Chapter 20
Applying Discrete Event Simulation (DES) in Healthcare: The Case for Outpatient Facility Capacity Planning

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ABSTRACT

This paper highlights the opportunities and challenges of applying Discrete Event Simulation (DES) to support capacity planning of a network of outpatient facilities. Despite an abundance of studies using simulation techniques to examine the operation and performance of outpatient clinics, the problem of capacity allocation and planning of medical services within a network of outpatient healthcare facilities appears to be underexplored. Here, a case study of a health insurance provider that operates a network of six outpatient medical facilities in the US is used to illustrate and explore the synthesizing and adaptive, yet parsimonious nature of using DES methodology for network design and capacity planning. Results of this case study demonstrate that significant performance improvements for the network operator can be achieved with applying DES method to support the network facility capacity planning process.

INTRODUCTION

For the past three decades, healthcare expenditure has continued to escalate in most developed countries (Wand, 2009). In the UK, for example, the National Health System (NHS), when established in 1948, spent about 11.4 billion GBP for health. In 2009, this figure has multiplied ten times to exceed 110 billion GBP with per capita health expenditure in England estimated to be 1,774 GBP (Harker 2011). At the same time, US health expenditure surpassed $2.3 trillion in 2008, more

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than three times the $714 billion spent in 1990, and over eight times the $253 billion spent in 1980 with per capita US healthcare expenditure estimated at $7,681 (Kimbuende, Ranji, Lundy, & Salganicoff, 2010). For a smaller country such as Greece, healthcare expenditure for 2008 was 28 billion Euros, which represent 9.6% of the country's GDP, while the per capita spending is calculated as $2,724 (OECD, 2011).

Today, healthcare organizations are challenged with increased pressures to deliver quality care at reduced costs, with lowering reimbursement and operating under evolving or increasingly complex regulatory requirements (Leskovar, Accetto, Baggia, Lazarevic, Vulkovic, & Pozun, 2011). In light of the recent financial crisis, it is certain that governments and policymakers will further limit healthcare expenditure and push for transforming, rationalizing and reengineering the way healthcare business has been conducted. As healthcare services continue to expand and the delivery of such services becomes more complex (Wand, 2009), there is an intrinsic uncertainty of healthcare demands and outcomes (Katsaliaki & Mustafee, 2011). This situation has motivated researchers and healthcare professionals alike to seek out new methods to improve efficiencies and cost-effectiveness of healthcare operations and services (Jacobson, Hall, & Schwiser, 2006). Mathematical models and computer simulations are now widely recognized and used as decision support tools to aid changes in many and all facets of administrative, corporate and clinical work processes (Rentizelas, Tziralis, & Kirytopoulos, 2007; Thorwarth & Arisha, 2009).

Among the more prominent simulation methods applied for healthcare and the broader industries, based on the impact and frequency of applications, are: artificial intelligence algorithms, 3-D and virtual reality simulations, system dynamics (SD), agent-based simulation, Monte Carlo simulation, hybrid simulation, continuous simulation as well as discrete-event simulation (Kuljis, Paul, & Stergioulas, 2007). Even so, the way simulation methods are to be applied in the healthcare industry requires clever adaptation from those of other industries, as patients are atypical customers. Specifically, patients have raised expectation thresholds and often perceive themselves as the "centre" of the service, being more responsive and increasingly keen to exercise meaningful and informed choice (Littlejohn, Wyatt, & Garvican, 2003). Hence, applying computer simulation in health care is a non-trivial endeavor.

In this article, we emphasize the use of computer simulation as a decision-aiding tool for the performance assessment and reengineering of a healthcare organization. A major advantage of simulation over other operational research (OR) techniques is that it allows for experimentation with any element of a business system. Moreover, simulation allows the decision makers to maintain a system-wide view of the effects of local changes in a system and allows for the identification of implicit dependencies between (adaptive) parts of the system. Discrete event simulation (DES) has been touted as a significant tool for analyzing and solving complex transaction processing problems (Lawrence, 2003), such as those met in healthcare. Still, in our literature review, we found that despite an abundance of studies using simulation techniques to examine the operation and performance of outpatient clinics, the problem of capacity allocation and planning of medical services within a network of outpatient healthcare facilities remains underexplored. In closing such a knowledge gap, we employ an illustrative DES application on a health insurance provider that operates a network of six outpatient medical facilities.

The remainder of this paper is organized as follows. First, the extant literature concerning DES method and its applications in healthcare is reviewed. Details of how the review was conducted, its methodological aspects and results are also discussed. Next, we enhance the results of literature review by filling in part of the noted knowledge gap with an illustrative case, demonstrating the