

Using Prediction to Improve Elective Surgery Scheduling

Zahra Shahabi Kargar^{1,2}, Sankalp Khanna^{1,2}, Abdul Sattar¹

¹Institute for Integrated and Intelligent Systems, Griffith University, Australia
{Zahra.Shahabikargar, A.Sattar}@griffith.edu.au

²The Australian e-Health Research Centre, RBWH, Herston, Australia
{Sankalp.Khanna}@csiro.au

Abstract. Stochastic activity durations, uncertainty in the arrival process of patients, and coordination of multiple activities are some key features of surgery planning and scheduling. In this paper we provide an overview of challenges around elective surgery scheduling and propose a predictive model for elective surgery scheduling to be evaluated in a major tertiary hospital in Queensland. The proposed model employs waiting lists, peri-operative information, workload predictions, and improved procedure time estimation models, to optimise surgery scheduling. It is expected that the resulting improvement in scheduling processes will lead to more efficient use of surgical suites, higher productivity, and lower labour costs, and ultimately improve patient outcomes.

Keywords: Surgery scheduling, Predictive optimisation, Waiting list

1 Introduction

Ageing population and higher rates of chronic disease increase the demand on health services. The Australian Institute of Health and Welfare reports a 3.6% per year increase in total elective surgery admissions over the past four years [1]. These factors stress the need for efficiency and necessitate the development of adequate planning and scheduling systems in hospitals. Since operating rooms (ORs) are the hospital's largest cost and revenue centre that has a major impact on the performance of the hospital, OR scheduling has been studied by many researchers.

The surgery scheduling problem deals with the allocation of ORs under uncertain demand in a complex and dynamic hospital environment to optimise use of resources. Different techniques such as Mathematical programming [2-4], simulation [5, 6], Meta-heuristics [5, 7] and Distributed Constraint Optimization [8] have been proposed to address this problem. However most current efforts to solve this problem either make simplifying assumptions (e.g. considering only one department or type of surgery [4]), or employ theoretic data [3, 5] which make them difficult to use in hospitals.

In this paper, we propose a prediction based methodology for surgery scheduling to address the above limitations. By using predicted workload information and retrospective analysis of waiting lists and theatre utilization, we predict a theatre template representing optimal case mix. The proposed model also employs accurate estimation of procedure time and predicted workload information to drive optimal elective surgery scheduling, and help hospitals fulfil National Elective Surgery Targets (NEST) [1].

2 Elective Surgery Scheduling at the Evaluation Hospital

Long waiting lists for elective surgery in Australian hospitals during recent years has driven a nationwide research agenda to improve the planning, management and delivery of health care services. This work is to be evaluated at a major tertiary hospital which has a total of 15 operating theatres performing 124 elective operating sessions and 23 emergency sessions per week. Currently allocation of available elective operating sessions at the hospital have been broken down to different specialties and teams of surgeons based on a static case mix planning. This static allocation of available sessions between emergency and elective patients and among different departments results in underutilization or cancellation due to demand fluctuations. Also, the allocation of patients to theatres is carried out without considering the uncertainty and possible changes that might happen. Procedure times are estimated by using generic data or recommended by relevant surgeons not based on individual patient and surgery characteristics. Patients are booked into schedules in a joint process between surgeons and the booking department. Due to the dynamic environment and rapid changes, these schedules need to be updated quickly. Usually department managers have regular meetings to make any changes needed. Department managers try to locally optimise their department goals, but since there is no global objective usually these solutions are not the optimal global solutions.

3 An Optimal Surgery Scheduling Model

Although the surgery scheduling problem has been well addressed in literature, it still remains an open problem in Operations Research and Artificial Intelligence. Despite the dynamic nature of the hospital environment, the majority of previous studies ignore the underlying uncertainty. This leads to simplistic models that are not applicable in real world situations.

