studies have concentrated on subsystems of the hospital rather than on the hospital as a whole. Studies that have tried to encompass the whole hospital often got entangled in the complexity of the hospital organization, resulting in complicated models that did not reach implementation. For example, studies to determine the optimal size of a hospital. Hospital applications in this area are predominantly of a strategic kind.

More recent applications in this area are less ambitious (no optimization is attempted), and take the form of decision support models. Using real hospital data these models try to visualize the impact of, for example, different models of care: outpatient care in stead of inpatient care, etc. One of these studies is listed in the references. The illustration on the next paragraph is part of this study.

One other type of problem falling into this category is multi-location management. As more hospital are going to merge into bigger hospital-systems, medical staff and facilities are to be managed over the different locations the hospital system encompasses.

Outpatient scheduling

One of the classical areas of OR in hospitals is scheduling of outpatient classic in hospital. This is because waiting-times in outpatient department are one of the most-occurring complaints of
patients visiting the specialist. Using mathematical techniques of queuing theory it was possible to estimate the effect on waiting-time with varying appointment systems. More recent simulation approaches have increased the insight into the balance between waiting for patients and waiting (idle-time) for medical professionals. However, long waiting times still exist. More improvements can be expected if consumer-organizations will take position in what is supposed to be a right balance.

Inpatient scheduling

Admissions of patients to hospitals are either scheduled admission or emergency admissions. The second category is out of control by the hospital, but one can determine on average the amount of capacity needed to cope with these emergencies. Scheduled admissions are used as control mechanism to make the best use of resources in inpatient care, like operating theaters, beds and nursing staff. Also studies that look at waiting list problems fall into this area of applications. There are many example-studies which could be mentioned, because this is also one of the classical areas of OR in hospitals.

Nurse staffing

As nursing staff shortages are nowadays a problem in most countries there is a revival of studies in this area. One important category of studies deals with visualizing workload in nursing wards. This involves classification of patients according to their needs of care and assessing needs. A more recent development is to use these nursing workload data also in the triangle admission-planning - operating theatre workload - nursing workload.

In this way a link is developed between this application area and the previous area of inpatient scheduling. The area of nurse staffing differs from the other areas in a well-developed relation between strategic planning, planning at management level and operational planning. This was already mentioned when we illustrated figure 2. At operational level a lot of energy has been spent at developing a duty rota system for day-to-day scheduling of nurses. This appeared to be very difficult, because the large number of variables involved. Again, a less ambitious level of support by a computerized nurse scheduling system seems to produce the best results.
Support services

This area contains applications looking at a wide range of supporting services, like X-ray and laboratory (medical service departments), catering, cleaning and laundry (hotel services) and purchasing and storing of supplies (commercial services). The X-ray department is one of the major subsystems of the hospital. It has been the subject of many OR-studies. The X-ray department has to deal with inpatients, outpatients and patients sent in directly by general practitioners. This makes managing an X-ray department a difficult task. Especially because a large part of the X-ray workload (outpatients) is determined by the way outpatient clinic are organized.

Since hospitals carry large amounts of a variety of items, inventory control studies have been another important area of application from the start of OR in hospitals.

More-detailed information regarding these application-areas can be found in the overview-publications, mentioned earlier [1]-[4]. An attempt has been made to list as references a number of more recent OR-studies for each of the application-areas discussed. Drawing heavily on the papers presented at previous working group meetings and the authors experiences in these areas, the references mentioned should be regarded as a selection and not as a complete overview of OR-studies performed in each of the application areas.

4. An illustration: a DSS-model for resource-planning of hospitals

The patientflow models is a decision support model that has been developed to support hospital management to balance resources with demand for services by patients using the hospital. The model visualizes the impact of changes in population, demand, orientation to hospitals and alternative models of care, on the flow of patients to hospitals in a geographical defined area and on the need of resources to cope with this demand.

The model in its present condition is to be regarded as a first prototype. It has been developed in cooperation between the National Hospital Institute and a hospital in the eastern part of Holland. The experiences with this prototype will be used to improve the model for general use by hospitals.

Planning problem

The pilot-hospital was a merger of three local hospitals, two big hospitals of 400-450 beds and one small hospital of 150 beds. Together they serve a population of about 250 000 inhabitants.
Because of this merger the hospital wanted to redefine its services that is way the management was interested to project the expected flow of patients to these different hospital-locations and their resource-implications. More specifically, the following list of questions illustrate the managerial context of the problem:

- What are the effects of changes in the population, such as: increase or decrease in the size of the population, growing percentage of elderly people?
- What are the effect of change in demand for hospital care, such as: increase of cardio-vascular diseases, cancer, hip-replacements?
- What are the effect of changes in alternative models of care, such as: increase of day-surgery and outpatient care, decrease of length of stay?
- What are the effects of changes in orientation of patients to hospitals, because of a new specialty, improvement in the reputation of a specialty, or a marketing-campaign with a new type of clinic, etc?
- What are the effects of changes in the environment of the hospital in general, for example in the specialty-mix of competing hospitals?
- What are the effects of changes in the amount or configuration of resources, for example combining resources of the same type on one location?

