Supply chain redesign in the healthcare industry of Singapore

Arun Kumar, Linet Ozdamar and Chun Ning Zhang
Systems and Engineering Management Division, School of Mechanical and Production Engineering, Nanyang Technological University, Singapore

Abstract

Purpose – The paper aims to investigate cost reduction in logistics and supply chain management of medical supplies.

Design/methodology/approach – The paper takes the form of a case study.

Findings – In many healthcare systems, executives focus on cost containment efforts to lower acquisition price of supplies instead of lowering the total delivered cost. However, the case in this research presents a novel contemporary approach to reduce costs by process reengineering in supply chain management.

Originality/value – Healthcare managers are continually searching for innovative ways to contain costs without sacrificing quality. To achieve a reduction in costs, hospitals need to review their activities and associated costs, and eliminate nonvalue-added activities. The novel process reengineering presented in this paper is concerned with the centralization of warehousing and the control of non-production goods.

Keywords Just in time, Supply chain management, Health services, Outsourcing, Business process reengineering, Singapore

Paper type Case study

Introduction

Supply chain management has become increasingly important in recent years. Companies analyse their internal operations in detail to establish relationships with their external organisations so as to identify supply/demand fluctuations and amplitudes. Competitive pressures in the market have increased, resulting in faster and more reliable customer service. Due to the critical role supply chains play in the healthcare industry, cost control has been the subject of numerous studies, and different methods have been suggested in the literature for cost reduction. To our knowledge, there is little research on cost containment by applying cutting edge logistics concepts in Singapore's healthcare industry. Concerning reengineering in the supply chain, Vasoo (2000) states that reforms in healthcare were initiated in 1982 to find solutions that improve health services and contain long-term cost increase and government subsidies in the provisions of healthcare. Singapore's National Health Plan (NHP) was developed and released in 1983 (Phua, 1991). This was the beginning of a comprehensive proposal to restructure the healthcare system and tackle a number of underlying concerns in the healthcare scene.

In this paper, we explore the possibilities of cost containment in Singapore's healthcare industry through the application of process reengineering in supply chain management, and identify the hindrances and benefits for the final implementation. Based on this, a survey of healthcare systems in Singapore has been conducted, and several reengineering conceptual and simulation models are developed.

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Supply chain management in healthcare system

The healthcare business is provided by a variety of product and service enterprises including medical consumables, pharmaceuticals, catering, laundry cleaning, waste management, home-care products, information technology, vehicle fleet management and general supplies (Gattorna, 1998). Analysis of the complete healthcare system indicates that the supply management system is one of the primary areas where cost reductions are a predictable outcome (Butters and Eom, 1992). Jarrett (1998) describes the advantage of reengineering in the healthcare supply chain, noting that the healthcare industry has historically viewed itself as being operationally different from other businesses. This is due to healthcare providers' belief that, unlike managers in manufacturing industry, they cannot control or project their production schedules. The healthcare industry's supply chain management problems do not only end up with poor inventory control, and stem from years of outdated supply chain strategies.

Adams (1995) highlighted that healthcare costs are under attack by the public because healthcare information management systems are merging and consolidating. Rundle (1997) also argues that bar codes must be implemented on all medical supply packaging to control the healthcare industry's increasing costs. Alt (1997) clarifies that the increase in

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healthcare cost and inefficiencies are due to inadequate and tedious purchasing procedures and purchasing information systems, and inefficient delivery of healthcare. Willmott (1989) states that healthcare supply chains have evolved from mass to focused marketing and the facilities in future must concentrate on single integrated supply chains.

Numerous investigators have studied the cases of process redesign in healthcare supply chains. Young (1992) examined the materials management departments (MMD) of 22 general hospitals in the state of Georgia using two approaches:

1. the multi-criteria performance/productivity measurement technique (MCP/PMT); and
2. data envelopment analysis (DEA).

