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A comprehensive simulation for wait time reduction and capacity planning applied in general surgery

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Abstract This paper describes the use of operational research techniques to analyze the wait list for the Division of General Surgery at the Capital District Health Authority in Halifax, Nova Scotia, Canada. A discrete event simulation model was developed to aid capacity planning decisions and to analyze the performance of the division. The analysis examined the consequences of redistributing beds between sites, and achieving standard patient lengths of stay, while contrasting them to current and additional resource options. From the results, multiple independent and combined options for stabilizing and decreasing waits for elective procedures were proposed.

Keywords Simulation · General surgery · Capacity planning · Wait list management · Access to medical care

1 Introduction

Studies have shown that the demand for health care service exceeding supply is an issue faced by every industrialized nation [1]. "It is patently obvious that available monies will never be enough to meet all demands for health care, and that rationalization of resource allocation is necessary to obtain the best outcomes possible with that money" [2]. Methods of rationing must therefore be implemented to maintain a sustainable health care system. "In Canada, as in many countries, the existence of a cash-limited, publicly funded health care system implies that queue-based rationing of services is a necessity" [3]. In Canada access to health care services is not distributed on ability to pay and thus, is not rationed through price mechanisms, but rather by time. In Canada, citizens can expect to wait; those who feel that the inconvenience of waiting is greater than the potential gain for service will remove themselves from the queue accordingly.

It is thought that time based queue rationing is more equitable than market-driven rationing methods because time is more equally distributed than money. Problems arise with this logic as a strict first-come first-serve queue policy ignores the relative urgencies of a patient's ailment. To combat the resulting absurd resource allocations, patients are often given priorities. Blake et al. [3] summarize the problems associated with prioritization: "since individuals with greater wealth are able to lobby or exert influence, expert prioritization is known to exhibit inegalitarian tendencies. Despite these shortfalls, few alternatives to expert prioritization are available or practical in publicly funded health care systems." Pitt et al. [4] addressed preferential treatment as an ethical issue and recommends that "decision makers at all levels should deal with these ethical considerations as systematically and rigorously as they would management, political and legal considerations."

"Canadians believe that access to essential health care services should be fair, and based on need and urgency" [5]. If we trust wait lists as an instrument to ration health care, we must ensure that the time a patient waits achieves this, without jeopardizing the benefit of the procedure or causing undue stress and anxiety on the patient. Achieving such a delicate balance requires proper resource allocation and sound capacity planning.

Efforts in wait list management in Canada have largely focused on documenting and standardizing the measure-

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ment of patient waits and surgeon prioritization techniques. Somewhat less effort has been spent quantifying and projecting expected patient waits through analytical decision support models.

The surgery division to be studied in this paper is the General Surgery Division, within the Queen Elizabeth II Health Science Centre (QEII), located in Halifax, Nova Scotia, Canada. The division consists of 15 full time surgeons. The QEII is a teaching hospital and has approximately 30 postgraduate general surgery residents [6]. As part of the Capital District Health Authority (CDHA) the division's surgeons provide surgical care for the Halifax community and surrounding areas and tertiary care to a catchment population of 970,000 from Nova Scotia, Prince Edward Island, and New Brunswick. Analysis have shown that the division has an aggregate capacity of approximately 4400 surgeries per year and, depending on patient urgency and responsible physician, elective waits range from one to 25 weeks.

In 2004, the division's surgeons believed that wait times had reached a critical point. Their beliefs were supported by data that indicated that less than 30% of patients received treatment within the time criteria set forth by the Canadian Society of Oncology Specialties and the Canadian Society of Surgical Oncology. The division members had opinions on possible causes and possible cures, but were unable to substantiate their hypotheses. It was felt that a systematic review of the flow of patients through their Operating Rooms (ORs) was needed. The objectives of the review were to determine how to maximize throughput with current resources, determine the effects of process bottlenecks, and develop a plan to achieve the wait time standards set forth by professional health care societies. All factors hindering the flow of patients were to be studied. Accordingly, an instrument with which strategies could be tested and analyzed before implementation was required.

2 Literature review

Models for resource planning described in the literature can be broadly categorized as analytical or simulation based. Since the complex nature of health care often makes analytical models intractable, researchers must decide between simple, but tractable models, or opt for complex, but realistic models. Harper and Shahani [7] argue that reducing the complexity of a problem to make solution methods tractable is less than ideal. Not surprisingly, the literature recommends simulations over analytical and deterministic approaches [8]. Everett [9] notes that given the variety of objective functions that may be appropriate to the various stakeholders within a health care environment, 'optimality' is an ill-defined and unobtainable objective.

Simulation models have been used extensively to study health care operations. Lagergren [10] notes that simulation models make it possible to study systems that do not exist, to predict complicated consequences of actions and developments and to do experiments that are impossible or too costly to perform in reality. Many of the simulation models in the literature can be defined as capacity planning models where the goal of the study is to match hospital resources to demand. Generalized capacity planning models often assume the current resources are achieving maximum capacity.

Many papers in the literature outline the appropriate use of simulation and present structured frameworks to help increase a project's success. Lowery [8] argues for an approach in which simple models, without great detail, are developed quickly to engage decision makers. Lowery suggests that accurate documentation of assumptions and extensive sensitivity analysis allows modellers to increase success rates where quick and reasonably reliable results are required. For larger, more robust models, Harper [11] suggests a framework that focuses on the importance of the creation of statistically and clinically meaningful patient groups, mathematically correct models, and outputs which provide the necessary information for end-users. De Angelis, et al. [12] suggest determining the impact of each variable on the model's objective function and optimizing an extrapolated objective function. Everett [9] argues that the function of a model is not simply to provide information to managers but rather to engage them in the development process so as to allow them to use the model independently as a decision support tool.

Even a cursory search of the literature reveals a plethora of models for resource capacity planning in health care. Preater [13] divides the major areas for the application of simulation into outpatient clinics (including patient and staff scheduling systems), inpatient facilities, emergency services, and clinical and systems issues. England and Roberts [14], Preater [13] and Worthington [15, 16] provide rich bibliographic resources for readers interested in wait list management models and health care simulation.

Harper and Shahani [7] describe a general surgery simulation designed to alter queue policies and day-to-day scheduling. Results indicate that a potential increase in throughput was possible without additional resources. Harper [7] outlines a generic modelling approach including a system for extracting data and determining meaningful patient classifications (Classification and Regression Tree), a mechanism for using a simplex algorithm to estimate data parameters, and a generic tool for building hospital simulations. The framework is illustrated by cases drawn from a set of local hospitals. Harper and Gamlin [17] show how visual interactive simulation can be used within a structured environment to address wait list issues and build acceptance of results amongst managers.