

INTEGRATION OF OPERATING ROOM PLANNING AND SCHEDULING
THROUGH MANAGING UNCERTAINTY FOR EMERGENCY PATIENTS
IN ORTHOPEDIC SURGERY

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requirements for the award of the degree of
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Thanks God to enable me performing this research.

I would like to dedicate this thesis with respect and love to my father's, mother's and brother's soul that love them wholeheartedly and all my beloved family members.

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I would like to convey the most appreciation to my supervisor, Dr. Syed Ahmad Helmi B. Syed Hassan, for his rigorous oversight of this study which always gave me the motivation to do my best for this thesis.

My appreciation also goes to those who taught me knowledge and different experiences in the University of Life.

ABSTRACT

Today, Health care management is becoming increasingly important for patients in hospitals. Hospital managers want to increase patient satisfaction and hospital's efficiency, particularly in Operating Rooms (OR). Therefore, the development of adequate planning and scheduling procedures are the necessity and importance in OR. This project performs an analysis on the operating room planning at a department of orthopedic surgery and particularly concentrates on the problem of meeting the uncertainty in demand of patient arrival and surgery duration and at the same time maximizing the utilization of OR. By means of a discrete-event model and using Arena Software, proposed management policy effects on different performance metrics such as patient waiting time and the utilization of OR is simulated. The experiments show that the performance of the operating room department can be improved significantly by applying a proposed policy in reserving operating rooms for emergency. The results of this study led to assigning of two OR for emergency patients in orthopedic surgery department. Moreover, these results cause to reduce patient waiting time, number of Emergency Patients rejection and to increase utilization of OR and to prevent rejected patients from Hospital for Orthopedic surgery.

ABSTRAK

Dewasa ini, pengurusan penjagaan kesihatan untuk pesakit di hospital menjadi semakin penting. Hal ini terbukti, apabila pengurus-pengurus hospital membuat keputusan untuk meningkatkan kepuasan hati pesakit terhadap kecekapan perkhidmatan di hospital terutamanya di bilik operasi. Oleh yang demikian, perancangan dan jadual yang teratur perlu dilaksanakan di bilik operasi. Bagi menyempurnakan projek ini, suatu analisis berkaitan perancangan di bilik operasi telah dilakukan di Jabatan Pembedahan Ortopedik . Analisis ini ditumpukan pada masalah yang berkaitan dengan jumlah pesakit yang memenuhi bilik operasi pada suatu-suatu masa, jangka masa pembedahan dilakukan dan juga memaksimumkan penggunaan bilik operasi. Simulasi kesan polisi pengurusan terhadap prestasi metrik yang berbeza seperti masa menunggu pesakit dan penggunaan bilik operasi telah dilaksanakan menggunakan perisian arena melalui model "discrete-event". Kajian ini menunjukkan bahawa prestasi di bilik operasi boleh ditingkatkan dengan melaksanakan dasar yang dicadangkan dalam menempah bilik operasi bagi kes kecemasan. Hasil kajian ini telah membawa kepada penetapan 2 bilik operasi untuk pesakit kecemasan di Jabatan Pembedahan Ortopedik. Selain itu, hasil kajian ini juga telah menunjukkan masa menunggu pesakit, bilangan penolakan pesakit kecemasan, peningkatan penggunaan bilik operasi dan juga untuk mengelakkan penolakan pesakit untuk pembedahan ortopedik dari hospital.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Health care management is becoming increasingly important for patients in hospitals. On the one hand, hospitals want to reduce costs and improve their financial assets while they want to increase patient satisfaction and hospital's efficiency, on the other hand. One of the particular interested unit is operating Room. Because operating room has a major impact and role on the performance of the hospital. This facility can impose high expenditure to a hospital while it can eventuate high profit as well. However, operating rooms management can be challenging due to the conflicting priorities and the preferences of hospital's stakeholders, but also due to the lack of costly resources. Furthermore, the aging population can be due to the growth of demand for surgical services. Hence, health managers have to forecast this demand growth. Therefore, these factors clearly show the necessity and importance of the development of adequate planning and scheduling procedures in operating room (Cardoen et al., 2009).

1.2 Background of the study

Over decades, many studies have been done on the management of operating room. Surgical demand scheduling and distinguish between advance scheduling and allocation scheduling are reviewed. Advance scheduling is the process of fixing a surgery date for a patient, whereas allocation scheduling determines the operating

room and the starting time of the procedure on the specific day of surgery (Magerlein & Martin, 1978). The domain of external resource scheduling elaborate are added on this taxonomy in literature review, which the process are identified and reserved all resources external to the surgical suite necessary to ensure appropriate care for a patient before and after an instance of surgery. Furthermore, each domain in a strategic, administrative and operational level is divided (Blake & Carter, 1997). The literature on operating room scheduling based on general areas of concern is structured, such as cost containment or scheduling of specific resources (Przasnyski, 1986). In some other reviews, operating room management is considered as a part of global health care services (Boldy, 1976; Pierskalla & Brailer, 1994; Daniels et al., 1988; Yang et al., 2000)

The focus of this reviews is on the articles that clearly incorporate planning and scheduling considerations in order to keep a homogeneous set of contributions. Planning is defined as “the process of reconciling supply and demand” (i.e., dealing with capacity decisions). Scheduling is described as “defining the sequence and time allocated to the activities of an operation. It is the structure of a detailed timetable that shows at what time or date jobs should start and when they should end” (Slack, 1999).