3.1 Current State of the Art

Cardoen et al. present a comprehensive literature review on operating room scheduling including different features such as performance measures, patient classes, solution technique and uncertainty [9]. One of the major issues associated with the development of accurate operating room schedules or capacity planning strategies is the uncertainty inherent to surgical services. Uncertainty and variability of frequency and distribution of patient arrivals, patient conditions, and procedure durations, as well as “add-on” cases are some instances of uncertainty in surgery scheduling [10]. Among them stochastic arrival and procedure duration are two type of uncertainty studied by many researchers. Procedure duration depends on several factors such as experience of the surgeon, supporting staff, type of anaesthesia, and pre-condition of the patient. Devi et al. estimate surgery times by using Adaptive Nero Fuzzy Inference Systems, Artificial Neural Networks and Multiple Linear Regression Analysis [2] but they just focus on one department and use a very limited sample to build and validate their model. Lamiri et al. developed a stochastic model for planning elective surgeries under uncertain demand for emergency surgery [3]. Lamiri et al. also address the elective surgery planning under uncertainties related to surgery times and emergency surgery demands by combining Monte Carlo simulation and a column generation approach[5]. Although their method addresses uncertainties, it is based on theoretic data and it has not been tested on real data. What is needed is a whole of theatre approach to provide better prediction of surgery time, incorporation of predicted workload in planning the weekly surgery template, and target guided optimization to ensure optimal allocation of resources.

3.2 Proposed Method

To improve the planning and optimization tasks underlying the process, we propose a two stage methodology for elective surgery scheduling. As a first stage, predicted workload information (drawn from Patient Admission Prediction Tool [11] currently used at the evaluation hospital), current Waiting List information and Historic utilization information is used to manage theatre allocation and case mix distribution for each week (see Figure 1). This allows the prediction based sharing of theatres between elective and emergency surgery, and allocation of theatre time to surgery teams/departments and results in a theatre schedule template that works better than a static allocation model (as demonstrated by Khanna et al. [8]).

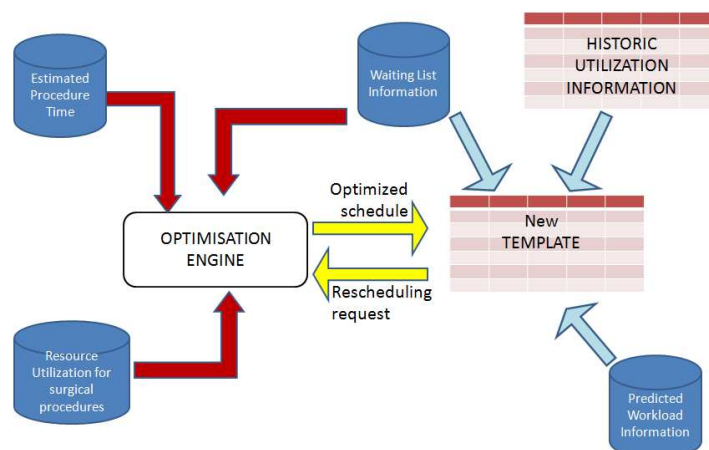


Figure 1. Proposed Methodology for Improving Surgery Scheduling

In the second stage of the process, the allocation of patients to the weekly theatre schedule is guided by an improved prediction algorithm to estimate the surgery duration. The algorithm takes into account current patient, surgery, and surgeon information and related historic peri-operative information to forecast the planned procedure time. Incorporating NEST compliance in the optimization function and improved resource estimation deliver further improvements to the scheduling process and help deliver a more robust and optimal schedule (Figure 1). We are currently working towards collecting over 5 years of surgery scheduling, waiting list and peri-operative information for the evaluation hospital from the corporate information systems. This data will be used for modelling and independently validating the prediction algorithms and building historic resource utilization knowledge banks to guide other stage of the scheduling process.

4 Conclusion

The proposed model has the potential to improve elective surgery scheduling by providing more accurate procedure time estimation and predicting arrival demand of elective and emergency patients.

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