A HOSPITAL ADMISSION PLANNING MODEL TO IMPROVE OPERATING ROOM RESOURCE UTILIZATION

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ตัวแบบการวางแผนการรับเข้าผู้ป่วยในโรงพยาบาล เพื่อปรับปรุงการใช้ทรัพยากรห้องผ่าตัด

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วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิศวกรรมศาสตรมหาบัณฑิต
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Suranaree University of Technology has approved this thesis submitted in partial fulfillment of the requirements for a Master's Degree.

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ถิรพันธ์ กังวานสุระ : ตัวแบบการวางแผนการรับเข้าผู้ป่วยในโรงพยาบาลเพื่อปรับปรุงการใช้ทรัพยากรห้องผ่าตัด (A HOSPITAL ADMISSION PLANNING MODEL TO IMPROVE OPERATING ROOM RESOURCE UTILIZATION)
อาจารย์ที่ปรึกษา : ผู้ช่วยศาสตราจารย์ ดร.พงษ์ชัย จิตตะมัย, 123 หน้า.

เป็นที่ทราบกันดีว่าห้องผ่าตัดถือเป็นทรัพยากรที่ขาดแคลนที่สุดอย่างหนึ่งในระบบโรงพยาบาล วัตถุประสงค์งานวิจัยนี้คือการสร้างตัวแบบทางคณิตศาสตร์เพื่อใช้ในการวางแผน และการสร้างตารางการรับเข้ากลุ่มผู้ป่วย (Patient Mix Admission Planning Model) ที่เหมาะสมเพื่อปรับปรุงประสิทธิภาพของระดับการใช้ทรัพยากรห้องผ่าตัดโดยรวม โดยการทำให้ความผันแปรระหว่างระดับการใช้ทรัพยากร และเป้าหมายการใช้ทรัพยากรมีค่าน้อยที่สุด ตัวแบบการโปรแกรมเชิงเส้นจำนวนเต็มแบบผสม (Mixed Integer Linear Programming Model) เพื่อใช้ในการวางแผนและสร้างตารางดังกล่าวได้ถูกพัฒนาขึ้น โดยการพิจารณาความต้องการที่ไม่แน่นอนต่างๆ เช่น ระยะเวลาในการพักฟื้นของผู้ป่วย การเข้ามาของผู้ป่วยฉุกเฉิน และการพิจารณาเงื่อนไขการยกเลิกการนัดหมาย และการไม่ปรากฏตัวของผู้ป่วยนัดหมาย (Cancellation and No-show) เมื่อเปรียบเทียบผลลัพธ์กับตัวแบบที่เป็นที่รู้จัก การวิเคราะห์ผลแสดงให้เห็นว่า การพิจารณาปัจจัยการยกเลิกการนัดหมาย และการไม่ปรากฏตัวของผู้ป่วยนัดหมาย เข้าไปในตัวแบบที่นำเสนอ สามารถลดความผันแปรของระดับการใช้ทรัพยากรห้องผ่าตัดได้ พร้อมกันนี้ผลลัพธ์จากตัวแบบ สามารถนำไปใช้สร้างตารางวางแผนการรับเข้าผู้ป่วยที่มีประสิทธิภาพที่ดียิ่งขึ้น และลดความผันแปรระหว่างระดับการใช้ และเป้าหมายการใช้ทรัพยากร อีกทั้งยังบรรลุข้อจำกัดต่างๆ ที่ถูกกำหนดไว้ในตัวแบบ ผู้ทำการวางแผนการรับเข้าผู้ป่วยในโรงพยาบาล สามารถนำตัวแบบที่นำเสนอนี้ ไปประยุกต์ใช้ในการวางแผนการรับเข้าผู้ป่วยผ่าตัดในโรงพยาบาลได้ ในใช้งานจริงผู้วางแผนฯ อาจจะต้องปรับระดับการจัดสรรทรัพยากรของห้องผ่าตัด เพื่อให้เกิดความสมดุลระหว่างอุปสงค์ และอุปทานของห้องผ่าตัดมากที่สุด

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THIRAPAN KANGWANSURA : A HOSPITAL ADMISSION PLANNING MODEL TO IMPROVE OPERATING ROOM RESOURCE UTILIZATION. THESIS ADVISOR : ASST. PROF. PHONGCHAI JITTAMAI, Ph.D. 123 PP.

DEMAND AND CAPACITY MANAGEMENT/OPERATING ROOM ADMISSION PLANNING/MIXED INTEGER LINEAR PROGRAMMING (MILP)/UNCERTAIN DEMANDS/NO-SHOW

Operating room (OR) is known as one of scarce resources in the hospital system. The aim of this study is to obtain an admission schedule for the patient mix which improves overall operating room performance by minimizing the shortfalls of the resource consumption to their target utilizations. The MILP formulation to generate this plan is developed by incorporating the uncertain demand requirements such as length of stay, emergency arrival, and the introduction of no-show condition into the model. By benchmarking with some known models, the analysis reveals that the proposed model yields a decreasing in gap of the usages of OR resources by considering the no-show. An admission plan created by the model indicates a better performance that results in fewer deviations between actual and target utilizations while satisfying the given restrictions. In application, the hospital admission planner may need a minor modification on the resource allocation levels to achieve the proper balance between the demands and capacities.

School of Industrial Engineering Student's Signature_____

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Thirapan Kangwansura

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CHAPTER I

INTRODUCTION

1.1 Significance of the Problem

Nowadays, disasters happen frequently around the world and the occurrence rate is apparently increasing compared to those in the past decades. Disasters may occur naturally or be originated by human. Earthquakes, volcanic eruptions, floods, tsunamis, and storms are examples of natural disasters. Man-made disasters include nuclear plant explosions, terrorist attacks, building collapses, transportation accidents, act of war, etc. Disasters may occur anytime and anywhere and incur substantial ecology and economic losses. According to the 2012 annual disaster report conducted by Guha-Sapir, Hoyois, and Below (2013), there are approximately 400 disasters emerge every year over the last decade, causing around 100,000 fatalities and affecting more than 260 million people worldwide (see Figure 1.1). To encounter these uncertain incidents, emergency management is currently a realizing issue in various countries (Van Wassenhove, 2006). One important task in emergency management is emergency logistics or humanitarian logistics. Jiuh-Biing (2007) proposed definition of emergency logistics as “a process of planning, managing and controlling the efficient flows of relief, information, and services from the points of origin to the points of destination to meet urgent needs of affected people under emergency conditions.”

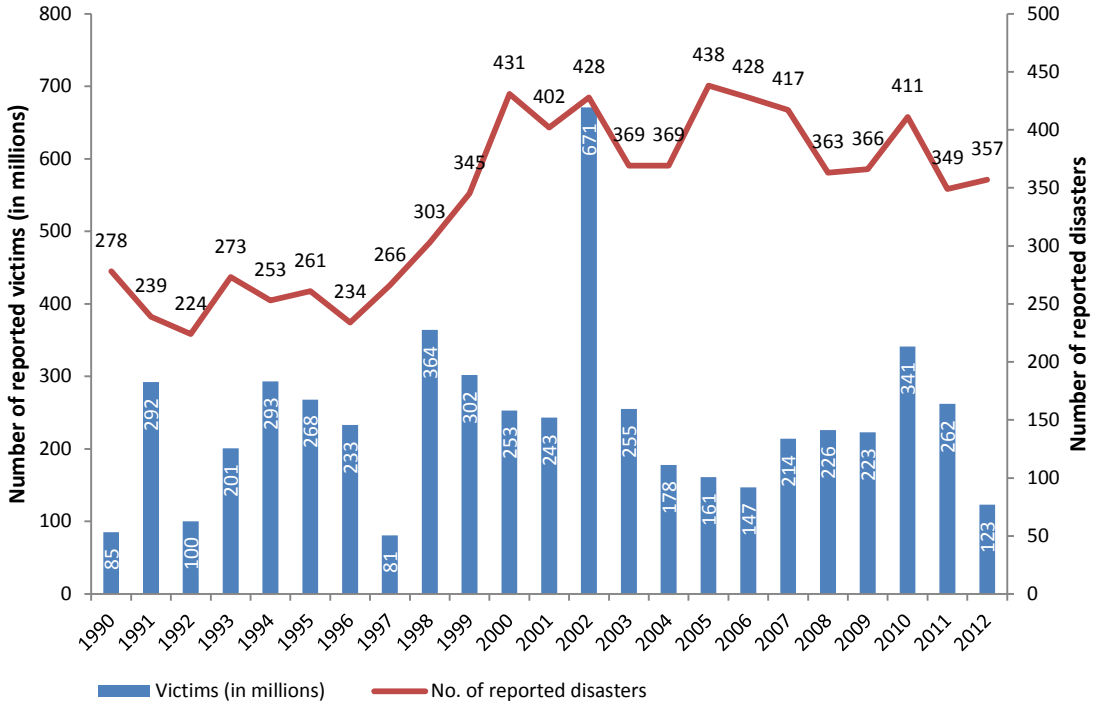

Figure 1.1 Trends in disaster occurrence and victims

In practice, effective emergency logistics planning is not usually well-prepared. Fritz Institute (2005) observed the effectiveness of the emergency logistics planning during the 2004 Indian Ocean tsunami attack and found that most logistics activities in the field were conducted manually without supervision of logistics experts. Moreover, assessments and planning were inadequate due to limited collaboration and coordination from the relevant functions. Recently, the situation has remained unchanged. The 2010 Haiti earthquake is a good example of this insufficiency of expert planning (Caunhye, Nie, and Pokharel, 2012), and the 2011 Thailand's major inundation reflected an unsystematic relief operation as well as a lack of emergency logistics planning (Koontanakulvong, 2012). As of today,

insufficiency in emergency logistics planning is still a critical topic in relieving the victims of the super typhoon Haiyan in the Philippines.

1.2 Objective of Emergency Logistics and Their Threats

The purpose of emergency logistics planning is to rapidly provide humanitarian assistance in the form of food, water, medicine, clothes, shelter, and supplies to affected areas by the large-scale emergencies such as Emergency Medical Services (EMS), in order to minimize human suffering and mortalities. The relief activities include emergency evacuation and medical resource management (Beamon and Blacik, 2008). The key characteristics in emergency logistics that bring complexity and distinctive challenges from the business logistics are described by Jiuh-Biing (2007) and Blacik and Beamon (2008). These challenges comprise an additional uncertainty such as inaccessible route that makes the timeframe of relief supply and distribution practically uncontrollable. Communication and cooperation in affected areas are dysfunctional due to the damage of telephone lines as well as incorrect and non-real-time demand requirements from information providers. Furthermore, demands in terms of type, size, timing and location are unpredictable and occur massively and instantaneously within short lead times. In addition, relief resources are limited, especially medical supplies, physicians, medical staff, medicines, emergency rooms, ambulances, recovery beds, and operating rooms.

1.3 Emergency Logistics Operations within the Context of Hospital Resource Planning

Emergency and relief logistics operations can be implemented pre- and post-disaster occurrence. Short-notice evacuation, facility location and stock pre-positioning are primary pre-disaster operations. While relief distribution, casualty transportation and resource allocation are the main activities in the post-disaster operations (Caunhye, Nie, and Pokharel, 2012). Emergency or disaster relief resources, especially medical resources, should be allocated efficiently. Scanty resource in health care is an extremely vital issue in health care management. World Health Organization (WHO) has suggested the minimum standard doctor consultation per capita as 1:600. In 2014, the medical personnel per capita in Thailand have been reported as follows: there is approximately a physician for population of 2,500; and a nursing workforce for a population of 480 (World Health Organization, 2014). Furthermore, bed shortage is also an important problem. A bed per capita is at 1:470 and hospital bed occupancy rate is around 80 % whereas some provinces have high bed occupancy rates such as Phitsanulok, Satun, and Chumphon where the rates are as high as 215 %, 141 %, and 109 %, respectively (Minister of Public Health, 2010).

One of the most vital and expensive resources in the medical service is the operating room (OR). Practically, approximately 60 to 70 percent of patients admitted to the hospital are operative patients (Denton, Viapiano, and Vogl, 2007). In most hospitals, it is ideal for patients to undergo surgeries as immediately as they are requested. In reality, inpatients may need to wait in beds for a day or longer for their surgeries. Outpatients may not have their operations on schedule. The delays in OR are caused by many reasons such as equipment failure, inadequate number of

recovery beds, nursing and anesthesia staff and OR facilities, arrivals of emergency patients, and late arrivals or cancellation of appointed patients. The delay in the first case can cause a subsequent delay to the cases that await. These delays have a major effect on OR performance with unsmooth patient flow and under/over resource utilization (Wong, Khu, Kaderali, and Bernstein, 2010).

1.4 OR Performance Evaluation: the Admission Planning and the Patient Mix

The criteria for evaluating the OR performance consist of waiting time, throughput, utilization, leveling, makespan, patient deferrals, financial measure and preferences. One of the widely studied criteria is OR utilization or utilization rate. A method for managing the OR utilization is scheduling the patients who need to be admitted as inpatients to the hospital for undergoing surgeries in order to maximize utilization rate or minimize the shortfall between target resource utilization and resource usage (Cardoen, Demeulemeester, and Beliën, 2010). The process of planning the appointments of patients to be admitted as inpatients to the hospital is called admission planning. The concept has been intensively used in scheduling the patients to undergo surgeries. It shows trade-off between medical staff and patients. The staff prefer to have as little idle time as possible while patients expect to have short waiting times (Kaandorp and Koole, 2007). Admission planning for OR aims to balance daily demands and available OR capacities by selecting the right patient from waiting list and admitting him/her as an inpatient. OR demands compose of patients who need to undergo surgeries. OR capacities include available recovery beds as well as medical staff and operating room time (Kusters and Groot, 1996). In order to make

the planning problem more manageable, admission planning task is done by classifying patients as groups of different pathology types and determining which patient from the groups has to be admitted to the hospital. These groups are known as patient mixes or diagnosis related groups (DRGs). Patient mix is a method of grouping the related patients according to disease severity or hospital treatments (Fetter, Shin, Freeman, Averill, and Thompson, 1980). Initially, patient mix was developed and adopted to serve the Medicare's payment system for the US hospitals. Therefore, it resulted in saving of over $50 billion in Medicare hospital payments (Fetter, 1991). Adan and Vissers (2002) deployed patient mix in OR admission planning and revealed that it offered superior admission schedules with fewer resource deviations between actual and target consumptions. Patient mix in OR is classified according to operation procedures and the amount of resources consumed such as the expected operation duration, the average length of stay at the pre- and post-operation care unit, and the amount of nursing time (Vissers and Beech, 2005).

1.5 Sources of the OR Requirements

In this study, OR requirements compose of elective and emergency patients, length of stay, no-show and cancellation of the patients.

1.5.1 Elective and emergency patients

In general, OR demand patterns (i.e. patient arrivals) are classified into two types, elective and emergency patients. Elective patients, also called scheduled patients, are those who do not require immediate medical attention and are put on waiting list for their turns of medical services, or those who are given appointments for particular admission dates (Adan and Vissers, 2002). Emergency patients are those

who arrive randomly to the hospital without prior appointments and need immediate surgical intervention. These two types of demand share the same OR resources. Hence, planning of the admission for surgical activities must consider uncertain resource requirements for emergency arrivals in order to avoid any delays of surgeries, postponement or overtime of the operations, and over/under utilization or overuses of resources, which have significant effects on service quality and/or add unnecessary costs to the hospital (Lamiri, Grimaud, and Xie, 2009). OR emergency demands arise from ill and injured patients. Accidents and disasters mainly cause the latter ones. In the case of unexpected disaster events, the hospital OR may encounter a sudden surge of emergency demands.

Yi, George, Paul, and Lin (2010) suggest several requirements for hospitals on preparation to confront with disasters, which include;

(1) To have sufficient personnel to meet emergency care needs.

(2) To meet sudden surge of demand with temporary additional capacity.

(3) To conduct resource planning and coordination between the emergency operation center (EOC) and hospitals in the disaster area.

(4) To continuously treat those patients who were already under care prior to the disaster.

1.5.2 Length of stay

Another uncertain requirement in OR supplies is length of stay (LOS). Variable LOS of patients will bring fluctuation in beds capacity planning. Inadequate deliberation on indeterminate LOS for the admission planning will lead to a bed shortage phenomenon. That may lower the patient satisfaction because of

cancellations of scheduled patients and/or inappropriate recover areas for post-operative patients (Ma and Demeulemeester, 2013).

1.5.3 No-show and cancellation of the patient

Appointment cancellations and no-shows of scheduled patients appear to be a further source of uncertainty in OR capacity planning. Cancellations of planned surgeries have a negative effect on the quality of patient care and management system. It brings to an underutilization of costly resources and amount of prepared works for the surgeries. Kumar and Gandhi (2012) reported that the hospital cancellation rate ranges from 10 % to 40 %. The most common cause of cancellation is lack of availability of operation time (more than 60 % of total cancellations and no-shows). This implies that the appropriate planning of the admission can avoid the appointment cancellation. To date, there are a few works that consider the effect of cancellation and no-shows in planning the admission of the patient mix. Therefore, this work focuses on determining appropriate mixes of patients to be admitted for surgery each day over a planning horizon to optimize the use of OR resources. The shortfalls between planned and actual usages of resources reflect the performance on admission schedules. A mixed integer linear programming (MILP) is developed in this study in order to minimize the total absolute deviations of the utilization of OR resources from their targets over all days in the planning period. Uncertain demands can cause the hospital encountering with the vast fluctuations in resource planning. Hence, it is important to deliberate some uncertain resource requirements such as length of stay, emergency arrivals and no-shows in the planning problem in order to diminish the variations and adjust capacity including taking alternative action to achieve the resource usage goal.

1.6 Research Objectives

The main objectives of this study are as below;

(i) To develop a mathematical model in order to minimize the total absolute deviation of the utilization of the operating room resources from their targets over all days of the planning horizon.

(ii) To generate an appointment scheduling for elective patients to have an operation with better utilization of the relevant resources.

1.7 Scope of the Study

This study aims to develop the master surgery schedules for the elective patients under uncertain demand requirement and unpredicted patient arrivals. The main purpose for conducting of this research is to provide the mathematical formulation and practical solution methodologies in order to minimize the total absolute deviation of the utilization of the resources from their target over all days of the planning period. To accomplish this objective, the following issues will be considered:

(1) Construct the mathematical model to maximize the major resource utilization by minimizing the total absolute deviation of the relevant OR resources from their target utilization over all days of the planning period. The objective is subjected to the uncertain demand requirements, for instance, emergency patient arrivals, length of stay and no-show. The impact of emergency patient arrivals and the no-show will be considered.

(2) Compute the mathematical model using computer software and find an optimal solution of the problem.

(3) Discuss the computational results and analyze the effect of the stochastic demand requirements compared to deterministic demand requirements.

(4) Generate the master surgery scheduling over the planning horizon based on the computational results in order to improve operational scheduling for the hospital operating theatre appointment system.

1.8 Research Hypothesis

According to the limitation in term of cost and time, this study is conducted by considering the following assumptions;

(1) This study is only focused on the operating room planning and scheduling for the elective patients in the hospital.

(2) The relevant resources of interest are the operating room time (OT), number of intensive-care beds (IC), IC nursing staff (NH), and medium-care beds (MC). The workloads of these resources are utilized primarily by surgical interventions. Other resources, which are commonly occupied with outpatients such as nursing hours at MC, other specialists, laboratory, and radiology capacities, are not considered as constraints in the planning problem.

(3) Uncertain demand requirement such as emergency arrivals, length of stay, no-show are considered in this study. Empirical distributions based on the actual data are used in model formulation.

(4) All unscheduled patients are assumed to be emergency patients

(5) All vanished patients including cancellations with and without prior notification are assumed to be no-shows

1.9 Expected Usefulness

(1) Application of the model will lead to a good admission schedule for surgery which results in a tiny fluctuation between actual and target resource utilization.

(2) Model output will emphasize the medical staff and management to be keenly aware of the importance OR resource allocation.

1.10 Organization of Thesis

This thesis consists of 5 chapters as follows. Chapter 1 illustrates the significance of the problem and research objectives. Chapter 2 presents literature reviews of the related works. In Chapter 3, we provide a mathematical formulation for the planning problem as well as the case settings. The computational results and discussions are proposed in Chapter 4 including the sensitivity analysis of the model. Chapter 5 summarizes all the findings and the contributions of the thesis and the possible future work.

CHAPTER II

LITERATURE REVIEW

This chapter highlights the comprehensive reviews of the related literatures in OR planning and resource allocation models.

2.1 ILP and MILP in OR Planning

Due to scarceness and costliness, OR resources have long been considered by practitioners and academics in developing and planning for the best use. The broadly used and beneficial tools for capacity planning and resource allocation in OR is integer and mixed integer linear programming (ILP and MILP). There are several distinct objectives in deploying ILP and MILP for improving the OR planning performances. For example, Pham and Klinkert (2008) focused on decreasing the makespan by extending a well-known job shop scheduling problem to determine a schedule for a given set of surgical cases in such a way, that the time to finish all cases over the planning horizon is minimized. Some studies are concerned with the cost function. For example, Jebali, Hadj Alouane, and Ladet (2006) proposed a two-step approach to address daily OR scheduling problem comprising of assigning operations to ORs and operating sequencing in order to minimize the cost incurred by keeping the patients in hospital waiting to be treated in the OR, and Zhang, Murali, Dessouky, and Belson (2009) presented a model for constructing a weekly OR

allocation template, which minimizes inpatients' in-hospital cost calculated as their length of stay. Some works concentrated on the leveling of OR resources, which is a method to develop OR schedule that smoothes the resource occupancies without peaks. For example, Beliën and Demeulemeester (2007) developed a model to minimize the expected total bed shortage. The number of operated patients per block and the length of stay of each operated patient were both deliberated stochastically. Carter and Ketabi (2012) created a surgery schedule to assign surgeons to the blocks which aims at minimizing the maximum number of required beds on different days. Much research involved multiple objectives. For instance, Santibáñez, Begen, and Atkins (2007) offered a number of possible objectives proposed by hospital management to schedule surgical blocks for each specialty into ORs in order to expose its trade-offs between OR availability, bed capacity, surgeons' booking privileges, and wait lists, and Beliën, Demeulemeester, and Cardoen (2009) demonstrated a decision support system for determining the repetitive surgery schedules that satisfies multiple objectives including optimization of the resulting bed occupancy, the best allocation for surgeons of the same group to the same OR, and maintaining the master surgery schedule consistent from week to week.

2.2 OR Performance Evaluation using Utilization

A widely studied objective that has been implicated in recent research in OR planning is utilization. It represents the workload of a resource. Hence, some research attempted to maximize the utilization of resources such as van Oostrum, Van Houdenhoven, Hurink, Hans, Wullink, and Kazemier (2008) who generated cyclic operation room schedules that maximize OR utilization involving the stochastic

operation durations. Another tried to minimize the unutilized resource. For example, Hans, Nieberg, and Oostrum (2007) deployed ILP technique to optimize the OR utilization by minimizing the unused OR time. Maximizing the utilization is a way to avoid any unnecessary costs incurred by underutilized OR resources. On the other hand, a tightly scheduled OR without proper time buffers may lead to an overutilization or overtime that can add extra costs like staff overtime costs and patient deferrals (Cardoen, Demeulemeester, and Beliën, 2010). To encounter these circumstances, the admission schedule for OR should emphasize the minimization of the gap between planned and actual usages of resources. Some studies follow this concept, For example, Blake, Dexter, and Donald (2002) focused on creating a master schedule for assigning surgical block-times to surgeons in order to minimize the difference between targeted and allocated OR times and improve accuracy of the schedule, and Chaabane, Meskens, Guinet, and Laurent (2008) constructed a model to minimize the gap between the total supply and the weekly requests of the surgical specialty.

2.3 Hospital Admission Planning for Surgical Activity

For a better understanding of hospital admission planning task for surgery, Figure 2.1 illustrates the flow of patients for the hospital admission planning. Generally, an elective patient is waiting at home or department inside the hospital for an operation and is admitted either to pre-operative wards or the Medium Care unit (MC) one day before performing an operation or directly to the operating room. In contrast, an emergency patient is admitted to hospital without prior appointment and need immediate surgery. After the operation, both types of patients can either stay for

a few days at the Intensive Care unit (IC) or spend a few more days recovering at post-operative wards or the MC unit. If the surgical patient does not need a recovery process at IC and MC, he/she is allowed to return either to home or to other units inside the hospital. An efficient surgery admission planning can lead the hospital to allocate their relevant resources more realistically and practically.

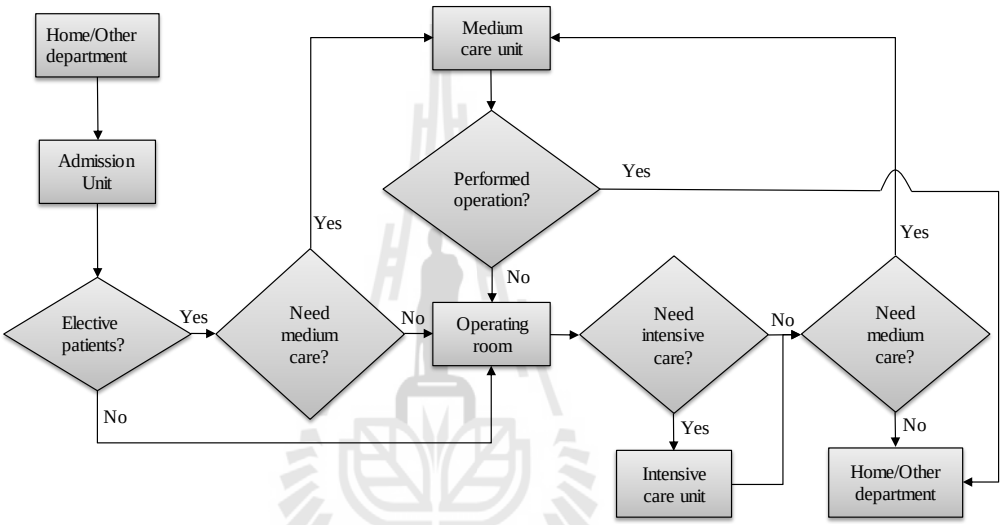

Figure 2.1 Flow of patients through the hospital admission process for operating room

2.4 Deploying a MILP Technique in Hospital Admission Planning for OR

Gemmel and Dierdonck (1999) proposed a very first intensive review on hospital admission planning by collecting a number of works on hospital admission planning and patient classification from 1960s to 1990s. Their work revealed that those studies have not much considered on planning of admissions and resources

based on the mix of different categories of patients within a specialty. Patient mix is mostly used for marketing and finance purpose such as the billing system of hospitals or units (Barnes and Krinsky, 1999). Adan and Vissers (2002) first introduced patient mix methodology in patient flow planning. They developed an integer linear model to generate an admission schedule for OR that minimizes the total absolute deviations between resource consumption and their targets. OR time, number of beds at medium-care unit, nursing hour and number of beds at intensive-care unit are all critical resources put in this model. Vissers, Adan, and Bekkers (2005) furthermore provided a case study in cardiothoracic surgery planning by implementing the model developed by Adan and Vissers (2002) to derive the weekly OR plan. Along the same line, Vissers, Adan, and Dellaert (2007) continued working on a similar problem with the introduction of stochastic requirement of resources. In this contribution, length of stay, both at medium and intensive care units is fitted as distribution from the empirical data. However, the three above-mentioned works focus on planning of OR resources at a tactical level, which are based on average arrivals of patient and provided guidelines of the mix of patients to be admitted in long term periods such as a month, a quarter, or a year. Adan, Bekkers, Dellaert, Vissers, and Yu (2009) extended those works by developing several strategies using actual arrivals of patients to determine the best scheduling of individual patients on an operational level. Their work illustrates that introducing the stochastic durations can decrease the deviations by more than 40 %.

2.5 Uncertainties in OR Planning

A key feature of the surgery planning and scheduling processes is the coordination of multiple activities in an uncertain environment. Two types of uncertainty that seem to be well addressed in the stochastic literature are arrival uncertainty and duration uncertainty. The former points, for instance, at unpredictable 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. Harper (2002) presents a detailed hospital capacity simulation model that enables system evaluations by means of a scenario analysis. The participation of multiple hospitals in the development phase resulted in a generic framework that allows incorporating uncertainty or trends in arrival profiles of patient groups as well as duration variability (e.g., length of stay or surgery durations). Persson and Persson (2009) describe a discrete-event simulation model to study how resource allocation policies at the department of orthopedics affect the waiting time and utilization of emergency resources, taking into account both patient arrival uncertainty and surgery duration variability.

Next to arrival and duration uncertainty, other types of uncertainty may be addressed. Dexter and Ledolter (2003) examine to what extent uncertainty in the estimated contribution margin of surgeons may lead to inferior allocations of operating room capacity when the goal is to maximize a hospital expected financial return.

2.6 Challenges of OR Admission Planning

The vital challenges in planning the admission schedule in order to allocate OR resources more efficiently are dealing with uncertainty. The duration of activities related to the intake process, the recovery process, surgeries, availability of medical staff and emergency patient arrivals are assumed to be stochastic. There are few literatures focusing on hospital admission planning of patient mix to optimize major resources utilization with stochastic demand requirements. Adan, Bekkers, Dellaert, Jeunet, and Vissers (2011) presented a goal programming approach to obtain a tactical plan for patient mix which accounts for emergency patients by reserving capacities for these patients. An intensive review shows none of work studies the effects of no-shows or appointment cancellation in an MILP model to optimize patient mix for surgery. Consequently, there is still a room for improving a better model to allocate of OR resources.

CHAPTER III

RESEARCH METHODOLOGY

This study is based on the framework proposed by Adan et al. (2009) and Adan et al. (2011). This chapter proposes an MILP model for generating a hospital admission planning for surgical patients in order to maximize the OR resource utilization by minimizing the gap between resource consumptions and their targets. To be able to accomplish the goal, indeterminate demand requirements composing length of stay at IC and MC, emergency arrivals and no-shows are comprised in the planning model in order to decrease the resource deviations. This study concentrates on four scarce operating room resources in the planning problem, i.e. operating time (OT), IC-beds, IC-nursing hours, and MC-beds. The workloads of these resources are utilized primarily by surgical interventions. Other resources, which are commonly occupied with outpatients such as nursing hours at MC, other specialists, laboratory, and radiology capacities, are not considered as constraints in the planning problem.

3.1 The Concept

The utilization is a key performance indicator in this study. OR utilization represents amount of consumed resources for surgical intervention comprising the pre- and post-operative activities. Figure 3.1 illustrates the concept behind the study. The under-utilization and over-utilization of resources indicate the amount of resource

consumed below and beyond target utilization level, respectively. An overuse of resources denotes the amount of consumed resources beyond the maximum capacities.

Figure 3.1 Demonstration of under-, target, over-utilization, and overuse of resources

The total absolute deviations, as depicted in Figure 3.2, mean the absolute summation of the under-utilization, over-utilization and overuse of resources. The lesser deviations imply the better utilization of the resources. Hence, this research deals with the minimization of the total absolute deviations of OR resources between target utilization and actual usage. The model fulfills this assumption is proposed in the following sub-section.

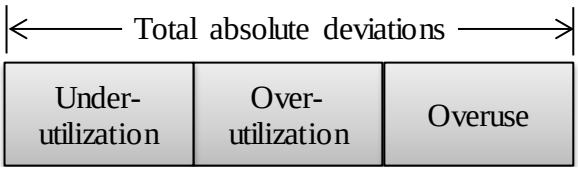

Figure 3.2 Depiction of total absolute deviations

3.2 Research Procedure

This research begins with a problem statement and literature review in the preceding chapters. Figure 3.3 illustrates the research steps for this study. In this chapter, the research concept is exaggerated as a planning model. The significant factors of interest, notations and model formulation, as well as the model validation and data sets, are proposed. The result discussion and interpretation including conclusions and recommendations are exemplified in the succeeding chapters.

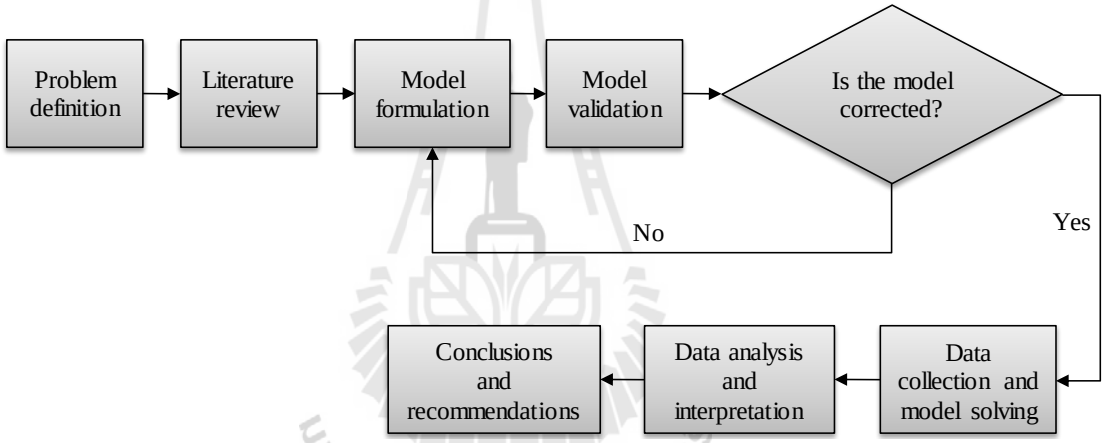

Figure 3.3 Research procedure

3.3 The Model

This section explains the influencing factors of the model including the notations and mathematical formulation of the planning problem.

3.3.1 Relevant factors

The following factors play an important role in the planning problem;

(1) *Planning period.* This is the complete time period over which the admittance of patients has to be planned, usually several months or a year.

(2) *Patient groups.* There are typically such a wide variety of patients that they need to be categorized for planning purposes to make the planning problem more manageable. In this study, patients are categorized according to their workload for the resources. Patients in the same category have a similar length of stay in IC and require on average the same amount of IC nursing staff and operating theatre time.

(3) *Resources.* The resources available are operating room time (*ot*), intensive-care (*ic*) beds, medium-care (mc) beds, and intensive-care nursing hour (*nh*)

(4) *Available capacity of the resources.* An operating room capacity is total operating time available per day. The IC and MC bed capacity are the total number of beds available to the specialty at the IC unit and wards, respectively. IC nursing hour is measured in number of hours per day.

(5) *Planning cycle.* Since the capacity is cyclically allocated, the cyclic admission pattern should be considered. On one hand, the cycle length should be long enough to accommodate patient admission and treatment cycle. On the other hand, a lengthy cycle may result in a planning problem that is computationally too big to handle. In practice, the cycle length typically varies from one week to four weeks.

(6) *Admission schedule.* The admission schedule describes the inflow of patients, i.e. the number and mix of patients admitted on each day within the planning cycle.

(7) *Target patient throughput*. The target patient throughput (*TPT*) is the number of patients that should be admitted within the planning cycle. The number can be easily deduced from the target number of patients set for the whole planning period.

