APPLYING TOC BUFFER MANAGEMENT IN HEALTH INFORMATION SYSTEMS TO IMPROVE HOSPITAL PERFORMANCE

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Abstract: Health care systems around the world are under pressure, the costs are high and rising, and the population is growing and ageing. Health information technology is expected to help improving the health care processes capacity. The aim of this work is to analyze the benefits of the Theory of Constraints (TOC) buffer management implementation in the health care environment concerning the improvement in the patient flow and its management. A literature review was conducted, with an automated search on four databases to identify relevant published articles, written in English language between 2000 and 2010, about the TOC buffer management applied to the health care patient flow. Only three relevant articles were included. The analysis was based on the measurements of the implementations realized in seven different hospitals and for three different purposes: Accident & Emergency department (A&E), admissions and discharge. A statistical analysis conducted in the A&E and admissions post-implementation results demonstrated a significant improvement achieved. Four management control functions improvements were also obtained: prioritize, expedite, escalate and improve. Although few papers were available, TOC buffer management appears to be a good solution to improve performance and management in health care.

1 INTRODUCTION

Along the years, all countries have been dealing with similar problems in health care. The high and rising costs are not followed by improvements in quality. The services are rationed and the care patients receive lags currently standards (Porter and Teisberg, 2006). In addition, the ageing and still growing population contributes to the perspective of putting more pressure on the system due to its rising demand of healthcare services (The Economist, 2009).

The delay of care is a major issue, a persistent and undesirable feature of current health care systems (Murray and Berwick, 2003). No country, regardless its wealth, can ensure immediate access to every technology and intervention that may improve health or prolong life to everyone. The fundamental problem is availability of resources (World Health Organization, 2010). Although variable, the waiting times can lead to substantial impact in individuals' health (Koopmanschap et al., 2005). The pressure made England adopt an aggressive policy of targets coupled with publication of hospitals waiting times, dubbed "target and terror", with strong sanctions for poor performing (Rotstein et al., 2002).

Huge investments have been made in health information technology (HIT), and it is expected to be a solution to the healthcare rising cost, improving the workflow, efficiency and quality (Adler-Milstein, 2009). The advantages of HIT over paper records are readily discernible. However, HIT continues to increase expenditure to levels that nearly all decision makers believe that clear profitability has not been demonstrated (Meyer and Degoulet, 2010); (Chaudhry et al., 2006).

The Theory of Constraints (TOC) is an emerging philosophy born to solve industries problems. It is based on the idea that any system or organization has at least one constraint, which limits the performance of the system as a whole (Goldratt and Cox, 2004). As it showed to be a powerful solution, its implementation rapidly spread to other areas,

such as project management, financing, services, education and health care. One of the TOC tools, the buffer management, is used with success in the shop floor and project management and has been used in health care practice to improve the hospitals workflow. The idea behind this tool is to monitor the quantity of work in front of a resource and compare the actual versus the planned performance (Schragenheim and Ronen, 1991); (Cox III and Schleier Jr, 2010).

The purpose of this article is to analyze the benefits of the TOC buffer management implementation in the health care environment concerning the improvement in the patient flow and its management.

2 METHODS

It was conducted an automated literature search on four databases to identify relevant published articles, written in English language between 2000 and 2010. The databases used were Pubmed, Scopus, ISI Web of Knowledge and Google Scholar. The terms ((“theory of constraints” OR “buffer management”) AND health care) were used to search in titles, abstracts and keywords. The last search made was on January 1st, 2011. The total number of found articles was 1,307, including all the four literature databases used. But most of them were found in Google Scholar (1,160), followed by Pubmed (126), Scopus (13) and ISI Web of Knowledge (8). In this first stage, by reading the titles and the abstracts, were excluded the non-articles results (most of them in Google Scholar), repeated articles and the TOC not related articles (the ones that just cited the TOC). The left 15 articles were TOC related articles, but analyzing the titles and abstracts, were excluded 4 articles related to TOC other issues but buffer management and patient flow (e.g. thinking processes). One of them was just an interview and was excluded as well. The eleven TOC left articles were analyzed beyond the abstract, it was searched along the text about TOC and the buffer management implementation, excluding 7 articles that did not addressed specifically the TOC buffer management implementation in the healthcare and the patient flow. Thus, the final number of papers included in the review was 3.

