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Case Study

Deploying lean in healthcare: Evaluating information technology effectiveness in U.S. hospital pharmacies

Jun-Ing Ker[a], Yichuan Wang[b], M. Nick Hajli[c,*], Jiahe Song[b], Cappi W. Ker[d]

[a] Department of Industrial Engineering, Louisiana Tech University, Ruston, LA 71272, USA
[b] Department of Aviation and Supply Chain Management, Raymond J. Harbert College of Business, Auburn University, Auburn, AL 36849, USA
[c] Department of Management, Birkbeck University of London, London, UK
[d] Engineering & Technology Management, Louisiana Tech University, Ruston, LA 71272, USA

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ABSTRACT

This case study provides a lens of operation research for evaluating the use of technology on medication distribution systems in U.S. hospital and helps better understand how technologies improve the healthcare operational performance in terms of processing time and cost. We analyze two prescribing technologies, namely no carbon required (NCR) and digital scanning technologies to quantify the advantages of the medication ordering, transcribing, and dispensing process in a multi-hospital health system. With comparison between these two technologies, the statistical analysis results show a significant reduction on process times by adopting digital scanning technology. The results indicated a reduction of 54.5% in queue time, 32.4% in order entry time, 76.9% in outgoing delay time, and 67.7% in outgoing transit time with the use of digital scanning technology. We also conducted a cost analysis on each of the two technologies, illustrating that the total cost generated by using digital scanning was as low as 37.31% of that generated by NCR. Lessons learned about how to evaluate IT effectiveness by lean methods are presented for both theoretical and practical perspectives.

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1. Introduction

The medication distribution system in hospitals deals with the high volume of medication transfers from when the medication is dispended to when it is administered, and physician prescriptions. According to the National Community Pharmacists Association (NCPA)'s report, the number of prescriptions being dispended in a pharmacy per day in the United States rose, on average, approximately 12% (from 178 to 201) from 2006 to 2011 (NCPA, 2012). The great challenge that hospitals confront is the long delays on medications and prescriptions in that the demand pressure on them continuously grows. Thus, improving workflow in medication distribution systems to enable pharmacists to allocate their time more effectively is vital to proving a high quality healthcare service and beneficial to patient safety.

To address this, research indicates that many hospitals have adopted technologies to improve their existing operational processes (Agarwal, Gao, DesRoches, & Jha, 2010; Calderia, Serrano, Quaresma, Pedron, & Romao, 2012; Goh, Gao, & Agarwal, 2011). This practice is particularly important for pharmacies. A vast body of research demonstrates that the use of information technologies (IT), such as computerized physician order entry system, has benefits on reducing prescribing errors (e.g., Shawahna et al., 2011) and decreasing dispensing delays in the pharmacy units (e.g., Chuang, Wang, Chen, & Cham, 2012). However, little is known about the actual performance of information technology (IT) effectiveness to be accomplished (e.g., how much time or cost is saved) regarding medication distribution process in hospital pharmacies. Measuring healthcare information system (IS)/IT performance is challenging to IS researchers (Jones, Heaton, Rudin, & Schneider, 2012), because the performance measures used to evaluate the healthcare IT input and output are drawn from administrative data that are short of detail-oriented, detecting information (Jones et al., 2012). This gap is worth researchers to solve in that a quantified performance assessment is critical for hospitals to maintain their service qualities (Douglas & Judge, 2001).

Therefore, drawing on the lean methods from operation research filed, time study and cost analysis, the reported cases analyze the two common prescribing technologies used in U.S. hospital pharmacies via comparing their operational time and IT cost spending. In doing so, this case study not only has better chance to deeply understand the effectiveness of IT usage in healthcare, but only

* Corresponding author. Tel.: +44 7951537481.
E-mail address: m.hajli@bbk.ac.uk (M.N. Hajli).

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demonstrates the cost and time analysis methods to evaluate IT effectiveness for the practitioners.

2. Research background

2.1. Medication distribution systems in hospital pharmacy

A medication distribution system in hospitals is one of the most complex workflow that consists of prescribing, ordering, transcribing and dispensing medications (Flynn, Barker, & Carnahan, 2003). This system, which involves a number of procedures and a variety of supporting staff, starts from the moment a physician writes the prescription, then goes to the nursing station or any other dispensing station, and ends at the point the medication reaches the patient. The main goal of this system is to ensure that the correct drug is administered in the appropriate dose to patients at the correct time.