He solved the multiple productivity measurement problems presented by MMD. Christopher and Marino (1995) also proposed six basic steps for successful reengineering. Through a case study, reengineering steps were proved to double the inventory turnover rate and reduce inventory, labor expense and storage space. Cynthia and Muller (1997) studied the integration of materials management processes using a team model. Huarng (1998) classified different types of materials management systems among Taiwanese hospitals by using a fuzzy clustering method. Inventory turnover and fill rates were compared, and it was found that the differences were statistically significant. Chow-Chua and Goh (2000) studied how total quality management principles improved the healthcare sector in Singapore. According to the Singapore Ministry of Health (1993), activities related to the purchase, distribution, and management of supplies account for about one third of the operating costs of healthcare facilities; hence, there is much room for improvement. According to Whitson (1997), the weakness in the healthcare supply chain is the difference between traditional buyer-seller relationships. These relationships are built up in a partnering arrangement, where each party shares benefits and burdens over a long period of time so that all parties gain competitive advantage.

Healthcare systems are dynamic systems with complex interactions, in which simulation techniques might play a virtual role to get a satisfactory result (Proctor, 1996) by enabling scenario analysis. Liyanage and Gale (1995) used an optimization and simulation algorithm involving queuing theory to find the optimal number of servers in hospital emergency service. Valdivia and Crowe (1997) developed a methodology to measure operating systems based on customer service.

Survey of healthcare supply chain in Singapore

A survey of the healthcare industry in Singapore has been conducted to find the hindrances in the existing system. A 28-question multiple-choice survey questionnaire was designed which identified the hospital's background, utilization of information technology, process reengineering and logistics status. Subsequently, the questionnaires were mailed to each hospital in Singapore and the response rate was 60 percent. The size of the responding hospitals ranges from fewer than 100 employees to over 1,000 employees. The findings of this survey are summarized in Table I and Figure 1.

Profile of hospitals

The size of hospitals in Singapore is usually medium, and the number of operating rooms and cases per day match the size.

Table I Survey on Singapore's healthcare industry

	Percentage of hopitals
No. of employees	
<50	8.33
50-100	16.67
101-600	41.66
601-1,000	16.67
>1,000	16.67
IT implemention	
Ready	8.33
Future	25.00
Partial	41.67
Full	25.00
IT implementation benefits	
Improve productivity	58.33
Better integration	58.33
Reduce transaction time	50.00
Reduce cycle time	50.00
Improve customer service	41.67
Reduce supply costs	16.67
IT implementation hindrances	
Lack of management support	8.33
Unreliable system	25.00
Lack of supplier cooperation	41.67
Training needs	41.67
Lack of expertise	58.33
Initial cost	75.00
Interest in medical outsourcing	
Done	0.00
Interest	25.00
Little interest	8.33
No interest	50.00
Strictly no interest	16.67

Information technology (IT) has played a major role in healthcare over the past few years. As well as plans to implement electronic medical records in hospitals, telemedicine technologies are being applied to enhance patient care. Twenty-five percent of respondents claim that they have fully implemented IT. Furthermore, electronic integration with suppliers was reported by less than 35 percent of respondents. IT-integrated hospitals report that the number of the suppliers via electronic access is less than three. Meanwhile, some hospitals have recently launched online access to patient records. The benefits of IT are aggregated into six performance indicators, among which supply cost reduction gains the least recognition among respondents. The reason for this is partial electronic integration with suppliers. Top management is not a hindrance and the majority of respondents are committed to IT implementation. The most paramount problem appears to be the high initial cost: 75 percent of respondents mentioned that initial cost was the biggest handicap. Other problems include lack of expertise and the need for training. Lack of cooperation among suppliers is another issue.

The situation of supplies and inventories is displayed in Figure 1. Since most suppliers have agents in Singapore,

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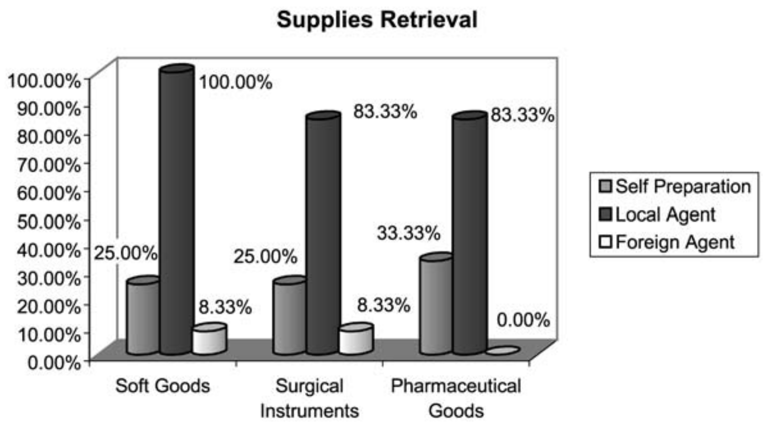
Figure 1 Distribution of supplies retrieval



