

# Chapter 10

## Modeling and Simulation Analyses of Healthcare Delivery Operations for Inter- Hospital Patient Transfers

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### **ABSTRACT**

*Inter-hospital transfers of patients for different elements of care have been increasingly used as a common strategy for providing quality healthcares through sharing limited resources worldwide. In this paper, the authors study the problem of healthcare delivery operations for inter-hospital patient transfers motivated by a real-world case within the South East Local Health Integration Network of Ontario. The authors use a directed graph to develop a general model for obtaining the solution that minimizes the overall transportation time while satisfying all the inter-hospital transfer requests with identical or different start and end points. The authors also perform simulation analyses to study the fleet sizing problem through evaluating different service performances with different fleet sizes. A number of implementation issues for managing inter-hospital patient transfer services are also discussed.*

### **INTRODUCTION**

Healthcare systems around the world have been challenged in recent years to deliver high quality care with limited physical, human, and financial resources. For example, it has been well documented that, in the United States, large segments of the population have inadequate health insurance coverage, forcing them to rely on an underfunded public health system (U.S. Census Bureau, 2008). Even in countries with government-run healthcare systems, such as Canada and United Kingdom, providing quality care while controlling the soaring costs has also become a major concern, especially for rural and remote

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communities which tend to have a larger percentage of elderly in relatively poor health, have fewer doctors, hospitals, and other health resources, and face more difficulty getting to health services (Romanow, 2002). To share the limited physical and human resources which are only available in certain hospitals, inter-hospital patient transfers, i.e., transferring a patient to another hospital where specialized physicians and/or treatments are available, have therefore become a common and important practice for providing necessary cares to patients around the world. From the perspective of service operations management, the practice of inter-hospital patient transfers is an application of the “risk pooling” concept in supply chain management (Simchi-Levi et al., 2007; Tang, 2006). Under the traditional manufacturing setting, risk pooling allows a firm to adopt a centralized planning approach to share physical resources across different locations. Similarly, for healthcare service operations, the practice of inter-hospital patient transfers allows a network of hospitals to share knowledge and resources across different locations.

Today managing inter-hospital patient transfers has become an emerging issue in providing quality healthcares through sharing limited physical and human resources within various geographic regions worldwide. For example, according to Robinson et al. (2009), approximately 1,000 inter-hospital patient transfers occur in the Province of Ontario each day, and every day and a half, the total distance travelled for these transfers equals the distance around the earth’s circumference. The annual cost for patient transfers in Ontario is approximately \$283 million. Therefore, developing cost-effective methods for managing inter-hospital patient transfers as well as to ensure service quality is of crucial importance to the success of today’s healthcare systems. Various protocols and guidelines have been developed to address the safety and information privacy issues in inter-hospital patient transfers (U.S. National Guideline Clearing House, 2004; U.K. National Library of Guidelines, 2006). The application of operations research methodologies for managing inter-hospital patient transfers to minimize wait times and transport distances, however, has not received significant attention from either researchers or practitioners. Since most hospitals do not own dedicated vehicles for inter-hospital patient transfers, ambulance vehicles are usually used on the first-come-first-serve basis. Unless there happens to be another patient to be transferred back from a destination hospital, an ambulance is often empty on the back trip of an inter-hospital patient transfer. This creates a potentially serious problem since most inter-hospital patient transfer needs are for non-emergency situations, and using ambulances under such situations can be a costly and even risky option that compromises a hospital’s capacity to respond to actual emergency situations (Robinson et al., 2009). Even for hospitals or regions with dedicated vehicles for non-emergency inter-hospital patient transfers, the lack of cost-effective scientific methods often leads to higher operations costs and longer wait times (Williams et al., 2004; Hall et al., 2006).

In this paper, we study the problem of healthcare delivery operations for inter-hospital patient transfers motivated by a real-world case of inter-hospital patient transfers in the Prince Edward and Lennox Addington (PELA) community within the South East Local Health Integration Network of Ontario (SELHINO) formed by fourteen healthcare facilities, as listed in Table 1, in seven counties. The geographical locations of the fourteen healthcare facilities are also shown in Figure 1. PELA is a scarcely populated community located between Toronto and Kingston in Eastern Ontario. Different healthcare institutions are located in the surrounding PELA region. However, these institutions may specialize in treating only a limited numbers of medical conditions or providing limited types of healthcare services. For example, one hospital may specialize in cardiological treatments while another hospital may have extra beds available for patient recovery. When patients require a certain treatment or service that is not available at their local healthcare facilities, inter-hospital transfer requests will be initiated to transport them to another hospital that provides the necessary healthcare services. Currently, there is no established

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