Chapter 18
Evaluating Patient Flow Based on Waiting Time and Travel Distance for Outpatient Clinic Visits

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ABSTRACT

Patient flow greatly affects the quality of service delivered to the patients. Among various performance measures identified for patient flow, this chapter focuses on the analytical modeling of two key measures, namely, patient waiting time and travel distance. Waiting time is analyzed by a promising yet simple analytical tool – queuing theory. Three queuing models, including single station, multiple serial stations, and network systems are presented. Moreover, patient travel distance is investigated by an analytical model to evaluate the patient flow. For both measures, the applicability of models is illustrated with numerical examples.

INTRODUCTION

There are many indices in healthcare delivery by which the quality of service provided to patients can be evaluated. One aspect for evaluation is the smoothness of the patients' movement in their visit to medical facilities, known as patient flow. At the first glance, patient flow is related to the time a patient consumes in a medical facility from arrival to discharge. Any time in which the patient waits to receive the service is considered as waste that might result in the patient's dissatisfaction. As such, patient waiting time is essential to the measurement of patient flow. Combined with

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data collection, analytical modeling approaches can help the management to develop a systematical understanding about operations and make better decisions. Queuing models as a powerful tool have been extensively used in analyzing manufacturing and service systems. Such a tool furnishes mathematical formulas to approximate performance measures in a system. A queuing system can be simply described as customers arriving for service and waiting for service if it is not immediate available, as well as leaving the system after being served. Although the *theory* of queuing requires advanced mathematical background, its *application* side is relatively easier. Being compatible with spreadsheet programs such as Microsoft Excel®, healthcare practitioners can effectively apply the tool. On the other hand, it is also natural to evaluate the patient flow based on the distance a patient travels in a medical facility. In most cases, patients need to travel among multiple places in a visit. Therefore, the total distance traveled during a visit can be considered another key factor for the patient flow. Based on the probability of traveling from one department to another department in a facility, a score can be assigned to each patient route in the facility. The score can be then considered as a performance measure of patient flow.

In this chapter, we focus on the patient flow in outpatient clinics. The second section of this chapter briefly reviews the literature on the general aspects of patient flow. Meanwhile, the management tools and performance measures which have been used in the literature to analyze the patient flow are reviewed. Thereafter, the waiting time is analyzed by queuing models for various healthcare settings in the third section. Queuing principles and applications in healthcare are covered. Three queuing systems known as single station, multiple serial station, and network are then discussed and case studies are provided. In the fourth section, an algorithmic approach is presented by which the patient flow can be measured from the perspective of travel distance. By introducing "from-to" matrix, patient route probability vector, and route accessibility concept, a simple-to-use analytical approach including a case study is furnished to compute the patient flow travel score.

BRIEF LITERATURE REVIEW ON PATIENT FLOW

General Patient Flow

An effective and efficient patient flow is characterized by high patient throughput, low patient waiting time, short length of stay, and low clinic overtime, while maintaining adequate staff utilization rates and low physician idle times(Jun et al., 1999). Potisek et al. (2007) performed a patient flow analysis to identify specific areas of inefficiencies in patient visits and thus improve patient visit efficiency through developing interventions to decrease the mean time of patient visit. It is found that patient flow analysis is an effective method for identifying the inefficiencies and efficiently collecting patient flow data. Generally, patient flow analysis is closely related to three main areas: (i) patient scheduling and admissions, (ii) patient routing and flow schemes, (iii) scheduling and availability of resources (Jun et al., 1999). Patrick et al. (2008) addressed the incorporation of patient priority in a scheduling problem where patients are scheduled to the fixed scheduling slots of a diagnostic resource within the maximum waiting time recommended for each priority. St. John's hospital (Henderson et al., 2004) teamed up with Institute for Healthcare Improvement (IHI) to improve the patient flow in its emergency department. The first approach that they took is to provide a dedicated operating room for the unscheduled and "add-on" cases. By doing so, the number of surgical cases went up by 5 percent and the overall time decreased by 2 percent. Also, the staffing need could be more accurately predicted. Another major approach is to add a standardized fax report form to facili-