These are the type of management questions that have load to the development of the patientflow model.

Outline model

Looking at the list of questions one can already see the main components of the model: population, demand, orientation and hospital characteristics (resources).

The outline of the model is shown in figure 3.

```
DEMAND
population by age-sex cat

orientation

demand by age-sex cat.

SUPPLY
hospital A
specialties
beds, clinics
theaters etc.

hospital B
specialties
beds, clinics
theaters etc.
```

Figure 3: Outline patientflow model.
Demand is this approach is met by supply via "orientations". This is the percentage of patients that require a given specialty and use a given hospital included in the model. Orientations offers a structure to reflect changes in a hospital's relative attractiveness to patients. It is mainly this feature of the model that makes it different from the PHASE-model developed by D. Clayden (Leeds University) in 1983-1985. PHASE (a resource allocation model in health care) looked at patient flows and resources from a regional level of planning. The patient flow model looks at patient flows and resources from the viewpoint of an individual hospital. This makes it suitable for marketing purposes of a hospital as well as regional planning of a number of hospitals. This paper does not permit a more elaborate description of the model. More documentation is available.

Application

To use the model you need data about population, inpatient demand and orientation. Population projection data are generally available. In Holland almost all hospitals participate in a national information system on hospital inpatient care. This makes it possible to produce statistics about demand and about orientation of communities on neighbouring hospitals. Availability of these data could be a problem in other countries. However, you need these data to be able to look at demand supply at a local level. Having dealt with data, one can use the model to show the impact of a number of changes, such as:
- Changes in the hospital characteristic. For example increasing the number of beds one specialty and decreasing it for another specialty to get a more balanced occupancy-rate of beds.
- Changes in the patient orientation. For example, one expects an increase of orientation to the hospital because of the introduction of a new specialty in the hospital.
- Changes in the demand. For example, one expect an increase of demand for cardiology by elderly people.

These are the type of changes that can be support in terms of visualizing the impacts of these changes on the use of resources, like beds, operating theaters, etc.

More detailed information about the use of the model and the available output can be found in the documentation of the model.

5. Conclusions

I hope that the previous paragraphs have illustrated the content of hospital planning and the range of OR-applications in this area.
From this we can draw the following conclusions regarding OR and the hospital sector:
- Hospital planning will stay as an important area of OR-applications.
- Applications will shift to the strategic level and to visualizing the overall-performance of (parts of) the hospital.
- It's not so much the application-areas that will change, but the type of contribution the OR-model has. This will move from an optimizing contribution to a decision support contribution. This will decrease the level of ambition of the solution, but it reflects better the multi-decision making hospital organization, where improvements are reached via negotiations between the different parties involved. In this type of organization communication becomes very important. A decision support model - regarded as a vehicle for the OR-model - can provide this information. Moreover, it eases the use of OR-models by decision-makers - models that were up to now mainly in the hands of researches advising decision-makers.

OR in hospitals has until now been predominantly occupied with subsystems within the hospital and sometimes with the hospital as a total system. This has resulted in a deep insight into the behaviour of the hospital as a system. This knowledge of the hospital and its components makes that OR can play an important role in improving the contribution of the hospital as a subsystem of health care (e.g. bridging the gap between primary care and hospital care), which I see as yet another challenge for hospital OR.

References


Hospitals, general:

Outpatient scheduling:


Inpatient scheduling:


Nurse staffing:

[16] T. Ross, A nurse staffing model for a university hospital adult ward, ORAHS-meeting 1989, Urbino Italy.

Support services:


PLANOWANIE SZPITALNE - PRZEGŁĄD I ILUSTRACJA

Artykuł dotyczy problemów i obszarów zastosowań badań operacyjnych w sektorze szpitalnym. Omawia również doświadczenia praktyczne. W artykule pokazane są różnice pomiędzy planowaniem na poziomie operacyjnym, poziomie kontroli zarządzania i poziomie strategicznym. Odpowiednio, omawiane zastosowania będą obejmować problemy: od planowania przyjęć szpitalnych i pomiarów obciążenia, do alokacji i planowania zasobów.

Oprócz ogólnej analizy zagadnienia planowania szpitalnego, artykuł opisuje również zastosowania praktyczne na poziomie strategicznym: model wspomagający decyzje dla badania regionalnego przepływu pacjentów. Model ten został opracowany aby pomóc kierownictwu szpitala w podejmowaniu decyzji dotyczących wielkości zasobów niezbędnych do właściwej obsługi obecnej i spodziewanej liczby pacjentów szpitala.