Hospital Planning Environment Variables Applied in Practice: A Multiple Danish Case Study

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Abstract. The issue of hospital planning has taken a central position in increasing hospital performance. Applied hospital planning methods are found to be misaligned with hospital environments in existing research. Thus, it is relevant to increase the understanding of hospital environment variables in order to improve applied hospital planning methods. In this paper, we identify and describe the hospital environment and applied planning methods from an environment variables perspective through an in-depth case study of three Danish hospital environments and their corresponding adaptive planning frameworks. The results include suggestions for further research on improving the match between identified environment variables and the corresponding planning methods.

Keywords: Hospital environment variables, hospital planning, case study.

1 Introduction

During the previous decade, public healthcare expenditures in Western European countries have increased drastically, especially in secondary healthcare providers, i.e. hospitals. Due to this large share of total expenditures the issue of hospital planning and control has taken a central position in increasing hospital performance. Existing hospital planning frameworks have been inspired by manufacturing planning and control [1] [2] [3]. In hospital industry, the patient flow is important and is not the same as the material flow[4]. Hence, the planning and control of the two environments will be different. Thus, it is relevant to conduct empirical evaluations of hospital planning and control approaches in the relation to the planning environment of a hospital. This papers objective is to describe the current planning processes based on case studies with the purpose of identifying and understanding the hospitals planning environmental variables in relation to planning and control. From previous research, we have identified planning environmental variables for the hospital industry, which can be grouped into three category, namely: patient, resources, and process [4]. Thus, this paper will identify the hospital environment and applied planning methods from an environment variables perspective through an in-depth case study of three Danish hospital environments and their corresponding adaptive planning frameworks.

2 Method

An in-depth multiple case study approach has been conducted comprising a total of three case studies [1] from different departments in two Danish Hospitals:

1. The department of Heart-Lung Surgery (case 1),
2. The department of ear and throat cancer treatment (case 2),
3. The emergency department (case 3).

Both hospitals are large hospitals with a bed capacity of 929 beds and 482 beds respectively. The cases were chosen from different hospital processes to identify the variety in the processes of the operations within similar applied planning frameworks, but within the same country and regional setting to avoid cultural environmental effects [5]. Data on environmental variables was derived primarily through interviews, conducted using a semi-structured interview guide. The environmental variables were identified through previous research study [4]. Furthermore, the applied planning framework was identified through a triangulation between results from the interview study, the formal planning framework of the case, and the requirements of the planning forecasting software applied in each case respectively. The total amount of interviews was 72 divided among the three cases, which is presented in Table 1.

Table 1. Overview of conducted interviews during the multiple case study.

Interviewees/Case	Case 1	Case 2	Case 3
Patients	7	3	13
Lab staff		3	2
Nurses	7	2	4
Administration/secretary	5	3	2
Special Doctors	2	4	12
General Practitioner			2
Ambulance assistants			1

Each interview lasted approximately one hour and, in addition, a total of 10 1-hour observation studies were conducted to observe the hospital processes in practice. All interviews were recorded, whenever possible, and notes were made during each session, followed by development of extensive summaries of each interview. Afterwards, recordings were transcribed and compared to the notes, and then analyzed using pattern matching and grouping of variables in a conceptually ordered display according to the procedures outlined by Yin[5],[6], [7].

3 Hospital Environment Planning Variables

The 3 case descriptions are structured according to the identified hospital environmental variable groups, explaining firstly the patients, secondly the resources, and thirdly the hospital process. The variables will be described in relation to their involvement in applied planning methods.

3.1 Case 1 - Surgery

Case 1 mainly performs surgical interventions after the treatment therapy of *the patient* has been determined. The department collaborates with other departments of the Clinical Center of Heart and Lung in determining a pathway of diagnosis and treatment of patients with heart and lung problems. Whenever, surgical intervention is needed to heart or lungs, the patient becomes the department's responsibility. In order manage and plan facilities and resources to job task, the patients are categorized based on their medical profile, where weekly surgery plans are made for only elective patients. The department has seven medical profile groups; four medical groups with heart specialty and three medical groups with lung specialty. However, prioritizing patients in the sequence of surgeries, the medical urgency is classified into emergent, urgent, and elective patients. Table 2 presents the classification of the patients;

Table 2. Patient group variables in case 1.