(8) *Target utilization of the resources*. This is desired utilization (or occupancy rate) of the resources on each day of the planning cycle. It should be realized as close as possible.

(9) *Length of stay*. The length of stay can be measured as the number of days that patients stay at IC and MC. This study will incorporate an uncertain length of stay into the model in order to evaluate its impact on resource utilization.

(10) *Emergency Admission*. An emergency admission is an unscheduled admission of a patient who needs immediate medical attention, either an operation or a treatment. Daily emergency arrival rate and the probability of an emergency arrival of each patient type are considered in this study.

(11) *Unattended patient (No-Show) and appointment cancellation*. The numbers of no-shows and appointment cancellation have a significant impact on the revenue, cost and resource utilization. They may cause substantial disturbances on the operations scheduling of the admission planning system.

3.3.2 Notations

Input Parameters

T Planning cycle length (days)

TPT_c Target patient throughput of category c patients,

$c = 1, 2, \ldots, N$.

N	Number of patient categories
R	Set of resources including *operating room time (ot), intensive care beds (ic), medium care beds (mc), and nursing hours (nh)*
$C_{r,t}$	Available capacity of resource r on day t, $r \in R = \{ot, ic, mc, nh\}$ and $t = 1, 2, \ldots, T$.
$U_{r,t}$	Target utilization of resource r on day t, $r \in R = \{ot, ic, mc, nh\}$ and $t = 1, 2, \ldots, T$.
O_c	Operation duration (hours) of category c patient, $c = 1, 2, \ldots, N$.
$p_{ic,c,j}$	Probability that a patient of category c remains at the IC unit j days after operation, $c = 1, \ldots, N$ and $j = 0, 1, 2, \ldots, L_{ic}^{\max}$.
$L_{ic}^{\max}$	Maximum length of stay recorded at IC over all categories
lc	Number of pre-operative days in MC unit for one patient of category c
$p_{mc,c,j}$	Probability that a patient of category c is at the MC unit j days after operation, $c = 1, \ldots, N$ and $j = 0, 1, 2, \ldots, L_{mc}^{\max}$.
$L_{mc}^{\max}$	Maximum length of stay recorded at MC over all categories
$p_{emg,c,t}$	Probability that an emergency patient of category c arrives during day t, $c = 1, \ldots, N$ and $t = 1, 2, \ldots, T$.
$\lambda_{c,t}$	Arrival rate of emergency patients of category c on day t, $c = 1, \ldots, N$ and $t = 1, 2, \ldots, T$.

$p_{NS,c,t}$ Probability that an elective patient of category c is absent (no-show) and makes a cancellation on day t, $c = 1, \ldots, N$ and $t = 1, 2, \ldots, T$.

$\gamma_{c,t}$ No-show and cancellation rate of category c patients on day t, $c = 1, \ldots, N$ and $t = 1, 2, \ldots, T$.

$nw_{c,t}$ IC nursing workload (in hours) required for a patient category c, j days after operation, $c = 1, \ldots, N$ and $t = 1, 2, \ldots, T$.

α_r Relative weight of resource r, $r \in R = \{ot, ic, mc, nh\}$

B_t Maximum number of patients form categories that can be operated on day t, $t = 1, 2, \ldots, T$.

Variables

$X_{c,t}$ Number of category c patients to be operated on day t, $c = 1, \ldots, N$ and $t = 1, 2, \ldots, T$.

$UU_{r,t}$ Under-utilization of resource r on day t, $r \in R = \{ot, ic, mc, nh\}$ and $t = 1, 2, \ldots, T$.

$OU_{r,t}$ Over-utilization of resource r on day t, $r \in R = \{ot, ic, mc, nh\}$ and $t = 1, 2, \ldots, T$.

$E_{r,t}$ Overuse of resource r on day t compared to maximum capacity, $r \in R = \{ot, ic, mc, nh\}$ and $t = 1, 2, \ldots, T$.

3.3.3 Mathematical model formulation

This sub-section translates the planning problem into a mathematical model, so called a mixed integer linear problem, by adopting the above-mentioned notations. The objective is to minimize the total deviations between expected utilizations of resources and target consumptions. The important decision variables

are $X_{c,t}$ which denote the number of patients from category c operated on day t where $c = 1, 2, \ldots, N$ and $t = 1, 2, \ldots, T$. Thus, the objective is to determine the variable $X_{c,t}$ satisfying certain constraints and for which the expected utilization of all resources matches the target as close as possible. Hence the formulation for the problem is as follows;

$$\text{Minimize} \quad \sum_{r \in R} \alpha_r \sum_{t=1}^{T} (UU_{r,t} + OU_{r,t} + b \cdot E_{r,t}), \tag{3.1}$$

The objective function (3.1) is to minimize the total deviations between expected utilizations of resources and target consumptions and the overuse of resources relative to the maximum capacities. The coefficient b is a constant penalty value for capacity excess. This constant is dimensionless and set to a sufficiently high value to avoid any capacity excess, where $b \geq 0$. The relative weight, α_r, is used to make dimensionless for the sum of each resource deviation and overuse. The weight also represents the importance of the resource according to the stakeholders in the hospital including IC nurses, MC nurses, surgeon and management staff. The relative weight α_r for resource r is defined as;

$$\alpha_r = \frac{\frac{g_r}{\sum_{j=1}^{T} C_{r,j}}}{\sum_{r} \frac{g_r}{\sum_{j=1}^{T} C_{r,j}}} \tag{3.2}$$

Where resource $r \in R = \{ot, ic, mc, nh\}$. g_r refers to an absolute weight for resource r accessed by the stakeholders. $C_{r,j}$ is the maximum capacity for resource r in period j.

The objective function is subjected to the following constraints;

$$\sum_{t=1}^{T} X_{c,t} = TPT_c, c = 1, 2, \ldots, N. \tag{3.3}$$

A balance constraint (3.3) ensures that the total number of patients of category c to undergo surgery in T-day period must be equal to the target patient throughput TPT_c.

$$\left(\sum_{c=1}^{N} O_c X_{c,t} + \sum_{c=1}^{N} O_c p_{emg,c,t} \lambda_{c,t} \right) - \sum_{c=1}^{N} O_c p_{NS,c,t} \gamma_{c,t} \begin{cases} \leq C_{ot,t} + E_{ot,t} \\ \leq U_{ot,t} + OU_{ot,t} \\ \geq U_{ot,t} - UU_{ot,t} \end{cases} t = 1, 2, \ldots, T. \tag{3.4}$$

The OT utilization constraint set (3.4) confirms that the expected utilization of the OT by both elective and emergency patients of category c on day t deducted by the no-shows should be less than or equal to its maximum capacity on day t and should be within its target utilization on day t.

$$\left(\sum_{c=1}^{N}\sum_{j=0}^{L_{ic}^{\max}} p_{ic,c,j} X_{c,t-j} + \sum_{c=1}^{N}\sum_{j=0}^{L_{ic}^{\max}} p_{ic,c,j} \lambda_{c,t-j}\right) - \sum_{c=1}^{N}\sum_{j=0}^{L_{ic}^{\max}} p_{ic,c,j} \gamma_{c,t-j}$$

$$\left.\begin{aligned} &\leq C_{ic,t} + E_{ic,t} \\ &\leq U_{ic,t} + OU_{ic,t} \\ &\geq U_{ic,t} - UU_{ic,t} \end{aligned}\right\} \; t = 1, 2, \ldots, T. \qquad (3.5)$$

The IC-bed utilization constraint set (3.5) guarantees that the expected utilization of IC beds for elective and emergency patients of category *c* on day *t* deducted by the no-shows should not be larger than its maximum capacity on day *t* and should be within its target utilization on day *t*. Because the recovery periods at IC and MC, *j* days, can be larger than the planning cycle *T* or smaller than 1 day, then the variable $X_{c,t}$ should be re-written. This constraint set should then adopt the system that wraps around the numbers upon reaching a certain value, called modular arithmetic. A familiar application of modular arithmetic is in the 12-hour clock as depicted in Figure 3.4. Suppose that we concentrate only on hours. If the time is 9:00 now, then 4 hours later will be 1:00. General addition would suggest that the later time should be 9 + 4 = 13, but the clock system wraps around every 12 hours. Modular arithmetic can be handled mathematically by introducing the theory of congruences which was developed by Karl Friedrich Gauss at the beginning of the nineteenth century (Rosen, 2010). The definition and basic properties of congruences can be defined as follows;

Definition Given integers *a*, *b*, *m* with $m > 0$. We say that *a* is *congruent to b modulo m* if $m \mid (a - b)$, and write $a \equiv b \pmod{m}$. If $m \nmid (a - b)$, we write $a \not\equiv b \pmod{m}$, and say that *a* and *b* are *incongruent modulo m*. The integer *m* is called the *modulus* of the congruence.

Example 3.1 we have 24 ≡ 3 (mod 7), since 7 | (24 – 3) = 21. Similarly, 3 ≡ –6 (mod 9) and 200 ≡ 2 (mod 9). In contrast, 23 ≢ 2 (mod 11) since 11 ∤ (23 – 2) = 21.

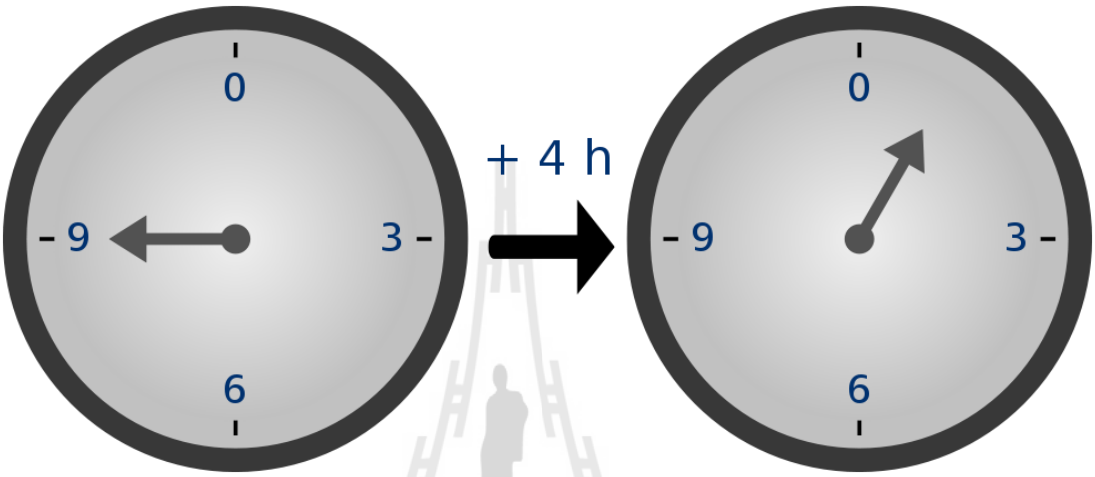

Figure 3.4 Demonstration of the clock using arithmetic modulo 12

A planning horizon in this study will wrap around every T period. Hence, the constraint sets (3.5), (3.6), and (3.7) occupy the convention that subscript t-j in $X_{c,t-j}$ should be treated *modulo* T: day 0 is the same as day T, day -1 is the same as day T-1, day -2 is day T-2 and so on. Table 3.1 shows example of treating $X_{c,t-j}$ *"Modulo T"* when T = 7, c = 1, t = 1 and j = 0,1,2,…, 10.

Table 3.1 Example of treating $X_{c,t-j}$ *"Modulo T"*

***T* = 7, *c* = 1, *t* = 1**	***j***										
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
$X_{c,t-j}$	$X_{1,1-0}$	$X_{1,1-1}$	$X_{1,1-2}$	$X_{1,1-3}$	$X_{1,1-4}$	$X_{1,1-5}$	$X_{1,1-6}$	$X_{1,1-7}$	$X_{1,1-8}$	$X_{1,1-9}$	$X_{1,1-10}$
	$X_{1,1}$	$X_{1,0}$	$X_{1,-1}$	$X_{1,-2}$	$X_{1,-3}$	$X_{1,-4}$	$X_{1,-5}$	$X_{1,-6}$	$X_{1,-7}$	$X_{1,-8}$	$X_{1,-9}$
modulo T	$X_{1,1}$	$X_{1,7}$	$X_{1,6}$	$X_{1,5}$	$X_{1,4}$	$X_{1,3}$	$X_{1,2}$	$X_{1,1}$	$X_{1,7}$	$X_{1,6}$	$X_{1,5}$

$$\left(\sum_{c=1}^{N}\sum_{j=0}^{L_{ic}^{\max}} nw_{c,j}\, p_{ic,c,j}\, X_{c,t-j} + \sum_{c=1}^{N}\sum_{j=0}^{L_{ic}^{\max}} nw_{c,j}\, p_{ic,c,j}\, \lambda_{c,t-j}\right) - \sum_{c=1}^{N}\sum_{j=0}^{L_{ic}^{\max}} nw_{c,j}\, p_{ic,c,j}\, \gamma_{c,t-j}$$

$$\left.\begin{aligned} &\le C_{nh,t} + E_{nh,t} \\ &\le U_{nh,t} + OU_{nh,t} \\ &\ge U_{nh,t} - UU_{nh,t} \end{aligned}\right\} \; t = 1, 2, \ldots, T. \qquad (3.6)$$

The nursing workload utilization constraint set (3.6) validates that the expected utilization of nursing hours for elective and emergency patients of category *c* on day *t* deducted by the no-shows should not be more than its maximum capacity and should be within its target utilization on day *t*.

$$\left(\sum_{c=1}^{N}\sum_{j=1}^{l_c} X_{c,t+j} + \sum_{c=1}^{N}\sum_{j=0}^{L_{mc}^{\max}} p_{mc,c,j}\, X_{c,t-j} + \sum_{c=1}^{N}\sum_{j=0}^{L_{mc}^{\max}} p_{mc,c,j}\, \lambda_{c,t-j}\right) - \sum_{c=1}^{N}\sum_{j=0}^{L_{mc}^{\max}} p_{mc,c,j}\, \gamma_{c,t-j}$$

$$\left.\begin{aligned} &\le C_{mc,t} + E_{mc,t} \\ &\le U_{mc,t} + OU_{mc,t} \\ &\ge U_{mc,t} - UU_{mc,t} \end{aligned}\right\} \; t = 1, 2, \ldots, T \qquad (3.7)$$

Similar to the constraint set (3.6), an MC-bed utilization constraint set (3.7) certifies that the expected utilization of MC beds for both elective and emergency patients in pre- and post-operation periods of patient category *c* on day *t* deducted by the no-shows should not exceed its maximum capacity and should be within its target utilization on day *t*.

$$\sum_{c \in S} X_{c,t} \leq B_t,\ t = 1, 2, \ldots, T. \tag{3.8}$$

In addition to the above-mentioned utilization of the resources constraints, the restrictions valid for specific days of the operation schedule are needed to be taken into account. The first restriction means that certain variables $X_{c,t}$ are fixed to prescribed values. The second restriction, B_t are introduced to indicate the maximum of patients from groups that can be performed surgeries on a day of the operation schedule. Then, the second restriction translates to a constraint (3.8) that ensures the total number of patients from categories $c \in S$, where S is a subset of {1, 2, …, N}, to be operated on day t must not exceed the maximum number of patients from categories $c \in S$ that can be operated on day t of the operation schedule.

$$X_{c,t} \in \{0, 1, 2, \ldots\},\ c = 1, 2, \ldots, N,\ t = 1, 2, \ldots, T. \tag{3.9}$$

A constraint (3.9) restricts all decision variables, $X_{c,t}$, to be positive integer values.

$$UU_{r,t} \geq 0,\ OU_{r,t} \geq 0,\ \mathrm{E}_{r,t} \geq 0,\ r \in R,\ t = 1, 2, \ldots, T. \tag{3.10}$$

Finally, constraints (3.10) are the non-negativity constraints of the under-utilization, over-utilization and overuse of resource r on day t, respectively.

The planning problem therefore consists of minimizing the objective function in (3.1) subjects to the constraints (3.3) – (3.8) and non-negativity constraints (3.9) – (3.10).

3.4 Model Validation

The proposed model has been validated for its tractability as presented in Jittamai and Kangwansura (2011). The pilot data sets were generated to verify the model. The study showed that the planning model is practical and can reach to the optimality.

3.5 Data Sets

The data sets used to solve this model are collected from a large community hospital in Thailand, called Hospital A, consisting of 6 operating rooms and performs surgery 24 hours a day. Hospital A undergoes more than 4,000 operations per year or, an average of 12 cases per day. The following sub-section will discuss data used in interpreting the model, e.g. patient mix, volume, demand requirements, length of stay both at IC and MC, available resources, emergency patient arrivals, and no-show or cancellation of elective patients.

3.5.1 Patient mix, volume and demand requirements

There are typically a wide variety of patients that need to be categorized in order to make the planning problem more manageable. Table 3.2 illustrates the 8 categories of patients classified by their usage of resources; namely, the expected operating room time, average length of stay at the IC, and average number of patients per mix.

To distinguish the patient in each mix, classification is based on their operating room time (in hours) and length of stay at ICU. The terms *"Very short/Short/Middle/Long OT"* and *"No/Short/Middle/Long IC"* are used in the

classification of each mix. The *"Very short OT"* represents the surgical cases that consume the operating room time less than or equal to an hour. The *"Short"* and *"Middle OT"* signifies the operation case that requires an operation for less than or equal to 3 hours and 6 hours, respectively. The *"Long OT"* is for the patient who requires more than 6 hours of operation time. In the same way, the *"No IC"* denotes the patient who requires no recovery in the intensive care unit after operation. The *"Short"* and *"Middle IC"* indicate the patient who needs to recover at IC for less than or equal to 1 day and 3 days, respectively. The *"Long IC"* means patients who require IC stays more than 5 days. The target patient throughput (TPT_c) indicates the total number of patients of each category that need to be admitted for operation within the planning cycle of a week. This number is deducted from the total number of patients which undergo operations in the hospital during the 3-month period from Mar 2011 to Mar 2011, containing 1,044 operation cases (See Appendix A).

Demand requirements of each patient category are depicted in Table 3.3. As an extension of Table 3.2, Table 3.3 provides the average length of stay at MC for pre- and post- operations of each category. Average IC nursing hours required for each patient category are derived from average of a total actual nursing time required for a patient divided by the number of days that a patient stays at IC.

Table 3.2 Patient category, use of OT and IC and Target patient throughput per week

Patient category, c	Description	Sample Procedures	Operating room time (h)	IC-Stay (days)	TPT_c
1	*Very short OT, No IC*	Colonoscopy, Gastroscope	0.5	0	25
2	*Short OT, Short IC*	C-Section, Appendectomy	1	0.15	50
3	*Middle OT, Short IC*	Rhinoplasty	3	0.1	15
4	*Long OT, Short IC*	Cranicetomy	8	0.12	1
5	*Short OT, Middle IC*	D&C	1	3	1
6	*Middle OT, Middle IC*	Craniotomy	3	2	3
7	*Long OT, Middle IC*	Abdominoplasty	6	2.3	1
8	*Long OT, Long IC*	loner	8	5	1

Table 3.3 Demand requirements of each resource for each patient category

Patient category, c	Description	Operating room time (h), O_c	Average IC-stay (days)	Average MC-stay (days)		Average IC nursing (h) per day, $nw_{c,t}$
				Pre-op avg	Post-op avg	
1	*Very short OT, No IC*	0.5	0	0.13	0.76	0
2	*Short OT, Short IC*	1	0.15	0.11	1.7	7.11
3	*Middle OT, Short IC*	3	0.1	0.13	1.39	0.92
4	*Long OT, Short IC*	8	0.12	0.09	2.61	24
5	*Short OT, Middle IC*	1	3	0	1	24
6	*Middle OT, Middle IC*	3	2	0.2	2.98	24
7	*Long OT, Middle IC*	6	2.3	0.11	3.38	24
8	*Long OT, Long IC*	8	5	0.5	2.68	24

3.5.2 Length of stay (LOS)

The length of stay is measured as the number of days that patients stay at IC and MC. This study incorporates a stochastic length of stay for IC and MC based on empirical data from an actual 3-month admission record. The total sample population consists of 1,044 operation cases, distributed as 282, 550, 157, 11, 1, 30, 9, and 4 for patient categories 1, 2, 3, 4, 5, 6, 7, and 8, respectively. Tables 3.4 and 3.5 illustrate the probability of length of stay at IC and MC for each patient category, respectively. The distribution was fitted using the number of days of each patient from

each category stay at IC and MC. The maximum length of stay recorded during the period of the study is 7 and 20 days at IC and MC, respectively.

Table 3.4 Probability of length of stay at IC for each patient category

Patient category, *c*	**Probability of length of stay at IC (days), $p_{ic,c,j}$**							
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1 *Very short OT, No IC*	1	0	0	0	0	0	0	0
2 *Short OT, Short IC*	0.902	0.093	0.002	0.003	0	0	0	0
3 *Middle OT, Short IC*	1	0	0	0	0	0	0	0
4 *Long OT, Short IC*	1	0	0	0	0	0	0	0
5 *Short OT, Middle IC*	0	0	0	1	0	0	0	0
6 *Middle OT, Middle IC*	0.333	0.167	0.133	0.167	0.1	0.067	0.033	0
7 *Long OT, Middle IC*	0.111	0.111	0.445	0.222	0	0.111	0	0
8 *Long OT, Long IC*	0	0	0	0	0.5	0.25	0	0.25

Table 3.5 Probability of length of at MC for each patient category

Patient category, *c*	**Probability of length of stay at post-operative MC (days), $p_{mc,c,j}$**										
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1 *Very short OT, No IC*	0.539	0.312	0.082	0.035	0.011	0.007	0.004	0.004	0.007	0	0
2 *Short OT, Short IC*	0.316	0.213	0.164	0.244	0.020	0.009	0.011	0.009	0.004	0.002	0.004
3 *Middle OT, Short IC*	0.548	0.083	0.172	0.115	0.019	0.013	0.019	0.013	0	0	0
4 *Long OT, Short IC*	0.364	0.091	0.182	0.091	0.091	0	0.091	0	0	0	0
5 *Short OT, Middle IC*	0	1	0	0	0	0	0	0	0	0	0
6 *Middle OT, Middle IC*	0.433	0.067	0.067	0.033	0.167	0.033	0.067	0.033	0	0.033	0.033
7 *Long OT, Middle IC*	0.111	0.111	0.222	0.333	0	0.111	0	0	0	0	0
8 *Long OT, Long IC*	0.250	0	0	0.500	0	0.250	0	0	0	0	0
	11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	
1 *Very short OT, No IC*	0	0	0	0	0	0	0	0	0	0	
2 *Short OT, Short IC*	0.002	0.002	0	0	0	0.002	0	0	0	0	
3 *Middle OT, Short IC*	0	0.006	0.006	0	0	0	0	0	0	0.006	
4 *Long OT, Short IC*	0.091	0	0	0	0	0	0	0	0	0	
5 *Short OT, Middle IC*	0	0	0	0	0	0	0	0	0	0	
6 *Middle OT, Middle IC*	0	0	0	0	0	0	0	0.033	0	0	
7 *Long OT, Middle IC*	0.111	0	0	0	0	0	0	0	0	0	
8 *Long OT, Long IC*	0	0	0	0	0	0	0	0	0	0	

3.5.3 Available resources and target utilization

Table 3.6 provides the information on the available daily capacity and target utilization of each resource in a week. Available capacity for operating rooms is

the total operating time available in each day. There are 6 operating rooms available for 24 hours a day. Hence, total capacity of the operating rooms is 144 hours a week. The target utilization is set to 76 hours per day for Monday to Saturday and 68 hours for Sunday. The IC and MC bed capacity are the total number of beds available to the post-operated patients at the IC and MC units. The total available beds at IC and MC equal to 12 and 157 beds per day, respectively. The target utilization for IC and MC are 10 and 126 beds per day, respectively. IC nursing workload is measured by the number of IC nursing hours available per day at the IC unit. The available IC nursing hour is 210 hours per day and 168 hours per day for its target usage. The parameter B_t denotes the daily maximum number of operated patients from every.

Table 3.6 Daily available resource capacity and target utilisation levels ($C_{r,t}$ and $U_{r,t}$)

Day,*t*	OT Hours		IC beds		MC beds		IC nursing hours		B_t
	Capacity, $C_{ot,t}$	Target, $U_{ot,t}$	Capacity, $C_{ic,t}$	Target, $U_{ic,t}$	Capacity, $C_{mc,t}$	Target, $U_{mc,t}$	Capacity, $C_{nh,t}$	Target, $U_{nh,t}$	
1 Monday	144	76	12	10	157	126	210	168	30
2 Tuesday	144	76	12	10	157	126	210	168	30
3 Wednesday	144	76	12	10	157	126	210	168	30
4 Thursday	144	76	12	10	157	126	210	168	30
5 Friday	144	76	12	10	157	126	210	168	30
6 Saturday	144	76	12	10	157	126	210	168	30
7 Sunday	144	68	12	10	157	126	210	168	30

3.5.4 Emergency patient arrival

In this study, all types of unscheduled arrivals of patients (emergency and urgent) to the admission for surgery are treated as emergency admissions. Tables 3.7 and 3.8 provide the probability of emergency arrivals and the daily arrival rates of each patient category, respectively. The probability is based on empirical data from the same data set used in the distribution of probability of the length of stay. The total

number of unscheduled arrivals for surgery is 285 cases from the total arrival samples of 1,044 cases.

Table 3.7 Probability of emergency patient arrivals

Patient category, *c*	**Probability of emergency patient of category *c* arriving during day *t* , $p_{emg,c,t}$**						
	1	**2**	**3**	**4**	**5**	**6**	***7***
1 *Very short OT, No IC*	0.140	0.175	0.158	0.193	0.088	0.123	0.123
2 *Short OT, Short IC*	0.192	0.138	0.168	0.132	0.108	0.144	0.120
3 *Middle OT, Short IC*	0	0.136	0.091	0.136	0.273	0.091	0.273
4 *Long OT, Short IC*	0	0	0	0	0	1	0
5 *Short OT, Middle IC*	0	0	0	0	1	0	0
6 *Middle OT, Middle IC*	0.500	0.200	0	0	0.1	0.100	0.100
7 *Long OT, Middle IC*	0.333	0.333	0.333	0	0	0	0
8 *Long OT, Long IC*	0	0	0	0	0	0	0

Table 3.8 Emergency patient arrival rates, $l_{c,t}$

Patient category, *c*	**Day *t***						
	1	**2**	**3**	**4**	**5**	**6**	**7**
1 *Very short OT, No IC*	0.62	0.71	0.69	0.85	0.38	0.54	0.54
2 *Short OT, Short IC*	2.46	10.68	2.15	1.69	1.38	1.85	1.54
3 *Middle OT, short IC*	0	0.21	0.15	0.23	0.46	0.15	0.46
4 *Long OT, Short IC*	0	0	0	0	0	0.08	0
5 *Short OT, Middle IC*	0	0	0	0	0.08	0	0
6 *Middle OT, Middle IC*	0.38	0.14	0	0	0.08	0.08	0.08
7 *Long OT, Middle IC*	0.08	0.07	0.08	0	0	0	0
8 *Long OT, Long IC*	0	0	0	0	0	0	0

3.5.5 No-show and appointment cancellation

No-show and appointment cancellation, in this study, refer to the patients who are unable to attend the hospital appointment either with or without prior notification. Tables 3.9 and 3.10 provide probability distribution of daily no-show and cancellation for each patient category and daily no-show and cancellation rates,

respectively. Data were collected from a hospital appointment record consisting of 100 no-show cases from the total of 1,029 appointments (See Appendix B).

Table 3.9 Probability of no-shows and appointment cancellations

Patient category, *c*	**Probability of patient category *c* cancels the appointment or be absent during day *t* , $p_{NS,c,t}$**						
	1	**2**	**3**	**4**	**5**	**6**	**7**
1 *Very short OT, No IC*	0.273	0.091	0.091	0	0.182	0.091	0.273
2 *Short OT, Short IC*	0.018	0.196	0.089	0.179	0.304	0.125	0.089
3 *Middle OT, Short IC*	0.217	0.304	0.217	0.130	0.087	0	0.043
4 *Long OT, Short IC*	0	0	0	1	0	0	0
5 *Short OT, Middle IC*	0	0	0.167	0.333	0.333	0.167	0
6 *Middle OT, Middle IC*	0	0	0	1	0	0	0
7 *Long OT, Middle IC*	1	0	0	0	0	0	0
8 *Long OT, Long IC*	0	1	0	0	0	0	0

Table 3.10 No-show and appointment cancellation rates, $g_{c,t}$

Patient category, *c*	**Day *t***						
	1	**2**	**3**	**4**	**5**	**6**	**7**
1 *Very short OT, No IC*	0.231	0.071	0.077	0	0.154	0.077	0.231
2 *Short OT, Short IC*	0.077	0.786	0.385	0.769	1.308	0.538	0.385
3 *Middle OT, Short IC*	0.385	0.500	0.385	0.231	0.154	0	0.077
4 *Long OT, Short IC*	0	0	0	0.077	0	0	0
5 *Short OT, Middle IC*	0	0	0.077	0.154	0.154	0.077	0
6 *Middle OT, Middle IC*	0	0	0	0.077	0	0	0
7 *Long OT, Middle IC*	0.077	0	0	0	0	0	0
8 *Long OT, Long IC*	0	0.071	0	0	0	0	0

3.5.6 Relative weights

The hospital stakeholders have scored an absolute weight of each resource for calculating of relative weights as defined in (3.2) and the results are shown in Table 3.11. Note that, in the study, the maximum capacity for resource *r* remains unchanged for period *j*.

Table 3.11 Value of relative weight per resource

Resource *r*	g_r	$C_{r,j}$	T	**Weight for Resource r,** α_r
OT Hours	10	144	7	0.128
IC beds	5	12	7	0.769
MC beds	5	157	7	0.059
IC nursing	5	210	7	0.044

3.6 Computational Methodology

The LINGO version 11.0, an optimization modeling software, is adopted to solve the model. Solutions could be obtained within a few seconds. The subsequent chapter will discuss and interpret the obtained results.

CHAPTER IV

RESULTS AND DISCUSSIONS

In this chapter, the numerical results of the planning problem and the discussions are provided. The planning model is solved by LINGO version 11.0 with data sets in the aforementioned section. Solutions could be obtained within a few seconds.

The objective values, model output of the utilization of each resource, admission schedule for the current setting, sensitivity analysis and proposed admission schedule will be shown in the following sections.

4.1 The Values of the Objective Function

The values of the objective function are the total absolute deviations between expected resource utilizations and their target consumptions. To benchmark with the proposed model, we select the models of Adan and Vissers (2002), called Model A, and Adan et al. (2011), called Model B, to be bases for comparison. The former one is an early patient mix admission planning model with a deterministic approach and the latter one is the developed version of Model A incorporating with a stochastic length of stay and emergency arrivals. The proposed model is a modified version of Model B by adding no-show and cancellation conditions. In this research, we expect that the proposed model can lead to a decreasing of the deviations in OR resource planning. The aforementioned data sets are used for evaluation of these models and assessment

the effect of no-show and cancellation conditions. Table 4.1 summarises the computational results of the objective values for the Model A, Model B, and the proposed model (The LINGO programming results are provided in Appendix C). A lesser objective value implies a more satisfying the objective function of minimizing the shortfalls. Deliberating a stochastic length of stay and emergency arrivals of Model B can decrease the deviations by 93.58 % compared to a deterministic model (Model A). Introducing the patient no-show factor of the proposed model leads to decreasing in the total absolute deviations of resources by 12.58 % compared to Model B. Hence, this finding confirms our assumption that the no-show can bring fewer fluctuations to the OR resource planning. This outcome implies that the proposed planning model leads to a more efficient use of the OR resources.

Table 4.1 Total absolute deviation of resources

	Model A	**Model B**	**Proposed Model: Current setting**
Objective value	7719.96	495.94	433.56
% decrease from Model A	-	93.58%	94.38%
% decrease from Model B	-	-	12.58%

4.2 Admission Schedule and Resource Utilization for the Current Setting

The output of the proposed model also gives an optimal admission schedule for the current setting as depicted in Table 4.2. To satisfy the objective value of the proposed model, the hospital should, for example, assign 2, 8, 5 and 10 patients from group 1 to be admitted for surgery on days 2, 3, 6, and 7, respectively. The schedule derived from the proposed model can be used as a guideline for a hospital planner in

order to develop an operational plan such as planning for surgeons and physicians. Apparently, the total number of scheduled patients from each group should be equal to the target patient throughput per group (TPT_c). In the same way, the total number of patients from groups to be undergone surgery on each day must not exceed the maximum number of patients that can be operated on each day (B_t).

Table 4.2 Admission schedule for the current setting

Patient Group	**Day**							**Target patient throughput, TPT_c**
	1	**2**	**3**	**4**	**5**	**6**	**7**	
1 *Very short OT, No IC*	0	2	8	0	0	5	10	25
2 *Short OT, Short IC*	7	0	0	30	8	5	0	50
3 *Middle OT, Short IC*	15	0	0	0	0	0	0	15
4 *Long OT, Short IC*	1	0	0	0	0	0	0	1
5 *Short OT, Middle IC*	0	1	0	0	0	0	0	1
6 *Middle OT, Middle IC*	3	0	0	0	0	0	0	3
7 *Long OT, Middle IC*	1	0	0	0	0	0	0	1
8 *Long OT, Long IC*	0	0	1	0	0	0	0	1
Total # of planned patients	27	3	9	30	8	10	10	

Although the proposed model generates a better admission plan with less resource usage deviations, the output remains unable to provide the best allocation of resources. The computational results further pinpoint the level of the resource usages. Table 4.3 presents the daily target and actual utilizations and utilization rate (UR) for the current setting. The outcome indicates an unsatisfied performance on the OR resource utilization due to an over-utilization and over-capacity of IC-bed resource. The over-utilizations from the target reflect an inefficient plan and the overuses imply a deficient amount of resource allocated. To attain a better resource allocation, adjustments on the amount of assigned resources should be made. In the next sub-

section, we continue performing sensitivity analysis with the purpose of improving for a better allocation of resources.

Table 4.3 Model output of resource utilization for the current setting

Day	Operating room			IC beds			IC nursing hours			MC beds		
no.	Target	Actual	UR	Target	Actual	UR	Target	Actual	UR	Target	Actual	UR
1	76	76	99%	10	26	261%	168	6	4%	126	25	20%
2	76	3	4%	10	13	128%	168	21	12%	126	21	17%
3	76	12	16%	10	12	121%	168	36	21%	126	46	36%
4	76	29	39%	10	30	297%	168	22	13%	126	28	23%
5	76	8	11%	10	12	122%	168	54	32%	126	25	20%
6	76	8	11%	10	12	125%	168	12	7%	126	24	19%
7	68	6	8%	10	13	129%	168	16	10%	126	47	37%

4.3 Sensitivity Analysis

This section provides further discussions on sensitivity analysis of resource utilization. We attempt to reallocate the OR resources with the intention of obtaining a better balance between OR demands and supplies. IC-bed resource is the potential resource to consider in reallocation because of its over-capacity. Table 4.4 depicts the settings of target resource utilization and absolute weight for all scenarios. A scenario 1 is an adjustment on the amount of IC-bed resource from the current setting. At this scenario, the IC-bed resource is reallocated to 12 beds per day or its maximum availability. The outcome from a scenario 1 gives a tiny improvement on the objective function compared to the current setting as illustrated in Table 4.5 (Admission schedules and resource utilization of all scenarios are provided in Appendix D and E, respectively). This implies that the reallocation of the resource can attain a better usage of the resource and a decreasing in overall resource deviations. Average weekly resource utilization rate of a scenario 1 is demonstrated in Figure 4.1. While the IC-

bed resource is better utilized, the other resources such as operating theatre time (OT), nursing hours (NH), and medium care beds (MC), remain vastly unused. The utilization levels of OT, NH, and MC for a scenario 1 are far underneath the target values. The hospital might encounter the opportunity losses in leaving these costly resources idle. To address with this issue, we continue to develop more settings for the admission planning model.

