

# Hospital production system modelling and simulation insight of operating theatre planning

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Nowadays, hospitals undergo massive changes. The changes in demography (e.g. ageing), in economy (work organization, European harmonization) and in the society (unemployment, precariousness) destabilize the way hospitals usually work and their economic balance.

To face these problems, the social protection system has to turn over a new leaf. This system that has been in a crisis for more than thirty years has experienced many plans to control outlays related to health. These plans lead to the reduction of health services' budgets and keep only those deemed financially viable (that is in relationship with the costs/efficiency criterion) alive (Claveranne et Lardy, 1999 ; Cremadez et Gateau, 1997 ; Beresniak et Duru, 1995). Besides, the rise in competition in Europe compels private and public hospitals to modernize themselves (e.g. equipment) and to produce more (the number of patients, duration of the stay at hospital,...). On these challenges depends the hospital efficiency, in other words their survival.

The objective that hospital managers must reach is to optimise its production by meeting the customers' demands. It is translated into a rational use of resources (human, financial and material resources) and the maximization of the customers' satisfaction, who contributes to the enterprise's durability. This ambition is really hard to achieve since :

- Hospitals have to meet a demand that depends on the seasons;
- Material and human means used to meet this demand are not always the same for a given pathology (which defines the kind of service to be offered) and are limited;
- Although health care procedures do exist, the notion of technical data is not as obvious as for the manufacturing industry.

Conversely to the industrial sector, hospitals can't freely determine their tariffs but have to guarantee appropriate and high quality health care at the lowest cost. Controlling the cost price is the only thing to be concerned with and is thus a necessity.

In other words, hospitals can be considered as a service enterprise offering several kinds of products that are subjected to constraints resulting from limited human and material resources, and which is trying to offer better health care and to spend less money at the same time. The main feature of this enterprise is the difficulty in quantifying and formalising its processes.

In the field of hospital management, the planning of material and human resources is achieved on the basis of health care expectations and by taking the heavy constraints of the personnel (e.g. a reduced number of practitioners, personnel's varied timetables, timetables that are specific to the practitioners etc.) into consideration. This process aims at the improvement of the quality criteria (time patients have to wait, number of patients waiting before being treated etc.) as well as the minimization of cost criteria (supplementary work hours, equipment usage cost). This prediction-based management must be flexible, so that we can include the hazardous nature of hospital activities. It can be compared with the preparation of an organized planning for any industries' production.

In a more limited context, the optimisation of the hospitals production system can't be achieved by taking all the services into account. To the best of our knowledge, the analysis of a determined service or of a prominent activity seems more realistic and fruitful. We are more particularly interested in the operating theatre management, which is the actual matter of great concern to hospitals. Planning operations is really difficult to get. Indeed, hazards (emergencies, complications etc.) may change the initial planning. Moreover, the most sophisticated surgical operations are difficult to standardize and, consequently, to coordinate. Finally, the importance of the services and of the number of people involved in the treatment process (before or after the operation) hinders considerably optimal organization.

In this research, simulation is of the utmost importance. It has three advantages. At first, it can help us realize how an operating theatre works. It allows us then to implement and to test planning algorithms or heuristics coming from the production management. Finally, it involves risky phenomena that are peculiar to hospitals' activities.

In general, the main steps to the achievement of a simulation project are how to delimit the problem, how to conceptualise and to build a model that can be treated, how to instantiate it (information supply), how to use it and, at last, what decision has to be made.

Some specialists' articles have already shown how the simulation approach can be applied to a hospital management problem (Jun et al, 1999) . What makes our approach original is how to instantiate this model.

Two important parameters have to be taken into account for any traditional simulation model :

- The patients' arrival rates;
- The duration of operation (how long the operation lasts).

As far as the duration of operations is concerned, specialists usually use averages arranged on the basis of operations records.

Now, we deem this way of working inappropriate. In our opinion, it is really necessary to link the duration of operation with the operated patient's characteristics. For example, will the same kind of operation last the same time for two women, one of 20 and the other of 60? We don't think it can be possible. Even if the question appears to be rather simplistic and though we can expect the 20-year-old woman to recover faster than the older, several other factors may come into play, in a more accurate assessment of the duration of a stay at hospital or in the detection of hypothetical complications, for example.

We have consequently tried to improve the way the duration of an operation can be calculated according to the operated patient's profile. This has two implications for the simulation model as, on the one hand, the duration of operation must be determined on a dynamic basis according to the patient's profile and, on the other hand, the creation of the model's entities, which correspond to the

patients to operate on, must take this supplementary information into account, making it possible to generate a determined patient's profile and giving more precision about the kind of operation that each patient must have.

Our research unfolded in several steps. It must be noted that we collaborated closely with a hospital in the surroundings of Mons (Belgium).

Firstly, we had to collect all the information regarding the patients staying at this hospital. To make it more easier to understand, we focused on a determined service of this hospital : the orthopaedics service. The gathered information is of three kinds :

- Information about the patient's privacy (name, age, home location etc.)
- Information about her/his stay at hospital (when she/he arrived at hospital, the services that he/she has been offered, the technical care that she/he has experienced, details about the operation, duration of the stay at hospital etc.)
- Medical information about the patient (pathologies, main and secondary diagnosis, the kind of operation etc.)

Secondly, the gathered information, and more particularly the information about the stay of the patient at hospital, allowed us to draw up a rather general draft of simulation model that shows the different patient flows through the concerned service. It must be noticed that the temporal information (duration of operation, duration of stay) have been calculated on the basis of averages per pathology and kind of operation, just to see if our first model works in practice, while establishing a closer connection with the orthopaedics service's present way of working. It should be remarked that the simulation project has been carried out with the AWESIM software (Pritsker et al, 1997).

Thirdly, we focused more particularly on the main core of our research, that is the adjustment of the temporal information, and more precisely about the duration of operation, according to the patient's profile. To reach this goal, we used methods from data mining and, to be more precise, the rough set theory.

Rough set theory developed by Pawlak (Pawlak, 1991) proved to be a very effective tool for the analysis of information describing a set of objects (patients) by a set of multi-values attributes (medical and social data). On the basis of an information system including objects classified according to the decision maker knowledge, the rough set approach allows us to deal with two major problems :

- Reduction of the set of attributes in order to build a minimal subset of independent attributes ensuring the same quality of sorting as the whole set. All superfluous data are eliminated;
- Generation of a set of sorting rules from the reduced decision table

It is worth saying the whole analysis has been carried of using ROSE software (Predki, 1998).

In fact, we used this method to determine the factors that are the most explanatory of a great change in the duration of operation. So, we have at first created sets of patients with roughly the same duration of operation. On the basis of these sets, the rough set theory helped us to determine the profile of the patients and classify them into the right category according to the duration of operation.

The obtained results are a set of decision rules of the following kind : if...*conditions*, then...*action*, precisning that if the patient present this or that characteristic, we can say that she/he belongs to the category of patients whose duration of operation will be the one represented by the corresponding set.

From these profiles and this set of rules, it is consequently possible to use the simulation model in a different way, no more by using averages about the durations of operation but by giving more precision about these averages according to the profile of the patients who must have an operation.

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