Patient groups		Medical profile complexity	Planning time frame	Patient volume
Heart	Emergent	High	Short	Low
patients	Urgent	High	Medium	Low
	Elective	High	Long	Medium
Lung	Emergent	High	Short	Low
patients	Urgent	High	Medium	Medium
	Elective	High	Long	Medium

The *hospital resources* are classified for execution purposes, except for doctors, who are classified in order to match patients' medical profile and patient urgency to the right competences in the planning activity. Doctors are classified as either clinical or research doctors, and according to level of experience. Operating theatre nurses are divided into assistance nurses, direct nurses, and a coordinator nurse. The coordination nurse along with doctors are responsible for coordinating and changing plans of the operations activity, informing the patient's condition for preparation and share and align the information with anesthesia staff and other staff from different parts of the hospital. All activities are coordinated through frequent meetings during the day due to regular changes and disruptions.

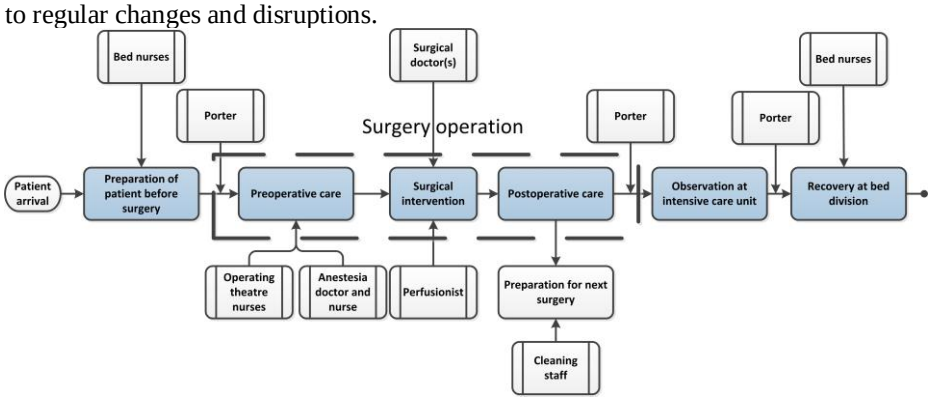

Fig. 1. Process flow in case 1

The *process* in the department mainly focus on the therapy phase, where there exist three entries for a patient to enter the department based on several gatekeepers or tiers in the hospital, which are Ambulatory of heart and lung, the Emergency Department, Cardiology, and Lung Medical department (in the clinical center). The elective patient can either come from the bed division or come from home before the surgery. A pre-operative process is organized to prepare the patient for the surgery by operating nurses, where the patient will be checked to make sure that their condition is as expected and medical supply will be prepared and checked before for the surgery. The surgical doctor, anesthesia doctor, and perfusionists will be involved during the surgical intervention until the end at postoperative care. After surgery the patient is transported to the intensive care unit for observation, thereafter the patient will return to the bed division for recovery. The process is depicted in Figure 1.

3.2 Case 2 – Diagnostic of Cancer

Case 2 is the Ear-, Nose- and Throat-department, treating ear and throat cancer particularly in the diagnostic phase. The department has classified *the patient* into three groups as depicted in Table 3.

Table 3. Patient group variables in case 2.

Patient groups	Medical profile complexity	Planning time frame	Patient volume
Emergency patient	High	Short	Low
Cancer patient	High	Short	Medium
Routine patients	Low	Long	High

Emergency patients are the most critical and are categorized as a highly complex medical profile. These patients are treated as fast as possible, whereas the volume of these patients are lowest, which is called a rush order in manufacturing terminology. The routine patients have a less critical medical profile, which gives the department a longer planning time frame. The volume of the routine patients is approximately 90% of the patients entering the department. The cancer patients are critical with complex medical profile due to time frame and high uncertainty in the diagnostic process.

The resources are managed by a department manager responsible for a leading chief doctor, a leading nurse, and a coordinator. Within the doctors group sub-specialties are present meaning that the doctors have different capabilities, divided into ear, nose and throat. However, the only planning resource, which is incorporated within the activity plan, is the doctors' work schedule, even though high interdependency with the personnel and supportive resources such as x-ray and pathology occurs.