The prescribing process is one of the important components in every community or hospital pharmacy due to the widespread use of drug prescription. Pharmacies in hospitals use different prescribing methods. For example, the traditional approach to medication management is handwritten prescriptions, but it is inefficient and error-prone. Illegible or unclear prescriptions result in more than 150 million calls from pharmacists to physicians and nurses, asking for clarification, a time-consuming process that tremendously costs the healthcare providers economic input due to the long operational time each year. Therefore, there is a need for IT usage in hospital pharmacies. In the next sections, we describe some technologies that have been adopted for medication distribution process.

2.2. The use of prescribing technology

Current studies show that many IT tools or systems for prescribing and dispensing practices are available in the market and have the abilities to enhance the accuracy and improve the efficiency of prescribing practices. Indeed, the use of information system (IT) can significantly improve healthcare performance (Karsh, Holden, Alper, & Or, 2006). For example, pharmacists at one U.S. hospital used a computerized prescription order entry system to review all prescriptions, which alerts the prescriber and pharmacist on dosage errors to reduce misinterpretation of prescriptions (Jayawardena et al., 2007). In addition, Wang and Chang (2002) indicated that the introduction of personal digital assistants (PDAs) into prescription system could prevent errors that occurred during the prescription of drugs in a teaching hospital setting.

2.3. Performance measurement of IT effectiveness

Measuring hospital performance is a crucial task for managers within healthcare industry to understand its ability to provide high quality of healthcare service and thus to maintain or seize the competitive advantage (Douglas & Judge, 2001). Handler, Issel, & Turnock, (2001) conceptualized a framework for measuring performance and monitoring public healthcare systems. Yet, their research does not consider the contribution of IT resource utilization to the hospitals.

Of equal importance for pharmacy units is to provide a set of clear criteria to understand the effectiveness of the use of technology. Few studies have been conducted to evaluate the IT effectiveness of medication distribution by a comparison study in order to better understand their effectiveness (Chuang et al., 2012; Cochran & Haynatzki, 2013). For example, Chuang et al. (2012) implemented a new drug storage label system that had important drug items circled (e.g., drug name and packaging dose). Compared to the old drug stage label, the overall drug-dispensing error rate was decreased, and the pharmacists' degree of satisfaction was increased. Based on the literature, we found that the pharmacy efficiency can be measured by operational time and costs on the target level of inputs that is utilized to achieve the outputs in the drug distribution processes.

3. Case study approach

3.1. Hospital pharmacy selection

This case study was conducted to examine the processing time involved in administering the medication distribution process and its cost at two public hospitals, A and B, in Louisiana, United States. In 2012, Hospital A had approximately 450 licensed inpatient beds and 430,000 outpatient visits, and Hospital B had approximately 250 licensed inpatient beds and 141,000 outpatient visits. The pharmacies at both hospitals were chosen to be involved in this study, as both had different prescribing technologies. The pharmacy at Hospital A used NCR copies for prescribing, and Hospital B used digital scanning technology.

3.2. The use of prescribing technology

The two methods of drug distribution were NCR technology and digital scanning technology in the selected pharmacy, respectively. At Hospital A, the physicians and pharmacists used NCR technology. The NCR technology is where medication orders are written on a "no carbon required" physician order form. The NCR copies have four parts altogether. The first part is the chart copy, in which the physician writes and puts on a patient's chart. The remaining three copies are the pharmacy copies on which the order is imprinted. Those copies are sent to the pharmacy through a "tubing system" by the unit secretary or nurse for the pharmacists to fill in the prescriptions. Digital scanning technology, on the other hand, was used in Hospital B. The medication orders are scanned by the unit secretaries or nurse. Once the scanning is done, the prescriptions appear on the pharmacy monitor in the order in which the physicians' orders are, and it allows the pharmacists at order entry to enlarge the image, turn the image, and change the contrast of the image, all which are used to improve readability.

3.3. Data collection

Data was collected over a 2-week period from both hospital pharmacies to determine the time elapsed from when the orders were sent to the pharmacy from the nursing station to the time the medication was sent back to the nursing station from the pharmacy.

An investigator can achieve high levels of precision by increasing the sample size. Should there be constraints, because of budgetary limitations or a shortage of time, a proper sample size has to be determined. Eq. (1) was used to calculate the required sample size "n" for estimating the mean. For this data, we set d to 2 s; σ was estimated to be 9.4 by the sample standard deviation; and the value of critical deviate with a 0.001 α error was 2.326. After calculating, we estimated that the minimum sample size needed for this research was 107 cases of prescription. We collected 107 prescription cases which every individual copy of prescription the physician wrote down as an official copy would be seen as 1 case.

$$n = \frac{t_{2/\alpha}\sigma^2}{d^2} \quad (1)$$

where d = desired precision (or maximum error); $t_{\alpha/2}$ = critical deviate for specified reliability $1-\alpha$; σ = population standard deviation.

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