almost all supplies are retrieved through local agents. Only one large hospital retrieves its surgical supplies through both local and foreign agents. This indicates that supplies are available easily through local agents providing a high potential for JIT purchasing. However, the results show that no hospital has been practicing it yet. Some of the supplies are ordered directly from the manufacturer (especially for surgical and pharmaceutical supplies). Two hospitals retrieve surgical supplies directly from the manufacturers, one hospital gets them from both local and direct manufacturers, and the rest obtain them through local agents. Although most of the supplies are retrieved through local agents, daily delivery/supply is very rarely found. Most supplies take a lead-time of less than three days and some longer, but always less than seven days. All respondents claim that they have more than one week's stock of supplies. The survey identifies that at least four-day stock can be eliminated leading to significant cost reduction in material management.

Another underlying area is the development and coordination of suppliers. All respondents have more than six suppliers for all supplies and 50 percent have only one supplier for each item. Nearly all respondents are quite satisfied with their present suppliers regarding the quality of the supply, on-time delivery, and meeting urgent demand, except one large hospital. After restructuring, productivity and customer service have improved significantly, while the cycle time did not reduce explicitly. Among obstacles to redesign, the resistance of employees seems to be important. A lack of knowledge and expertise are the other two unsettled problems that are closely concerned with employees. Surprisingly, no hospital mentions that it has difficulties in management support. Apparently, resistance to reengineering does not come from the high levels of the organization, but from the operating workforce. Only one hospital has completely accomplished outsourcing, some have partially done it, and the rest have interest in it. On the other hand, outsourcing for medical supplies has not received strong support, especially from large hospitals. Although there is a strong interest for outsourcing of sterile supplies, an initiative is required since only one hospital has achieved total outsourcing. Large hospitals doubt the benefits of outsourcing. Cost, service quality and turnaround time on outsourcing sterile items were also assessed. The outsourcing area presents a very good opportunity for integrating sterile supplies with other hospitals. Additionally, it offers a chance for process reengineering. Nevertheless, the responding hospitals had a strong interest in outsourcing sterile supplies, but were not eager to outsource medical supplies.

Supply chain redesign: conceptual model

This study is concerned with a healthcare group which owns more than ten hospitals in Asia and Europe. There are three hospitals in Singapore and each has the same organizational structure except for their scale, which includes factors such as, manpower, equipment, layout, floor area, and building. A vital department called the Center for Sterilization Service Department (CSSD) exists in each hospital, the functions of which include materials management, receiving instruments, decontamination, packing, sterilization, and instrument distribution. The healthcare group plans to reduce increasing operating costs by innovating on its existing supply chain. Currently, these three hospitals are independent and have separate supply chains and warehouses (Figure 2). As cost reduction measures, Batchelor *et al.* (1995) present alternatives such as contracting out the logistics function, and centralizing distribution centers.