Table 4.4 The target resource utilization and absolute weight settings for all scenarios

	Resource	**Current Setting**	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**
Target resource utilisations	*ot*	76	76	76	21	21
	ic	10	12	12	12	17
	mc	126	126	126	26	28
	nh	168	168	168	32	32
Absolute weight	*ot*	10	10	1	10	10
	ic	5	5	10	5	5
	mc	5	5	1	5	5
	nh	5	5	1	5	5

An absolute weight might be a factor affecting the overall resource deviations and resource utilizations. According to this assumption, we develop a Scenario 2 as defined in Table 4.4 which is a modified setting of a scenario 1 by varying the resource absolute weights. An absolute weight of each resource has first scored by the hospital stakeholders in Table 3.11. At this scenario, we focus on optimizing of an IC-bed resource because of its scarceness. Hence the weight function is adjusted to the maximum weight of 10 for the IC bed and the minimum weight of 1 for the other resources. As can be seen from Table 4.5, an adjustment on the weight function gives a small improvement on the objective value. It means that the total resource usage

deviations can be decreased by varying the absolute weight. However, the weight score adjustment takes no effect on the resource utilizations as shown in Figure 4.1. The average resource utilization of a scenario 2 and a scenario 1 are identical. Focusing on the resource utilization, we can conclude that the setting of the weight has no effect on average resource deviations and resource utilization rates. Hence, finding the proper settings for the resource usages can neglect the influence of the weight function.

Table 4.5 Model output of average deviations and objective value for all scenarios

	Resource	**Current Setting**	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**
Average deviations	*ot*	54.59	54.59	54.59	0.73	0.76
	ic	6.90	4.90	4.90	4.90	0.10
	mc	144.04	144.04	144.04	2.04	4.06
	nh	95.22	95.22	95.22	1.22	1.29
Objective value		433.56	422.79	383.20	291.98	3.07
% decrease from current		-	2.48%	11.61%	32.66%	99.29%

4.4 Finding the Proper Allocation of Resources

Concentrating on the proper resource utilizations, we attempt to find a better fit between resource usages and amount of allocated resources. The setting for the resource target utilizations of a scenario 3 is defined in Table 4.4. At this setting, the amount of resource is assigned based on availability in order to attain a better resource utilization rate. The weight function of a scenario 3 remains unchanged from the current setting. As shown in Table 4.5, the average resource deviations and the objective value of a scenario 3 are significant reduced compared to the previous settings. Therefore, an appropriate allocation of resource leads to an improvement on

resource utilization. Nevertheless, the setting of a scenario 3 remains unable to completely satisfy the OR requirements. As can be seen from Figure 4.1, the amount of IC-bed capacity used of a scenario 3 is still overutilized due to its availability. We continue to find the theoretical settings of an IC-bed resource in order to avoid an overutilization. The setting of a scenario 4, as specified in Table 4.4, reflects the best uses of all resources incorporating the high level of resource usages without any overutilization (See Figure 4.1). Although the scenario 4 gives a best resource setting that leads to the least deviations, the hospital might need to consider the economic feasibility in investing on the IC-bed resource. Expanding the IC-bed resource of a scenario 4, however, might not have a significant benefit due to its tiny improvement (See the average deviations of the scenario 3 and 4 in Table 4.5). A hospital, therefore, should address the level of the resource usages based on the available capacities in order to achieve a good admission schedule with the proper resource utilizations.

The proposed model indicates the improvement on OR resource utilization compared to the previous study; nevertheless, it is unable to give a fixed allocation of resources. A manual configuration on resource allocation should be made in order to increase the OR resource usage performance.

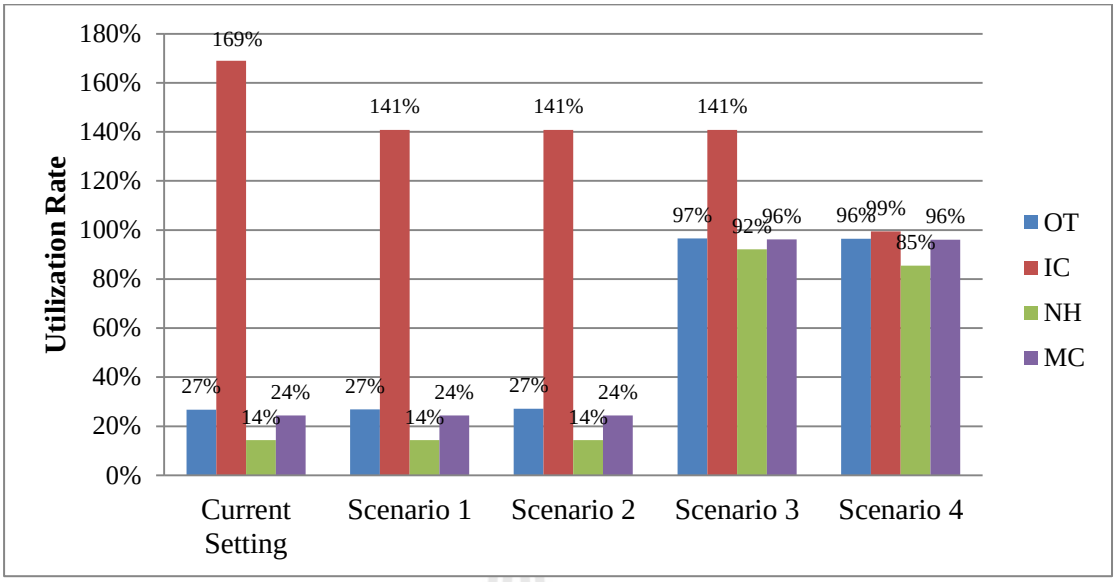

Figure 4.1 Average weekly resource utilizations for all scenarios

CHAPTER V

CONCLUSIONS

5.1 Conclusion

A patient admission planning is an indispensable part of a hospital management. A good plan leads to a better care with a smoother a patient flow and gives superior utilisations of costly and scanty resources. Operating room (OR) is one of the scarce resources in a hospital requiring a proper planning of its utilisation. The OR associated with relevant resources, i.e., operating room time, intensive care bed, intensive care nursing hour, and medium care bed, which also need an effective resource management. In this study, we presented a mixed integer linear programming model to obtain a better admission plan for a patient mix. A model incorporates the uncertain conditions such as length of stay, emergency patients and introduction of no-show that help the planning problem more practical. Even though the background data setup for validating the model is captured from a large community hospital in Thailand, it should be noted that the model formulation is readily to apply in the other environments. By benchmarking with the previous known, presenting of the patient no-show condition into the proposed model can help decrease the total absolute deviations between resource consumption and their target utilisations. Reducing in the deviations signifies a better admission plan with more efficient use of the OR resources. The model outcome also generates a good admission plan that can be used as a guideline for hospital planners in order to

develop an operational plan. The output further exhibits the utilisation rates of each resource that reflect the performance of the plan. A higher performance plan can be achieved by a higher resource utilisation without an over-utilisation.

5.2 Limitation of the Study

Although the proposed study leads to obtaining a better performance plan with smaller deviations of resource usages, it is unable to give the best allocation level of resources. Modifications on resource allocation levels might be required in order to find a better balance of the resource usages. Further analysis on the model sensitivity discloses that variations in the weight functions yield small improvement on the total absolute deviations, but do not affect the average utilisation of each resource. Hence, the absolute weight can be avoided from the resource allocation target adjustment. In practice, hospital planners should focus in the proper amount of resource capacities that result in a good plan with smaller deviations. The proposed model and obtained results unveil some understanding of the hospital resource management and indicate some significant issues in hospital admission planning task.

5.3 Applications of the Work

The development of the mathematical model in this study is applicable to planning the admission of the patient mix for the hospital operating room. The model is designed to account for the elective patients including the reservation of some capacities for emergency patients and possible capacity excess and cancellations.

Despite the approach in this study is based on the hospital operating room setting, it can be deployed on the resource allocation activity in other medical cares.

The home health care resource planning is one of the potential topics to adopt this technique. The proposed method is able to use determining the periodic schedule for the medical home. The home health care case-mix can be classified by the skilled nurse required for a visit and visit lengths.

5.4 Recommendation for Future Work

Further improvements in the planning model may be brought by considering stochastic operating duration. Because the demands in the hospital system are unpredictable, the future recommendation is to design more robust systems such as expert systems that help hospital planners to deal with the changing demands in order to obtain a higher plan performance.

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APPENDIX A

HOSPITAL OPERATION RECORD

Table A.1 Hospital operation record

No.	Operation Date	Operation Description	Admission Type 1 = EL (Elective) 2 = UR (Urgent) 3 = EM (Emergency)		Operation Starting Time	Operation Ending Time	Total Operation Time (Hrs)	No. of Day stay in Ward before operation	No. of days stay in ICU	No. of days stay in ward after operation	Nursing Time Required for a Patient in IC Unit (Hours)	Category	Weekday (1 = Monday, 2 = Tuesday, …, 7 = Sunday)
1	1-Mar-11	C-Section	1	EL	8:45	9:30	0:45	0	0	3.00	0	1	2
2	1-Mar-11	C-Section	1	EL	6:50	8:25	1:35	0	0	3.00	0	2	2
3	1-Mar-11	Gastroscope	1	EL	7:00	7:20	0:20	0	0	0	0	1	2
4	1-Mar-11	Gastroscope	1	EL	9:00	9:15	0:15	0	0	0	0	1	2
5	1-Mar-11	Gastroscope	1	EL	8:20	8:30	0:10	0	0	0	0	1	2
6	1-Mar-11	repair tenter	2	UR	9:30	10:30	1:00	0	0	0	0	2	2
7	1-Mar-11	repair tenter	1	EL	10:20	11:10	0:50	0	0.40	0	9.60	2	2
8	1-Mar-11	Gastroscope	1	EL	10:45	11:00	0:15	0	0	0	0	1	2
9	1-Mar-11	Dac	1	EL	12:50	13:30	0:40	0	0	2.00	0	1	2
10	1-Mar-11	Colonoscopy	1	EL	15:00	15:15	0:15	0	0	0	0	1	2
11	1-Mar-11	GSWL	1	EL	15:15	16:35	1:20	0	0.25	1.00	6.00	2	2
12	1-Mar-11	AR	1	EL	13:45	16:25	2:40	0	3.20	0	76.80	6	2
13	1-Mar-11	Excision	1	EL	18:00	18:30	0:30	0	0	0	0	1	2
14	1-Mar-11	Aug Rhinoplasty	1	EL	10:30	12:45	2:15	0	2.40	0	57.60	6	2
15	2-Mar-11	C-Section	2	UR	10:00	11:20	1:20	0.47	0	3.17	0	2	3
16	2-Mar-11	Aug Rhinoplasty	1	EL	10:40	12:55	2:15	0	0	0	0	3	3
17	2-Mar-11	ORIF c-bar wiring fixation at frontalbone	2	UR	10:25	11:50	1:25	0.98	0	2.42	0	2	3
18	2-Mar-11	C-Section	1	EL	13:05	14:15	1:10	0	0	2.92	0	2	3
19	2-Mar-11	D&C	2	UR	14:05	14:40	0:35	0	0	0.31	0	1	3
20	2-Mar-11	Alarplasty	1	EL	13:10	14:25	1:15	0	0.25	0	6.00	2	3
21	2-Mar-11	ORIF	2	UR	14:25	16:20	1:55	0	0	1.38	0	2	3
22	2-Mar-11	Gastroscope	1	EL	15:15	15:30	0:15	0.77	0	1.08	0	1	3
23	2-Mar-11	AR	1	EL	16:20	18:40	2:20	0	0	0	0	3	3
24	2-Mar-11	open cholecystectoy	1	EL	22:05	0:20	2:15	0.23	0	1.63	0	3	3
25	3-Mar-11	C-Section	1	EL	7:00	8:25	1:25	0.21	0.33	3.08	7.92	2	4
26	3-Mar-11	ORIF c-bar narrow DCP/Screw	2	UR	8:15	9:30	1:15	0	0	2.17	0	2	4
27	3-Mar-11	C-Section	1	EL	8:20	9:30	1:10	0.58	0	3.13	0	2	4
28	3-Mar-11	Abdominoplasty	1	EL	9:00	14:30	5:30	0	2.40	2.15	57.60	7	4
29	3-Mar-11	lap cystectomy	1	EL	10:00	13:20	3:20	0	0	0	0	3	4
30	3-Mar-11	remove FB 2wrist	1	EL	12:30	13:20	0:50	0.83	0.25	0	6.00	2	4
31	3-Mar-11	remove pse 2wrist	1	EL	14:00	15:20	1:20	0	0	1.21	0	2	4
32	3-Mar-11	OFF IMF	1	EL	15:30	16:00	0:30	0.36	0	0	0	1	4
33	3-Mar-11	Rhinoplasty	1	EL	16:00	18:00	2:00	0	0	0	0	2	4
34	3-Mar-11	ORIF c TBW 2patell	2	UR	17:15	18:20	1:05	0	0	1.00	0	2	4
35	3-Mar-11	Gastroscope	2	UR	16:00	16:50	0:50	0	0	1.00	0	2	4
36	3-Mar-11	Excision	1	EL	18:10	18:45	0:35	0	0	0	0	1	4
37	3-Mar-11	ORIF	2	UR	18:10	20:30	2:20	0.36	0	0.08	0	3	4
38	4-Mar-11	AR	1	EL	12:15	13:00	0:45	0	0	0	0	1	5

Table A.1 Hospital operation record (Continued)

No.	Operation Date	Operation Description	Admission Type 1 = EL (Elective) 2 = UR (Urgent) 3 = EM (Emergency)		Operation Starting Time	Operation Ending Time	Total Operation Time (Hrs)	No. of Day stay in Ward before operation	No. of days stay in ICU	No. of days stay in ward after operation	Nursing Time Required for a Patient in IC Unit (Hours)	Category	Weekday (1 = Monday, 2 = Tuesday, …, 7 = Sunday)
39	4-Mar-11	AR	1	EL	18:00	20:25	2:25	0	0	0	0	3	5
40	4-Mar-11	Explor lap for Jejunum Resection c Anastomosi	2	UR	21:55	1:30	3:35	0.60	0	3.00	0	3	5
41	4-Mar-11	Gastroscope	1	EL	12:35	12:50	0:15	0	0	0	0	1	5
42	4-Mar-11	C-Section & TR	1	EL	13:30	14:35	1:05	0	0.33	3.00	7.92	2	5
43	4-Mar-11	Appendectomy	1	EL	13:30	14:40	1:10	0	0.50	1.92	12.00	2	5
44	4-Mar-11	close stump	1	EL	14:50	16:10	1:20	0	0	0.92	0	2	5
45	4-Mar-11	Tonsillectomy	1	EL	20:10	21:00	0:50	0	0	1.67	0	2	5
46	4-Mar-11	Excision 1subcutaneus cyst at neck 2 mass at R	1	EL	11:00	11:45	0:45	0	0	0	0	1	5
47	4-Mar-11	Colonoscopy	1	EL	10:15	10:50	0:35	0.79	0	0	0	1	5
48	4-Mar-11	Revise Rhinoplasty	1	EL	10:50	13:50	3:00	0	1.80	0	43.20	6	5
49	4-Mar-11	CRaNIECTOmy	3	EM	10:50	13:55	3:05	0	0	1.88	0	3	5
50	4-Mar-11	Gastroscope	1	EL	11:30	11:40	0:10	0	0	0	0	1	5
51	5-Mar-11	Explor-lap	2	UR	6:00	8:00	2:00	0	0	3.38	0	2	6
52	5-Mar-11	Excision umbilical cast	1	EL	9:00	10:20	1:20	0	0.40	3.21	9.60	2	6
53	5-Mar-11	Explor-lap Cysteetomy	2	UR	10:00	11:30	1:30	0	0	3.00	0	2	6
54	5-Mar-11	AR	1	EL	10:00	12:15	2:15	0	0	0	0	3	6
55	5-Mar-11	Excision Pterygism	1	EL	11:00	11:50	0:50	0	0	0	0	2	6
56	5-Mar-11	Rhinoplasty	1	EL	12:30	15:30	3:00	0	0	0	0	3	6
57	5-Mar-11	External DCR	1	EL	13:30	15:35	2:05	0	0	0	0	3	6
58	5-Mar-11	ORIF	1	EL	15:00	16:30	1:30	0	0	3.00	0	2	6
59	5-Mar-11	Excision cyst	1	EL	14:00	15:00	1:00	0.57	0	0	0	2	6
60	5-Mar-11	Excision Sear	1	EL	14:30	15:30	1:00	0	0.60	0	14.40	2	6
61	5-Mar-11	1CRIF 2debridement	2	UR	14:00	18:15	4:15	0	0	3.00	0	3	6
62	5-Mar-11	Gastroscope	1	EL	18:00	18:20	0:20	0	0	2.00	0	1	6
63	5-Mar-11	Colonoscopy	1	EL	21:00	21:20	0:20	0	0	0	0	1	6
64	5-Mar-11	Gastroscope	1	EL	21:30	22:30	1:00	1.27	0	0.67	0	2	6
65	6-Mar-11	Appendectomy	2	UR	1:30	2:15	0:45	0.23	0.25	1.75	6.00	2	7
66	6-Mar-11	C-section	1	EL	8:55	9:55	1:00	0.94	0	3.13	0	2	7
67	6-Mar-11	Closed reduct nasal bone	2	UR	11:00	11:30	0:30	0	0	1.29	0	1	7
68	6-Mar-11	Marsupialization	2	UR	10:50	11:30	0:40	0	0	0.25	0	1	7
69	6-Mar-11	Excision	1	EL	11:20	12:05	0:45	0	0	0	0	1	7
70	6-Mar-11	D&C	2	UR	21:00	21:40	0:40	0	0.38	0.71	9.00	2	7
71	6-Mar-11	Closedredretion	2	UR	21:35	22:05	0:30	0	0	0.75	0	1	7
72	6-Mar-11	C-Section	1	EL	22:00	23:55	1:55	0	0.42	2.67	10.00	2	7
73	7-Mar-11	Tonsillectomy	1	EL	9:05	9:55	0:50	0	0	2.08	0	2	1
74	7-Mar-11	Appendectomy	1	EL	11:25	12:25	1:00	0	0.50	1.33	12.00	2	1
75	7-Mar-11	Open Rhinoplasty	1	EL	11:30	15:15	3:45	0	0	0	0	3	1
76	7-Mar-11	I&D	1	EL	12:55	13:50	0:55	0	0	2.00	0	2	1

Table A.1 Hospital operation record (Continued)

No.	Operation Date	Operation Description	Admission Type 1 = EL (Elective) 2 = UR (Urgent) 3 = EM (Emergency)		Operation Starting Time	Operation Ending Time	Total Operation Time (Hrs)	No. of Day stay in Ward before operation	No. of days stay in ICU	No. of days stay in ward after operation	Nursing Time Required for a Patient in IC Unit (Hours)	Category	Weekday (1 = Monday, 2 = Tuesday, …, 7 = Sunday)
77	7-Mar-11	AR	1	EL	16:00	16:30	0:30	0.89	0	0	0	1	1
78	7-Mar-11	Appendectomy	2	UR	15:30	16:45	1:15	0	0	2.00	0	2	1
79	7-Mar-11	CRIF	2	UR	18:00	19:00	1:00	0	0	1.00	0	2	1
80	7-Mar-11	Remise Rhinoplasty	1	EL	18:30	20:00	1:30	0	0.60	0	14.40	2	1
81	7-Mar-11	URS c Stone breaher	1	EL	19:25	20:15	0:50	0.30	0	1.00	0	2	1
82	8-Mar-11	I&D + fistulotomy	2	UR	21:40	22:30	0:50	0	0	2.00	0	2	2
83	8-Mar-11	Craniotomy remove depressed skull	2	UR	22:55	1:20	2:25	0	1.92	4.00	46.00	6	2
84	8-Mar-11	AR	1	EL	14:00	16:25	2:25	0	0	0	0	3	2
85	8-Mar-11	AR	1	EL	15:35	16:25	0:50	0	0	0	0	2	2
86	8-Mar-11	STSG	2	UR	16:15	20:15	4:00	1.29	0	6.00	0	3	2
87	8-Mar-11	ORIF cTBW at Claricle	2	UR	18:10	19:45	1:35	0	0	1.10	0	2	2
88	8-Mar-11	2ORIF	2	UR	20:25	2:15	5:50	0	2.80	10.63	67.20	7	2
89	8-Mar-11	c-section	1	EL	8:40	10:00	1:20	0	0.33	3.00	7.92	2	2
90	8-Mar-11	TAH &BSO	1	EL	9:00	12:35	3:35	0	0	3.17	0	3	2
91	8-Mar-11	Posterior repair	1	EL	10:20	11:20	1:00	0	0.25	1.08	6.00	2	2
92	8-Mar-11	AR	1	EL	10:50	12:50	2:00	0	0	0	0	2	2
93	8-Mar-11	Previous C-Section	1	EL	10:55	12:20	1:25	0	0	3.00	0	2	2
94	9-Mar-11	Repair tendon Lt.Thumb	2	UR	2:15	2:55	0:40	0	0	1.00	0	1	3
95	9-Mar-11	Closed Reduction	2	UR	2:50	3:25	0:35	0	0	3.00	0	1	3
96	9-Mar-11	Gastroscope	1	EL	10:00	10:15	0:15	0	0	0	0	1	3
97	9-Mar-11	AR	1	EL	10:00	11:45	1:45	0	0	0	0	2	3
98	9-Mar-11	Exam	1	EL	11:10	11:25	0:15	0	0	0	0	1	3
99	9-Mar-11	Excision	1	EL	11:15	12:00	0:45	0	0	0	0	1	3
100	9-Mar-11	Lower Blepharoplasty	1	EL	10:30	12:30	2:00	0	0	0	0	2	3
101	9-Mar-11	Release tonguetie	1	EL	9:10	9:30	0:20	1.20	0	1.00	0	1	3
102	9-Mar-11	Appendectomy	1	EL	13:15	15:15	2:00	0	0	2.00	0	2	3
103	9-Mar-11	AR	1	EL	14:00	16:00	2:00	0	0	0	0	2	3
104	9-Mar-11	C-Section	1	EL	9:00	10:40	1:40	0	0	3.13	0	2	3
105	9-Mar-11	AR	1	EL	16:30	19:00	2:30	0.63	0	0	0	3	3
106	9-Mar-11	Amputation	1	EL	15:15	15:55	0:40	0	0	8.00	0	1	3
107	9-Mar-11	Gastroscope	1	EL	15:10	15:30	0:20	0	0	1.00	0	1	3
108	9-Mar-11	C-Section due to arrest of dilatation	1	EL	23:20	1:00	1:40	0	0.29	3.42	7.00	2	3
109	10-Mar-11	Appendectomy	2	UR	0:50	1:45	0:55	0.96	0.29	1.13	7.00	2	4
110	10-Mar-11	C-section	1	EL	9:10	10:20	1:10	0	0.75	3.21	18.00	2	4
111	10-Mar-11	C-section	1	EL	9:50	10:55	1:05	0	0	3.08	0	2	4
112	10-Mar-11	Myomectomy	1	EL	10:35	12:25	1:50	0	0	3.13	0	2	4
113	10-Mar-11	Gastroscope	1	EL	10:10	10:15	0:05	0	0	0	0	1	4
114	10-Mar-11	C-Section	1	EL	12:00	13:20	1:20	0	0	3.00	0	2	4

Table A.1 Hospital operation record (Continued)

No.	Operation Date	Operation Description	Admission Type 1 = EL (Elective) 2 = UR (Urgent) 3 = EM (Emergency)		Operation Starting Time	Operation Ending Time	Total Operation Time (Hrs)	No. of Day stay in Ward before operation	No. of days stay in ICU	No. of days stay in ward after operation	Nursing Time Required for a Patient in IC Unit (Hours)	Category	Weekday (1 = Monday, 2 = Tuesday, …, 7 = Sunday)
115	10-Mar-11	partial Excision	1	EL	11:30	12:20	0:50	1.19	0	0	0	2	4
116	10-Mar-11	Gastroscope	1	EL	12:20	12:35	0:15	0	0	1.00	0	1	4
117	10-Mar-11	Excision	1	EL	12:00	13:00	1:00	0	0.60	0	14.40	2	4
118	10-Mar-11	Wide Excision	1	EL	11:50	13:35	1:45	0	0	0	0	2	4
119	10-Mar-11	Open Rhinoplasty	1	EL	15:30	17:55	2:25	0	0	0	0	3	4
120	10-Mar-11	Wide Excision	1	EL	16:00	17:00	1:00	0	0	0	0	2	4
121	10-Mar-11	ORIF	2	UR	18:30	20:00	1:30	0	0	2.00	0	2	4
122	11-Mar-11	ORIF c k-wire	2	UR	0:30	1:40	1:10	0	0.25	0.21	6.00	2	5
123	11-Mar-11	Rhinoplasty	1	EL	11:30	13:15	1:45	0	0	0	0	2	5
124	11-Mar-11	Rhinoplasty	1	EL	10:50	13:20	2:30	0	0	0	0	3	5
125	11-Mar-11	Revise V-P shunt	2	UR	12:30	15:00	2:30	0	0	20.00	0	3	5
126	11-Mar-11	Explor-lop simple suture	3	EM	14:30	15:30	1:00	0	0	5.00	0	2	5
127	11-Mar-11	Excision pterysive	1	EL	15:30	16:00	0:30	0	0	0	0	1	5
128	11-Mar-11	eXcision weer@arm	1	EL	16:00	17:35	1:35	0	0	0	0	2	5
129	11-Mar-11	Crameatomy	3	EM	17:00	20:30	3:30	0.50	0	13.00	0	3	5
130	11-Mar-11	Gastroscope	1	EL	13:00	13:30	0:30	0	0	0	0	1	5
131	11-Mar-11	Appendectomy	2	UR	21:30	22:40	1:10	1.19	0.38	2.13	9.00	2	5
132	11-Mar-11	Gastroscope	1	EL	15:00	15:30	0:30	0	0	0	0	1	5
133	11-Mar-11	c-section	1	EL	22:45	0:15	1:30	0	0.25	4.13	6.00	2	5
134	12-Mar-11	1close reduction 2ORIF TBW screw	2	UR	1:30	2:45	1:15	0.38	0.17	3.33	4.00	2	6
135	12-Mar-11	AR	1	EL	12:05	13:45	1:40	0	0.50	0	12.00	2	6
136	12-Mar-11	Gastroscope	1	EL	16:00	16:10	0:10	0	0	1.00	0	1	6
137	12-Mar-11	Aug Rhinoplasty	1	EL	16:15	17:20	1:05	0	0	0	0	2	6
138	12-Mar-11	Gastroscope	1	EL	18:00	18:20	0:20	0	0	1.00	0	1	6
139	12-Mar-11	Ar	1	EL	18:30	20:10	1:40	0	0	0	0	2	6
140	12-Mar-11	Excision	1	EL	21:55	22:35	0:40	0	0	1.00	0	1	6
141	12-Mar-11	Gastroscope	1	EL	21:40	22:00	0:20	0	0	2.00	0	1	6
142	13-Mar-11	Gastroscope	1	EL	9:30	9:55	0:25	0	0	4.00	0	1	7
143	13-Mar-11	D&C	1	EL	10:00	10:30	0:30	0	0	1.00	0	1	7
144	13-Mar-11	Gastroscope	1	EL	12:55	13:15	0:20	0	0	2.21	0	1	7
145	13-Mar-11	Excision mass	1	EL	13:40	14:50	1:10	0	0	0	0	2	7
146	13-Mar-11	AR	1	EL	14:50	17:25	2:35	0	0	0	0	3	7
147	13-Mar-11	CRIF e k-wire	2	UR	21:00	22:05	1:05	0	0.35	0.38	8.50	2	7
148	13-Mar-11	CRIF e k-wire	2	UR	18:05	19:40	1:35	0	0	1.00	0	2	7
149	14-Mar-11	Hermorrkoid	1	EL	13:45	15:30	1:45	0	0	2.00	0	2	1
150	14-Mar-11	Alarplasty	1	EL	13:05	13:50	0:45	0.56	0	0	0	1	1
151	14-Mar-11	Aug Mammoplusty	1	EL	15:40	18:15	2:35	0	0	2.00	0	3	1
152	14-Mar-11	Closed reduction Nased bone	2	UR	17:00	17:40	0:40	0	0	3.00	0	1	1

Table A.1 Hospital operation record (Continued)

No.	Operation Date	Operation Description	Admission Type 1 = EL (Elective) 2 = UR (Urgent) 3 = EM (Emergency)		Operation Starting Time	Operation Ending Time	Total Operation Time (Hrs)	No. of Day stay in Ward before operation	No. of days stay in ICU	No. of days stay in ward after operation	Nursing Time Required for a Patient in IC Unit (Hours)	Category	Weekday (1 = Monday, 2 = Tuesday, …, 7 = Sunday)
153	14-Mar-11	Laminee e Dedicle screw	1	EL	14:00	16:45	2:45	0	0	2.92	0	3	1
154	14-Mar-11	Debrid+suture	2	UR	0:15	1:00	0:45	0	0.23	0.42	5.50	2	1
155	14-Mar-11	Gastroscope	1	EL	8:00	8:15	0:15	0	0	0.40	0	1	1
156	14-Mar-11	C-Section & TR	1	EL	9:00	10:25	1:25	0.78	0	3.13	0	2	1
157	14-Mar-11	Repair e Mesh graft	1	EL	11:00	13:20	2:20	0	0	2.00	0	3	1
158	14-Mar-11	Explor wound e Release adhesin	1	EL	13:20	14:30	1:10	0	0.70	2.00	16.80	2	1
159	14-Mar-11	Debridment e k-wire fix	1	EL	19:55	20:25	0:30	0	0	0.71	0	1	1
160	14-Mar-11	Cystoscope+Proctoscope	1	EL	18:30	18:55	0:25	1.08	0	1.79	0	1	1
161	14-Mar-11	Appendectomy	1	EL	22:55	23:50	0:55	0	0.35	2.13	8.50	2	1
162	14-Mar-11	Debridment e suture at scalp+lip	1	EL	20:30	22:20	1:50	0	0	8.38	0	2	1
163	14-Mar-11	AR	1	EL	17:30	18:25	0:55	0	0	0	0	2	1
164	14-Mar-11	Excisnat	1	EL	11:30	12:30	1:00	0	0	0	0	2	1
165	15-Mar-11	Explor Lap e Stopped bleeding	2	UR	1:10	3:05	1:55	0	0	10.00	0	2	2
166	15-Mar-11	Excision at Cheek	1	EL	9:20	10:05	0:45	1.07	0	0	0	1	2
167	15-Mar-11	Rhinoplasty	1	EL	10:00	13:00	3:00	0	0.60	0	14.40	6	2
168	15-Mar-11	Phaco	1	EL	11:00	12:00	1:00	0	0	0	0	2	2
169	15-Mar-11	Anterior Fusion	1	EL	12:30	16:00	3:30	0	0	3.00	0	3	2
170	15-Mar-11	Hermorrkoidectomy	1	EL	14:30	16:00	1:30	0	0.10	2.00	2.40	2	2
171	15-Mar-11	Rhinoplasty revise	1	EL	14:00	18:30	4:30	0.88	3.00	0	72.00	7	2
172	15-Mar-11	c-section	1	EL	13:00	14:00	1:00	0	0	3.00	0	2	2
173	15-Mar-11	Rhinoplasty	1	EL	18:00	20:40	2:40	0	0	0	0	3	2
174	15-Mar-11	closed reduction e wasal packing	1	EL	17:45	18:30	0:45	0	0	1.83	0	1	2
175	15-Mar-11	Suture wound	1	EL	21:00	21:45	0:45	0.20	0	0.79	0	1	2
176	15-Mar-11	Fistulectomy	1	EL	22:00	22:30	0:30	0	0	0.75	0	1	2
177	16-Mar-11	upper Blepharoplasty	1	EL	10:20	14:35	4:15	0	0	0	0	3	3
178	16-Mar-11	Gastroscope	2	UR	11:40	12:00	0:20	0	0	0	0	1	3
179	16-Mar-11	Debridment c suture	2	UR	11:45	12:50	1:05	0	0	0	0	2	3
180	16-Mar-11	Excision Pterygium	1	EL	10:20	11:05	0:45	0.67	0	0	0	1	3
181	16-Mar-11	AR+alarplasty	1	EL	14:30	16:45	2:15	0	0	0	0	3	3
182	16-Mar-11	AR	1	EL	15:30	17:30	2:00	1.00	0.25	0	6.00	2	3
183	16-Mar-11	AR +suture	1	EL	17:00	19:00	2:00	0	0	0	0	2	3
184	16-Mar-11	Appendectomy	2	UR	17:00	18:20	1:20	0.23	0	2.00	0	2	3
185	16-Mar-11	Appendectomy	2	UR	19:00	20:10	1:10	0	0	2.00	0	2	3
186	16-Mar-11	Appendectomy	2	UR	22:05	23:15	1:10	0	0.40	1.46	9.50	2	3
187	16-Mar-11	upper+Lower Blepharoplasty	1	EL	18:15	22:00	3:45	0	0	0	0	3	3
188	17-Mar-11	C-Section	1	EL	8:15	9:35	1:20	0.88	0	3.00	0	2	4
189	17-Mar-11	C-Section	1	EL	9:10	10:25	1:15	0	0.20	3.00	4.80	2	4
190	17-Mar-11	C-Section	1	EL	10:10	11:25	1:15	0	0.10	3.00	2.40	2	4

Table A.1 Hospital operation record (Continued)