The process of the cancer treatment is divided into a diagnostic phase and the treatment phase by the legislation of Minister of Health in Denmark, however the focus is narrowed to the diagnostic process flow The treatment begins when the department receives referrals from the general practitioner, the specialist doctors, or other departments, and a first consultation is required within 72 hours. Once the path coordinator books the first patient appointment, all the following consultations and therapy processes are booked in advance to make sure that they meet the service goal

from legislation. Even though, forecasts are essential, they are based solely on subjective opinions and historical views of the calendar. Thus, in order to ensure available times, the path coordinator reserves time slots for patients in advance, approximately two months beforehand and then they reschedule continuously. During the first consultation, biopsies are taken in order to diagnose the type kind of cancer the patient might have. Based on the medical profile and examination, the doctors will design the treatment plan in the diagnostic phase for the patient. The biopsies are sent to the pathological department for analysis and they have a permitted analysis time of five days. Most patients have to get scanned, MRI, CT or PET-CT scanner, which have an analysis frame of no more than two days. As the pathological deadline is the longest, the patient must wait for this result and come back five days later for a second consultation to be informed of the results. If a complex biopsy is required at the first consultation, the patient has a slightly different flow. The patient is put in full anesthesia and transported to the operation theatre of the department, where the biopsy is taken. After wake-up, the patient is sent home with an appointment for the second consultation. A generic view of the process is presented in Figure 2.

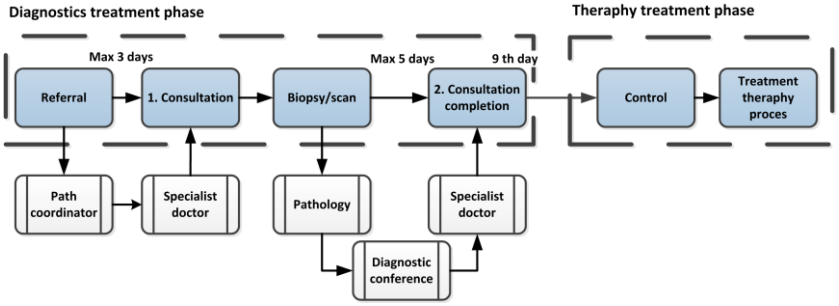

Fig. 2. Process flow in case 2

3.3 Case 3 - Emergency

Case 3 is the Emergency Department (ED) responsible for *accident and emergent patients.* The ED is a medical treatment facility specializing in acute care of patients without prior appointments, who come in either by their own means or by ambulance. Moreover, ED manages almost all hospital incoming patients and creates the opportunity to discharge patients more efficiently. The length of stay at the ED is maximum 48 hours, where other departments in the hospital need to take the patient into care afterwards otherwise a discharge will occur. This enhances the incentives to collaborate among departments of the hospital, integrate their plans with each other, and speeding the diagnostics process within the emergency department. In order to accommodate the variety of incoming patients the department has categorized the patients based on the triage-categorization as illustrated in Table 4. The triage-categorization is based on the planning time frame of medical urgency. If the patient is the triage color red then they are treated immediately in the trauma section. If the patient is orange or yellow and have to wait they are referred to the waiting section. The same is present with the green and blue triage colors. The department chief fore-

casts the volume of incoming patient types, which is used to estimate the peak of incoming patients every day and create an overlap between morning shift and day shift in order to accommodate the volume of patients.

Table 4. Patient group variables in case 3.

Triage-Patient	Medical profile complexity	Planning time frame	Patient volume (% of total)
Red	High	Zero	1 %
Orange	High	15 min	10 %
Yellow	Medium	60 min	13 %
Green	Low	120 min	26 %
Blue	Low	N/A	50 %

The chief of the department, the nurse coordinator, and the administration manager manage the department's *resources*. Each of these is responsible for doctors, nurses and secretaries respectively. From the resource capability perspective, the emergency department differs from other special departments as all doctors can provide the same job task, as well as for the nurses. They are trained to have the same capability within the emergency specialty, which means that manage and plan the resources become less complex. Daily planning consists of frequent meetings with all involved stake-holders to allocate resources and facilities most efficiently. However, the planned activity only takes doctors into account even though there is high interdependency with supportive resources such as x-ray and laboratory.

