Improving Health Care Management Through the Use of Dynamic Simulation Modeling and Health Information Systems

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ABSTRACT
To better understand the performance of hospital operations in response to IT-enabled improvement, this paper reports the results of a system dynamics model designed to improve core medical processes. Utilizing system dynamics modeling and emerging Health Information Systems (HIS) data, the authors demonstrate how current behavior within the hospital leads to a ‘stove-pipe’ effect, in which each functional group employs policies that are rational at the group level, but that lead to inefficiencies at the hospital level. The authors recommend management improvements in both materials and staff utilization to address the stove-pipe effect, estimate the resultant cost-saving, and report the results of an experiment conducted in the hospital to validate the approach. Results indicate that the major gains in health information systems use will accompany new information gathering capabilities, as these capabilities result in collections of data that can be used to greatly improve patient safety, hospital operations, and medical decision support.

Keywords: Health Care, Health Information Systems, Hospital Management, Process Improvement, System Dynamics

INTRODUCTION
This paper discusses the strategies required to develop system dynamics capabilities in hospital environments and to use simulation analysis to help hospital organizations address important operational problems. The system dynamics perspective has the ability to create improvements in strategic management, both

DOI: 10.4018/jitsa.2012010102
This work, however, contributes to a growing body of literature that focuses on how structures and decisions embedded within hospital organizations subvert efforts to change and improve the performance of health care delivery, such as ward management (Akiyama et al., 2009); patient flow (Wolstenholme, 1999); and safe design capacity (Wolstenholme et al., 2007).

Of particular importance are the dynamics relating to the emergence of new Health Information Systems (HIS) that have the potential to revolutionize hospital practice and management, improve patient safety, and create vast new rich new datasets. Many excellent HIS systems, however, go unused or under-utilized because HIS implementation is met with resistance by staff and managers. For example, Dr. Steven Cantrill, a practicing emergency medical doctor, describes the challenge as thus: “health-care providers (especially physicians) have little tolerance for systems that serve as impediments to getting their work done, often regardless of what positives might accrue from using such a system.” (Cantrill, 2010) Further, if HIS are implemented, unanticipated behavioral decisions resulting from HIS implementation can create counterintuitive outcomes that actually subvert overall hospital efficiency. Implementations resulting in unintended negative “side-effects” include computerized prescriber order entry (Zhan et al., 2006), electronic health records (Sidorov, 2006), bar code technology (Poon, 2006), and overall HIT systems (Ash et al., 2003; Wears & Berg, 2005; Kohn, 2000). Finally, once developed, there are often significant barriers to utilize HIS data-sets to help hospitals implement changes and manage operations (Goodman et al., 2011).

While the need for new HIS in hospital environments has been well documented, system managers, as well as medical practitioners, have both recorded their disappointment with many HIS implementations (see Mathews & Pronovost, 2011 for recent commentary on this subject). Part of the reason for suboptimal performance is that many approaches to HIS fail to take full advantage of the new opportunities provided by data collections systems as a tool to: a) understand, measure, and track hospital operations, b) identify and implement high-leverage improvements, and c) provide opportunities for hospital staff to train and learn more effectively. Our research suggests avenues to utilize the rich data set provided by HIS to improve hospital efficiency, patient safety, and the receptiveness of staff to IT enabled-improvements. Comprehensive HIS allow for the development of new modeling tools to support effective integration and success operation of new systems.

This research addresses the ways in which new technology innovations can help both improve performance and reduce costs. The challenges of demonstrating returns from information technology investments, however, confronts not only health care, but virtually all major industries, and have been noted by both practitioners and academics. While we do not give this issue a complete review in this paper, it is important to note that we direct our attention to the performance of innovations over time. For example, improvement in one phase of operations (time) or department (location) may in fact lead to problems at another time or in another location. Further, we note that some traditional methods of understanding and quantifying IT benefits overlook these dynamics. Understanding the disconnection between cause and effect in time and space within health care environments is vital for system designers, managers, and policy officials to solving systematic health care challenges.

In the following section, we describe our work using system dynamics modeling in healthcare settings, position our work in this area, and present a case study of a Japanese hospital system. We introduce the operations at the ward-level as they relate to injections processes and represent these operations in model structure. We describe the pharmacy operations and document a “silo” effect. We then relate the dynamics of different operations and utilize modeling to present analysis and recommendations for the improved management of hospital operations. Finally, we present data that
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