No.	Operation Date	Operation Description	Admission Type 1 = EL (Elective) 2 = UR (Urgent) 3 = EM (Emergency)		Operation Starting Time	Operation Ending Time	Total Operation Time (Hrs)	No. of Day stay in Ward before operation	No. of days stay in ICU	No. of days stay in ward after operation	Nursing Time Required for a Patient in IC Unit (Hours)	Category	Weekday (1 = Monday, 2 = Tuesday, …, 7 = Sunday)
191	17-Mar-11	Phace e SOL	1	EL	10:15	11:20	1:05	0	0	0	0	2	4
192	17-Mar-11	Gastroscope	2	UR	11:40	12:15	0:35	0	0	1.00	0	1	4
193	17-Mar-11	Dissectomy	1	EL	10:30	13:15	2:45	0	0	3.08	0	3	4
194	17-Mar-11	AR	1	EL	10:35	13:20	2:45	0	0	0	0	3	4
195	17-Mar-11	revise AR	1	EL	15:20	19:50	4:30	0	0.17	0	4.08	3	4
196	17-Mar-11	Circumasion	1	EL	15:10	15:50	0:40	0	0	0	0	1	4
197	17-Mar-11	ORIF e small ORIF e Anatomucal	3	EM	20:45	23:15	2:30	0	0.38	4.00	9.00	6	4
198	17-Mar-11	Closed Reduce	1	EL	23:35	23:55	0:20	0	0.40	1.71	9.50	2	4
199	18-Mar-11	Closed reduce e k-wire	1	EL	1:55	2:45	0:50	0	0.67	0	16.00	2	5
200	18-Mar-11	c-section	1	EL	9:00	10:30	1:30	0	0	3.17	0	2	5
201	18-Mar-11	Tonsillectomy	1	EL	10:00	12:00	2:00	0.92	0	2.00	0	2	5
202	18-Mar-11	Rhinoplasty	1	EL	9:30	11:15	1:45	0	0	0	0	2	5
203	18-Mar-11	Rhinoplasty	1	EL	10:00	13:15	3:15	0	0	0	0	3	5
204	18-Mar-11	Excision Lipoma	1	EL	10:30	11:30	1:00	0	0.15	0	3.60	2	5
205	18-Mar-11	Gastroscope	1	EL	11:00	11:35	0:35	0	0	0	0	1	5
206	18-Mar-11	Rhinoplasty	1	EL	12:10	14:30	2:20	1.14	0	0	0	3	5
207	18-Mar-11	Posterier	1	EL	13:00	14:30	1:30	0	0	1.00	0	2	5
208	18-Mar-11	Rhinoplasty	1	EL	15:35	17:10	1:35	0	0	0	0	2	5
209	18-Mar-11	Gastroscope	1	EL	14:00	14:30	0:30	0	0	0	0	1	5
210	18-Mar-11	Lap-Diagnosis	1	EL	14:30	18:00	3:30	0	0	1.88	0	3	5
211	18-Mar-11	Rhinoplasty	1	EL	15:00	17:15	2:15	0	0	0	0	3	5
212	18-Mar-11	Gastroscope	1	EL	17:20	18:10	0:50	0	0	0.75	0	2	5
213	18-Mar-11	Rhinoplasty	1	EL	18:30	21:15	2:45	1.22	0.38	0	9.12	6	5
214	18-Mar-11	Debridment e fasiatomy	1	EL	21:30	23:15	1:45	0	0.50	10.00	12.00	2	5
215	18-Mar-11	Excision Ptery	1	EL	19:10	20:00	0:50	0	0	0	0	2	5
216	19-Mar-11	Closed stump	2	UR	1:05	2:10	1:05	0	0	0	0	2	6
217	19-Mar-11	c-section	3	EM	1:00	2:10	1:10	0	0.25	3.08	6.00	2	6
218	19-Mar-11	Laminectomy	1	EL	6:00	9:10	3:10	0	0	7.00	0	3	6
219	19-Mar-11	Colonoscopy	1	EL	7:00	7:30	0:30	0	0	0.38	0	1	6
220	19-Mar-11	Tonsil e ad renridectomy	1	EL	9:30	11:30	2:00	0	0	2.13	0	2	6
221	19-Mar-11	Excision Pterygism	1	EL	10:00	10:50	0:50	0	0	0	0	2	6
222	19-Mar-11	Gastroscope	1	EL	11:00	11:20	0:20	0	0	1.00	0	1	6
223	19-Mar-11	Gastroscope	1	EL	12:00	12:20	0:20	0	0	0	0	1	6
224	19-Mar-11	ORIF k-wire	2	UR	12:30	13:45	1:15	0	0.40	1.00	9.60	2	6
225	19-Mar-11	1upper blepharoplasty 2Release Csar c ear 3 sm	1	EL	9:30	18:50	9:20	0	1.50	2.00	36.00	7	6
226	19-Mar-11	Debridement e suture	2	UR	15:00	16:05	1:05	0	0	2.00	0	2	6
227	19-Mar-11	L-Blep	1	EL	18:15	19:20	1:05	0	0	0	0	2	6
228	19-Mar-11	C-Section	2	UR	19:00	20:20	1:20	0	0	3.00	0	2	6

Table A.1 Hospital operation record (Continued)

No.	Operation Date	Operation Description	Admission Type 1 = EL (Elective) 2 = UR (Urgent) 3 = EM (Emergency)		Operation Starting Time	Operation Ending Time	Total Operation Time (Hrs)	No. of Day stay in Ward before operation	No. of days stay in ICU	No. of days stay in ward after operation	Nursing Time Required for a Patient in IC Unit (Hours)	Category	Weekday (1 = Monday, 2 = Tuesday, …, 7 = Sunday)
229	20-Mar-11	Tracheostomy	2	UR	9:20	10:10	0:50	0	0	4.17	0	2	7
230	20-Mar-11	Gastroscope	2	UR	10:55	11:25	0:30	0	0	0	0	1	7
231	20-Mar-11	Gastroscope	2	UR	12:25	12:50	0:25	0	0	8.00	0	1	7
232	20-Mar-11	Upper Blepharoplasty + Revise Rhinoplasy	1	EL	15:30	17:00	1:30	0	0.25	0	6.00	2	7
233	20-Mar-11	Rhinoplasty	1	EL	17:40	18:35	0:55	0	0	0	0	2	7
234	20-Mar-11	Excision mass	1	EL	17:00	18:00	1:00	0	0.33	1.00	7.92	2	7
235	20-Mar-11	Gastroscope	1	EL	16:00	16:45	0:45	0	0	1.00	0	1	7
236	20-Mar-11	Rhinoplasty	1	EL	17:00	18:00	1:00	0.52	0.50	0	12.00	2	7
237	20-Mar-11	Colonoscopy	1	EL	21:00	22:00	1:00	0	0	1.00	0	2	7
238	21-Mar-11	Colonoscopy	1	EL	7:00	7:35	0:35	0	0	0	0	1	1
239	21-Mar-11	c-section	1	EL	9:10	10:35	1:25	0	0	3.00	0	2	1
240	21-Mar-11	Debridment	2	UR	9:30	11:00	1:30	0	0	0	0	2	1
241	21-Mar-11	U-Blep	1	EL	12:45	13:55	1:10	0	0.80	0	19.20	2	1
242	21-Mar-11	Closed Reduction e packing	1	EL	11:00	14:40	3:40	0	0	2.00	0	3	1
243	21-Mar-11	Tracheostomy	1	EL	14:00	15:50	1:50	0	0	5.00	0	2	1
244	21-Mar-11	Dissectomy	1	EL	16:00	18:30	2:30	0	0	1.83	0	3	1
245	21-Mar-11	Gastroscope	1	EL	14:50	15:00	0:10	0	0	1.00	0	1	1
246	21-Mar-11	ORIF	2	UR	19:00	23:30	4:30	0	4.50	1.25	108.00	7	1
247	21-Mar-11	Debridment	2	UR	18:10	18:45	0:35	0	0	0.79	0	1	1
248	21-Mar-11	Gastroscope	1	EL	21:00	21:30	0:30	0	0	1.00	0	1	1
249	21-Mar-11	URS c Stone	1	EL	21:30	22:10	0:40	0	0.42	1.25	10.00	2	1
250	22-Mar-11	c-section	1	EL	8:40	9:35	0:55	0	0.60	3.17	14.40	2	2
251	22-Mar-11	c-section	1	EL	9:00	10:00	1:00	0	0	3.13	0	2	2
252	22-Mar-11	Excision	1	EL	11:50	13:45	1:55	0	0	1.00	0	2	2
253	22-Mar-11	Revise Scar	1	EL	11:20	12:20	1:00	0	0	0	0	2	2
254	22-Mar-11	Gastroscope	1	EL	12:15	13:05	0:50	0	0	6.00	0	2	2
255	22-Mar-11	Aug Rhinoplasty	1	EL	10:20	13:15	2:55	0	0	1.00	0	3	2
256	22-Mar-11	Appendectomy	1	EL	14:15	15:35	1:20	0	0.60	2.00	14.40	2	2
257	22-Mar-11	AR	1	EL	13:45	16:30	2:45	0	0	0	0	3	2
258	22-Mar-11	AR	1	EL	16:50	19:05	2:15	0.90	0	0	0	3	2
259	22-Mar-11	Excision mass	1	EL	9:15	10:30	1:15	0	0	1.00	0	2	2
260	22-Mar-11	Debridment suture	3	EM	18:25	20:05	1:40	0	0	7.00	0	2	2
261	23-Mar-11	Appendectomy	2	UR	5:40	6:45	1:05	1.22	0.80	1.00	19.20	2	3
262	23-Mar-11	C-Section	2	UR	6:35	8:10	1:35	0	0.60	3.00	14.40	2	3
263	23-Mar-11	AR	1	EL	10:00	13:00	3:00	0	0	0	0	3	3
264	23-Mar-11	Lower Blepharoplasty	1	EL	9:30	12:25	2:55	0	0	0	0	3	3
265	23-Mar-11	AR	1	EL	14:00	17:00	3:00	0	3.50	0	84.00	6	3
266	23-Mar-11	Excision	1	EL	13:00	14:45	1:45	0	0	2.00	0	2	3

Table A.1 Hospital operation record (Continued)

No.	Operation Date	Operation Description	Admission Type 1 = EL (Elective) 2 = UR (Urgent) 3 = EM (Emergency)		Operation Starting Time	Operation Ending Time	Total Operation Time (Hrs)	No. of Day stay in Ward before operation	No. of days stay in ICU	No. of days stay in ward after operation	Nursing Time Required for a Patient in IC Unit (Hours)	Category	Weekday (1 = Monday, 2 = Tuesday, …, 7 = Sunday)
267	23-Mar-11	c-section	1	EL	18:00	19:10	1:10	0	0	3.00	0	2	3
268	23-Mar-11	EGD	1	EL	22:05	22:30	0:25	0	0	1.00	0	1	3
269	23-Mar-11	ORIF e k-wire	2	UR	22:20	23:15	0:55	0	0	1.00	0	2	3
270	24-Mar-11	Laminectomy	1	EL	8:30	12:00	3:30	0.92	0	3.00	0	3	4
271	24-Mar-11	Colonoscopy	1	EL	7:30	8:30	1:00	0	0.10	0	2.40	2	4
272	24-Mar-11	Repair NLD	2	UR	13:00	14:10	1:10	0	0.10	2.00	2.40	2	4
273	24-Mar-11	Rhinoplasty	1	EL	11:00	14:10	3:10	0	0	0	0	3	4
274	24-Mar-11	Rhinoplasty	1	EL	14:50	17:30	2:40	0	2.50	0	60.00	6	4
275	24-Mar-11	Gastroscope	1	EL	13:10	14:00	0:50	0	0	7.00	0	2	4
276	24-Mar-11	c-section	1	EL	15:00	16:20	1:20	0	0	3.00	0	2	4
277	24-Mar-11	D&C	2	UR	19:50	19:55	0:05	0	0	1.00	0	1	4
278	24-Mar-11	Gastroscope	1	EL	19:15	19:25	0:10	0.24	0	0	0	1	4
279	24-Mar-11	Excision	1	EL	18:15	19:00	0:45	1.09	0	1.00	0	1	4
280	24-Mar-11	U-Blep	1	EL	17:45	20:25	2:40	0	0	0	0	3	4
281	25-Mar-11	Closed Reduction	2	UR	0:00	0:45	0:45	1.16	0.33	1.29	8.00	2	5
282	25-Mar-11	C-Section	1	EL	9:10	10:30	1:20	0	0	3.00	0	2	5
283	25-Mar-11	C-Section	1	EL	10:00	11:10	1:10	0	0.50	3.00	12.00	2	5
284	25-Mar-11	Adeno	1	EL	10:35	11:35	1:00	0	0	1.00	0	2	5
285	25-Mar-11	1AR 2aud mammoplusty	1	EL	9:30	15:10	5:40	0	0.20	2.00	4.80	4	5
286	25-Mar-11	Gastroscope	1	EL	12:00	12:10	0:10	0.47	0	0	0	1	5
287	25-Mar-11	AR	1	EL	17:50	19:50	2:00	0	0	0	0	2	5
288	25-Mar-11	Closed reduction c External Fixation	2	UR	16:00	18:00	2:00	0	0	4.00	0	2	5
289	26-Mar-11	TAH Ovary	1	EL	8:00	10:20	2:20	1.09	0	3.00	0	3	6
290	26-Mar-11	Right Herniotomy	1	EL	8:00	9:00	1:00	0	0	1.29	0	2	6
291	26-Mar-11	Mammiplsty	1	EL	9:00	12:30	3:30	0	0	2.00	0	3	6
292	26-Mar-11	ORIF	1	EL	11:00	13:00	2:00	0	0	1.00	0	2	6
293	26-Mar-11	Cyctocsope	1	EL	12:45	13:25	0:40	0	0	2.25	0	1	6
294	26-Mar-11	Excision Ptergium	1	EL	13:00	13:30	0:30	0	0	0	0	1	6
295	26-Mar-11	Phaco	1	EL	13:50	14:35	0:45	0	0	0	0	1	6
296	26-Mar-11	Gastroscope	1	EL	14:30	14:55	0:25	0	0	0.92	0	1	6
297	26-Mar-11	Gastroscope	1	EL	16:30	16:45	0:15	0	0	0.83	0	1	6
298	26-Mar-11	AR	1	EL	14:30	17:30	3:00	0	0	0	0	3	6
299	26-Mar-11	Gastroscope	1	EL	15:30	16:00	0:30	0.71	0	0	0	1	6
300	26-Mar-11	1Debirement 2ORIF	2	UR	17:00	22:00	5:00	0.45	0.08	6.00	1.92	4	6
301	26-Mar-11	D&C	2	UR	16:30	17:10	0:40	0	0	2.00	0	1	6
302	26-Mar-11	Rhinoplasty	1	EL	19:30	21:30	2:00	0	0.50	0	12.00	2	6
303	26-Mar-11	ORIF	2	UR	22:00	1:20	3:20	0	0	12.00	0	3	6
304	26-Mar-11	c-section	3	EM	21:15	23:30	2:15	0	0	3.00	0	3	6

Table A.1 Hospital operation record (Continued)

No.	Operation Date	Operation Description	Admission Type 1 = EL (Elective) 2 = UR (Urgent) 3 = EM (Emergency)		Operation Starting Time	Operation Ending Time	Total Operation Time (Hrs)	No. of Day stay in Ward before operation	No. of days stay in ICU	No. of days stay in ward after operation	Nursing Time Required for a Patient in IC Unit (Hours)	Category	Weekday (1 = Monday, 2 = Tuesday, …, 7 = Sunday)
305	27-Mar-11	ROIF	2	UR	5:00	7:30	2:30	0	0	2.46	0	3	7
306	27-Mar-11	Revise Scar	1	EL	11:00	12:20	1:20	0.74	0	0	0	2	7
307	27-Mar-11	C-Section	1	EL	15:10	16:30	1:20	0	0	2.75	0	2	7
308	27-Mar-11	Craniotomy	2	UR	14:25	16:20	1:55	0	4.00	5.00	96.00	2	7
309	27-Mar-11	AR	1	EL	18:00	18:30	0:30	0	0	0	0	1	7
310	27-Mar-11	Permanent tursorohaphy	1	EL	15:15	15:40	0:25	0	0	0	0	1	7
311	27-Mar-11	repai nail	1	EL	17:30	18:35	1:05	0.24	0.45	0	10.80	2	7
312	27-Mar-11	two burr hole	1	EL	23:10	1:00	1:50	0	4.00	4.00	96.00	2	7
313	28-Mar-11	Replantation	3	EM	0:00	5:30	5:30	0	0.10	0	2.40	4	1
314	28-Mar-11	ERCP	1	EL	7:00	9:00	2:00	0	1.00	1.00	24.00	2	1
315	28-Mar-11	Explor lap	1	EL	7:30	9:00	1:30	0.70	0	3.00	0	2	1
316	28-Mar-11	Tonsillectomy	1	EL	9:00	11:10	2:10	0.62	0.30	1.00	7.20	6	1
317	28-Mar-11	Gastroscope	1	EL	9:30	10:30	1:00	0	0	0.25	0	2	1
318	28-Mar-11	c-section	3	EM	11:30	12:30	1:00	0.73	0	3.00	0	2	1
319	28-Mar-11	Arthroscope Synovectomy	1	EL	13:00	17:30	4:30	0.88	0	3.00	0	3	1
320	28-Mar-11	Remove Plate Screw	1	EL	16:00	17:15	1:15	0.35	0.40	1.00	9.60	2	1
321	28-Mar-11	c-section	3	EM	17:00	18:35	1:35	0	0	3.00	0	2	1
322	28-Mar-11	Ganicetomy	3	EM	18:20	22:00	3:40	0	0.25	1.00	6.00	3	1
323	28-Mar-11	Colonoscopy	1	EL	19:00	19:20	0:20	0	0	1.00	0	1	1
324	29-Mar-11	Gastroscope	1	EL	7:30	8:00	0:30	0.66	0	1.29	0	1	2
325	29-Mar-11	c-section	1	EL	9:00	10:35	1:35	0	0.20	3.00	4.80	2	2
326	29-Mar-11	Gastroscope	1	EL	8:50	10:20	1:30	0	0	0	0	2	2
327	29-Mar-11	c-section	1	EL	10:30	11:50	1:20	0	0	3.00	0	2	2
328	29-Mar-11	CRIF e k-wire	1	EL	10:30	11:05	0:35	0.94	0	0	0	1	2
329	29-Mar-11	1ORIF TBW 2CRIF e Slab	1	EL	11:00	12:30	1:30	0.72	0.50	1.21	12.00	2	2
330	29-Mar-11	1 ORIF small OCP 2CRIF e case screw 3 CRIF	1	EL	13:00	15:00	2:00	0	0	1.08	0	2	2
331	29-Mar-11	Alarplasty	1	EL	14:00	15:30	1:30	1.19	0	0	0	2	2
332	29-Mar-11	Mammiplsty	1	EL	14:20	17:50	3:30	0	0	1.92	0	3	2
333	29-Mar-11	Disectory	1	EL	15:10	17:30	2:20	0	0	0.92	0	3	2
334	29-Mar-11	Horniorrhap	1	EL	16:40	18:50	2:10	0	0	0.71	0	3	2
335	29-Mar-11	AR	1	EL	14:10	14:45	0:35	0	0	0	0	1	2
336	29-Mar-11	ORIF c TBW fixation	2	UR	15:10	16:40	1:30	0	0	3.00	0	2	2
337	30-Mar-11	Debridment c suture	2	UR	2:00	2:55	0:55	0	0	0.67	0	2	3
338	30-Mar-11	C-Section	1	EL	8:40	10:05	1:25	0	0	3.08	0	2	3
339	30-Mar-11	C-section	1	EL	9:00	10:05	1:05	0	0	3.17	0	2	3
340	30-Mar-11	Rhinoplasty	1	EL	11:30	16:30	5:00	0	0.05	0	1.20	4	3
341	30-Mar-11	Excision mass	1	EL	14:00	15:00	1:00	0.41	0.33	1.00	7.92	2	3
342	30-Mar-11	Rhinoplasty	1	EL	12:40	13:40	1:00	0	0	0	0	2	3

Table A.1 Hospital operation record (Continued)

No.	Operation Date	Operation Description	Admission Type 1 = EL (Elective) 2 = UR (Urgent) 3 = EM (Emergency)		Operation Starting Time	Operation Ending Time	Total Operation Time (Hrs)	No. of Day stay in Ward before operation	No. of days stay in ICU	No. of days stay in ward after operation	Nursing Time Required for a Patient in IC Unit (Hours)	Category	Weekday (1 = Monday, 2 = Tuesday, …, 7 = Sunday)
343	30-Mar-11	Repair incisional	1	EL	16:00	18:55	2:55	0	0	3.00	0	3	3
344	30-Mar-11	Explor lap	1	EL	14:00	15:50	1:50	0	0.40	3.00	9.60	2	3
345	31-Mar-11	Gastroscope	1	EL	13:00	13:30	0:30	0	0	1.00	0	1	4
346	31-Mar-11	Rhinoplasty	1	EL	13:10	15:55	2:45	0.38	0	0	0	3	4
347	31-Mar-11	Excision mass	1	EL	14:30	15:20	0:50	0	0	0	0	2	4
348	31-Mar-11	upper Blipharaplasty	1	EL	17:40	19:05	1:25	0.37	0	0	0	2	4
349	31-Mar-11	closed reduction c hip spica	2	UR	18:10	19:00	0:50	0.54	0	2.00	0	2	4
350	31-Mar-11	C-section	2	UR	7:00	8:00	1:00	0	0	3.00	0	2	4
351	31-Mar-11	C-Section	1	EL	9:00	10:20	1:20	0	0.25	3.00	6.00	2	4
352	31-Mar-11	Debridment c suture	2	UR	9:50	11:30	1:40	0	0	1.00	0	2	4
353	31-Mar-11	Rhinoplasty	1	EL	10:00	12:30	2:30	0.44	0	0	0	3	4
354	31-Mar-11	Close stump	1	EL	13:00	14:00	1:00	0	0	1.00	0	2	4
355	1-Apr-11	Elective C-Section	1	EL	9:35	10:55	1:20	0	0	3.00	0	2	5
356	1-Apr-11	Previous C-Section	1	EL	10:40	12:10	1:30	0	0.40	3.00	9.60	2	5
357	1-Apr-11	C-Section	1	EL	8:25	9:55	1:30	0	0	3.00	0	2	5
358	1-Apr-11	C-Section	1	EL	9:35	10:55	1:20	0	0	3.00	0	2	5
359	1-Apr-11	Ex Pterggion C-bar	1	EL	13:20	13:50	0:30	0	0	0.29	0	1	5
360	1-Apr-11	AR	1	EL	10:10	12:30	2:20	0	0	0	0	3	5
361	1-Apr-11	Disectory	1	EL	13:30	15:20	1:50	0	0	3.00	0	2	5
362	1-Apr-11	AR	1	EL	14:00	16:14	2:14	0	0	2.92	0	3	5
363	1-Apr-11	Herriotory	1	EL	18:30	19:30	1:00	0	0	0.71	0	2	5
364	1-Apr-11	ORRE EPHS	2	UR	20:00	21:45	1:45	0	0.21	1.42	5.00	2	5
365	1-Apr-11	Explore lap	2	UR	21:30	0:00	2:30	0	4.00	5.50	96.00	6	5
366	2-Apr-11	Epidiral	2	UR	1:35	2:55	1:20	0	0.50	7.00	12.00	2	6
367	2-Apr-11	C-Section	3	EM	7:00	8:15	1:15	0	0	3.21	0	2	6
368	2-Apr-11	C-Section	1	EL	8:15	9:45	1:30	0	0	3.00	0	2	6
369	2-Apr-11	Upper-blepharoplasty	1	EL	10:00	13:00	3:00	0	0	0	0	3	6
370	2-Apr-11	ACL Reconstruction	1	EL	13:00	15:00	2:00	0	0	3.00	0	2	6
371	2-Apr-11	AR	1	EL	13:45	15:45	2:00	0.85	0	0	0	2	6
372	2-Apr-11	Excision pteryigium LE	1	EL	13:45	14:30	0:45	0	0	0	0	1	6
373	2-Apr-11	Chaco c-bar Right	1	EL	14:30	16:00	1:30	0	0	0	0	2	6
374	2-Apr-11	Excision Nevus	1	EL	14:10	15:00	0:50	0	0	0	0	2	6
375	2-Apr-11	AR	1	EL	16:00	18:00	2:00	1.16	0	0	0	2	6
376	2-Apr-11	C-Section	1	EL	18:30	20:05	1:35	0	0	3.00	0	2	6
377	2-Apr-11	Repair conjunctiva	2	UR	20:10	20:55	0:45	0	0	0	0	1	6
378	2-Apr-11	C-Section	2	UR	23:00	0:15	1:15	0	0.33	1.50	8.00	2	6
379	2-Apr-11	D&C	2	UR	21:15	21:35	0:20	0	0	0.63	0	1	6
380	2-Apr-11	Augmentation Rhinoplasty	1	EL	18:30	20:50	2:20	0	0	0	0	3	6

Table A.1 Hospital operation record (Continued)

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381	3-Apr-11	C-section	1	EL	8:30	9:35	1:05	0	0.70	3.13	16.80	2	7
382	3-Apr-11	Revision Upper Blepharoplasty	1	EL	10:30	11:35	1:05	0	0	0	0	2	7
383	3-Apr-11	Gastroscope	2	UR	13:00	13:50	0:50	0.60	0	2.21	0	2	7
384	3-Apr-11	Wide excision massat addominal wall	1	EL	14:10	15:15	1:05	0	0.80	1.17	19.20	2	7
385	3-Apr-11	Appendectomy	2	UR	15:00	16:30	1:30	0	0	1.79	0	2	7
386	3-Apr-11	AR	1	EL	14:50	17:20	2:30	0.49	0	0	0	3	7
387	3-Apr-11	Gastroscope	1	EL	15:55	16:10	0:15	0	0	0.92	0	1	7
388	4-Apr-11	Laparoscope Cystectomy	1	EL	9:00	11:00	2:00	0	0	1.04	0	2	1
389	4-Apr-11	Fistulectomy	1	EL	11:00	12:00	1:00	0	0	0	0	2	1
390	4-Apr-11	Rhinoplasty	1	EL	11:10	12:30	1:20	0	0	0	0	2	1
391	4-Apr-11	D&C	1	EL	13:00	13:45	0:45	0	0	1.00	0	1	1
392	4-Apr-11	Excision	1	EL	13:30	14:15	0:45	0.38	0	0	0	1	1
393	4-Apr-11	Gastroscope	1	EL	14:00	14:30	0:30	0	0	2.00	0	1	1
394	4-Apr-11	Knee open synoreck	1	EL	14:00	17:05	3:05	0	0	2.00	0	3	1
395	4-Apr-11	Appendectomy	2	UR	17:25	19:15	1:50	0	0	1.79	0	2	1
396	4-Apr-11	C-Section	1	EL	18:40	19:50	1:10	0	0	0.63	0	2	1
397	4-Apr-11	repair nail bed	2	UR	19:50	20:45	0:55	0	0	0.71	0	2	1
398	4-Apr-11	Cysto- remove	1	EL	20:20	20:40	0:20	0	0	0	0	1	1
399	5-Apr-11	Rhinoplasty	1	EL	11:30	14:55	3:25	0.36	0.30	0	7.20	6	2
400	5-Apr-11	Excision hematoma	2	UR	12:14	13:15	1:01	0	0.90	1.00	21.60	2	2
401	5-Apr-11	AR	1	EL	11:25	11:55	0:30	0	0	0	0	1	2
402	5-Apr-11	Appendectomy	2	UR	14:25	15:50	1:25	0	0	1.92	0	2	2
403	5-Apr-11	Rhinoplasty	1	EL	15:40	19:20	3:40	0	0	0	0	3	2
404	5-Apr-11	Debride Suture Skin flap	2	UR	16:20	17:40	1:20	0	0.42	4.29	10.00	2	2
405	6-Apr-11	Debride Suture	2	UR	5:10	6:30	1:20	0	0	1.29	0	2	3
406	6-Apr-11	C-section	2	UR	6:00	7:05	1:05	0	0	3.25	0	2	3
407	6-Apr-11	Gastroscope	2	UR	7:35	9:20	1:45	0	0	1.00	0	2	3
408	6-Apr-11	C-section	1	EL	9:00	10:20	1:20	0	0	2.00	0	2	3
409	6-Apr-11	Excision mass	1	EL	9:20	10:10	0:50	0	0	0	0	2	3
410	6-Apr-11	Augmentation Rhinoplasty	1	EL	11:20	13:50	2:30	0	0	0	0	3	3
411	6-Apr-11	Release CTR	1	EL	13:20	13:50	0:30	0	0	0	0	1	3
412	6-Apr-11	Excision mass	1	EL	13:00	13:40	0:40	0	0	0	0	1	3
413	6-Apr-11	AR	1	EL	15:00	17:05	2:05	0	0	0	0	3	3
414	6-Apr-11	D&C	1	EL	15:20	16:05	0:45	0	0	0.83	0	1	3
415	6-Apr-11	Release plantar fascia	1	EL	17:10	18:05	0:55	0.28	0	0.88	0	2	3
416	6-Apr-11	Dilate prepuce of penis	1	EL	14:50	15:10	0:20	0.53	0	0	0	1	3
417	7-Apr-11	C-section	1	EL	9:10	10:10	1:00	0	0	3.33	0	2	4
418	7-Apr-11	AR	1	EL	10:30	13:00	2:30	0.71	0	0	0	3	4

Table A.1 Hospital operation record (Continued)

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419	7-Apr-11	Excision mass	1	EL	10:20	10:45	0:25	0	0	0	0	1	4
420	7-Apr-11	Release dequarrim	1	EL	11:00	11:50	0:50	0	0	1.08	0	2	4
421	7-Apr-11	Lap	1	EL	11:50	13:45	1:55	0	0	0.92	0	2	4
422	7-Apr-11	Gastroscope	1	EL	12:45	12:55	0:10	0	0	2.13	0	1	4
423	7-Apr-11	Appendectomy	2	UR	14:30	16:15	1:45	0	0	1.75	0	2	4
424	7-Apr-11	AR	1	EL	13:40	16:20	2:40	0	0	0	0	3	4
425	7-Apr-11	closed reduction nasal bone	1	EL	18:15	19:00	0:45	1.19	0	0.42	0	1	4
426	7-Apr-11	ESWL c-bar cystoscopy	1	EL	18:30	20:45	2:15	1.28	0.40	1.71	9.60	6	4
427	7-Apr-11	U-blep	1	EL	16:40	18:05	1:25	0	0	0	0	2	4
428	7-Apr-11	Esophagoscopy remove FB	2	UR	21:05	22:00	0:55	0	0	0.88	0	2	4
429	7-Apr-11	ORIF c-bar interoching mil	2	UR	10:30	12:00	1:30	0.29	0.33	5.25	8.00	2	4
430	7-Apr-11	Gastroscope	1	EL	11:55	12:05	0:10	0	0	0	0	1	4
431	8-Apr-11	C-section	2	UR	2:10	3:05	0:55	0	0.23	4.00	5.50	2	5
432	8-Apr-11	C-section	1	EL	9:25	10:00	0:35	0	0	4.08	0	1	5
433	8-Apr-11	AR	1	EL	9:00	11:10	2:10	0	0	0	0	3	5
434	8-Apr-11	ACL c-bar repair minicus	1	EL	13:00	15:37	2:37	0	0	4.13	0	3	5
435	8-Apr-11	Exsicion mass	1	EL	13:00	13:30	0:30	0	0	0	0	1	5
436	8-Apr-11	AR	1	EL	13:40	15:30	1:50	0.36	0	0	0	2	5
437	8-Apr-11	Exsicion pterygion c-bar mmc	1	EL	15:30	15:55	0:25	1.22	0	0	0	1	5
438	8-Apr-11	Colonoscopy c-bar	1	EL	23:00	1:00	2:00	0	0	0.56	0	2	5
439	8-Apr-11	Diag DU c-bar patict gastric outlet obstruction g	1	EL	18:10	19:10	1:00	0	0	0.79	0	2	5
440	8-Apr-11	Tonsillectomy	1	EL	20:00	20:50	0:50	0	0	0.83	0	2	5
441	9-Apr-11	Excision breast mass	1	EL	10:05	11:00	0:55	0.43	0	0	0	2	6
442	9-Apr-11	AR	1	EL	12:35	13:30	0:55	1.01	0	0	0	2	6
443	9-Apr-11	Excision mass	1	EL	13:00	13:30	0:30	0	0	0	0	1	6
444	9-Apr-11	Excision pteryigium RE	1	EL	13:00	13:30	0:30	1.16	0	0	0	1	6
445	9-Apr-11	Upper-blepharoplasty	1	EL	13:30	16:30	3:00	0	0	0	0	3	6
446	9-Apr-11	Excision external hemonhoidectomy	1	EL	13:45	14:45	1:00	0	0	1.00	0	2	6
447	9-Apr-11	ORIT c-bar miniscrew	2	UR	14:00	15:00	1:00	0	0	0.92	0	2	6
448	9-Apr-11	excision carpal glanglion	1	EL	14:00	14:45	0:45	0	0	0	0	1	6
449	9-Apr-11	remove plate screw	1	EL	15:05	17:00	1:55	0	0	2.92	0	2	6
450	9-Apr-11	debridement c-bar amputation	2	UR	21:40	22:10	0:30	1.10	0	3.00	0	1	6
451	9-Apr-11	Tonsillectomy	2	UR	18:55	20:00	1:05	0	0	1.00	0	2	6
452	9-Apr-11	MRI	1	EL	17:00	18:00	1:00	0	0	0	0	2	6
453	9-Apr-11	AR	1	EL	16:40	19:15	2:35	0	0	0	0	3	6
454	9-Apr-11	Gastroscope	2	UR	20:15	21:25	1:10	1.04	0	2.63	0	2	6
455	9-Apr-11	D&C	2	UR	20:10	21:02	0:52	0.41	0.10	0.71	2.40	2	6
456	9-Apr-11	Upper-blepharoplasty	1	EL	17:10	19:10	2:00	0	0	0	0	2	6

Table A.1 Hospital operation record (Continued)