According to these definitions, some important aspects are noticeable. They are patient characteristics, performance criteria (waiting time and utilization), type and level of decisions, integrated and or isolated operating room, uncertainty approach as well as deterministic approach, respectively. Following paragraphs clarify operating room planning and scheduling procedures and the meaning and importance of above-mentioned aspects by means of some interesting research contributions.

Two major patient classes are considered in the literature on operating room planning and scheduling, namely elective and non-elective patients. Although many researchers do not indicate what type of elective patients they are considering, some distinguish between inpatients and outpatients. Inpatients refer to hospitalized patients who have to stay overnight, whereas outpatients typically enter and leave the hospital on the same day. When considering non-elective patients, a distinction can be made between urgent and emergent surgery based on the responsiveness to the patient's

arrival (i.e., the waiting time until the start of the surgery). The surgery of emergent patients (emergencies) has to be performed as soon as possible, whereas urgent patients (urgencies) refer to non-elective patients that are sufficiently stable so that their surgery can possibly be postponed for a short period (Cardoen et al., 2009).

Various performance criteria are used to evaluate operating room planning and scheduling procedures. This study distinguishes between eight main performance measures, namely waiting time, throughput, utilization, leveling, makespan, patient deferrals, financial measures, preferences and other (Cardoen et al., 2009). This work aims to address two performance measures that include waiting time and utilization for operating room planning and scheduling. The next paragraphs explain the meaning and importance of these terms by means of some interesting research contributions.

- i. Long waiting lists are among the most heard complaints in general health care, which justifies the many studies aiming at decreasing the waiting times for patients. Also, a decrease in the surgeon's waiting time has been the subject of many research efforts, as the surgeon is a very expensive resource in the operating room (Cardoen et al., 2009).
- ii. Utilization actually refers to the workload of a resource, whereas undertime or overtime includes some timing aspect. Hence, it is possible to have an underutilized operating room complex, although overtime may occur in some of the operating rooms. (Cardoen et al., 2009).

A variety of planning and scheduling decision types with a resulting impact on the performance of the operating theater such as the date of assignment (e.g., on Monday, on January 17th), a time indication (e.g., at 11 a.m.), an operating room (e.g., operating room 2) or the allocation of capacity (e.g., three hours of operating room time) are investigated in this study (Cardoen et al., 2009).

The articles are categorized according to the decision level they address, i.e., to whom the particular decisions apply. The scheduling levels are discriminated into the discipline, the surgeon and the patient level.

The discipline level unites contributions in which decisions are taken for a medical specialty or department as a whole. An integer programming model and an improvement heuristic are reported to construct a cyclic timetable that minimizes the under allocation of a specialties' operating room time with respect to its predetermined target time. The model determines for each specialty what operating room types are assigned to what days of the week (i.e., a decision concerning date and room) (Blake et al., 2002; Blake & Donald, 2002).

At the surgeon level, a software tool in which decisions for specific surgeons is introduced, instead of disciplines (Beliën et al., 2006). For each surgeon, the planner has to decide on what day and in which room surgeries have to be performed. Since operating rooms may be divided in a morning and an afternoon session, the block assignments also incorporate a time indication. The impact of the cyclic timetable decisions on the use of various resources, such as nurses, arthroscopic towers or lasers, is visualized and guides the planner in improving the constructed surgery schedule. Since the amount of operating room time for each surgeon in the planning horizon is predetermined, no capacity decisions have to be made (Cardoen et al., 2009).

On patient level, decisions are made for individual patients or patient types. Although patient types may represent the distinction between, for instance, elective or non-elective patients, they frequently refer to surgical procedure types. Starting from a list of recurring procedure types (i.e., types that are frequently performed and hence have to be scheduled in each planning cycle), they decide what mix of procedures will be performed on what day and in which operating room. They aim at the minimization of the number of operating rooms in use, on the one hand, and the leveling of the hospital bed requirements, on the other hand. A two phase decomposition approach is formulated that is heuristically solved by column generation and mixed integer programming (van Oostrum et al., 2008).