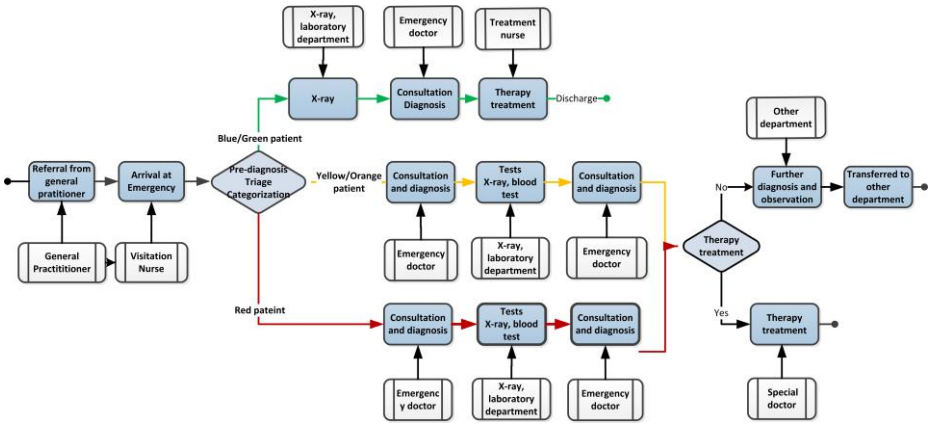

Fig. 3. Process flow in case 3

Figure 3 shows *the process*, which begins when patients are referred to the ED by practitioners in the office hours and by doctor from the emergency services outside office hours. The patient is then placed in a triage category (red, orange, yellow, green and blue) by a visitation nurse based on the information from practitioner's referral and examination of the patient. If, the ED can provide therapy treatment, the patient can go home afterwards. If, on the other hand, observation of the patient is necessary, the patient will be transferred to the emergency bed division. During the process the ED interacts with different supporting resources such as X-ray, laboratories, and other

special departments. Therefore, a need for close collaboration and integration with plans with others unity is necessary to provide efficient health care service in the ED.

4 Discussion

The analysis indicates several challenges regarding planning and control of incoming patients and resources. The cases are different in patient requirement, resource availability, and process flow. It indicates that there does not exist a silver bullet approach for hospital planning and control. Thus, a more patient oriented approach such as differentiated planning and control is needed. The process flow of case 1 shows, the focus should be predicting the lead time, since this is the most critical element. Time is also critical in case 2. Hence, the process flow shows that it is important to be within the estimated lead time otherwise postponement will occur for other planned surgeries in line. The process in case 3 is very different from the other two cases, since it has the least linear process flow. Therefore, the focus here relies on short timeframe, patient predictability, and fast determination of resource requirement for incoming patients. Thus, Case 3 planning environment requires flexibility and agility in the planning in order to accommodate the different type of patients.

All three cases deal with the high complexity, high variability, and high uncertainty, especially within patient variables. The high uncertainty increases the risk of induced changes and disruptions in the process affecting other patients negatively [8], unless appropriate approaches of dealing with uncertainty occur. To accommodate for the uncertainty, all three cases use large time slots, slack time, and frequent meetings for both information sharing, coordination, and re-scheduling. Furthermore, all three cases use simple planning methods, which only include elective patients, even though historical data is stored for use in more reliable planning methods. Thus, we suggest that '*applied hospital planning can be significantly improved through incorporation of existing patient variables and historic data in hospital planning methods'*.

Resource constraints are one of the cornerstones in hospital planning [9]. Despite interdependencies between limited resources, none of the three cases' planning approaches acknowledge the diversity of involved resource types beyond doctors, which frequently stresses the system and involved staff with overload of job tasks. Thus, we propose that *'under- capacity of limited resource types is enhanced or even generated by lack of incorporation of relevant resources in hospital planning.'* Based on this proposition, we call for further research on incorporation of all necessary interdependent resource types into hospital planning methods.

Finally, the process variables are neglected in similar ways in planning at all three cases, predicting and planning only on simple process flows and without iterations due to emergent changes regarding patient conditions or interdependencies to support processes. To compensate there active planning approach, there occur several coordination meetings during the day. This approach, however, leads to frequently re-planning and re-scheduling which is time consuming for multiple resources. Thus, we propose that *'deterministic processes are unsuitable for adapted hospital planning due to the degree of emergent changes and continuous iterations related to dynamic*

patient variables.' Thus, we recommend further research clarifying the appropriateness of process design and performance measures in different planning environments in hospitals.

5 Conclusion

The aim of this paper is to increase understanding of hospital environment variables in order to improve applied hospital planning methods. We have identified and described the hospital environment and applied planning methods from an environment variables perspective through an in-depth case study of three Danish hospital environments and their corresponding adaptive planning frameworks. It indicates that several challenges regarding planning and control of incoming patients and resource, where further suggestion might be in a direction of a more patient oriented approach such as differentiated planning and control. All three cases use simple planning methods, which only include elective patients, even though historical data is stored for use in more reliable planning methods. Thus, large time slots, slack time, and frequent meetings for information sharing, coordination, and re-scheduling are necessary in order to overcome the uncertainty of patient planning. The results include suggestions for further research on improving the match between identified environment variables and the corresponding planning methods and framework.

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