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457	9-Apr-11	AR	1	EL	17:00	18:10	1:10	0	0	0	0	2	6
458	10-Apr-11	C-Section	1	EL	4:30	5:55	1:25	0	0	3.17	0	2	7
459	10-Apr-11	C-Section	1	EL	6:10	7:45	1:35	0	0	3.29	0	2	7
460	10-Apr-11	Laparoscope Cystectomy	2	UR	8:00	10:15	2:15	0	0	0	0	3	7
461	10-Apr-11	Phaco c-bar IOL	1	EL	9:20	9:55	0:35	0	0	1.00	0	1	7
462	10-Apr-11	C-Section	2	UR	9:30	10:45	1:15	0	0	3.00	0	2	7
463	10-Apr-11	LIS c-bar excision anal slein toact	1	EL	10:00	10:30	0:30	0	0	0	0	1	7
464	10-Apr-11	AR	1	EL	10:30	12:50	2:20	0.59	0	0	0	3	7
465	10-Apr-11	AR	1	EL	11:30	12:15	0:45	1.06	0	0	0	1	7
466	10-Apr-11	AR	1	EL	12:00	13:10	1:10	0	0	0	0	2	7
467	10-Apr-11	Reria scar at knee	1	EL	15:00	16:55	1:55	0	0	0	0	2	7
468	10-Apr-11	AR	1	EL	13:00	13:50	0:50	0	0.10	0	2.40	2	7
469	10-Apr-11	C-Section	1	EL	18:35	19:55	1:20	0	0	2.63	0	2	7
470	10-Apr-11	AR	1	EL	16:30	17:10	0:40	0	0	0	0	1	7
471	10-Apr-11	AR	1	EL	17:15	17:55	0:40	0.94	0	0	0	1	7
472	10-Apr-11	EGD+adrenaline+gddprobe	1	EL	18:00	18:50	0:50	1.02	0	2.00	0	2	7
473	10-Apr-11	U+L Blep	1	EL	17:45	21:10	3:25	1.05	0	0	0	3	7
474	10-Apr-11	Colonoscopy	1	EL	20:15	20:50	0:35	0	0	0.75	0	1	7
475	10-Apr-11	Gastroscope	1	EL	22:30	23:08	0:38	0	0	0.58	0	1	7
476	11-Apr-11	C-section	1	EL	8:00	9:00	1:00	0	0	3.13	0	2	1
477	11-Apr-11	C-Section	1	EL	9:00	13:35	4:35	0	0.10	3.00	2.40	4	1
478	11-Apr-11	Phaco c-bar IOL	1	EL	9:00	9:50	0:50	0	0	2.33	0	2	1
479	11-Apr-11	excision carpal glanglion	1	EL	13:00	14:00	1:00	0	0	1.00	0	2	1
480	11-Apr-11	C5-C6 Anterior dissctomy c-bar P/S	1	EL	13:50	16:00	2:10	0	0	2.88	0	3	1
481	11-Apr-11	AR	1	EL	17:40	17:50	0:10	0	0	0	0	1	1
482	11-Apr-11	Repair ear c-bar suture	2	UR	21:10	22:05	0:55	0.34	0.20	0.58	4.80	2	1
483	11-Apr-11	Repair tendon c-bar primacast	1	EL	20:30	21:15	0:45	1.07	0	1.00	0	1	1
484	11-Apr-11	C-section	3	EM	22:20	23:15	0:55	0	0.35	2.29	8.50	2	1
485	12-Apr-11	C-section	1	EL	9:05	9:45	0:40	0	0	3.00	0	1	2
486	12-Apr-11	C-section	1	EL	9:25	10:00	0:35	0	0	3.08	0	1	2
487	12-Apr-11	C-section	1	EL	10:05	11:10	1:05	0	0	3.17	0	2	2
488	12-Apr-11	AR	1	EL	10:10	12:00	1:50	0	0	0	0	2	2
489	12-Apr-11	AR	1	EL	10:35	12:35	2:00	0	0	0	0	2	2
490	12-Apr-11	AR	1	EL	11:15	12:10	0:55	0	0	0	0	2	2
491	12-Apr-11	Suture	2	UR	12:20	12:50	0:30	0	0	2.04	0	1	2
492	12-Apr-11	AR	1	EL	17:20	17:55	0:35	0	0	0	0	1	2
493	12-Apr-11	Revator	1	EL	14:25	15:05	0:40	0	0	1.00	0	1	2
494	12-Apr-11	AR	1	EL	15:15	15:45	0:30	0	0	0	0	1	2

Table A.1 Hospital operation record (Continued)

No.	Operation Date	Operation Description	Admission Type 1 = EL (Elective) 2 = UR (Urgent) 3 = EM (Emergency)		Operation Starting Time	Operation Ending Time	Total Operation Time (Hrs)	No. of Day stay in Ward before operation	No. of days stay in ICU	No. of days stay in ward after operation	Nursing Time Required for a Patient in IC Unit (Hours)	Category	Weekday (1 = Monday, 2 = Tuesday, …, 7 = Sunday)
495	12-Apr-11	AR	1	EL	18:45	20:30	1:45	0	0	0	0	2	2
496	12-Apr-11	C-Section	2	UR	18:30	19:40	1:10	0.64	0	2.71	0	2	2
497	12-Apr-11	Cholecystectomy	2	UR	19:40	22:15	2:35	0	5.20	4.13	124.80	6	2
498	12-Apr-11	Hemorrhoidectomy	2	UR	22:00	23:00	1:00	0	1.08	0	26.00	2	2
499	12-Apr-11	Appendectomy	2	UR	22:00	23:55	1:55	0.84	0.38	1.21	9.00	2	2
500	12-Apr-11	Appendectomy	2	UR	23:05	0:15	1:10	0	0.35	2.08	8.50	2	2
501	12-Apr-11	CRIF C-bar	1	EL	14:20	15:50	1:30	0	0.29	0.71	7.00	2	2
502	13-Apr-11	I&D middle finger c-bar debridement	1	EL	2:00	2:50	0:50	0	0.08	3.42	2.00	2	3
503	13-Apr-11	Phaco c-bar IOL	1	EL	8:50	9:55	1:05	0	0	0	0	2	3
504	13-Apr-11	Craniotomy	1	EL	9:00	14:50	5:50	0	5.00	5.00	120.00	8	3
505	13-Apr-11	AR	1	EL	10:00	10:45	0:45	0.21	0	0	0	1	3
506	13-Apr-11	AR	1	EL	10:00	12:25	2:25	0.56	0	0	0	3	3
507	13-Apr-11	Appendectomy	2	UR	14:20	15:45	1:25	0	0	3.00	0	2	3
508	13-Apr-11	Gastroscope	2	UR	13:10	13:40	0:30	0	0	2.00	0	1	3
509	13-Apr-11	Gastroscope	1	EL	14:20	14:35	0:15	0	0	0	0	1	3
510	13-Apr-11	C-section	1	EL	9:30	11:00	1:30	0	0.38	2.21	9.00	2	3
511	13-Apr-11	AR	1	EL	13:10	13:40	0:30	0	0	0	0	1	3
512	13-Apr-11	AR	1	EL	15:40	17:45	2:05	0	0	0	0	3	3
513	13-Apr-11	Appendectomy	1	EL	23:00	0:05	1:05	0	0.35	2.33	8.50	2	3
514	14-Apr-11	C-section	3	EM	2:00	3:00	1:00	0	0.19	3.17	4.50	2	4
515	14-Apr-11	C-section	1	EL	8:00	8:50	0:50	0	0	3.13	0	2	4
516	14-Apr-11	Hemorrhoidectomy	1	EL	11:40	12:30	0:50	0	0.80	1.00	19.20	2	4
517	14-Apr-11	Mammoplasty	2	UR	15:50	18:00	2:10	0	0	1.79	0	3	4
518	14-Apr-11	Upper-blepharoplasty	1	EL	11:50	13:30	1:40	0	0	0	0	2	4
519	14-Apr-11	Revise Rhinoplasty	1	EL	13:50	15:00	1:10	0	0	0	0	2	4
520	14-Apr-11	C-section	2	UR	20:20	21:05	0:45	0	0	2.71	0	1	4
521	14-Apr-11	D&C	2	UR	22:50	23:20	0:30	0	0.29	1.00	7.00	2	4
522	15-Apr-11	D&C	2	UR	4:35	5:10	0:35	0	3.00	1.00	72.00	5	5
523	15-Apr-11	Mammoplasty	2	UR	9:10	12:00	2:50	0	0	2.00	0	3	5
524	15-Apr-11	Gastroscope	1	EL	9:30	9:50	0:20	0	0	0	0	1	5
525	15-Apr-11	Revise Rhinoplasty	1	EL	9:30	11:00	1:30	0.85	0	0	0	2	5
526	15-Apr-11	Rhinoplasty	1	EL	11:55	13:50	1:55	0	0	0	0	2	5
527	15-Apr-11	Lateral epicondylar debridement & reconstructi	1	EL	12:40	13:50	1:10	0	0	1.00	0	2	5
528	15-Apr-11	AR	1	EL	14:00	16:55	2:55	0	0	0	0	3	5
529	15-Apr-11	AR	1	EL	16:30	19:25	2:55	0	0	0	0	3	5
530	15-Apr-11	C-Section	2	UR	16:20	17:30	1:10	0	0.25	3.00	6.00	2	5
531	15-Apr-11	Redo open rhinoplasty	1	EL	19:25	20:10	0:45	0	0	0	0	1	5
532	15-Apr-11	Appendectomy	2	UR	20:00	20:40	0:40	0	0	2.00	0	1	5

Table A.1 Hospital operation record (Continued)

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533	15-Apr-11	Explore lap	2	UR	22:00	23:50	1:50	0	0	8.00	0	2	5
534	15-Apr-11	CRIF C-bar	2	UR	23:00	23:25	0:25	0.84	0.38	0.17	9.00	2	5
535	16-Apr-11	C-Section	2	UR	8:40	10:00	1:20	0	0.50	3.13	12.00	2	6
536	16-Apr-11	Rhinoplasty	1	EL	11:30	13:05	1:35	0	0	0	0	2	6
537	16-Apr-11	Gastroscope	1	EL	11:10	3:36	16:26	0	4.20	0	100.80	8	6
538	16-Apr-11	Rhinoplasty	1	EL	14:00	16:00	2:00	1.02	0	0	0	2	6
539	16-Apr-11	Gastroscope	1	EL	18:00	18:30	0:30	0	0	1.00	0	1	6
540	16-Apr-11	CRIF C-bar	2	UR	18:00	20:00	2:00	0	0	1.00	0	2	6
541	16-Apr-11	Excision mass	1	EL	22:00	23:25	1:25	0	0.38	0.38	9.00	2	6
542	16-Apr-11	Rhinoplasty	1	EL	18:00	20:00	2:00	0	0	0	0	2	6
543	16-Apr-11	Rhinoplasty	1	EL	17:50	18:15	0:25	1.00	0	0	0	1	6
544	16-Apr-11	Gastroscope	2	UR	21:00	21:30	0:30	0	0	1.00	0	1	6
545	17-Apr-11	Remove FB	1	EL	1:00	1:30	0:30	0	0.27	0.42	6.50	2	7
546	17-Apr-11	C-section	1	EL	6:10	7:30	1:20	0	0	3.13	0	2	7
547	17-Apr-11	D&C	1	EL	8:00	9:10	1:10	0	0	0.38	0	2	7
548	17-Apr-11	Gastroscope	1	EL	7:00	7:30	0:30	0.88	0	1.38	0	1	7
549	17-Apr-11	Gastroscope	1	EL	9:05	9:20	0:15	0	0	0	0	1	7
550	17-Apr-11	D&C	1	EL	10:05	10:35	0:30	0.71	0	2.29	0	1	7
551	17-Apr-11	C-section	1	EL	9:05	10:00	0:55	0	0	3.38	0	2	7
552	17-Apr-11	U-blep	1	EL	11:00	11:35	0:35	0	0	0	0	1	7
553	17-Apr-11	Appendectomy	2	UR	13:40	14:45	1:05	0	0.60	2.00	14.40	2	7
554	17-Apr-11	ORIF c-bar	1	EL	11:05	13:30	2:25	1.06	0	2.21	0	3	7
555	17-Apr-11	Closed reduction c-bar K-wire finger fix	2	UR	18:00	19:00	1:00	0.92	0	0.71	0	2	7
556	17-Apr-11	Excision	1	EL	18:00	18:30	0:30	0	0	0	0	1	7
557	17-Apr-11	ORIF C-bar P/S Lt. Clavicle	2	UR	22:00	0:45	2:45	0	0.29	2.46	7.00	3	7
558	18-Apr-11	Colonoscopy	2	UR	6:10	6:40	0:30	0	0	0.60	0	1	1
559	18-Apr-11	Gastroscope	2	UR	6:55	7:40	0:45	0	0	1.00	0	1	1
560	18-Apr-11	Colonoscopy	2	UR	7:40	8:40	1:00	0	0	7.00	0	2	1
561	18-Apr-11	ORIF c-bar K-wire fix	2	UR	13:30	15:30	2:00	0	0.15	2.00	3.60	2	1
562	18-Apr-11	C-Section	2	UR	1:00	2:45	1:45	0	0.25	3.00	6.00	2	1
563	18-Apr-11	Lower Blephareplaty	1	EL	10:00	11:30	1:30	0	0.80	0	19.20	2	1
564	18-Apr-11	Appendectomy	2	UR	15:25	16:30	1:05	0	0	6.00	0	2	1
565	18-Apr-11	Remove P/S	1	EL	17:10	18:20	1:10	0	0	1.00	0	2	1
566	18-Apr-11	C-Section	2	UR	18:30	19:50	1:20	0	0.50	3.00	12.00	2	1
567	18-Apr-11	Internal usethrotomy	1	EL	22:00	22:25	0:25	0	0	1.00	0	1	1
568	18-Apr-11	ESWL	1	EL	23:15	0:00	0:45	0	0.33	0.29	8.00	2	1
569	19-Apr-11	closed reduction nasal bone	2	UR	8:00	8:15	0:15	0	0	6.29	0	1	2
570	19-Apr-11	Previous C-Section	1	EL	9:00	10:35	1:35	0.73	0	3.00	0	2	2

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571	19-Apr-11	debridement c-bar K-wire foot	2	UR	10:15	11:30	1:15	0	0	0	0	2	2
572	19-Apr-11	Excision mass	1	EL	10:30	11:10	0:40	0.87	0	0	0	1	2
573	19-Apr-11	AR	1	EL	11:00	17:00	6:00	0.88	0.05	0	1.20	4	2
574	19-Apr-11	Revise upper blepharoplasty	1	EL	11:30	12:30	1:00	0	0	0	0	2	2
575	19-Apr-11	Excision	1	EL	12:30	13:30	1:00	0	0.40	0	9.60	2	2
576	19-Apr-11	Arthoscope c-bar ACLR	1	EL	13:00	16:05	3:05	0	0	2.00	0	3	2
577	19-Apr-11	Lamineetomy c-bar	1	EL	10:25	14:35	4:10	0	2.00	5.00	48.00	7	2
578	19-Apr-11	D&C	1	EL	18:00	19:00	1:00	0	0	7.00	0	2	2
579	19-Apr-11	Appendectomy	1	EL	19:00	21:00	2:00	0	0	1.63	0	2	2
580	19-Apr-11	Hydrocollectomy	1	EL	22:00	23:30	1:30	0	0.42	0.19	10.00	2	2
581	19-Apr-11	C-Section	2	UR	17:00	18:20	1:20	0	0	2.83	0	2	2
582	20-Apr-11	Upper-blepharoplasty	1	EL	10:30	12:50	2:20	0	0	0	0	3	3
583	20-Apr-11	Excision cyst hand and knee	1	EL	13:20	14:10	0:50	0	0.50	0	12.00	2	3
584	20-Apr-11	Pahco c-bar IOL	1	EL	13:35	14:30	0:55	0	0	0	0	2	3
585	20-Apr-11	AR	1	EL	14:00	16:25	2:25	0	0	0	0	3	3
586	20-Apr-11	Gastroscope	2	UR	13:00	13:50	0:50	0	0	1.88	0	2	3
587	20-Apr-11	AR	1	EL	16:30	19:20	2:50	0	0	0	0	3	3
588	20-Apr-11	C-section	2	UR	19:10	20:15	1:05	0	0	2.67	0	2	3
589	20-Apr-11	Upper-blepharoplasty	1	EL	20:00	21:40	1:40	0	0	0	0	2	3
590	20-Apr-11	CRIF C-bar	2	UR	20:40	22:40	2:00	0	0	2.00	0	2	3
591	20-Apr-11	Explore wound + repair tendon	2	UR	23:10	23:50	0:40	0	0	1.00	0	1	3
592	20-Apr-11	Excision mass	1	EL	22:00	22:30	0:30	0	0	1.00	0	1	3
593	21-Apr-11	Adreno-tensillectomy	1	EL	9:25	10:25	1:00	0.94	0	2.00	0	2	4
594	21-Apr-11	Fistulectomy	1	EL	9:00	10:25	1:25	0.40	0.60	3.13	14.40	2	4
595	21-Apr-11	AR	1	EL	10:45	13:40	2:55	0	0	0	0	3	4
596	21-Apr-11	Arthoscope c-bar debridement	1	EL	11:15	13:10	1:55	0	0	6.00	0	2	4
597	21-Apr-11	Excision PTG	1	EL	13:00	13:45	0:45	0	0	0	0	1	4
598	21-Apr-11	Upper-blepharoplasty	1	EL	15:00	17:05	2:05	0	0	0	0	3	4
599	21-Apr-11	Excision bursitis elbow	1	EL	14:30	15:15	0:45	0	0	0	0	1	4
600	21-Apr-11	Debridement c-bar repair nail bed thumb	1	EL	16:25	17:00	0:35	0.46	0	1.00	0	1	4
601	21-Apr-11	Alarplasty	1	EL	18:15	20:10	1:55	0	0	0	0	2	4
602	21-Apr-11	Alarplasty	1	EL	20:00	21:45	1:45	0	0	0	0	2	4
603	22-Apr-11	Revision endoscopic sinus surgery	1	EL	9:00	11:00	2:00	0.29	0	2.00	0	2	5
604	22-Apr-11	C-Section	1	EL	9:00	10:15	1:15	0	0	3.00	0	2	5
605	22-Apr-11	Colonoscopy	1	EL	9:30	10:00	0:30	0	0	0	0	1	5
606	22-Apr-11	Release CTS wrist	1	EL	9:40	10:35	0:55	0.31	0	0	0	2	5
607	22-Apr-11	Rhinoplasty	1	EL	12:00	13:30	1:30	0	0	0	0	2	5
608	22-Apr-11	Rhinoplasty	1	EL	12:30	14:35	2:05	0	0	0	0	3	5

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609	22-Apr-11	CRIF C-bar Miniplate c-bar screw	1	EL	13:00	15:30	2:30	0	0	1.00	0	3	5
610	22-Apr-11	Repair tendon foot	1	EL	14:30	15:20	0:50	0	0	1.08	0	2	5
611	22-Apr-11	AR	1	EL	14:30	17:00	2:30	0	0	0	0	3	5
612	22-Apr-11	Excision	1	EL	18:00	18:35	0:35	0	0	0	0	1	5
613	22-Apr-11	Open cholecystoctomy	1	EL	22:00	23:30	1:30	0	0.46	3.21	11.00	2	5
614	22-Apr-11	Appendectomy	2	UR	23:35	0:30	0:55	0	0.44	2.13	10.50	2	5
615	23-Apr-11	C-section	3	EM	0:30	1:40	1:10	1.15	3.00	3.00	72.00	2	6
616	23-Apr-11	C-section	1	EL	3:30	5:00	1:30	0	0.70	3.00	16.80	2	6
617	23-Apr-11	Excision breast mass	1	EL	11:00	12:20	1:20	0	0	1.00	0	2	6
618	23-Apr-11	Sphinoterotomy	1	EL	10:30	11:00	0:30	0	0	1.00	0	1	6
619	23-Apr-11	repair nail bed	2	UR	15:00	16:15	1:15	0.48	0	1.00	0	2	6
620	23-Apr-11	Release middle finger	1	EL	13:00	13:40	0:40	0.40	0	0	0	1	6
621	23-Apr-11	Excision PTG c-bar MMC	1	EL	13:00	13:55	0:55	0	0	0	0	2	6
622	23-Apr-11	External DCR c-bar silicone ctent	1	EL	14:50	16:25	1:35	0	0.60	0	14.40	2	6
623	23-Apr-11	Excision PTG c-bar conjunctiva graft	1	EL	14:10	14:45	0:35	0	0	1.00	0	1	6
624	23-Apr-11	Colonoscopy	1	EL	17:00	17:40	0:40	0	0	2.00	0	1	6
625	23-Apr-11	Colonoscopy	1	EL	19:00	19:15	0:15	0.26	0	1.00	0	1	6
626	23-Apr-11	ICD, debride c-bar suture	1	EL	13:05	14:30	1:25	0	0	8.75	0	2	6
627	24-Apr-11	C-section	1	EL	8:25	9:45	1:20	0.49	0.80	3.00	19.20	2	7
628	24-Apr-11	Phaco c-bar IOL	1	EL	10:00	11:35	1:35	1.07	0	0	0	2	7
629	24-Apr-11	Gastroscope	1	EL	10:35	10:45	0:10	0	0	0	0	1	7
630	24-Apr-11	Excision loop	1	EL	12:40	13:20	0:40	0	0	0	0	1	7
631	24-Apr-11	ORIF v0ar plate & screw	1	EL	14:20	15:55	1:35	0	0	2.00	0	2	7
632	24-Apr-11	Gastroscope	1	EL	22:30	22:40	0:10	0	0	1.00	0	1	7
633	24-Apr-11	D&C	1	EL	16:25	17:00	0:35	1.00	0	1.00	0	1	7
634	24-Apr-11	C-Section	1	EL	17:00	18:20	1:20	0	0	3.00	0	2	7
635	24-Apr-11	Colonoscopy c-bar	1	EL	16:20	16:40	0:20	0	0	1.00	0	1	7
636	24-Apr-11	Colonoscopy c-bar	1	EL	19:20	20:10	0:50	0	0	1.00	0	2	7
637	24-Apr-11	C-Section	3	EM	17:55	19:05	1:10	0	0	3.00	0	2	7
638	24-Apr-11	Gastroscope	1	EL	23:10	23:30	0:20	0.80	0	1.00	0	1	7
639	25-Apr-11	C-section	3	EM	1:20	2:20	1:00	0	0	3.00	0	2	1
640	25-Apr-11	Colonoscopy	1	EL	7:00	7:35	0:35	0	0	0	0	1	1
641	25-Apr-11	Circumcision	1	EL	9:45	10:30	0:45	0	0	1.21	0	1	1
642	25-Apr-11	C-section	2	UR	10:40	11:30	0:50	0	0.50	3.00	12.00	2	1
643	25-Apr-11	CRIF c-bar K-wire short arm cast	1	EL	10:30	12:05	1:35	0	0	2.00	0	2	1
644	25-Apr-11	Debridement c-bar suture	1	EL	11:50	13:00	1:10	0	0	1.00	0	2	1
645	25-Apr-11	AR	1	EL	12:00	13:10	1:10	0	0	0	0	2	1
646	25-Apr-11	Excision mass	1	EL	11:15	11:50	0:35	1.03	0	0	0	1	1

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647	25-Apr-11	Circumcision	1	EL	14:30	15:00	0:30	0	0	1.00	0	1	1
648	25-Apr-11	Appendectomy	1	EL	12:50	14:10	1:20	0.23	0	1.00	0	2	1
649	25-Apr-11	ESWL	1	EL	18:10	19:10	1:00	0	0.60	0.92	14.40	2	1
650	25-Apr-11	STSG	1	EL	18:40	19:55	1:15	0	0	16.00	0	2	1
651	25-Apr-11	ORIF c-bar K-wire	2	UR	20:10	21:00	0:50	0	0	6.00	0	2	1
652	26-Apr-11	C-Section	2	UR	6:25	8:40	2:15	0	0	0.92	0	3	2
653	26-Apr-11	Excision mass	1	EL	10:45	12:05	1:20	0	0	3.17	0	2	2
654	26-Apr-11	Explore TRA c-bar	1	EL	10:20	13:10	2:50	0	0	1.00	0	3	2
655	26-Apr-11	Revise scar	1	EL	10:30	11:15	0:45	0	0	1.00	0	1	2
656	26-Apr-11	AR	1	EL	10:10	11:55	1:45	0	0	2.00	0	2	2
657	26-Apr-11	Change V-P shurt	1	EL	12:30	15:45	3:15	0	1.50	0	36.00	6	2
658	26-Apr-11	MRI	2	UR	16:30	17:40	1:10	0	0.20	11.00	4.80	2	2
659	26-Apr-11	ORIF c-ar small T-plate	1	EL	17:50	20:25	2:35	0	0.50	1.00	12.00	6	2
660	26-Apr-11	ORIT c-bar narrow plate at tibia	1	EL	21:10	22:30	1:20	0	0.44	2.00	10.50	2	2
661	26-Apr-11	CRIF c-bar K-wire at little finger	1	EL	17:00	18:00	1:00	0.23	0	12.21	0	2	2
662	27-Apr-11	C-Section	2	UR	8:10	9:15	1:05	0	0	0	0	2	3
663	27-Apr-11	TAH	1	EL	9:00	11:30	2:30	0	0	1.00	0	3	3
664	27-Apr-11	Rhinoplasty	1	EL	9:50	11:40	1:50	0.21	0	3.00	0	2	3
665	27-Apr-11	Upper-blepharoplasty	1	EL	10:00	12:30	2:30	0	0	0	0	3	3
666	27-Apr-11	Upper-blepharoplasty	1	EL	14:00	16:15	2:15	1.08	0	0	0	3	3
667	27-Apr-11	Revision Rhinoplasty	1	EL	14:00	16:00	2:00	0	0	0	0	2	3
668	27-Apr-11	Rhinoplasty	1	EL	16:30	18:40	2:10	0	4.50	0	108.00	6	3
669	27-Apr-11	Rhinoplasty	1	EL	19:00	21:50	2:50	0	2.80	0	67.20	6	3
670	27-Apr-11	Cramatomy c-bar	3	EM	20:00	22:20	2:20	0	0	5.58	0	3	3
671	27-Apr-11	Closed reduction shoulder	2	UR	21:30	22:00	0:30	0	0	0.67	0	1	3
672	28-Apr-11	Excision pterygium	1	EL	9:30	10:00	0:30	0	0	0	0	1	4
673	28-Apr-11	Upper-blepharoplasty	1	EL	11:00	12:50	1:50	1.12	0	0	0	2	4
674	28-Apr-11	ORIF interoching nail	2	UR	11:00	15:15	4:15	0	0	5.00	0	3	4
675	28-Apr-11	U+L Blep	1	EL	14:10	17:50	3:40	0	0	0	0	3	4
676	28-Apr-11	AR	1	EL	18:15	20:15	2:00	0	0	0	0	2	4
677	28-Apr-11	Debride + packing	1	EL	22:15	22:45	0:30	0.69	0	4.67	0	1	4
678	28-Apr-11	CRIF c-bar slab	2	UR	22:15	23:00	0:45	0	0	0.58	0	1	4
679	28-Apr-11	Explore for simple suture c-bar omental	2	UR	22:45	0:25	1:40	0	0.90	0.46	21.60	2	4
680	29-Apr-11	Tracheostomy + ORIF c-bar	1	EL	6:00	20:30	14:30	0	0.30	3.75	7.20	4	5
681	29-Apr-11	C-Section	2	UR	9:30	10:45	1:15	0	0	3.04	0	2	5
682	29-Apr-11	C-section	2	UR	10:00	10:45	0:45	0	0	2.88	0	1	5
683	29-Apr-11	LC	2	UR	12:10	13:25	1:15	0	0.10	2.00	2.40	2	5
684	29-Apr-11	AR	1	EL	11:50	13:40	1:50	1.23	0	0	0	2	5

Table A.1 Hospital operation record (Continued)

No.	Operation Date	Operation Description	Admission Type 1 = EL (Elective) 2 = UR (Urgent) 3 = EM (Emergency)		Operation Starting Time	Operation Ending Time	Total Operation Time (Hrs)	No. of Day stay in Ward before operation	No. of days stay in ICU	No. of days stay in ward after operation	Nursing Time Required for a Patient in IC Unit (Hours)	Category	Weekday (1 = Monday, 2 = Tuesday, …, 7 = Sunday)
685	29-Apr-11	AR	1	EL	14:10	16:00	1:50	0.46	0	0	0	2	5
686	29-Apr-11	AR	1	EL	16:15	18:05	1:50	0	0	0	0	2	5
687	29-Apr-11	Tensillectomy	2	UR	20:00	21:05	1:05	0	0	1.00	0	2	5
688	29-Apr-11	ORIF c-bar K-wire thumb	2	UR	21:00	22:00	1:00	0	0	2.00	0	2	5
689	29-Apr-11	Rhinoplasty	1	EL	20:30	22:00	1:30	0	0	0	0	2	5
690	29-Apr-11	Debridement suturn	1	EL	20:45	21:15	0:30	0	0	1.00	0	1	5
691	30-Apr-11	Appendectomy	2	UR	0:00	2:05	2:05	0	2.50	7.00	60.00	6	6
692	30-Apr-11	Fistulectomy	1	EL	8:00	9:00	1:00	0	0.08	3.00	1.92	2	6
693	30-Apr-11	Adreno-tensillectomy	1	EL	8:30	9:50	1:20	0	0	1.00	0	2	6
694	30-Apr-11	Upper-blepharoplasty	1	EL	11:00	13:30	2:30	0	0	0	0	3	6
695	30-Apr-11	Debridement c-bar K-wire fix	1	EL	18:30	19:25	0:55	1.01	0	3.00	0	2	6
696	30-Apr-11	AR	1	EL	14:30	16:45	2:15	0.90	0	0	0	3	6
697	30-Apr-11	Appendectomy	1	EL	21:50	22:25	0:35	0.85	0	2.46	0	1	6
698	30-Apr-11	AR	1	EL	17:00	18:45	1:45	1.08	0	0	0	2	6
699	30-Apr-11	Appendectomy	1	EL	20:10	21:15	1:05	0	0	0	0	2	6
700	30-Apr-11	Gastroscope	1	EL	19:00	19:17	0:17	0	0	1.00	0	1	6
701	1-May-11	Cystoscope	1	EL	7:00	8:40	1:40	0	0	1.00	0	2	7
702	1-May-11	Excision both breast	1	EL	9:30	10:20	0:50	0	0	0	0	2	7
703	1-May-11	Debridement	1	EL	9:30	9:55	0:25	0	0	0	0	1	7
704	1-May-11	STSG	1	EL	10:30	11:20	0:50	0	0	3.00	0	2	7
705	1-May-11	Lamineetomy	1	EL	10:30	13:20	2:50	0	0.40	9.00	9.60	6	7
706	1-May-11	STSG	1	EL	9:00	10:00	1:00	1.20	0.10	0	2.40	2	7
707	1-May-11	Release	1	EL	12:20	12:55	0:35	0	0	0	0	1	7
708	1-May-11	Gastroscope	1	EL	14:00	14:30	0:30	0	0	0.33	0	1	7
709	1-May-11	Colonoscopy	1	EL	16:55	17:10	0:15	0	0	0	0	1	7
710	1-May-11	ORIF e k-wire	2	UR	18:20	18:50	0:30	0	0	1.00	0	1	7
711	1-May-11	ORIF c Reconstrunction	2	UR	19:00	20:20	1:20	0	0	3.00	0	2	7
712	2-May-11	C-Section	2	UR	5:55	7:20	1:25	0	0	3.00	0	2	1
713	2-May-11	ORIF c k-wire	2	UR	7:20	8:35	1:15	1.21	0	1.00	0	2	1
714	2-May-11	Herniorohaphy	1	EL	9:35	11:30	1:55	0	0	0	0	2	1
715	2-May-11	C-Section	2	UR	11:15	12:30	1:15	0.96	0	3.00	0	2	1
716	2-May-11	Excision mass left upper eyelid	1	EL	11:30	12:30	1:00	0	0	0	0	2	1
717	2-May-11	AR	1	EL	13:40	15:05	1:25	0	0.25	0	6.00	2	1
718	2-May-11	Hemorrhoidectomy	1	EL	13:10	14:10	1:00	0	0	3.00	0	2	1
719	2-May-11	Debridement c suture	2	UR	16:35	17:45	1:10	0	0	2.00	0	2	1
720	2-May-11	Correction c demofat c Levator plication	1	EL	17:45	18:50	1:05	0	0	0	0	2	1
721	2-May-11	Debridement c Repair tendon at L foot	2	UR	17:25	18:25	1:00	0	0.60	2.00	14.40	2	1
722	2-May-11	Cystoscope	1	EL	18:05	18:20	0:15	0	0	0	0	1	1

Table A.1 Hospital operation record (Continued)

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723	2-May-11	Fistulectomy	2	UR	19:35	20:30	0:55	1.11	0	1.00	0	2	1
724	2-May-11	ORIF C T-Plate	2	UR	18:50	22:15	3:25	0.87	0.46	0.25	11.00	6	1
725	3-May-11	Explor TAH	1	EL	9:00	11:15	2:15	0	0	0	0	3	2
726	3-May-11	AR	1	EL	10:00	12:15	2:15	0	0	0	0	3	2
727	3-May-11	Colonoscopy	1	EL	10:30	11:05	0:35	0	0	0	0	1	2
728	3-May-11	Excision	1	EL	12:10	20:00	7:50	0	2.20	3.00	52.80	7	2
729	3-May-11	L-Blid	1	EL	11:00	12:00	1:00	0	0	0	0	2	2
730	3-May-11	Repair tendon	2	UR	11:45	12:20	0:35	0	0	0	0	1	2
731	3-May-11	Debridement+repair	2	UR	10:30	11:10	0:40	0	0	1.13	0	1	2
732	3-May-11	TAH	1	EL	13:00	16:40	3:40	0	0	2.83	0	3	2
733	3-May-11	Revise Rhino	1	EL	13:00	14:25	1:25	0.50	0	0	0	2	2
734	3-May-11	Circumeision+ACL	1	EL	13:05	16:25	3:20	0.76	0	3.00	0	3	2
735	3-May-11	C-Section	2	UR	14:00	15:30	1:30	0.62	0	2.92	0	2	2
736	3-May-11	Wide Excision+ serotum	1	EL	15:45	19:00	3:15	0	0	1.75	0	3	2
737	3-May-11	Excision	1	EL	17:25	17:50	0:25	0	0	0	0	1	2
738	3-May-11	Fistulectomy	1	EL	22:00	23:00	1:00	0	0.42	1.38	10.00	2	2
739	3-May-11	Appendectomy	2	UR	23:00	0:15	1:15	0.63	0.31	2.33	7.50	2	2
740	4-May-11	U-slep	1	EL	10:30	12:45	2:15	0	3.10	0	74.40	6	3
741	4-May-11	Closed reduction	2	UR	12:30	13:40	1:10	0	0.75	1.00	18.00	2	3
742	4-May-11	ORIF ep/s	2	UR	12:00	16:00	4:00	0	0	6.83	0	3	3
743	4-May-11	Excision	1	EL	11:00	12:00	1:00	0	0	0	0	2	3
744	4-May-11	Appendectomy	2	UR	16:30	17:30	1:00	0	0	1.00	0	2	3
745	4-May-11	Gastroscope	1	EL	13:30	13:40	0:10	0.94	0	1.00	0	1	3
746	4-May-11	MIS Dissecotomy	1	EL	14:00	16:10	2:10	0	0	1.83	0	3	3
747	4-May-11	Excision	1	EL	13:30	14:10	0:40	0	0	0	0	1	3
748	4-May-11	Appendectomy	2	UR	14:40	16:00	1:20	0	0	2.00	0	2	3
749	4-May-11	Gastroscope	1	EL	15:15	16:00	0:45	0	0	0	0	1	3
750	4-May-11	U+L Blep	1	EL	14:40	18:00	3:20	0.64	0	0	0	3	3
751	4-May-11	Hemorrhoidectomy	1	EL	17:20	18:20	1:00	0	0	2.00	0	2	3
752	4-May-11	Debridement	2	UR	21:30	23:30	2:00	0	0	0	0	2	3
753	5-May-11	Debridement	2	UR	0:30	1:20	0:50	0	0.80	0	19.20	2	4
754	5-May-11	D&C	1	EL	7:20	7:55	0:35	0	0	1.00	0	1	4
755	5-May-11	C-section	1	EL	9:00	10:30	1:30	0	0	3.00	0	2	4
756	5-May-11	C-section	1	EL	9:20	10:15	0:55	0	0	3.29	0	2	4
757	5-May-11	Phaco	1	EL	10:00	11:45	1:45	0	0	0	0	2	4
758	5-May-11	Colonoscopy	2	UR	10:00	10:50	0:50	0	0	2.25	0	2	4
759	5-May-11	AR	1	EL	11:45	14:30	2:45	0.21	0	0	0	3	4
760	5-May-11	LoCo	1	EL	12:15	14:00	1:45	0	0.87	2.00	20.88	2	4