Operating room planning and scheduling decisions affect facilities throughout the entire hospital. Therefore, it seems to be useful to incorporate facilities, such as the Intensive Care Unit (ICU) or Post Anesthesia Care Unit (PACU or Recovery Room), in the decision process and try to improve the global performance. If not, improving the operating room schedule may worsen the practice and efficiency of those related facilities. Isolated operating room and integrated class papers that study the impact on the PACU (Recovery Room), the ICU and the wards (Cardoen et al., 2009) are distinguished. Master scheduling system is integrated with all kind of user specific resources of which the consumption is directly related to the timing of the surgeries (e.g., the radiology department) (Beliën et al., 2006). Although, the concept of general resources are used, without exactly specifying which ones (Velasquez, 2006; Melo, 2007).

One of the major reasons for simplifying the research scope probably stems from the increased complexity, both in formulation and in computation, of the decision process caused by the integration. Note that this integration should not be limited to facilities that are situated within one hospital, as studies on multi-facility or multi-site operating room planning and scheduling are currently emerging (Everett, 2002; Santibanez et al, Begen & Atkins, 2007; VanBerkel & Blake, 2007).

Techniques were indicated for integrating operating room scheduling with other hospital operations were urgently required (Blake & Carter, 1997). A further integration of the operating room with other hospital facilities can remain a main topic for future research, especially in combination with the incorporation of uncertainty (Cardoen et al., 2009).

The uncertainty inherent to surgical services is one of the major problems associated with the development of accurate operating room schedules or capacity planning strategies. Deterministic planning and scheduling approaches ignore such uncertainty or variability, whereas stochastic approaches explicitly try to incorporate it. Two types of uncertainty that seem to be well addressed are arrival uncertainty and duration uncertainty. For example, at the unpredictable arrival of emergency patients or at the lateness of surgeons at the beginning of the surgery session, whereas the latter

represents deviations between the actual and the planned durations of activities related to the surgical process (Cardoen et al., 2009).

Since the total number of papers is large and our main interest is directed towards the recent advances proposed by the scientific community, the set of articles are restricted to those investigated non-elective (emergent) patient, waiting time, utilization of operating room, type of decision making (capacity and room) and level of decision (patient).

1.3 Problem Statement

This study investigates the operating room planning in an orthopedic surgery department at a hospital located in Johor Bahru, the capital of Johor state, Malaysia. The hospital is a private-funded multi-specialty hospital. In the Orthopedic Surgery department of target hospital, cancelations and overtime may increase for emergency surgeries due to enhancement of emergency patient operations and too much allocated time for elective surgeries. In addition to choose a proper allocation of resources for emergency surgical cases, it is important to achieve a high throughput for patient satisfaction due to decreasing waiting time and to reduce idle time to increase utilization. Therefore, the efficiency of the operating room can be increased through operating room planning and scheduling.

As mentioned above, this study attempted to investigate non-elective emergent patient with waiting time for patient, utilization for operating rooms as performance criteria in orthopedic surgery of the hospital for operating rooms planning and evaluating problem. In addition, the capacity and room as type of decision as well as patient as level of decision with integrated operating rooms with PACU department are being investigated in this research, especially in consideration of uncertainty in arrival patient and surgery duration.

Based on literature, there are few studies that investigated all above mentioned criteria and decision variable (assigning specific rooms for patients) through operating room planning and scheduling in Orthopedic Surgery in hospital.

1.4 Objective of the study

The major objectives of this study are as follows:

- Managing uncertainty especially in arrival Emergent Patient, Surgery Duration, Admission Time and Recovery Time (Post Anesthesia Care Unit-PACU Time).
- To reduce waiting time for emergent patient in Holing Area (Queue) as performance criteria (maximizing patient satisfaction)
- To maximize utilization for Oprating Rooms as performance criteria (To increase Oprating Rooms efficiency)
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1.5 Scope of the study

The hospital that has been investigated in this study is a private-funded multi-specialty hospital located in Johor Bahru, the capital of Johor state, Malaysia. It is the most popular hospital in Johor as well as the main referral health center for the state. Data is collected from historical information of registration system in the hospital's division of orthopedic Surgery. Questionnaire package and historical data of registration system in the hospital's division of orthopedic surgery are used for data

collection. This questionnaire include waitlist cases, available operating room time, surgical time, anesthetic times, operating room utilization, and surgical complications.

Following data collection, discrete-event simulation model is conducted to evaluate and quantify patient's waiting time and utilization of operating rooms for operating room planning and scheduling.

1.6 Significance of the study

In this study, a simulated model is developed for improvement of planning and scheduling in a multi-specialty hospital, for the division of orthopedic surgery. Non-elective emergent patient with waiting time and utilization for operating room are being studied as performance criteria in Orthopedic Surgery in hospital through operating rooms planning and evaluating for emergent patient.

The simulated model can be applied in the target hospital and any other hospitals in Malaysia in order to maximize patient satisfaction and to increase operating room efficiency. Furthermore, Graphical User Interface (GUI) - applicable software package or program- for solving operating room planning and scheduling optimization problems can be provided.

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