3 RESULTS

All the papers included in the present review were done and published (in three different European journals) in Europe, two of them in 2006 and one in 2010. Two of them are from United Kingdom and one from Netherlands.

All these studies say that the TOC buffer management had a positive impact in the patient flow in the health care environment and also brought benefits to better manage the system. But only one focused in demonstrating the benefits by measurements. Another one focused in describing the adverse issues overcame and the other one focused in explain how and why the TOC buffer management implementation resulted in success.

3.1 Performance Improvements

The oldest article (Umble and Umble, 2006) is the one that most detailed describes the results. TOC buffer management was applied using an information system developed on Microsoft Access software to record the actual data about the timing and content of activities performed in the treatment of each patient. The purpose was to generate performance improvements in the Accident and Emergency (A&E) departments and the hospital admissions process at three British National Health Service (NHS) facilities. The main measures were, (1) the percentage of patients spending more than 4 hours to be processed through the A&E department, since the government adopted a performance standard (90% of the patients to be processed within the time limit of 4 hours, from the time the patient arrives until the discharge or decision to admittance to an acute hospital); and (2) the time between the decision to release the patient and their admittance to an acute hospital (trolley waits), which was desired to be within 4 hours, but was recommended to do not exceed the 12 hours limit.

Before applying TOC buffer management, the percentage of patients that were processed through the A&E system under 4 hours varied between 50-75%. During the subsequent months (2-5 months) after the implementation, the percentage of A&E patients processed in less than 4 hours increased to at least 91% (Table 1). A statistical analysis was conducted only at the Milton Keynes District Hospital. The mean percentage for the pre and post-implementation periods were 69.07 (included 36 weeks) and 83.14 (included 11 weeks), respectively. After calculating t statistic, the difference of the means for the two periods was 11.42 ($\alpha = 0.01$). Hence, the analysis indicates a statistically significant reduction after the TOC buffer management implementation.

Table 1: Comparison between the percentage of patients processed in the ED before the TOC buffer management implementation and after.

	Milton Keynes District Hospital		Oxfordshire Horton Hospital		Oxfordshire Radcliffe Hospital	
	Before	In 5 months	Before	In 4 months	Before	In 2 months
A&E patients spending less than 4 hours (%)	60-75%	95%	50-60%	91%	50-60%	95%

A statistical analysis was also conducted to determine the effectiveness of the TOC buffer management implementation in reducing the discharged A&E patient admission waiting time to the acute hospital. The mean weekly numbers of A&E patients whose admission delayed 4-12 hours during the pre and post-implementation periods were 41.45 (included 38 weeks) and 6.36 (included 11 weeks), respectively. The calculated *t* statistic was -6.64, ($\alpha = 0.01$). Next was considered the weekly number of A&E patients whose acute hospital admission waiting time delayed more than 12 hours. The weekly mean numbers of patients during the pre and post-implementation periods were 2.76 and 0, respectively. The calculated *t* statistic was 3.81, ($\alpha = 0.01$). Thus, there was also statistically significant reduction in the number of A&E patients waiting to be admitted to the acute hospital.

The most recent article (Stratton and Knight 2010) included four hospital implementations of the QFI Jonah software and TOC buffer management methodology were investigated to establish how buffer management was applied and why the reported benefits were achieved. Buffer management application was implemented in all four hospitals for discharge of acute-hospital patients and in three cases for A&E. Although the emphasis was in determining how and why, this article also shows some results. The number of patients that breached the 4-hour limit in the A&E dropped to nearly zero after the TOC buffer management implementations at the three hospitals that implemented both the A&E and discharge systems. After 20 weeks, the number of patients exceeding the 4-hour limit decreased noticeably.