Table A.1 Hospital operation record (Continued)

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761	5-May-11	C-Section	1	EL	14:10	15:25	1:15	0	0.90	2.88	21.60	2	4
762	5-May-11	Tonsillectomy	1	EL	10:30	11:30	1:00	0	0	0	0	2	4
763	5-May-11	ORIF c k-wire	1	EL	23:00	0:15	1:15	0	0.38	1.29	9.00	2	4
764	6-May-11	Debridement	2	UR	0:15	1:45	1:30	0	0.08	0.50	2.00	2	5
765	6-May-11	Tonsillectomy	1	EL	8:30	9:30	1:00	0	0	2.04	0	2	5
766	6-May-11	Gastroscope	1	EL	13:20	13:50	0:30	0	0	0	0	1	5
767	6-May-11	U-Blep	1	EL	10:45	13:05	2:20	0	0	0	0	3	5
768	6-May-11	loner	1	EL	9:20	17:40	8:20	0.72	7.00	2.83	168.00	8	5
769	6-May-11	I&D	1	EL	13:00	13:55	0:55	0	0	1.00	0	2	5
770	6-May-11	AR	1	EL	14:00	16:00	2:00	0	0	0	0	2	5
771	6-May-11	AR	1	EL	16:20	18:10	1:50	0	0	0	0	2	5
772	6-May-11	ORIF	2	UR	17:45	19:50	2:05	0.44	0	1.75	0	3	5
773	6-May-11	Remove FB	2	UR	21:25	22:25	1:00	0	0.40	3.00	9.50	2	5
774	6-May-11	Debridement	2	UR	22:30	23:25	0:55	0.56	0.38	0.29	9.00	2	5
775	6-May-11	Selorsing injection	2	UR	22:00	22:40	0:40	0.36	0	0.50	0	1	5
776	7-May-11	Gastroscope	2	UR	3:20	4:30	1:10	0	0	6.38	0	2	6
777	7-May-11	Re-suture	1	EL	8:00	9:00	1:00	0.79	0	0.21	0	2	6
778	7-May-11	Gastroscope	1	EL	8:30	8:45	0:15	0	0	0	0	1	6
779	7-May-11	Sphinoterotomy	1	EL	11:30	12:30	1:00	0	0	1.00	0	2	6
780	7-May-11	Arthroscope	1	EL	13:00	15:20	2:20	0	0	3.00	0	3	6
781	7-May-11	Appendectomy	2	UR	14:00	15:30	1:30	0	0	2.00	0	2	6
782	7-May-11	Gastroscope	1	EL	15:00	15:50	0:50	0	0.10	6.42	2.40	2	6
783	7-May-11	Excision	1	EL	14:00	15:00	1:00	0	0	0	0	2	6
784	7-May-11	Rhinoplasty	1	EL	15:00	17:15	2:15	0	0	0	0	3	6
785	7-May-11	Revision Rhinoplasty	1	EL	15:30	16:30	1:00	0	0	0	0	2	6
786	7-May-11	Hemorrhoidectomy	1	EL	16:00	17:30	1:30	0	0	1.58	0	2	6
787	7-May-11	Colonoscopy	1	EL	17:00	17:40	0:40	0	0	5.00	0	1	6
788	7-May-11	C-section	1	EL	18:35	20:05	1:30	0	0	3.00	0	2	6
789	7-May-11	Endoscopi	1	EL	19:30	21:30	2:00	0	0.50	1.00	12.00	2	6
790	7-May-11	Colonoscopy	1	EL	21:50	22:15	0:25	0	0	2.71	0	1	6
791	7-May-11	Debridement	2	UR	19:30	21:00	1:30	0	0.15	1.75	3.60	2	6
792	7-May-11	Cervical	1	EL	22:05	2:00	3:55	0	0.27	2.25	6.50	3	6
793	7-May-11	Explore	3	EM	20:30	22:00	1:30	0	0	3.83	0	2	6
794	8-May-11	Ventriculostomy	2	UR	2:20	4:00	1:40	0	0	1.42	0	2	7
795	8-May-11	C-section	1	EL	5:30	7:00	1:30	0	0	3.00	0	2	7
796	8-May-11	palmso Flap Left	1	EL	10:30	11:25	0:55	0	0	0	0	2	7
797	8-May-11	ORIF	1	EL	14:30	16:45	2:15	0	0	5.00	0	3	7
798	8-May-11	AR	1	EL	13:30	15:50	2:20	0	0	0	0	3	7

Table A.1 Hospital operation record (Continued)

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799	8-May-11	Gastroscope	1	EL	13:30	14:30	1:00	1.00	0	1.00	0	2	7
800	8-May-11	Debridement	2	UR	17:25	18:50	1:25	0	0.55	1.00	13.20	2	7
801	8-May-11	AR	1	EL	17:20	18:35	1:15	0	0	0	0	2	7
802	8-May-11	Debridement	2	UR	18:20	19:20	1:00	0	0	5.00	0	2	7
803	8-May-11	Revise Right ear	1	EL	19:00	20:00	1:00	0	0	0	0	2	7
804	9-May-11	C-Section	1	EL	9:00	10:30	1:30	0	0	3.00	0	2	1
805	9-May-11	Excision	1	EL	11:00	13:30	2:30	0.87	0	2.00	0	3	1
806	9-May-11	Excision	1	EL	13:30	14:20	0:50	0	0	0	0	2	1
807	9-May-11	Epicondylectomy	1	EL	12:00	13:55	1:55	0	0	1.00	0	2	1
808	9-May-11	Excision	1	EL	13:30	15:45	2:15	0	0	1.00	0	3	1
809	9-May-11	V-Y	1	EL	13:25	14:20	0:55	1.01	0	1.00	0	2	1
810	9-May-11	AR	1	EL	15:15	16:15	1:00	0.41	0.35	0	8.40	2	1
811	9-May-11	D&C	2	UR	14:55	15:25	0:30	0	0	1.00	0	1	1
812	9-May-11	Rhinoplasty	1	EL	16:40	17:55	1:15	0	0	0	0	2	1
813	9-May-11	Excision mass	1	EL	14:10	15:30	1:20	0	0	1.00	0	2	1
814	9-May-11	Vassectomy	1	EL	18:20	19:00	0:40	0	0	0	0	1	1
815	9-May-11	ESWL	1	EL	18:50	20:05	1:15	0	0	0.75	0	2	1
816	9-May-11	Gastroscope	1	EL	20:10	20:45	0:35	1.02	0	1.63	0	1	1
817	9-May-11	Hemorrhoidectomy	2	UR	20:15	21:55	1:40	0	0.23	2.79	5.52	2	1
818	9-May-11	Fistulectomy	2	UR	21:20	22:15	0:55	0	0	2.00	0	2	1
819	9-May-11	URS c Stone breaker c insert D-J stone	2	UR	22:20	23:20	1:00	0	0.38	1.42	9.00	2	1
820	9-May-11	Colonoscopy	2	UR	20:45	21:20	0:35	0.97	0	0	0	1	1
821	9-May-11	C-Section	2	UR	23:45	1:05	1:20	0	0.31	3.00	7.50	2	1
822	10-May-11	Circumeision	1	EL	7:00	7:45	0:45	0	0	1.00	0	1	2
823	10-May-11	C-Section	1	EL	9:05	10:20	1:15	0	0	2.00	0	2	2
824	10-May-11	Lap TL	1	EL	9:05	13:35	4:30	0	0	2.08	0	3	2
825	10-May-11	C-section	1	EL	10:30	11:35	1:05	0	0	3.00	0	2	2
826	10-May-11	Arthroscope	1	EL	13:50	17:50	4:00	0	0	4.00	0	3	2
827	10-May-11	I&D	2	UR	15:10	15:40	0:30	0	0	2.00	0	1	2
828	10-May-11	AR	1	EL	14:00	16:15	2:15	0	0	0	0	3	2
829	10-May-11	Phaco	1	EL	14:30	15:20	0:50	1.03	0.45	0	10.80	2	2
830	10-May-11	Repair	2	UR	20:20	22:00	1:40	0	0	1.00	0	2	2
831	10-May-11	Explore lap	1	EL	15:00	16:00	1:00	0	0	3.00	0	2	2
832	10-May-11	Cramatomy	1	EL	22:40	0:55	2:15	1.18	0	2.00	0	3	2
833	11-May-11	C-section	3	EM	1:00	1:50	0:50	0	0.29	3.04	7.00	2	3
834	11-May-11	Tonsillectomy	1	EL	8:30	10:00	1:30	0	0	1.96	0	2	3
835	11-May-11	AR	1	EL	10:30	12:45	2:15	0	0	0	0	3	3
836	11-May-11	C-Section	1	EL	9:00	13:20	4:20	0	1.20	3.00	28.80	7	3

Table A.1 Hospital operation record (Continued)

No.	Operation Date	Operation Description	Admission Type 1 = EL (Elective) 2 = UR (Urgent) 3 = EM (Emergency)		Operation Starting Time	Operation Ending Time	Total Operation Time (Hrs)	No. of Day stay in Ward before operation	No. of days stay in ICU	No. of days stay in ward after operation	Nursing Time Required for a Patient in IC Unit (Hours)	Category	Weekday (1 = Monday, 2 = Tuesday, …, 7 = Sunday)
837	11-May-11	C-Section	1	EL	10:30	12:00	1:30	0.53	0	3.00	0	2	3
838	11-May-11	Lamineetomy	1	EL	10:00	13:25	3:25	0.27	0.88	3.00	21.00	6	3
839	11-May-11	U-Blep	1	EL	14:00	16:30	2:30	0	0	0	0	3	3
840	11-May-11	Appendectomy	2	UR	22:00	23:20	1:20	0	0.40	2.00	9.50	2	3
841	11-May-11	Gastroscope	1	EL	14:30	20:00	5:30	0	0.20	1.00	4.80	4	3
842	11-May-11	Gastroscope	1	EL	23:00	23:30	0:30	0	0	1.00	0	1	3
843	11-May-11	Debridement	2	UR	21:30	22:10	0:40	0	0.44	2.00	10.50	2	3
844	12-May-11	Remove FB	2	UR	0:00	0:30	0:30	0	0.38	1.00	9.00	2	4
845	12-May-11	Left Clavicle	2	UR	8:00	9:45	1:45	0	0	2.33	0	2	4
846	12-May-11	AR	1	EL	10:20	14:05	3:45	0.41	0	0	0	3	4
847	12-May-11	MIS c dissectomy	1	EL	13:45	16:50	3:05	1.08	0	2.00	0	3	4
848	12-May-11	Debridement	2	UR	15:20	16:15	0:55	1.16	0	0	0	2	4
849	12-May-11	Gastroscope	1	EL	17:30	18:00	0:30	0	0	0	0	1	4
850	12-May-11	CRIF c slab	2	UR	19:25	19:45	0:20	0	0	1.00	0	1	4
851	12-May-11	D/L to remove	2	UR	20:30	21:05	0:35	0	0	0	0	1	4
852	12-May-11	Appendectomy	2	UR	21:45	22:30	0:45	0	0.42	2.33	10.00	2	4
853	12-May-11	MRM	1	EL	22:30	0:50	2:20	0	0.35	2.08	8.50	6	4
854	12-May-11	CRIF e k-wire	2	UR	20:00	20:25	0:25	0.40	0	1.71	0	1	4
855	13-May-11	Appendectomy	2	UR	6:45	8:40	1:55	0	0	2.25	0	2	5
856	13-May-11	Lower Blephareplaty	1	EL	13:00	15:00	2:00	0	0	0	0	2	5
857	13-May-11	Debridement	2	UR	16:00	18:10	2:10	0	0	1.00	0	3	5
858	13-May-11	C-section	1	EL	18:30	19:45	1:15	0	0.40	3.00	9.60	2	5
859	14-May-11	Gastroscope	1	EL	7:30	8:30	1:00	0	0	2.38	0	2	6
860	14-May-11	Debridement	2	UR	7:30	9:30	2:00	0	0.40	4.29	9.60	2	6
861	14-May-11	C-section	1	EL	8:40	10:30	1:50	0	0	3.08	0	2	6
862	14-May-11	Excision	1	EL	9:30	10:45	1:15	0	0	1.08	0	2	6
863	14-May-11	Appendectomy	2	UR	8:00	9:00	1:00	0	0	2.13	0	2	6
864	14-May-11	Gastroscope	1	EL	8:30	9:00	0:30	0	0	0.33	0	1	6
865	14-May-11	Excision mass	1	EL	12:00	12:20	0:20	0	0	0	0	1	6
866	14-May-11	Revision Open Rhinoplasty	1	EL	10:30	15:25	4:55	0	0.05	0	1.20	4	6
867	14-May-11	Relea	1	EL	11:30	12:15	0:45	0	0	0	0	1	6
868	14-May-11	Remove TBW	1	EL	13:10	13:50	0:40	0	0	0	0	1	6
869	14-May-11	Excision	1	EL	14:20	14:55	0:35	0	0	0	0	1	6
870	14-May-11	Appendectomy	2	UR	13:55	14:55	1:00	0.29	0	2.00	0	2	6
871	14-May-11	Ficiaotomy	1	EL	14:20	15:15	0:55	0	0	3.92	0	2	6
872	14-May-11	Rhinoplasty	1	EL	15:40	18:00	2:20	0	0	0	0	3	6
873	14-May-11	Cranioplasty	1	EL	15:15	17:45	2:30	0	0.71	3.83	17.00	6	6
874	14-May-11	C-section	1	EL	16:00	17:15	1:15	0	0	0	0	2	6

Table A.1 Hospital operation record (Continued)

No.	Operation Date	Operation Description	Admission Type 1 = EL (Elective) 2 = UR (Urgent) 3 = EM (Emergency)		Operation Starting Time	Operation Ending Time	Total Operation Time (Hrs)	No. of Day stay in Ward before operation	No. of days stay in ICU	No. of days stay in ward after operation	Nursing Time Required for a Patient in IC Unit (Hours)	Category	Weekday (1 = Monday, 2 = Tuesday, …, 7 = Sunday)
875	14-May-11	D&C	2	UR	15:05	15:40	0:35	0	0	0.21	0	1	6
876	14-May-11	Excision	1	EL	15:50	16:20	0:30	0	0	0	0	1	6
877	14-May-11	Excision	1	EL	19:10	19:40	0:30	0	0	0.67	0	1	6
878	14-May-11	AR	1	EL	18:30	21:55	3:25	0	0	0	0	3	6
879	14-May-11	D&C	1	EL	20:00	20:20	0:20	0	0	1.00	0	1	6
880	15-May-11	Revision Rhinoplasty	1	EL	10:30	11:40	1:10	0	0	0	0	2	7
881	15-May-11	Lower Blephareplaty	1	EL	11:25	13:30	2:05	0	0	2.00	0	3	7
882	15-May-11	Fistulectomy	1	EL	12:35	13:30	0:55	0	0.55	2.00	13.20	2	7
883	15-May-11	Heermorrhaphy	1	EL	13:30	15:35	2:05	0	0	1.00	0	3	7
884	15-May-11	Debridement	2	UR	17:15	20:20	3:05	0	0	4.00	0	3	7
885	15-May-11	ORIF	2	UR	20:15	23:05	2:50	0	0.44	6.13	10.50	6	7
886	15-May-11	Appendectomy	2	UR	19:30	20:40	1:10	0	0	2.00	0	2	7
887	15-May-11	Closed Medid	2	UR	23:15	2:15	3:00	0.31	0.25	3.00	6.00	3	7
888	16-May-11	Debridement	2	UR	9:30	10:30	1:00	0	0	0	0	2	1
889	16-May-11	Excision	1	EL	10:00	11:10	1:10	0	0	0	0	2	1
890	16-May-11	Closed Reduction	1	EL	15:00	15:35	0:35	0	0	1.00	0	1	1
891	16-May-11	Release Trig	1	EL	14:00	14:25	0:25	0	0	0	0	1	1
892	16-May-11	Hemorrhoidectomy	1	EL	14:10	14:55	0:45	0	0	2.00	0	1	1
893	16-May-11	I&D	1	EL	17:30	18:00	0:30	0	0	1.00	0	1	1
894	16-May-11	Debridement	1	EL	15:20	15:40	0:20	0	0	0	0	1	1
895	16-May-11	Repair tender	2	UR	16:25	17:00	0:35	0	0	1.00	0	1	1
896	16-May-11	STSG	2	UR	18:15	20:30	2:15	0	5.50	5.00	132.00	6	1
897	16-May-11	Marsupialization	2	UR	19:45	20:30	0:45	0	0	0	0	1	1
898	16-May-11	Herniorohaphy	2	UR	21:30	22:55	1:25	0	0.40	1.08	9.50	2	1
899	16-May-11	ORIF c Reconstruction	2	UR	20:50	23:40	2:50	1.21	0.44	18.00	10.50	6	1
900	16-May-11	URS c Stone breaker c insert D-J stone	2	UR	19:05	20:50	1:45	0	0	0.58	0	2	1
901	17-May-11	C-Section	1	EL	8:00	16:55	8:55	0.77	3.50	2.88	84.00	8	2
902	17-May-11	Remove external fix	2	UR	8:05	8:35	0:30	0	0	0	0	1	2
903	17-May-11	Sphinoterotomy	2	UR	8:50	11:00	2:10	0.82	0	1.00	0	3	2
904	17-May-11	Colonoscopy	2	UR	9:20	9:45	0:25	0	0	0.17	0	1	2
905	17-May-11	C-section	1	EL	9:40	10:50	1:10	0	0	3.04	0	2	2
906	17-May-11	Colonoscopy	1	EL	8:10	8:40	0:30	0	0	0	0	1	2
907	17-May-11	Rhinoplasty	1	EL	10:45	13:00	2:15	0	0	0	0	3	2
908	17-May-11	DCL	1	EL	13:30	15:30	2:00	0	0.85	3.00	20.50	2	2
909	17-May-11	Revise	1	EL	12:30	14:15	1:45	0	0	0	0	2	2
910	17-May-11	OFF IMF	1	EL	15:15	15:50	0:35	1.25	0	0	0	1	2
911	17-May-11	Remove p/s	1	EL	16:00	17:40	1:40	0	0	0.71	0	2	2
912	17-May-11	Gastroscope	1	EL	18:30	18:50	0:20	0	0	0.83	0	1	2

Table A.1 Hospital operation record (Continued)

No.	Operation Date	Operation Description	Admission Type 1 = EL (Elective) 2 = UR (Urgent) 3 = EM (Emergency)		Operation Starting Time	Operation Ending Time	Total Operation Time (Hrs)	No. of Day stay in Ward before operation	No. of days stay in ICU	No. of days stay in ward after operation	Nursing Time Required for a Patient in IC Unit (Hours)	Category	Weekday (1 = Monday, 2 = Tuesday, …, 7 = Sunday)
913	17-May-11	D&C	1	EL	11:40	12:15	0:35	0	0	0	0	1	2
914	17-May-11	Appendectomy	2	UR	20:00	21:30	1:30	0	0	2.00	0	2	2
915	18-May-11	Colonoscopy	1	EL	10:00	11:00	1:00	0	0.15	2.46	3.60	2	3
916	18-May-11	AR	1	EL	10:30	12:45	2:15	0	0	0	0	3	3
917	18-May-11	Excision	1	EL	11:05	12:35	1:30	0	0	1.00	0	2	3
918	18-May-11	LEEP	1	EL	13:10	13:40	0:30	0	0	1.00	0	1	3
919	18-May-11	Ex pterygium	1	EL	14:00	15:00	1:00	0	0	0	0	2	3
920	18-May-11	Appendectomy	2	UR	14:00	15:25	1:25	0	0	2.00	0	2	3
921	18-May-11	Upper-blepharoplasty	1	EL	14:00	16:15	2:15	0	0	0	0	3	3
922	19-May-11	Ph	1	EL	10:00	11:45	1:45	0	0	0	0	2	4
923	19-May-11	Gastroscope	1	EL	11:25	11:40	0:15	0	0	0	0	1	4
924	19-May-11	Gastroscope	1	EL	13:15	13:20	0:05	0	0	1.00	0	1	4
925	19-May-11	Gastroscope	1	EL	15:30	15:50	0:20	0.35	0	2.00	0	1	4
926	19-May-11	Excision	1	EL	13:45	14:55	1:10	0	0	0	0	2	4
927	19-May-11	D&C	2	UR	19:00	19:35	0:35	0	0	1.00	0	1	4
928	19-May-11	ORIF c TBW	2	UR	21:00	22:15	1:15	0	0.46	0.33	11.00	2	4
929	19-May-11	Cystoscope	2	UR	17:30	17:50	0:20	0	0	0	0	1	4
930	20-May-11	Appendectomy	1	EL	9:20	10:25	1:05	0	0.29	1.21	7.00	2	5
931	20-May-11	Tonsillectomy	1	EL	8:30	10:05	1:35	0.22	0.95	1.00	22.80	2	5
932	20-May-11	C-Section	1	EL	9:00	10:20	1:20	0	0	3.00	0	2	5
933	20-May-11	Colonoscopy	1	EL	11:20	12:00	0:40	0	0	1.00	0	1	5
934	20-May-11	Colonoscopy	1	EL	15:00	15:30	0:30	0	0	0	0	1	5
935	20-May-11	Rhinoplasty	1	EL	18:00	20:15	2:15	0	0	0	0	3	5
936	20-May-11	Upper-blepharoplasty	1	EL	14:10	17:00	2:50	0	0	0	0	3	5
937	20-May-11	Rhinoplasty	1	EL	14:00	16:20	2:20	0	0	0	0	3	5
938	20-May-11	ORIF e k-wire	2	UR	20:30	23:00	2:30	0	0.08	0.75	2.00	3	5
939	21-May-11	Excision	1	EL	10:25	11:20	0:55	0	0.65	0	15.60	2	6
940	21-May-11	Excision	1	EL	13:00	13:45	0:45	0	0	0	0	1	6
941	21-May-11	Dressing wound	2	UR	14:50	15:10	0:20	0	0	0.21	0	1	6
942	21-May-11	Augmentation Rhinoplasty	1	EL	15:45	16:30	0:45	0	0	0	0	1	6
943	21-May-11	Revise Augmentation Rhinoplasty	1	EL	16:45	19:20	2:35	0	0	0	0	3	6
944	21-May-11	AR	1	EL	16:50	17:25	0:35	0	0	0	0	1	6
945	21-May-11	Upper-blepharoplasty	1	EL	15:30	17:00	1:30	0	0	0	0	2	6
946	22-May-11	ORIF c k-wire	1	EL	2:00	3:00	1:00	0.51	0.25	0.25	6.00	2	7
947	22-May-11	C-section	3	EM	7:00	8:00	1:00	0.75	0	3.00	0	2	7
948	22-May-11	Gastroscope	1	EL	8:20	8:30	0:10	0	0	0	0	1	7
949	22-May-11	palmso Flap Left	1	EL	10:40	11:45	1:05	0	0	0	0	2	7
950	22-May-11	AR	1	EL	13:00	13:30	0:30	0	0	0	0	1	7

Table A.1 Hospital operation record (Continued)

No.	Operation Date	Operation Description	Admission Type 1 = EL (Elective) 2 = UR (Urgent) 3 = EM (Emergency)		Operation Starting Time	Operation Ending Time	Total Operation Time (Hrs)	No. of Day stay in Ward before operation	No. of days stay in ICU	No. of days stay in ward after operation	Nursing Time Required for a Patient in IC Unit (Hours)	Category	Weekday (1 = Monday, 2 = Tuesday, …, 7 = Sunday)
951	22-May-11	Phaco	1	EL	13:30	14:15	0:45	0	0	0	0	1	7
952	22-May-11	Excision	1	EL	14:30	15:30	1:00	0	0	0	0	2	7
953	22-May-11	I&D	1	EL	18:30	19:30	1:00	0	0	1.00	0	2	7
954	22-May-11	Appendectomy	2	UR	17:30	18:45	1:15	0	0	1.79	0	2	7
955	22-May-11	Rhinoplasty	1	EL	17:00	18:50	1:50	0	0	0	0	2	7
956	22-May-11	MRI	1	EL	19:15	20:00	0:45	0	0	1.00	0	1	7
957	22-May-11	ORIF Plate	3	EM	20:00	0:05	4:05	0	0	2.00	0	3	7
958	22-May-11	Appendectomy	2	UR	21:30	22:45	1:15	0	0.40	1.00	9.50	2	7
959	22-May-11	Castre colonoscopy	1	EL	22:30	23:50	1:20	0	0	1.00	0	2	7
960	23-May-11	Gastroscope	1	EL	7:00	7:30	0:30	1.26	0	1.00	0	1	1
961	23-May-11	Gastroscope	1	EL	8:00	8:30	0:30	0.92	0	0	0	1	1
962	23-May-11	C-Section	2	UR	11:05	12:30	1:25	0.30	0.78	3.00	18.72	2	1
963	23-May-11	Gastroscope	1	EL	10:45	11:00	0:15	0	0	0	0	1	1
964	23-May-11	Excision	1	EL	13:40	15:05	1:25	0.39	0	1.00	0	2	1
965	23-May-11	U-Blep	1	EL	10:30	13:15	2:45	0	0	0	0	3	1
966	23-May-11	Colonoscopy	1	EL	17:00	17:20	0:20	0	0	0.83	0	1	1
967	23-May-11	Cystoscope	1	EL	18:00	18:15	0:15	0	0	0	0	1	1
968	23-May-11	Gastroscope	1	EL	18:45	19:05	0:20	0	0	1.00	0	1	1
969	23-May-11	Colonoscopy	1	EL	18:05	18:25	0:20	0.39	0	1.00	0	1	1
970	23-May-11	ESWL	1	EL	22:40	23:25	0:45	0	0.27	0.17	6.50	2	1
971	24-May-11	Lap TLH	1	EL	9:05	13:40	4:35	0	0.10	2.00	2.40	4	2
972	24-May-11	Repair tender	2	UR	11:30	12:25	0:55	0	0	1.00	0	2	2
973	24-May-11	Angiudgs plasia	1	EL	8:00	8:55	0:55	0	0	1.00	0	2	2
974	24-May-11	Excision	1	EL	13:30	15:10	1:40	1.21	0	1.00	0	2	2
975	24-May-11	ORIF e T-plate	1	EL	16:00	17:40	1:40	0	0	1.00	0	2	2
976	24-May-11	Circumeision	2	UR	16:30	17:15	0:45	0	0	1.00	0	1	2
977	24-May-11	Gastroscope	2	UR	18:10	18:40	0:30	0.42	0	7.00	0	1	2
978	25-May-11	Decompression Laminectomy	2	UR	8:45	13:10	4:25	0	0	6.00	0	3	3
979	25-May-11	D&C	2	UR	11:10	11:40	0:30	0	0	0.29	0	1	3
980	25-May-11	D&C	2	UR	11:50	12:40	0:50	0	0	0	0	2	3
981	25-May-11	Gastroscope	2	UR	15:10	15:50	0:40	0	0	0.92	0	1	3
982	25-May-11	Repair tender	1	EL	15:30	16:15	0:45	0	0	0	0	1	3
983	25-May-11	C-Section	2	UR	17:35	18:55	1:20	0	0	4.00	0	2	3
984	25-May-11	ORIF E p/s	2	UR	20:20	1:10	4:50	0	0.44	3.38	10.50	7	3
985	26-May-11	Resuturea stump	1	EL	9:00	10:30	1:30	0	0	0	0	2	4
986	26-May-11	Gastroscope	1	EL	10:00	10:30	0:30	0.34	0	2.00	0	1	4
987	26-May-11	Gastroscope	1	EL	11:30	11:45	0:15	0	0	0	0	1	4
988	26-May-11	Gastroscope	1	EL	13:45	14:00	0:15	0	0	0	0	1	4

Table A.1 Hospital operation record (Continued)

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989	26-May-11	Appendectomy	1	EL	15:00	16:15	1:15	0	0	2.00	0	2	4
990	26-May-11	Debridement	2	UR	18:00	19:45	1:45	0.28	0	2.00	0	2	4
991	26-May-11	debridement	2	UR	22:00	22:40	0:40	0	0	1.00	0	1	4
992	26-May-11	Scrub burn	2	UR	21:45	22:00	0:15	0	0	4.00	0	1	4
993	27-May-11	C-Section	1	EL	8:00	9:25	1:25	0	0	3.00	0	2	5
994	27-May-11	C-Section	1	EL	8:00	9:35	1:35	0	0	3.00	0	2	5
995	27-May-11	C-Section	1	EL	9:30	10:50	1:20	0.79	0	3.00	0	2	5
996	27-May-11	TR	1	EL	10:40	11:15	0:35	0	0	2.00	0	1	5
997	27-May-11	Augmentation Rhinoplasty	1	EL	10:50	12:30	1:40	0	0	0	0	2	5
998	27-May-11	Gastroscope	2	UR	11:50	12:08	0:18	0.46	0	0	0	1	5
999	27-May-11	Marsupialization	2	UR	12:35	13:10	0:35	1.24	0	0	0	1	5
1000	27-May-11	C-Section	1	EL	13:00	14:05	1:05	0	0.25	3.00	6.00	2	5
1001	28-May-11	Appendectomy	2	UR	3:50	5:00	1:10	0	0.17	2.00	4.00	2	6
1002	28-May-11	Appendectomy	2	UR	8:00	9:15	1:15	0	0	2.00	0	2	6
1003	28-May-11	TAH	1	EL	9:00	11:35	2:35	0	0	3.00	0	3	6
1004	28-May-11	Excision	1	EL	11:20	12:10	0:50	0	0	0	0	2	6
1005	28-May-11	Hemorrhoidectomy	1	EL	14:00	15:00	1:00	0	0	1.00	0	2	6
1006	28-May-11	C-section	1	EL	10:00	10:35	0:35	0	0	3.00	0	1	6
1007	28-May-11	Gastroscope	1	EL	12:40	13:00	0:20	0	0	0	0	1	6
1008	28-May-11	AR c cartilage	1	EL	17:00	18:00	1:00	0	0	0	0	2	6
1009	28-May-11	C-section	1	EL	22:30	0:00	1:30	0	0.33	3.46	8.00	2	6
1010	28-May-11	Marsupialization	1	EL	19:40	20:15	0:35	1.06	0	0	0	1	6
1011	29-May-11	Debridement	2	UR	7:00	9:20	2:20	0	0	0	0	3	7
1012	29-May-11	Repair nail bed	2	UR	11:10	11:40	0:30	0	0	0	0	1	7
1013	29-May-11	Colonoscopy	1	EL	10:55	11:25	0:30	0.33	0	0	0	1	7
1014	29-May-11	Excision	1	EL	13:00	14:10	1:10	0	0	1.00	0	2	7
1015	29-May-11	Explor lap for repair liner	3	EM	13:00	14:10	1:10	0.50	0.17	3.00	4.08	2	7
1016	29-May-11	AR	1	EL	15:50	16:35	0:45	1.23	0	0	0	1	7
1017	29-May-11	Cranicetomy	3	EM	19:20	0:20	5:00	0	0.10	11.00	2.40	4	7
1018	29-May-11	Appendectomy	2	UR	20:35	21:45	1:10	0	0	2.00	0	2	7
1019	29-May-11	CRIF	2	UR	22:10	23:00	0:50	0.68	0	0	0	2	7
1020	30-May-11	C-Section	2	UR	4:00	5:15	1:15	0	0	3.00	0	2	1
1021	30-May-11	Colonoscopy	1	EL	8:30	9:00	0:30	0	0	0	0	1	1
1022	30-May-11	Craniotomy	2	UR	9:10	12:50	3:40	0.53	3.50	10.00	84.00	6	1
1023	30-May-11	Excision	1	EL	10:20	11:00	0:40	0.48	0	0	0	1	1
1024	30-May-11	Colonoscopy	1	EL	13:45	14:55	1:10	0	0	2.17	0	2	1
1025	30-May-11	Colonoscopy	1	EL	15:00	15:35	0:35	0	0	0	0	1	1
1026	30-May-11	Marsupialization	1	EL	13:20	14:00	0:40	0	0	0	0	1	1

Table A.1 Hospital operation record (Continued)

No.	Operation Date	Operation Description	Admission Type 1 = EL (Elective) 2 = UR (Urgent) 3 = EM (Emergency)		Operation Starting Time	Operation Ending Time	Total Operation Time (Hrs)	No. of Day stay in Ward before operation	No. of days stay in ICU	No. of days stay in ward after operation	Nursing Time Required for a Patient in IC Unit (Hours)	Category	Weekday (1 = Monday, 2 = Tuesday, …, 7 = Sunday)
1027	30-May-11	Upper-blepharoplasty	1	EL	13:50	16:05	2:15	0	0	0	0	3	1
1028	30-May-11	Excision mass	1	EL	14:00	14:40	0:40	0	0	0	0	1	1
1029	30-May-11	I&D	1	EL	20:00	21:00	1:00	0	0	2.00	0	2	1
1030	30-May-11	Colonoscopy	1	EL	12:45	13:10	0:25	0	0	0	0	1	1
1031	30-May-11	Herriarthroplasty	2	UR	13:10	15:50	2:40	0	1.04	3.88	25.00	6	1
1032	30-May-11	Excision	1	EL	16:30	18:00	1:30	0	0	1.00	0	2	1
1033	30-May-11	Colonoscopy	1	EL	16:00	17:15	1:15	0	0.23	2.00	5.52	2	1
1034	30-May-11	CRIF e k-wire	2	UR	18:00	19:00	1:00	1.12	0	0.71	0	2	1
1035	30-May-11	Appendectomy	2	UR	19:20	20:20	1:00	0	0	2.75	0	2	1
1036	30-May-11	Cystoscope	1	EL	19:20	19:45	0:25	0	0	1.00	0	1	1
1037	30-May-11	Repair nail bed	2	UR	19:30	20:30	1:00	0	0	0.38	0	2	1
1038	31-May-11	Anterior decompression	1	EL	9:00	12:00	3:00	0	0	1.92	0	3	2
1039	31-May-11	C-Section	2	UR	9:00	10:10	1:10	0	0	3.08	0	2	2
1040	31-May-11	Excision	1	EL	10:00	11:20	1:20	0	0	0	0	2	2
1041	31-May-11	C-section	2	UR	15:00	16:25	1:25	0	0	2.88	0	2	2
1042	31-May-11	Debridement +repair tender	2	UR	14:35	15:00	0:25	0	0	0.29	0	1	2
1043	31-May-11	Appendectomy	2	UR	15:10	17:00	1:50	0	0	1.83	0	2	2
1044	31-May-11	Closed Reduction nasal bane	1	EL	20:30	21:20	0:50	0	0.80	4.00	19.20	2	2

APPENDIX B

OPERATION CANCELLATION AND NO-SHOW RECORD

Table B.1 Operation cancellation and no-show record

No	Date	Operation Description	Expectected Operating Time (hrs)	Expected ICU Time (days)	Category	Weekday (1 = Monday, 2 = Tuesday, …, 7 = Sunday)
1	1-Mar-11	C-Section	1:30	0.5	2	2
2	1-Mar-11	C-Section	1:30	0.5	2	2
3	2-Mar-11	C-Section	1:30	0.5	2	3
4	3-Mar-11	C-Section	1:30	0.5	2	4
5	4-Mar-11	C-Section	1:30	0.5	2	5
6	8-Mar-11	Gastroscope+Colonoscope	0:30	0	1	2
7	9-Mar-11	C-Section	1:30	0.5	2	3
8	10-Mar-11	C-Section	1:30	0.5	2	4
9	10-Mar-11	AR	2:00	0.1	3	4
10	14-Mar-11	D+C	0:45	0	1	1
11	15-Mar-11	C-Section	1:30	0.5	2	2
12	17-Mar-11	C-Section	1:30	0.5	2	4
13	19-Mar-11	Tonsil+Adrencidec	1:30	0.2	2	6
14	20-Mar-11	C-Section	1:30	0.5	2	7
15	21-Mar-11	C-Section	1:30	0.5	2	1
16	23-Mar-11	Laminect C PDS L3	3:30	0	3	3
17	24-Mar-11	Excision	1:30	0.1	2	4
18	25-Mar-11	Hermiotomy	1:00	0	2	5
19	25-Mar-11	Rhinoplasty	2:30	2	5	5
20	27-Mar-11	C-Section	1:30	0.5	2	7
21	27-Mar-11	Gastroscope+Colonoscope	0:30	0	1	7

Table B.1 Operation cancellation and no-show record (Continued)

No	Date	Operation Description	Expectected Operating Time (hrs)	Expected ICU Time (days)	Category	Weekday (1 = Monday, 2 = Tuesday, …, 7 = Sunday)
22	29-Mar-11	C-Section	1:30	0.5	2	2
23	30-Mar-11	U-Blep	2:00	0.1	3	3
24	1-Apr-11	C-Section	1:30	0.5	2	5
25	2-Apr-11	Phaco C IOL	1:10	0.5	2	6
26	6-Apr-11	Gastroscope	0:30	0	1	3
27	7-Apr-11	C-Section &TR	1:30	0.5	2	4
28	7-Apr-11	Electrical Cauterization	2:00	1	5	4
29	7-Apr-11	Vasectory	2:00	0	2	4
30	8-Apr-11	Release Derquervan Lt Hand	3:00	1	3	5
31	9-Apr-11	C-Section	1:30	0.5	2	6
32	10-Apr-11	C-Section & TR	1:30	0.5	2	7
33	11-Apr-11	Colonoscope	0:30	0	1	1
34	12-Apr-11	C-Section + Appendectomy	1:30	0.5	2	2
35	12-Apr-11	AR	2:00	0.1	3	2
36	12-Apr-11	AR	2:00	0.1	3	2
37	14-Apr-11	C-Section	1:30	0.5	2	4
38	14-Apr-11	C-Section	1:30	0.5	2	4
39	15-Apr-11	C-Section	1:30	0.5	2	5
40	17-Apr-11	C-Section	1:30	0.5	2	7
41	17-Apr-11	C-Section & TR	1:30	0.5	2	7
42	18-Apr-11	Gastroscope+Colonoscope	0:30	0	1	1

Table B.1 Operation cancellation and no-show record (Continued)

No	Date	Operation Description	Expectected Operating Time (hrs)	Expected ICU Time (days)	Category	Weekday (1 = Monday, 2 = Tuesday, …, 7 = Sunday)
43	18-Apr-11	Anterior Cervical Dissectomy C5-C6	3:00	0	3	1
44	19-Apr-11	Mammoplasty (325 ml)	2:30	0	3	2
45	20-Apr-11	Change V-P shunt	2:30	0	3	3
46	21-Apr-11	Abdominoplant + Liposection	5:00	1.5	4	4
47	22-Apr-11	Posterior Repair	1:00	0.25	2	5
48	23-Apr-11	C-Section	1:30	0.5	2	6
49	25-Apr-11	Intraritreous Wcentis injection	7:00	3	7	1
50	26-Apr-11	C-Section	1:30	0.5	2	2
51	26-Apr-11	C-Section	1:30	0.5	2	2
52	27-Apr-11	Lysis Adhesion Rt Little Finger	4:00	0	3	3
53	27-Apr-11	C-Section & TR	1:30	0.5	2	3
54	28-Apr-11	Phaco C IOL	1:10	0.5	2	4
55	28-Apr-11	Lysis Adhesion Rt Little Finger	4:00	0	3	4
56	28-Apr-11	Lab-Cystectomy Rt	2:30	5	6	4
57	29-Apr-11	Colonoscope	0:30	0	1	5
58	29-Apr-11	C-Section (Breech presentation)	1:30	0.5	2	5
59	29-Apr-11	C-Section	1:30	0.5	2	5
60	29-Apr-11	C-Section	1:30	0.5	2	5
61	29-Apr-11	C-Section & TR	1:30	0.5	2	5
62	29-Apr-11	C-Section (Breech presentation)	1:30	0.5	2	5
63	29-Apr-11	Gastroscope+Colonoscope	0:30	0	1	5

Table B.1 Operation cancellation and no-show record (Continued)

No	Date	Operation Description	Expectected Operating Time (hrs)	Expected ICU Time (days)	Category	Weekday (1 = Monday, 2 = Tuesday, …, 7 = Sunday)
64	30-Apr-11	Excision Ptenygium Rt Eye	1:30	0.1	2	6
65	30-Apr-11	Gastroscope	0:30	0	1	6
66	2-May-11	Augment Mammoplasty	2:30	0	3	1
67	2-May-11	ACL C Recon Rt Knee	3:00	0	3	1
68	3-May-11	Mammoplasty (325 ml)	2:30	0	3	2
69	3-May-11	Lap T, TAH	4:30	0.5	3	2
70	3-May-11	Phaco C IOL	1:10	0.5	2	2
71	4-May-11	AR	2:00	0.1	3	3
72	6-May-11	ACL + Repair minicus Rt	3:00	0	3	5
73	6-May-11	ECCE C ICL	2:00	2	5	5
74	7-May-11	Cranioplasty	2:30	1	5	6
75	7-May-11	C-Section & TR	1:30	0.5	2	6
76	8-May-11	Epicondylectomy	2:00	0	3	7
77	10-May-11	CRIF c TBW	1:30	0.5	2	2
78	10-May-11	Excision	1:30	0.1	2	2
79	11-May-11	C/O	2:00	1	5	3
80	11-May-11	C-Section	1:30	0.5	2	3
81	11-May-11	Alarplasty	1:30	0.5	2	3
82	12-May-11	ECCE C IOL	2:00	2	5	4
83	12-May-11	C-Section	1:30	0.5	2	4
84	13-May-11	C-Section	1:30	0.5	2	5

Table B.1 Operation cancellation and no-show record (Continued)

No	Date	Operation Description	Expectected Operating Time (hrs)	Expected ICU Time (days)	Category	Weekday (1 = Monday, 2 = Tuesday, …, 7 = Sunday)
85	13-May-11	C-Section	1:30	0.5	2	5
86	13-May-11	C-Section	1:30	0.5	2	5
87	13-May-11	C-Section	1:30	0.5	2	5
88	13-May-11	C-Section	1:30	0.5	2	5
89	14-May-11	Excision PTE	1:30	0.1	2	6
90	15-May-11	Colonoscope	0:30	0	1	7
91	17-May-11	Reconstruction Plate	8:00	5	8	2
92	17-May-11	Revise AR	2:00	0.1	3	2
93	19-May-11	Soft tissue Release	4:00	1	3	4
94	20-May-11	Excision PTG	1:30	0.1	2	5
95	23-May-11	D&G	2:00	0.5	3	1
96	23-May-11	U-Blep	2:00	0.1	3	1
97	24-May-11	Alarplasty	1:30	0.5	2	2
98	27-May-11	C-Section	1:30	0.5	2	5
99	29-May-11	Colonoscope	0:30	0	1	7
100	31-May-11	PCL Recon Arthroscope	4:30	0	3	2

APPENDIX C

LINGO PROGRAMMING RESULTS

Table C.1 Programming result for Model A

Global optimal solution found.	
Objective value:	7719.956
Objective bound:	7719.956
Infeasibilities:	0.5684342E-13
Extended solver steps:	0
Total solver iterations:	64

Variable	Value	Reduced Cost
UUOT_1	27.00000	0.000000
UUOT_2	34.00000	0.000000
UUOT_3	76.00000	0.000000
UUOT_4	31.00000	0.000000
UUOT_5	72.50000	0.000000
UUOT_6	76.00000	0.000000
UUOT_7	68.00000	0.000000
OUOT_1	0.000000	0.1280000
OUOT_2	0.000000	0.1280000
OUOT_3	0.000000	0.1280000
OUOT_4	0.000000	0.1280000
OUOT_5	0.000000	0.1280000
OUOT_6	0.000000	0.1280000
OUOT_7	0.000000	0.1280000
EOT_1	0.000000	1.280000
EOT_2	0.000000	1.280000
EOT_3	0.000000	1.280000
EOT_4	0.000000	1.280000
EOT_5	0.000000	1.280000
EOT_6	0.000000	1.280000
EOT_7	0.000000	1.280000
UUIC_1	0.000000	0.7690000
UUIC_2	0.000000	0.7690000
UUIC_3	0.000000	0.7690000
UUIC_4	0.000000	0.7690000
UUIC_5	0.000000	0.7690000
UUIC_6	0.000000	0.7690000
UUIC_7	0.000000	0.7690000
OUIC_1	117.0000	0.000000
OUIC_2	117.0000	0.000000
OUIC_3	87.00000	0.000000
OUIC_4	117.0000	0.000000
OUIC_5	94.00000	0.000000
OUIC_6	87.00000	0.000000
OUIC_7	87.00000	0.000000
EIC_1	115.0000	0.000000
EIC_2	115.0000	0.000000
EIC_3	85.00000	0.000000
EIC_4	115.0000	0.000000
EIC_5	92.00000	0.000000
EIC_6	85.00000	0.000000
EIC_7	85.00000	0.000000
UUMC_1	0.000000	0.5900000E-01
UUMC_2	0.000000	0.5900000E-01
UUMC_3	0.000000	0.5900000E-01
UUMC_4	0.000000	0.5900000E-01
UUMC_5	0.000000	0.5900000E-01
UUMC_6	0.000000	0.5900000E-01

Table C.1 Programming result for Model A (Continued)

Variable	Value	Reduced Cost
UUMC_7	0.000000	0.5900000E-01
OUMC_1	195.0000	0.000000
OUMC_2	165.0000	0.000000
OUMC_3	195.0000	0.000000
OUMC_4	172.0000	0.000000
OUMC_5	165.0000	0.000000
OUMC_6	165.0000	0.000000
OUMC_7	195.0000	0.000000
EMC_1	164.0000	0.000000
EMC_2	134.0000	0.000000
EMC_3	164.0000	0.000000
EMC_4	141.0000	0.000000
EMC_5	134.0000	0.000000
EMC_6	134.0000	0.000000
EMC_7	164.0000	0.000000
UUNH_1	0.000000	0.4400000E-01
UUNH_2	0.000000	0.4400000E-01
UUNH_3	0.000000	0.4400000E-01
UUNH_4	0.000000	0.4400000E-01
UUNH_5	0.000000	0.4400000E-01
UUNH_6	0.000000	0.4400000E-01
UUNH_7	0.000000	0.4400000E-01
OUNH_1	369.3000	0.000000
OUNH_2	369.3000	0.000000
OUNH_3	369.3000	0.000000
OUNH_4	369.3000	0.000000
OUNH_5	369.3000	0.000000
OUNH_6	369.3000	0.000000
OUNH_7	369.3000	0.000000
ENH_1	327.3000	0.000000
ENH_2	327.3000	0.000000
ENH_3	327.3000	0.000000
ENH_4	327.3000	0.000000
ENH_5	327.3000	0.000000
ENH_6	327.3000	0.000000
ENH_7	327.3000	0.000000
X_1_1	0.000000	81.88600
X_1_2	0.000000	81.88600
X_1_3	0.000000	81.88600
X_1_4	18.00000	81.88600
X_1_5	7.000000	81.88600
X_1_6	0.000000	81.88600
X_1_7	0.000000	81.88600
X_2_1	26.00000	105.9107
X_2_2	24.00000	105.9107
X_2_3	0.000000	105.9107
X_2_4	0.000000	105.9107
X_2_5	0.000000	105.9107
X_2_6	0.000000	105.9107
X_2_7	0.000000	105.9107
X_3_1	0.000000	84.68296
X_3_2	3.000000	84.68296
X_3_3	0.000000	84.68296
X_3_4	12.00000	84.68296
X_3_5	0.000000	84.68296

Table C.1 Programming result for Model A (Continued)

Variable	Value	Reduced Cost
X_3_6	0.000000	84.68296
X_3_7	0.000000	84.68296
X_4_1	1.000000	162.2380
X_4_2	0.000000	162.2380
X_4_3	0.000000	162.2380
X_4_4	0.000000	162.2380
X_4_5	0.000000	162.2380
X_4_6	0.000000	162.2380
X_4_7	0.000000	162.2380
X_5_1	1.000000	163.1340
X_5_2	0.000000	163.1340
X_5_3	0.000000	163.1340
X_5_4	0.000000	163.1340
X_5_5	0.000000	163.1340
X_5_6	0.000000	163.1340
X_5_7	0.000000	163.1340
X_6_1	0.000000	162.8780
X_6_2	3.000000	162.8780
X_6_3	0.000000	162.8780
X_6_4	0.000000	162.8780
X_6_5	0.000000	162.8780
X_6_6	0.000000	162.8780
X_6_7	0.000000	162.8780
X_7_1	1.000000	162.4940
X_7_2	0.000000	162.4940
X_7_3	0.000000	162.4940
X_7_4	0.000000	162.4940
X_7_5	0.000000	162.4940
X_7_6	0.000000	162.4940
X_7_7	0.000000	162.4940
X_8_1	1.000000	162.2380
X_8_2	0.000000	162.2380
X_8_3	0.000000	162.2380
X_8_4	0.000000	162.2380
X_8_5	0.000000	162.2380
X_8_6	0.000000	162.2380
X_8_7	0.000000	162.2380

Row	Slack or Surplus	Dual Price
1	7719.956	-1.000000
2	0.000000	0.000000
3	0.000000	0.000000
4	0.000000	0.000000
5	0.000000	0.000000
6	0.000000	0.000000
7	0.000000	0.000000
8	0.000000	0.000000
9	0.000000	0.000000
10	95.00000	0.000000
11	27.00000	0.000000
12	0.000000	-0.1280000
13	102.0000	0.000000
14	34.00000	0.000000
15	0.000000	-0.1280000
16	144.0000	0.000000

Table C.1 Programming result for Model A (Continued)

Row	Slack or Surplus	Dual Price
17	76.00000	0.000000
18	0.000000	-0.1280000
19	99.00000	0.000000
20	31.00000	0.000000
21	0.000000	-0.1280000
22	140.5000	0.000000
23	72.50000	0.000000
24	0.000000	-0.1280000
25	144.0000	0.000000
26	76.00000	0.000000
27	0.000000	-0.1280000
28	144.0000	0.000000
29	68.00000	0.000000
30	0.000000	-0.1280000
31	0.000000	0.7690000
32	117.0000	0.000000
33	0.000000	0.7690000
34	117.0000	0.000000
35	0.000000	0.7690000
36	87.00000	0.000000
37	0.000000	0.7690000
38	117.0000	0.000000
39	0.000000	0.7690000
40	94.00000	0.000000
41	0.000000	0.7690000
42	87.00000	0.000000
43	0.000000	0.7690000
44	87.00000	0.000000
45	0.000000	7.690000
46	0.000000	7.690000
47	0.000000	7.690000
48	0.000000	7.690000
49	0.000000	7.690000
50	0.000000	7.690000
51	0.000000	7.690000
52	0.000000	0.4400000E-01
53	369.3000	0.000000
54	0.000000	0.4400000E-01
55	369.3000	0.000000
56	0.000000	0.4400000E-01
57	369.3000	0.000000
58	0.000000	0.4400000E-01
59	369.3000	0.000000
60	0.000000	0.4400000E-01
61	369.3000	0.000000
62	0.000000	0.4400000E-01
63	369.3000	0.000000
64	0.000000	0.4400000E-01
65	369.3000	0.000000
66	0.000000	0.4400000
67	0.000000	0.4400000
68	0.000000	0.4400000
69	0.000000	0.4400000
70	0.000000	0.4400000
71	0.000000	0.4400000

Table C.1 Programming result for Model A (Continued)

Row	Slack or Surplus	Dual Price
72	0.000000	0.4400000
73	0.000000	0.5900000E-01
74	195.0000	0.000000
75	0.000000	0.5900000E-01
76	165.0000	0.000000
77	0.000000	0.5900000E-01
78	195.0000	0.000000
79	0.000000	0.5900000E-01
80	172.0000	0.000000
81	0.000000	0.5900000E-01
82	165.0000	0.000000
83	0.000000	0.5900000E-01
84	165.0000	0.000000
85	0.000000	0.5900000E-01
86	195.0000	0.000000
87	0.000000	0.5900000
88	0.000000	0.5900000
89	0.000000	0.5900000
90	0.000000	0.5900000
91	0.000000	0.5900000
92	0.000000	0.5900000
93	0.000000	0.5900000
94	0.000000	0.000000
95	0.000000	0.000000
96	30.00000	0.000000
97	0.000000	0.000000
98	23.00000	0.000000
99	30.00000	0.000000
100	30.00000	0.000000
101	27.00000	0.000000
102	34.00000	0.000000
103	76.00000	0.000000
104	31.00000	0.000000
105	72.50000	0.000000
106	76.00000	0.000000
107	68.00000	0.000000
108	0.000000	0.000000
109	0.000000	0.000000
110	0.000000	0.000000
111	0.000000	0.000000
112	0.000000	0.000000
113	0.000000	0.000000
114	0.000000	0.000000
115	0.000000	0.000000
116	0.000000	0.000000
117	0.000000	0.000000
118	0.000000	0.000000
119	0.000000	0.000000
120	0.000000	0.000000
121	0.000000	0.000000
122	117.0000	0.000000
123	117.0000	0.000000
124	87.00000	0.000000
125	117.0000	0.000000
126	94.00000	0.000000

Table C.1 Programming result for Model A (Continued)

Row	Slack or Surplus	Dual Price
127	87.00000	0.000000
128	87.00000	0.000000
129	0.000000	0.000000
130	0.000000	0.000000
131	0.000000	0.000000
132	0.000000	0.000000
133	0.000000	0.000000
134	0.000000	0.000000
135	0.000000	0.000000
136	195.0000	0.000000
137	165.0000	0.000000
138	195.0000	0.000000
139	172.0000	0.000000
140	165.0000	0.000000
141	165.0000	0.000000
142	195.0000	0.000000
143	0.000000	0.000000
144	0.000000	0.000000
145	0.000000	0.000000
146	0.000000	0.000000
147	0.000000	0.000000
148	0.000000	0.000000
149	0.000000	0.000000
150	369.3000	0.000000
151	369.3000	0.000000
152	369.3000	0.000000
153	369.3000	0.000000
154	369.3000	0.000000
155	369.3000	0.000000
156	369.3000	0.000000

Table C.2 Programming result for Model B

Global optimal solution found.	
Objective value:	495.9356
Objective bound:	495.9356
Infeasibilities:	0.1243450E-13
Extended solver steps:	4
Total solver iterations:	670

Variable	Value	Reduced Cost
UUOT_1	52.25444	0.000000
UUOT_2	65.15449	0.000000
UUOT_3	66.38350	0.000000
UUOT_4	46.60106	0.000000
UUOT_5	67.35350	0.000000
UUOT_6	57.99544	0.000000
UUOT_7	22.38125	0.000000
OUOT_1	0.000000	0.1280000
OUOT_2	0.000000	0.1280000
OUOT_3	0.000000	0.1280000
OUOT_4	0.000000	0.1280000
OUOT_5	0.000000	0.1280000
OUOT_6	0.000000	0.1280000

Table C.2 Programming result for Model B (Continued)

Variable	Value	Reduced Cost
OUOT_7	0.000000	0.1280000
EOT_1	0.000000	1.280000
EOT_2	0.000000	1.280000
EOT_3	0.000000	1.280000
EOT_4	0.000000	1.280000
EOT_5	0.000000	1.280000
EOT_6	0.000000	1.280000
EOT_7	0.000000	1.280000
UUIC_1	0.000000	0.7690000
UUIC_2	0.000000	0.7690000
UUIC_3	0.000000	0.7690000
UUIC_4	0.000000	0.7690000
UUIC_5	0.000000	0.7690000
UUIC_6	0.000000	0.7690000
UUIC_7	0.000000	0.7690000
OUIC_1	21.49926	0.000000
OUIC_2	2.021500	0.000000
OUIC_3	2.356970	0.000000
OUIC_4	14.88994	0.000000
OUIC_5	3.008430	0.000000
OUIC_6	2.662610	0.000000
OUIC_7	9.451290	0.000000
EIC_1	19.49926	0.000000
EIC_2	0.2150E-01	0.000000
EIC_3	0.3569700	0.000000
EIC_4	12.88994	0.000000
EIC_5	1.008430	0.000000
EIC_6	0.6626100	0.000000
EIC_7	7.451290	0.000000
UUMC_1	100.9054	0.000000
UUMC_2	97.01883	0.000000
UUMC_3	87.80265	0.000000
UUMC_4	101.8591	0.000000
UUMC_5	99.19460	0.000000
UUMC_6	95.32827	0.000000
UUMC_7	76.83225	0.000000
OUMC_1	0.000000	0.5900000E-01
OUMC_2	0.000000	0.5900000E-01
OUMC_3	0.000000	0.5900000E-01
OUMC_4	0.000000	0.5900000E-01
OUMC_5	0.000000	0.5900000E-01
OUMC_6	0.000000	0.5900000E-01
OUMC_7	0.000000	0.5900000E-01
EMC_1	0.000000	0.5900000
EMC_2	0.000000	0.5900000
EMC_3	0.000000	0.5900000
EMC_4	0.000000	0.5900000
EMC_5	0.000000	0.5900000
EMC_6	0.000000	0.5900000
EMC_7	0.000000	0.5900000
UUNH_1	153.9249	0.000000
UUNH_2	141.6268	0.000000
UUNH_3	150.1856	0.000000
UUNH_4	151.8154	0.000000
UUNH_5	119.3554	0.000000

Table C.2 Programming result for Model B (Continued)

Variable	Value	Reduced Cost
UUNH_6	136.5583	0.000000
UUNH_7	136.1863	0.000000
OUNH_1	0.000000	0.4400000E-01
OUNH_2	0.000000	0.4400000E-01
OUNH_3	0.000000	0.4400000E-01
OUNH_4	0.000000	0.4400000E-01
OUNH_5	0.000000	0.4400000E-01
OUNH_6	0.000000	0.4400000E-01
OUNH_7	0.000000	0.4400000
ENH_2	0.000000	0.4400000
ENH_3	0.000000	0.4400000
ENH_4	0.000000	0.4400000
ENH_5	0.000000	0.4400000
ENH_6	0.000000	0.4400000
ENH_7	0.000000	0.4400000
X_1_1	25.00000	8.276941
X_1_2	0.000000	8.276941
X_1_3	0.000000	8.276941
X_1_4	0.000000	8.276941
X_1_5	0.000000	8.276941
X_1_6	0.000000	8.276941
X_1_7	0.000000	8.276941
X_2_1	2.000000	8.182224
X_2_2	0.000000	8.182224
X_2_3	9.000000	8.182224
X_2_4	23.00000	8.182224
X_2_5	8.000000	8.182224
X_2_6	8.000000	8.182224
X_2_7	0.000000	8.182224
X_3_1	0.000000	7.957000
X_3_2	0.000000	7.957000
X_3_3	0.000000	7.957000
X_3_4	0.000000	7.957000
X_3_5	0.000000	7.957000
X_3_6	0.000000	7.957000
X_3_7	15.00000	7.957000
X_4_1	1.000000	7.316941
X_4_2	0.000000	7.316941
X_4_3	0.000000	7.316941
X_4_4	0.000000	7.316941
X_4_5	0.000000	7.316941
X_4_6	0.000000	7.316941
X_4_7	0.000000	7.316941
X_5_1	0.000000	7.157000
X_5_2	1.000000	7.157000
X_5_3	0.000000	7.157000
X_5_4	0.000000	7.157000
X_5_5	0.000000	7.157000
X_5_6	0.000000	7.157000
X_5_7	0.000000	7.157000
X_6_1	0.000000	7.252707
X_6_2	0.000000	7.252707
X_6_3	0.000000	7.252707
X_6_4	0.000000	7.252707
X_6_5	0.000000	7.252707

Table C.2 Programming result for Model B (Continued)

Variable	Value	Reduced Cost
X_6_6	3.000000	7.252707
X_6_7	0.000000	7.252707
X_7_1	0.000000	6.634275
X_7_2	0.000000	6.634275
X_7_3	0.000000	6.634275
X_7_4	1.000000	6.634275
X_7_5	0.000000	6.634275
X_7_6	0.000000	6.634275
X_7_7	0.000000	6.634275
X_8_1	0.000000	6.261000
X_8_2	1.000000	6.261000
X_8_3	0.000000	6.261000
X_8_4	0.000000	6.261000
X_8_5	0.000000	6.261000
X_8_6	0.000000	6.261000
X_8_7	0.000000	6.261000

Row	Slack or Surplus	Dual Price
1	495.9356	-1.000000
2	0.000000	0.000000
3	0.000000	0.000000
4	0.000000	0.000000
5	0.000000	0.000000
6	0.000000	0.000000
7	0.000000	0.000000
8	0.000000	0.000000
9	0.000000	0.000000
10	120.2544	0.000000
11	52.25444	0.000000
12	0.000000	-0.1280000
13	133.1545	0.000000
14	65.15449	0.000000
15	0.000000	-0.1280000
16	134.3835	0.000000
17	66.38350	0.000000
18	0.000000	-0.1280000
19	114.6011	0.000000
20	46.60106	0.000000
21	0.000000	-0.1280000
22	135.3535	0.000000
23	67.35350	0.000000
24	0.000000	-0.1280000
25	125.9954	0.000000
26	57.99544	0.000000
27	0.000000	-0.1280000
28	98.38125	0.000000
29	22.38125	0.000000
30	0.000000	-0.1280000
31	0.000000	0.7690000
32	21.49926	0.000000
33	0.000000	0.7690000
34	2.021500	0.000000
35	0.000000	0.7690000
36	2.356970	0.000000
37	0.000000	0.7690000

Table C.2 Programming result for Model B (Continued)

Row	Slack or Surplus	Dual Price
38	14.88994	0.000000
39	0.000000	0.7690000
40	3.008430	0.000000
41	0.000000	0.7690000
42	2.662610	0.000000
43	0.000000	0.7690000
44	9.451290	0.000000
45	0.000000	7.690000
46	0.000000	7.690000
47	0.000000	7.690000
48	0.000000	7.690000
49	0.000000	7.690000
50	0.000000	7.690000
51	0.000000	7.690000
52	153.9249	0.000000
53	0.000000	-0.4400000E-01
54	141.6268	0.000000
55	0.000000	-0.4400000E-01
56	150.1856	0.000000
57	0.000000	-0.4400000E-01
58	151.8154	0.000000
59	0.000000	-0.4400000E-01
60	119.3554	0.000000
61	0.000000	-0.4400000E-01
62	136.5583	0.000000
63	0.000000	-0.4400000E-01
64	136.1863	0.000000
65	0.000000	-0.4400000E-01
66	195.9249	0.000000
67	183.6268	0.000000
68	192.1856	0.000000
69	193.8154	0.000000
70	161.3554	0.000000
71	178.5583	0.000000
72	178.1863	0.000000
73	100.9054	0.000000
74	0.000000	-0.5900000E-01
75	97.01883	0.000000
76	0.000000	-0.5900000E-01
77	87.80265	0.000000
78	0.000000	-0.5900000E-01
79	101.8591	0.000000
80	0.000000	-0.5900000E-01
81	99.19460	0.000000
82	95.32827	0.000000
84	0.000000	-0.5900000E-01
85	76.83225	0.000000
86	0.000000	-0.5900000E-01
87	131.9054	0.000000
88	128.0188	0.000000
89	118.8026	0.000000
90	132.8591	0.000000
91	130.1946	0.000000
92	126.3283	0.000000
93	107.8323	0.000000

Table C.2 Programming result for Model B (Continued)

Row	Slack or Surplus	Dual Price
94	2.000000	0.000000
95	28.00000	0.000000
96	21.00000	0.000000
97	6.000000	0.000000
98	22.00000	0.000000
99	19.00000	0.000000
100	15.00000	0.000000
101	52.25444	0.000000
102	65.15449	0.000000
103	66.38350	0.000000
104	46.60106	0.000000
105	67.35350	0.000000
106	57.99544	0.000000
107	22.38125	0.000000
108	0.000000	0.000000
109	0.000000	0.000000
110	0.000000	0.000000
111	0.000000	0.000000
112	0.000000	0.000000
113	0.000000	0.000000
114	0.000000	0.000000
115	0.000000	0.000000
116	0.000000	0.000000
117	0.000000	0.000000
118	0.000000	0.000000
119	0.000000	0.000000
120	0.000000	0.000000
121	0.000000	0.000000
122	21.49926	0.000000
123	2.021500	0.000000
124	2.356970	0.000000
125	14.88994	0.000000
126	3.008430	0.000000
127	2.662610	0.000000
128	9.451290	0.000000
129	100.9054	0.000000
130	97.01883	0.000000
131	87.80265	0.000000
132	101.8591	0.000000
133	99.19460	0.000000
134	95.32827	0.000000
135	76.83225	0.000000
136	0.000000	0.000000
137	0.000000	0.000000
138	0.000000	0.000000
139	0.000000	0.000000
140	0.000000	0.000000
141	0.000000	0.000000
142	0.000000	0.000000
143	153.9249	0.000000
144	141.6268	0.000000
145	150.1856	0.000000
146	151.8154	0.000000
147	119.3554	0.000000
148	136.5583	0.000000

Table C.2 Programming result for Model B (Continued)

Row	Slack or Surplus	Dual Price
149	136.1863	0.000000
150	0.000000	0.000000
151	0.000000	0.000000
152	0.000000	0.000000
153	0.000000	0.000000
154	0.000000	0.000000
155	0.000000	0.000000
156	0.000000	0.000000

Table C.3 Programming result for the Current Setting

Global optimal solution found.	
Objective value:	433.5559
Objective bound:	433.5559
Infeasibilities:	0.3197442E-13
Extended solver steps:	0
Total solver iterations:	300

Variable	Value	Reduced Cost
UUOT_1	0.4999925	0.000000
UUOT_2	73.33578	0.000000
UUOT_3	63.68476	0.000000
UUOT_4	46.72708	0.000000
UUOT_5	67.85662	0.000000
UUOT_6	67.57905	0.000000
UUOT_7	62.45698	0.000000
OUOT_1	0.000000	0.1280000
OUOT_2	0.000000	0.1280000
OUOT_3	0.000000	0.1280000
OUOT_4	0.000000	0.1280000
OUOT_5	0.000000	0.1280000
OUOT_6	0.000000	0.1280000
OUOT_7	0.000000	0.1280000
EOT_1	0.000000	1.280000
EOT_2	0.000000	1.280000
EOT_3	0.000000	1.280000
EOT_4	0.000000	1.280000
EOT_5	0.000000	1.280000
EOT_6	0.000000	1.280000
EOT_7	0.000000	1.280000
UUIC_1	0.000000	0.7690000
UUIC_2	0.000000	0.7690000
UUIC_3	0.000000	0.7690000
UUIC_4	0.000000	0.7690000
UUIC_5	0.000000	0.7690000
UUIC_6	0.000000	0.7690000
UUIC_7	0.000000	0.7690000
OUIC_1	16.06775	0.000000
OUIC_2	2.829527	0.000000
OUIC_3	2.122487	0.000000
OUIC_4	19.71096	0.000000
OUIC_5	2.156110	0.000000
OUIC_6	2.493709	0.000000
OUIC_7	2.924454	0.000000

Table C.3 Programming result for the Current Setting (Continued)

Variable	Value	Reduced Cost
EIC_1	14.06775	0.000000
EIC_2	0.8295270	0.000000
EIC_3	0.1224870	0.000000
EIC_4	17.71096	0.000000
EIC_5	0.1561100	0.000000
EIC_6	0.4937090	0.000000
EIC_7	0.9244540	0.000000
UUMC_1	101.1925	0.000000
UUMC_2	105.1652	0.000000
UUMC_3	80.41676	0.000000
UUMC_4	97.60323	0.000000
UUMC_5	101.0792	0.000000
UUMC_6	101.6152	0.000000
UUMC_7	79.46327	0.000000
OUMC_1	0.000000	0.5900000E-01
OUMC_2	0.000000	0.5900000E-01
OUMC_3	0.000000	0.5900000E-01
OUMC_4	0.000000	0.5900000E-01
OUMC_5	0.000000	0.5900000E-01
OUMC_6	0.000000	0.5900000E-01
OUMC_7	0.000000	0.5900000E-01
EMC_1	0.000000	0.5900000
EMC_2	0.000000	0.5900000
EMC_3	0.000000	0.5900000
EMC_4	0.000000	0.5900000
EMC_5	0.000000	0.5900000
EMC_6	0.000000	0.5900000
EMC_7	0.000000	0.5900000
UUNH_1	161.7145	0.000000
UUNH_2	147.0554	0.000000
UUNH_3	132.4708	0.000000
UUNH_4	145.8095	0.000000
UUNH_5	113.5341	0.000000
UUNH_6	155.8777	0.000000
UUNH_7	151.8180	0.000000
OUNH_1	0.000000	0.4400000E-01
OUNH_2	0.000000	0.4400000E-01
OUNH_3	0.000000	0.4400000E-01
OUNH_4	0.000000	0.4400000E-01
OUNH_5	0.000000	0.4400000E-01
OUNH_6	0.000000	0.4400000E-01
OUNH_7	0.000000	0.4400000E-01
ENH_1	0.000000	0.4400000
ENH_2	0.000000	0.4400000
ENH_3	0.000000	0.4400000
ENH_4	0.000000	0.4400000
ENH_5	0.000000	0.4400000
ENH_6	0.000000	0.4400000
ENH_7	0.000000	0.4400000
X_1_1	0.000000	8.276941
X_1_2	2.000000	8.276941
X_1_3	8.000000	8.276941
X_1_4	0.000000	8.276941
X_1_5	0.000000	8.276941
X_1_6	5.000000	8.276941