3.2 Managerial Improvements

Mur-Veeman and Govers (2006) considered in their article the possible value and challenges offered by TOC buffer management applied in health supply chains, most specifically the Dutch bed-blocking problem and the intermediate care departments (ICD). The ICDs were created to act like a buffer and to solve the bed-blocking problem, but it just generated an additional link in the care chain and the problem still continued. Thus the article authors' suggestion was to implement the TOC buffer management prior to the ICD. According to the authors (Mur-Veeman and Grovers 2006; Stratton and Knight 2010), the TOC buffer management has many benefits to improve management. They were grouped in 4 managerial control functions, as proposed by Stratton and Knight:

Prioritize: Each patient is displayed on a computer screen, in priority order, and coded with a color (green, yellow, red and black), so it is easier to visualize the patients priority order regarding the discharge target. It is important to state that the clinical priorities are expected to override the defined priority order or discharge target.

Expedite: Patients entering in the red zone are within the last zone before breaching the target time limit and in the black zone have already done it. As the patients enter those zones, it is signalizes across the hospital the need to expedite action by the resource causing the delay.

Escalate: On a regular basis the delay reasons are analyzed and it allows escalating resources according to the fluctuations in the flow, before the system gets unstable.

Improve: As the reasons for delay are recorded, it is possible to identify and act on common causes regularly.

Table 2: Comparison of processing times in the A&E and acute hospital admission delays before and after the implementation of buffer management.

Variable	Mean	*p*-Value
A&E patients processed in less than 4 hours – Before (%)	69.07	<0.001
A&E patients processed in less than 4 hours – After (%)	83.14	
Patients waiting 4-12 hours for admission – Before (n)	41.45	<0.001
Patients waiting 4-12 hours for admission – After (n)	6.36	
Patients waiting longer than 12 hours for admission – Before (n)	2.76	<0.001
Patients waiting longer than 12 hours for admission – After (n)	0.00	

4 DISCUSSION

The TOC buffer management approach to manage the patient flow along the health care process seems to be a powerful solution. The two papers that analyzed the implementation in the health care environment showed good results in such a little time (Mur-Veeman and Grovers, 2006); (Stratton and Knight, 2010). Despite the fact that the TOC buffer management was utilized at seven different hospitals and for three different purposes (i.e. A&E, admissions and discharge), it showed some evidence to be powerful enough to improve their capacities. In addition, it is important to state that at the Milton Keynes District Hospital, the implementation was successful even counting with an increasing number of patients visiting the A&E, from about 1,200 patients per week to over 1,300 patients per week during the next 3-4 months after the implementation had started (Umble and Umble, 2006). But, on the other hand, there was only one hospital that had the results statically analyzed and described. All the others, if there were results statically analyzed, they were not described on any part of the papers, unfortunately.

Seeing from the patients' perspective, the results were worthy. Their waiting time decreased in the A&E and in the acute hospital admissions. Which in part means a better service quality, because it is essential to consider the maintenance of the clinical service quality. But this issue seemed to be addressed due to the weekly meetings reported by the authors (Umble and Umble, 2006); (Stratton and Knight, 2010). They were important to notice the function of the system, to analyze the performance of the resources, identify the most common causes of delay. These resources commonly causing delay were constraints and after being adjusted they improved the performance of the system as a whole.

The obtained improvements were achieved without any extra resource or expenditure. Since the TOC has the ability to better use the resources; optimizing the system so that hidden capacities arise and balance the flow, instead of balancing the resources capacities (Goldratt and Cox, 2004).

5 CONCLUSIONS

This paper analyzed and made possible to bring together the relevant papers about the described TOC buffer management implementations in the literature. Addressing two different purposes implementations (A&E and discharge of acute-hospital patients), the existing articles showed significant performance improvements achieved and explained the main managerial benefits that the TOC buffer management brought to the hospitals' departments.

Although the TOC buffer management is a relatively new managerial approach, it arises as a good possible solution for the health care systems. For now, there are only few papers available. It is expected that the TOC buffer management will be more utilized in the health care environment and more papers be written with a more rigorous statistical analysis about it in the scientific literature.

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