Table C.3 Programming result for the Current Setting (Continued)

Variable	Value	Reduced Cost
X_1_7	10.00000	8.276941
X_2_1	7.000000	8.182224
X_2_2	0.000000	8.182224
X_2_3	0.000000	8.182224
X_2_4	30.00000	8.182224
X_2_5	8.000000	8.182224
X_2_6	5.000000	8.182224
X_2_7	0.000000	8.182224
X_3_1	15.00000	7.957000
X_3_2	0.000000	7.957000
X_3_3	0.000000	7.957000
X_3_4	0.000000	7.957000
X_3_5	0.000000	7.957000
X_3_6	0.000000	7.957000
X_3_7	0.000000	7.957000
X_4_1	1.000000	7.316941
X_4_2	0.000000	7.316941
X_4_3	0.000000	7.316941
X_4_4	0.000000	7.316941
X_4_5	0.000000	7.316941
X_4_6	0.000000	7.316941
X_4_7	0.000000	7.316941
X_5_1	0.000000	7.157000
X_5_2	1.000000	7.157000
X_5_3	0.000000	7.157000
X_5_4	0.000000	7.157000
X_5_5	0.000000	7.157000
X_5_6	0.000000	7.157000
X_5_7	0.000000	7.157000
X_6_1	3.000000	7.252707
X_6_2	0.000000	7.252707
X_6_3	0.000000	7.252707
X_6_4	0.000000	7.252707
X_6_5	0.000000	7.252707
X_6_6	0.000000	7.252707
X_6_7	0.000000	7.252707
X_7_1	1.000000	6.634275
X_7_2	0.000000	6.634275
X_7_3	0.000000	6.634275
X_7_4	0.000000	6.634275
X_7_5	0.000000	6.634275
X_7_6	0.000000	6.634275
X_7_7	0.000000	6.634275
X_8_1	0.000000	6.261000
X_8_2	0.000000	6.261000
X_8_3	1.000000	6.261000
X_8_4	0.000000	6.261000
X_8_5	0.000000	6.261000
X_8_6	0.000000	6.261000
X_8_7	0.000000	6.261000

Row	Slack or Surplus	Dual Price
1	433.5559	-1.000000
2	0.000000	0.000000
3	0.000000	0.000000

Table C.3 Programming result for the Current Setting (Continued)

Row	Slack or Surplus	Dual Price
4	0.000000	0.000000
5	0.000000	0.000000
6	0.000000	0.000000
7	0.000000	0.000000
8	0.000000	0.000000
9	0.000000	0.000000
10	68.49999	0.000000
11	0.4999925	0.000000
12	0.000000	-0.1280000
13	141.3358	0.000000
14	73.33578	0.000000
15	0.000000	-0.1280000
16	131.6848	0.000000
17	63.68476	0.000000
18	0.000000	-0.1280000
19	114.7271	0.000000
20	46.72708	0.000000
21	0.000000	-0.1280000
22	135.8566	0.000000
23	67.85662	0.000000
24	0.000000	-0.1280000
25	135.5791	0.000000
26	67.57905	0.000000
27	0.000000	-0.1280000
28	138.4570	0.000000
29	62.45698	0.000000
30	0.000000	-0.1280000
31	0.000000	0.7690000
32	16.06775	0.000000
33	0.000000	0.7690000
34	2.829527	0.000000
35	0.000000	0.7690000
36	2.122487	0.000000
37	0.000000	0.7690000
38	19.71096	0.000000
39	0.000000	0.7690000
40	2.156110	0.000000
41	0.000000	0.7690000
42	2.493709	0.000000
43	0.000000	0.7690000
44	2.924454	0.000000
45	0.000000	7.690000
46	0.000000	7.690000
47	0.000000	7.690000
48	0.000000	7.690000
49	0.000000	7.690000
50	0.000000	7.690000
51	0.000000	7.690000
52	161.7145	0.000000
53	0.000000	-0.4400000E-01
54	147.0554	0.000000
55	0.000000	-0.4400000E-01
56	132.4708	0.000000
57	0.000000	-0.4400000E-01
58	145.8095	0.000000

Table C.3 Programming result for the Current Setting (Continued)

Row	Slack or Surplus	Dual Price
59	0.000000	-0.4400000E-01
60	113.5341	0.000000
61	0.000000	-0.4400000E-01
62	155.8777	0.000000
63	0.000000	-0.4400000E-01
64	151.8180	0.000000
65	0.000000	-0.4400000E-01
66	203.7145	0.000000
67	189.0554	0.000000
68	174.4708	0.000000
69	187.8095	0.000000
70	155.5341	0.000000
71	197.8777	0.000000
72	193.8180	0.000000
73	101.1925	0.000000
74	0.000000	-0.5900000E-01
75	105.1652	0.000000
76	0.000000	-0.5900000E-01
77	80.41676	0.000000
78	0.000000	-0.5900000E-01
79	97.60323	0.000000
80	0.000000	-0.5900000E-01
81	101.0792	0.000000
82	0.000000	-0.5900000E-01
83	101.6152	0.000000
84	0.000000	-0.5900000E-01
85	79.46327	0.000000
86	0.000000	-0.5900000E-01
87	132.1925	0.000000
88	136.1652	0.000000
89	111.4168	0.000000
90	128.6032	0.000000
91	132.0792	0.000000
92	132.6152	0.000000
93	110.4633	0.000000
94	3.000000	0.000000
95	27.00000	0.000000
96	21.00000	0.000000
97	0.000000	0.000000
98	22.00000	0.000000
99	20.00000	0.000000
100	20.00000	0.000000
101	0.4999925	0.000000
102	73.33578	0.000000
103	63.68476	0.000000
104	46.72708	0.000000
105	67.85662	0.000000
106	67.57905	0.000000
107	62.45698	0.000000
108	0.000000	0.000000
109	0.000000	0.000000
110	0.000000	0.000000
111	0.000000	0.000000
112	0.000000	0.000000
113	0.000000	0.000000

Table C.3 Programming result for the Current Setting (Continued)

Row	Slack or Surplus	Dual Price
114	0.000000	0.000000
115	0.000000	0.000000
116	0.000000	0.000000
117	0.000000	0.000000
118	0.000000	0.000000
119	0.000000	0.000000
120	0.000000	0.000000
121	0.000000	0.000000
122	16.06775	0.000000
123	2.829527	0.000000
124	2.122487	0.000000
125	19.71096	0.000000
126	2.156110	0.000000
127	2.493709	0.000000
128	2.924454	0.000000
129	101.1925	0.000000
130	105.1652	0.000000
131	80.41676	0.000000
132	97.60323	0.000000
133	101.0792	0.000000
134	101.6152	0.000000
135	79.46327	0.000000
136	0.000000	0.000000
137	0.000000	0.000000
138	0.000000	0.000000
139	0.000000	0.000000
140	0.000000	0.000000
141	0.000000	0.000000
142	0.000000	0.000000
143	161.7145	0.000000
144	147.0554	0.000000
145	132.4708	0.000000
146	145.8095	0.000000
147	113.5341	0.000000
148	155.8777	0.000000
149	151.8180	0.000000
150	0.000000	0.000000
151	0.000000	0.000000
152	0.000000	0.000000
153	0.000000	0.000000
154	0.000000	0.000000
155	0.000000	0.000000
156	0.000000	0.000000

APPENDIX D

ADMISSION SCHEDULES FOR ALL SCENARIOS

Table D.1 Admission schedule for scenario 1

Patient Group	Day							Target patient throughput, TPT_c
	1	**2**	**3**	**4**	**5**	**6**	**7**	
1 *Very short OT, No IC*	0	0	1	0	24	0	0	25
2 *Short OT, Short IC*	0	6	1	11	0	22	10	50
3 *Middle OT, Short IC*	9	0	6	0	0	0	0	15
4 *Long OT, Short IC*	0	0	0	0	0	1	0	1
5 *Short OT, Middle IC*	0	1	0	0	0	0	0	1
6 *Middle OT, Middle IC*	0	3	0	0	0	0	0	3
7 *Long OT, Middle IC*	0	0	0	1	0	0	0	1
8 *Long OT, Long IC*	0	1	0	0	0	0	0	1
Total # of planned patients	9	11	8	12	24	23	10	

Table D.2 Admission schedule for scenario 2

Patient Group	Day							Target patient throughput, TPT_c
	1	**2**	**3**	**4**	**5**	**6**	**7**	
1 *Very short OT, No IC*	7	0	0	0	9	0	9	25
2 *Short OT, Short IC*	0	0	0	12	13	10	15	50
3 *Middle OT, Short IC*	0	0	8	0	7	0	0	15
4 *Long OT, Short IC*	1	0	0	0	0	0	0	1
5 *Short OT, Middle IC*	0	0	0	0	0	1	0	1
6 *Middle OT, Middle IC*	0	3	0	0	0	0	0	3
7 *Long OT, Middle IC*	1	0	0	0	0	0	0	1
8 *Long OT, Long IC*	0	0	0	0	1	0	0	1
Total # of planned patients	9	3	8	12	30	11	24	

Table D.3 Admission schedule for scenario 3

Patient Group	Day							Target patient throughput, TPT_c
	1	**2**	**3**	**4**	**5**	**6**	**7**	
1 *Very short OT, No IC*	2	0	2	0	7	6	8	25
2 *Short OT, Short IC*	10	14	2	11	3	2	8	50
3 *Middle OT, Short IC*	3	2	5	3	2	0	0	15
4 *Long OT, Short IC*	0	0	0	0	1	0	0	1
5 *Short OT, Middle IC*	0	0	1	0	0	0	0	1
6 *Middle OT, Middle IC*	0	0	0	0	0	3	0	3
7 *Long OT, Middle IC*	0	0	0	0	0	1	0	1
8 *Long OT, Long IC*	0	0	0	0	0	0	1	1
Total # of planned patients	15	16	10	14	13	12	17	

Table D.4 Admission schedule for scenario 4

Patient Group	Day							Target patient throughput, TPT_c
	1	**2**	**3**	**4**	**5**	**6**	**7**	
1 *Very short OT, No IC*	9	1	7	3	0	0	5	25
2 *Short OT, Short IC*	1	6	1	11	15	11	5	50
3 *Middle OT, Short IC*	2	0	5	0	1	3	4	15
4 *Long OT, Short IC*	0	0	0	1	0	0	0	1
5 *Short OT, Middle IC*	0	0	0	0	1	0	0	1
6 *Middle OT, Middle IC*	3	0	0	0	0	0	0	3
7 *Long OT, Middle IC*	0	1	0	0	0	0	0	1
8 *Long OT, Long IC*	0	1	0	0	0	0	0	1
Total # of planned patients	15	9	13	15	17	14	14	

APPENDIX E

RESOURCE UTILIZATION OF ALL SCENARIOS

Table E.1 Resource utilization of scenario 1

Day	Operating room			IC beds			IC nursing hours			MC beds		
no.	Target	Actual	UR	Target	Actual	UR	Target	Actual	UR	Target	Actual	UR
1	76	28	36%	12	12	104%	168	9	6%	126	26	20%
2	76	25	32%	12	16	137%	168	11	6%	126	25	20%
3	76	20	26%	12	12	100%	168	25	15%	126	28	22%
4	76	16	21%	12	12	104%	168	15	9%	126	35	28%
5	76	12	16%	12	28	229%	168	50	29%	126	46	37%
6	76	31	41%	12	24	200%	168	29	17%	126	31	25%
7	68	11	16%	12	14	113%	168	29	17%	126	25	20%

Table E.2 Resource utilization of scenario 2

Day	Operating room			IC beds			IC nursing hours			MC beds		
no.	Target	Actual	UR	Target	Actual	UR	Target	Actual	UR	Target	Actual	UR
1	76	18	24%	12	12	100%	168	13	8%	126	22	18%
2	76	10	13%	12	12	102%	168	41	24%	126	23	18%
3	76	24	32%	12	12	102%	168	38	23%	126	27	21%
4	76	11	15%	12	13	111%	168	20	12%	126	40	32%
5	76	47	61%	12	30	254%	168	29	17%	126	33	26%
6	76	12	16%	12	13	104%	168	18	10%	126	39	31%
7	68	20	29%	12	25	212%	168	10	6%	126	31	25%

Table E.3 Resource utilization of scenario 3

Day	Operating room			IC beds			IC nursing hours			MC beds		
no.	Target	Actual	UR	Target	Actual	UR	Target	Actual	UR	Target	Actual	UR
1	21	21	98%	12	18	150%	26	26	99%	32	31	98%
2	21	21	98%	12	26	215%	26	26	99%	32	28	86%
3	21	19	92%	12	13	112%	26	26	100%	32	32	100%
4	21	19	92%	12	16	132%	26	26	100%	32	31	96%
5	21	21	98%	12	15	125%	26	19	75%	32	31	95%
6	21	21	100%	12	12	101%	26	25	97%	32	32	99%
7	21	21	98%	12	18	150%	26	20	77%	32	32	99%

Table E.4 Resource utilization of scenario 4

Day	Operating room			IC beds			IC nursing hours			MC beds		
no.	Target	Actual	UR	Target	Actual	UR	Target	Actual	UR	Target	Actual	UR
1	21	21	100%	17	17	99%	28	28	99%	32	28	89%
2	21	21	100%	17	17	100%	28	21	73%	32	30	93%
3	21	20	94%	17	17	100%	28	26	91%	32	32	99%
4	21	20	94%	17	17	99%	28	28	100%	32	32	100%
5	21	19	91%	17	17	100%	28	23	83%	32	32	99%
6	21	21	100%	17	17	99%	28	26	92%	32	29	92%
7	21	20	95%	17	17	99%	28	17	59%	32	32	100%

APPENDIX F

LIST OF PUBLICATIONS

List of Publication

Jittamai, P., and Kangwansura, T. (2011). A hospital admission planning model for emergency and elective patients under stochastic resource requirements and no-shows. In **Proceeding of the 2011 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM)** (pp.166-170). Singapore: IEEE.

A Hospital Admission Planning Model for Emergency and Elective Patients under Stochastic Resource Requirements and No-shows

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Hospital admission planning plays an important role for managing and allocating hospital resources by emphasizing on an optimal use of operating theater time. The objective of this work is to develop a mixed integer linear programming model in order to minimize the total absolute deviations of the operating room resource utilizations from their target utilizations for the multiple-day planning horizon. The stochastic resource requirements such as length of stay, emergency arrivals, and unattended patients (no-shows) are considered in the proposed formulation. The mathematical model was tested with a sample data set. Results show that the deviations from the target resource utilizations are decreased by 0%, 3.18%, 0.45%, and 3.00% for each type of hospital resources; namely, operating theater time, intensive-care beds, intensive-care nursing staff and medium-care beds, respectively. Moreover, the gap deviated from the overall target resource utilization is improved by 1%.

Keywords - **Hospital admission planning, mixed integer linear programming, emergency admission, no-shows**

I. INTRODUCTION

The health care system has been challenged in recent years to deliver superior quality care with limited resources. In Thailand, large segments of the population do not have health insurance coverage, forcing them to rely solely on either a social security system or a public health fund system. Over the past few decades, the national health care expenditures have dramatically increased. The total spending in 2005 amounted to 248,079 million baht (3.5% of the GDP), considerably amplified from the figure in 1995, where total spending was around 147,837 million baht (3.53% of the GDP) [1]. It is noted that the three-fourths of health-care budgets are disbursed to medical treatments. In contrast, the cost spent to health promotion and disease prevention is only 5% of the total expenditure [2]. Investments in health care promotion and disease prevention are required in order to better manage and operate the health care system.

Scanty resource in health care is an extremely vital issue in health care management. World Health Organization (WHO) has suggested the minimum standard for doctor consultation per capita as 1:600. In 2009, the medical personnel per capita in Thailand have been reported as follows: there is approximately a doctor for a population of 3,300; and a professional nurse for a population of 600. Furthermore, bed shortage is also an important problem in health care management. A bed per capita is at 1:540 in 2009 and hospital bed occupancy rate is around 76% while some provinces have high bed occupancy rates such as Nakhon Ratchasima where the occupancy rate is as high as 105% [3].

The procedures in the operating theater (OT) require various physical resources such as operating rooms (ORs), recovery rooms, nursing hours and the number of beds available. These are among the most critical, expensive and limited resources in the hospital and need to be utilized at the maximum level. Generally, 60-70% of hospital admissions are caused by surgical interventions. The OR department is a crucial hospital resource that consumes budget for more than 40% of the total hospital expenditures [4].

Admission planning is a scheduling task that hospital appoints a patient and admits him/her as an inpatient. Patient can be classified as elective and non-elective [6]. The former one, also called scheduled patients, represents those who do not have to be treated immediately and are put on waiting list for their turns of medical services, or those who are given appointments for particular admission dates. The latter one can be categorized as urgent and emergency patients. The urgent patients need to be admitted at a short notice, which is usually as soon as a bed becomes available. Emergency patients need to be admitted immediately. The different types of patients are categorized, also known in general as a patient mix, in order to make the planning function more manageable. Patient mix can be characterized by the amount of resources consumed such as the expected duration of operation, the average length of stay at the pre-operation and post-operation care unit, and amount of nursing time.

The flow of patients for the hospital resource planning is shown in Figure 1. Typically, elective patients are waiting at home or department inside the hospital for operations and admitted either to the Medium Care unit (MC) one day before an operation or directly to the operating theater. On the other hand, non-elective patients, namely, emergency patients, are admitted to hospital without prior appointments and need to be performed operations immediately. After operations, both types of patient might stay for some days in an Intensive Care unit (IC). After recovery patients can be proceeded to the Medium Care unit (MC) and stays there for a few days. Then, patients are allowed to return either home or other departments inside the hospital. Practically, scheduled but unattended patients (no shows) may occur and this causes significant disturbance for the planning staff and affect the utilization of operation theater facility

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[5]. The no shows of patients have significant impact on the revenue, cost and resource utilization for almost all health care provider units.

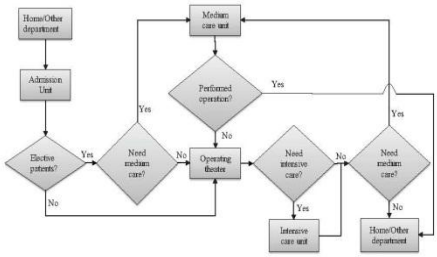

Fig. 1. The flow of patients through the hospital admission process for operating theater.

The objective of this work is to develop a mixed integer linear program in order to minimize the total absolute deviations of the operating room resource utilizations from their target utilizations for the multiple-days planning horizon.

The literature relates to this work was first introduced by Adan and Vissers [6]. They developed a model to generate a mix of patients planning that minimizes the deviations between resources consumption and their targets. The operating theater capacity, the number of beds in medium-care unit, the nursing hours, and the number of beds available in the intensive care unit are all critical resources put in this model. Vissers et al. [7] furthermore provided a case study based on the procedures developed in [6] and implemented to the department of cardiothoracic surgery. In the same vein, Vissers et al. [8] considered a similar problem with additional restrictions in planning some combinations of patients and availability of resources. In this contribution, lengths of stay, both in medium and intensive care units, are now assumed to be stochastic. Adan et al. [9] continued pursuing the three above-mentioned works, which focus on planning issue at a tactical level, by developing several strategies to determine the best scheduling of individual patients on an operational level. The tactical plan is based on average arrivals of patients whereas operational strategies treat actual arrivals that obviously deviate from average. Their work illustrates that introducing the stochastic durations turned out to decrease the deviations by more than 40%.

The crucial challenges in planning of the surgery admission schedule are dealing with uncertainty. The duration of activities related to the intake process, recovery processes, surgeries, availability of medical staffs, and emergency patient arrivals are needed to be considered stochastically in order to make the research problem more realistic and practical. Up to date, there are very few works that focus on an admission planning of the patient mix with the stochastic demand requirements. None of them considered the effects of emergency patient arrivals and no-show to the master schedules. Consequently, it is more challenging to work on admission planning of the patient mix with stochastic demand requirements and uncertain patient arrivals. In this research, emergency admission, unattended patients and appointment cancellations are considered as conditions to the planning problem.

II. METHODOLOGY

This study is based on the framework proposed by Adan et al [9]. In order to make the model more practical, emergency patient arrivals and no-shows are introduced as constraints to the model. In this section the mathematical model for the planning problem in the form of a mixed integer linear programming (MILP) is proposed. In the following subsections, relevant factors and details of each constraint are explained.

A. Relevant Factors

The following factors play an important role in the planning problem

(1) *Planning period.* This is the complete time period over which the admittance of patients has to be planned, usually several months or a year in advance.

(2) *Patient groups.* There are typically a wide variety of patients that need to be categorized in order to make the planning problem more manageable. In this paper, patients are categorized according to their needs for hospital resource. Patients in the same category are assumed to have a similar length of stay in IC and require the same amount of IC nursing staff and operating theater time.

(3) *Resources.* The resources available are medium-care (mc) beds, Intensive-care (ic) beds, IC nursing workload (nh) and operating theater time (ot).

(4) *Available capacity of the resources.* The MC and IC bed capacity are the total number of beds available to the specialty at the wards and IC unit, respectively. IC nursing workload is measured by the number of hours per day and the operating theater capacity is total operating time available in each day.

(5) *Planning cycle*. Since the capacity is cyclically allocated, the cyclic admission pattern should also be considered. On one hand, the cycle length should be long enough to accommodate patient admission and treatment cycle. On the other hand, a lengthy cycle may result in a planning problem that is computationally too big to handle. In practice, the cycle length typically varies from one week to four weeks.

(6) *Admission profile.* The admission profile describes the inflow of patients, i.e. the number and mix of patients admitted on each day within the planning cycle.

(7) *Target patient throughput*. The target number of patients is the number of patients that should be admitted

within the planning cycle. The number can be easily deduced from the target number of patients set for the whole planning period.

(8) *Target utilization of the resources*. This is desired utilization (or occupancy rate) of the resources on each day of the planning cycle.

(9) *Length of stay*. The length of stay can be measured as the number of days that patients stay at IC and MC. This study will incorporate the stochastic length of stay into the model in order to evaluate its impact on resource utilization.

(10)*Emergency Admission*. An emergency admission is an unscheduled admission of a patient who needs immediate medical attention, either an operation or a treatment. Daily emergency arrival rate and the probability of an emergency arrival of each patient type are considered in this study.

(11)*Unattended patient (No-Show) and appointment cancellation*. The numbers of no-shows and appointment cancellation have a significant impact on the revenue, cost and resource utilization. They may cause substantial disturbances on the operations scheduling of the admission planning system.

B. Mathematical Model Formulation

This subsection will transform the descriptive hospital admission planning problem into a mathematical model. The problem is formulated as a mixed integer linear programming problem adopting the aforementioned notations. The objective is to minimize the total deviations between expected utilizations of resources and target consumptions and minimize the overuse of resources relative to the maximum capacities. Hence, the objective function can be written as

$$\text{Minimize} \sum_{r\in R}\alpha_r \sum_{t=1}^{T}(UU_{r,t} + OU_{r,t} + b\cdot E_{r,t}), \tag{1}$$

where $b \geq 0$ is a constant value for capacity excess penalizing. This constant is set to have a sufficiently high value to avoid any capacity excess. The weight α_r is introduced to make the sum dimensionless. The weight also represents the importance of the resource according to the stakeholders. The parameter T denotes the planning cycle length (days), the variables $UU_{r,t}$, $OU_{r,t}$, and $E_{r,t}$ are the under-utilization, over-utilization and overuse compared to maximum capacity of resource r on day t, respectively, where $r \in R = \{ot, ic, mc, nh\}$ and $t = 1, 2, \ldots, T$.

The total number of patients of category c to be operated in T-days period should be equal to the target patient throughput TPT_c. Hence,

$$\sum_{t=1}^{T} X_{c,t} = TPT_c, \quad c = 1, 2, \ldots, N, \tag{2}$$

where N is a number of patient categories and $X_{c,t}$ is a number of category c patients to be operated on day t.

To describe constraints for utilization and capacity of the resources, parameters $C_{r,t}$ and $U_{r,t}$ are introduced to indicate available capacity and target utilization, respectively, for resource r on day t. Then, the expected utilization of the operating theater (OT) for both elective and emergency patients deducted the no-shows must be

$$\left.\begin{aligned} &\left(\sum_{c=1}^{N} O_c X_{c,t} + \sum_{c=1}^{N} O_c p_{emg,c,t}\lambda_{c,t}\right) - \sum_{c=1}^{N} O_c p_{NS,c,t}\gamma_{c,t} \\ &\leq C_{ot,t} + E_{ot,t} \\ &\leq U_{ot,t} + OU_{ot,t} \\ &\geq U_{ot,t} - UU_{ot,t} \end{aligned}\right\} \quad t = 1, 2, \ldots, T, \tag{3}$$

where O_c denotes the operation duration (in hours) required for a category c patient; $p_{emg,c,t}$ and $p_{NS,c,t}$ are a probability that an emergency patient of category c arrives during day t, and a probability that an elective patient of category c is unattended and makes a cancellation on day t, respectively; $\lambda_{c,t}$ and $\gamma_{c,t}$ are an arrival rate of emergency patient, and no-show and cancellation rate of category c patient on day t, $c = 1, 2, \ldots, N$, $t = 1, 2, \ldots, T$, respectively. To formulate constraints for the expected utilization of the IC unit, a probability $p_{ic,c,j}$ is introduced to indicate the probability that a patient of category c is (still) in the IC unit, j day after operation, $j = 0, 1, \ldots, L_{ic}^{\max}$. Thus, the expected utilization of the IC unit should satisfy three following inequalities:

$$\left.\begin{aligned} &\left(\sum_{c=1}^{N}\sum_{j=0}^{L_{ic}^{\max}} p_{ic,c,j} X_{c,t-j} + \sum_{c=1}^{N}\sum_{j=0}^{L_{ic}^{\max}} p_{ic,c,j}\lambda_{c,t-j}\right) - \sum_{c=1}^{N}\sum_{j=0}^{L_{ic}^{\max}} p_{ic,c,j}\gamma_{c,t-j} \\ &\leq C_{ic,t} + E_{ic,t} \\ &\leq U_{ic,t} + OU_{ic,t} \\ &\geq U_{ic,t} - UU_{ic,t} \end{aligned}\right\} \quad t = 1, 2, \ldots, T. \tag{4}$$

In the above constraints, the convention with subscript t-j in $X_{c,t-j}$ is adopted. It should be treated *modulo* T: day 0 is the same as day T, day -1 is the same as day T-1 and so on. If $nw_{c,j}$ denotes the IC nursing workload (in hours) required for a category c patient j day after operation, where $c = 1, 2, \ldots, N$, $j = 0, 1, \ldots, L_{ic}^{\max}$, and $L_{ic}^{\max}$ is the maximum length of stay recorded in the IC of over all categories then the expected nursing workload can be described as:

$$\left(\sum_{c=1}^{N}\sum_{j=0}^{L_{ic}^{\max}} nw_{c,j}\, p_{ic,c,j} X_{c,t-j} + \sum_{c=1}^{N}\sum_{j=0}^{L_{ic}^{\max}} nw_{c,j}\, p_{ic,c,j} \lambda_{c,t-j}\right)$$

$$-\sum_{c=1}^{N}\sum_{j=0}^{L_{ic}^{\max}} nw_{c,j}\, p_{ic,c,j} \gamma_{c,t-j} \le C_{nh,t} + E_{nh,t}$$

$$\le U_{nh,t} + OU_{nh,t} \Big\} t = 1, 2, \ldots, T. \quad (5)$$

$$\ge U_{nh,t} - UU_{nh,t}$$

Similarly, the expected utilization of the MC unit should satisfy

$$\left(\sum_{c=1}^{N}\sum_{j=1}^{l_c} X_{c,t+j} + \sum_{c=1}^{N}\sum_{j=0}^{L_{mc}^{\max}} p_{mc,c,j} X_{c,t\ j} + \sum_{c=1}^{N}\sum_{j=0}^{L_{mc}^{\max}} p_{mc,c,j} \lambda_{c,t\ j}\right)$$

$$-\sum_{c=1}^{N}\sum_{j=0}^{L_{mc}^{\max}} p_{mc,c,j} \gamma_{c,t\ j} \le C_{mc,t} + E_{mc,t}$$

$$\le U_{mc,t} + OU_{mc,t} \Big\} t = 1, 2, \ldots, T. \quad (6)$$

$$\ge U_{mc,t} - UU_{mc,t}$$

Where l_c is the number of pre-operative day in the MC unit for a patient of category c and $p_{mc,c,j}$ is the probability that a patient of category c is at the MC unit j days after operation, $c = 1, 2, \ldots, N$, $j = 0, 1, 2, \ldots, L_{mc}^{\max}$, and $L_{mc}^{\max}$ is the maximum length of stay recorded in MC over all categories.

In addition to the above-mentioned utilization of the resources constraints, the restrictions valid for specific days of the operation schedule are needed to be taken into account. The first restriction means that certain variables $X_{c,t}$ are fixed to prescribed values. The second restriction, B_t are introduced to indicate the maximum number of patients form categories $c \in S$ that can be operated on day t of the operation schedule, where S is a subset of $\{1, 2, \ldots, N\}$. Then, the second restriction translates to

$$\sum_{c \in S} X_{c,t} \le B_t, \quad t = 1, 2, \ldots, T. \quad (7)$$

The planning problem therefore consists of minimizing the objective function in (1) subject to constraints (2)-(7) and non-negativity constraints (8)-(9)

$$X_{c,t} \in \{0, 1, 2, \ldots\}, c = 1, 2, \ldots, N, t = 1, 2, \ldots, T, \quad (8)$$

$$UU_{r,t} \ge 0, OU_{r,t} \ge 0, E_{r,t} \ge 0, r \in R, t = 1, 2, \ldots, T, \quad (9)$$

III. RESULTS

The data was generated based on [9] in order to validate the tractability of the model. Patients are distinguished into 5 categories (c=5) and planning cycle is set equal to one week (T=7).

Available capacity and target utilization of operating theater on day t are 40 and 32, respectively, ($C_{ot,t}$ =40 and $U_{ot,t}$=32, $\forall t$= 1,…, 7). Available capacity and target utilization are equal to 10 and 8, respectively, for IC beds ($C_{ic,t}$ =10 and $U_{ic,t}$=8, $\forall t$= 1,…, 7); 40 and 32, respectively, for MC beds ($C_{mc,t}$ =40 and $U_{mc,t}$=32, $\forall t$= 1,…, 7); and 140 and 100, respectively, for IC nursing staff ($C_{nh,t}$ =140 and $U_{nh,t}$=100, $\forall t$= 1,…, 7).

Maximum number of patients to be admitted on day t from different categories is set to 20 persons (B_t=20, $\forall t$= 1,…,7), and maximum length of stay both in IC and MC is 6 days.

LINGO version 11.0 was run on a PC with CPU Intel Core 2 Duo 1.30 GHz including 4.00 GB RAM to solve the problem. With a number of 35 integer variables, 84 continuous variables and 153 constraints, the model was reached to the optimality in 546 iterations in less than one second with the objective function value of 46.18.

The total absolute deviations of the utilization of operating theater, IC beds, IC nursing staff, and MC beds are shown in Figure 2 to Figure 5, respectively. The charts illustrate the comparisons between the total deviations of each resource for the model, both with and without the emergency arrivals and no-shows constraints. The numbers shown in parentheses in each figure are the average of the total deviations.

IV. DISCUSSION

Figure 2 to Figure 5 illustrate the results obtained by including and excluding the conditions of emergency arrivals and no-shows into the models. With the introduction of emergency arrivals and no-shows, the results yield the decrease of total deviations of IC beds by 0.07 beds, IC nursing staff by 0.33 hours, and MC beds by 0.33 beds, or equivalent to 3.18%, 0.45%, and 3.00%, respectively. The results show no improvement on OT time. Furthermore, the overall resource deviation from the target utilization is decreased from 46.65 to 46.18, which is equivalent to 1% improvement.

V. CONCLUSION

Hospital admission unit plays a pivotal role in planning and scheduling patients to be admitted as inpatients into the hospital so that the deviations of the resource utilization from the target are minimized. Adan et al [9] have proposed the tactical planning and mathematical model formulation to determine the optimal patient mix for cardiothoracic surgery department. In this paper, we continue pursuing the idea by extending their model to improve the operating theater resource utilizations by incorporating the emergency admission and unattended patients (no-shows) as conditions to the model. The results gathered from the generated data show signs of improvement on total deviations of the resource

utilizations compared to the target utilizations. Empirically, introducing the emergency arrivals and no-shows resulted in a decrease of the deviations by 0%, 3.18%, 0.45%, and 3.00% for OT time, IC beds, IC nursing staff and MC beds, respectively. Moreover, it also brought about the improvement of the objective value by 1%. The approach in this paper implies the superior plan for the usage of operating theater resources by accumulating the emergency admission and unattended patients (no-shows) as constraints to the model. It also can be used, in application, as a guideline for hospitals in order to strategize the utilization of their resources. Future work will be done on the use of this planning model with larger samples and longer planning horizon (4-week cycle length) in order to verify the tested results.

A further recommendation on the future work in this area is to include the stochastic operating durations into the model.

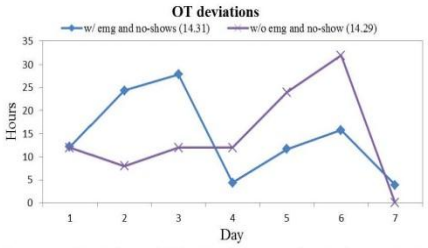

Fig. 2. Total deviations of OT utilization (comparing the impact of with and without emergency admission and no-shows).

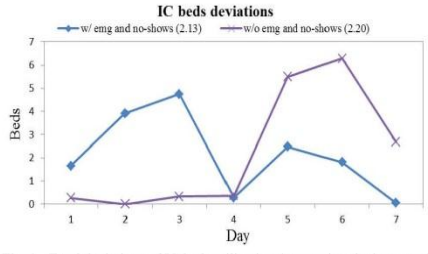

Fig. 3. Total deviations of IC beds utilization (comparing the impact of with and without emergency admission and no-shows).

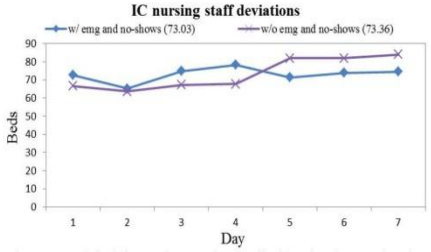

Fig. 4. Total deviations of IC nursing staff utilization (comparing the impact of with and without emergency admission and no-shows).

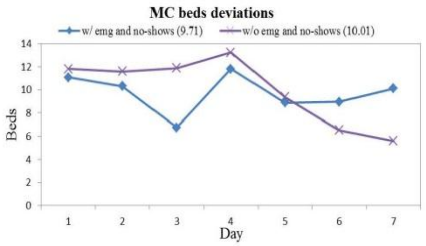

Fig. 5. Total deviations of MC beds utilization (comparing the impact of with and without emergency admission and no-shows).

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BIOGRAPHY

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