"As is" supply chain

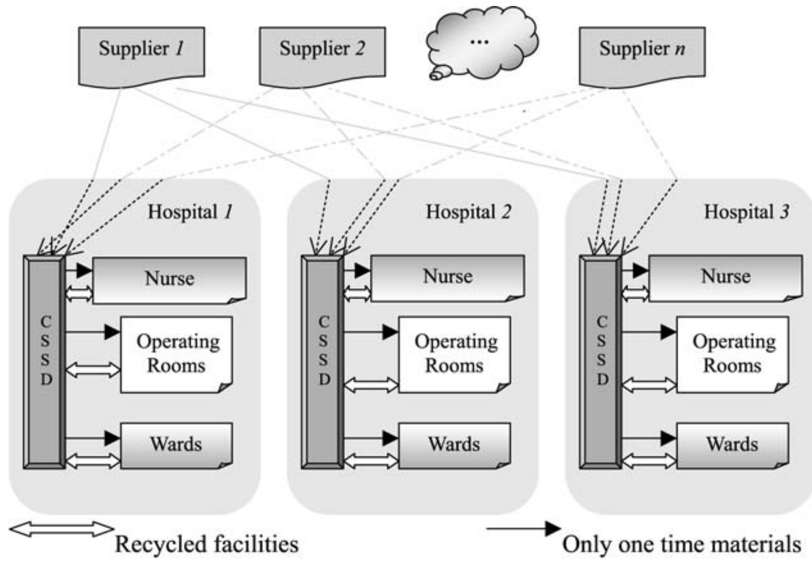
The three hospitals' scales are large, medium, and small. Periodically, the suppliers separately meet the requirements of the CSSD in each hospital according to orders and emergency needs. After processing in the CSSD, items and equipment are dispatched to nurse stations, operating rooms and wards by CSSD staff. Meanwhile, the staff takes back recycled items such as surgical instruments.

Opportunities of process reengineering

Generally, healthcare environments are likely candidates for business process reengineering, because their operations are repetitive, have reasonably high volume, and deal with tangible items such as mail, bills, soft goods and medical appliances. There are two opportunities in this research where reengineering is applied:

1 centralized supply system; and
2 materials management.

Figure 2 Present external supply chain



Centralized supply

The role of centralized supply is diminished in a reengineering environment due to a decreased need for storing goods between supplier delivery and internal delivery to departments. An efficient hospital would receive items from a supplier to go straight to the appropriate unit. This would be the blueprint in the redesign of supply chain, in which the supply of CSSD functions would be eliminated in each hospital. A new distribution center could be built to store materials from suppliers and sterilize and pack soiled medical instruments.

Materials management

Materials management creates opportunities for applying reengineering principles to healthcare. The relationships with suppliers focus on three areas:

1 reducing the number of suppliers;
2 using suppliers that are geographically closer to the hospital; and
3 improving relationships with suppliers.

The new distribution center is to embody these relationships. Since existing CSSDs will be reorganized into a single center, the number of suppliers will decrease. With the reduction in the number of suppliers, communication between the center and the suppliers will intensify. As to the location chosen, it should be optimized considering the distance between the hospitals and the suppliers.

"To be" supply chain management

The proposed supply chain reengineering affects all components of the external medical supply system, including the manufacturers, wholesalers, and their distribution channels. Using reengineering principles, a new scenario model has been designed, as illustrated in Figure 3. The CSSDs are to be combined into a single CSSD center, resulting in the elimination of supplies delivery at a loading dock in each hospital. Instead, staff can deliver orders directly to the hospital corridors from the center, dropping them to the stock supply closets in the nursing stations, operating rooms, and wards. This creates a "stockless inventory" effect serving as the hospital's warehouse and result in reduced storage space and personnel (Evans, 1997).

In the new system, labor utilization increases while inventory levels, fill rates diminish. The linkage between hospitals is achieved by a common network that allows for the sharing of expensive life-critical supplies and medical staff. Such partnerships help healthcare facilities to manage limited resources, resulting in savings and the possibility of other hospitals in Singapore joining the network. In a network, the marginal cost of adding another participant is about zero, whereas the marginal gain is much larger (Laudon and Laudon, 1998).

Supply chain modeling: simulation model

In order to reduce implementation risks, newly designed supply chain models must be evaluated in different aspects, such as cost, a combination of cost and customer responsiveness, system dynamics, inventory management, and minimum-cost production and distribution scheduling.

The conceptual model developed above is tested by simulation using the ProcessModel process reengineering tool.

"As is" supply chain modeling

Figure 4 shows the existing supply chain supported by ProcessModel. Three sorts of basic items – namely soft goods, linen, and surgical instruments – are defined as an Entity according to the terminology in ProcessModel, which are shown as solid balls. The reception areas of the clean store materials and soiled goods are pointed to the element of Storage, namely Store_x, and shown as triangles in the figure, as well as the sterile stores (Sterile Store_x). Store_x substitutes Store_1, Store_2 and Store_3, as well as Softgoods_x, Linen_x, Instruments_x, Pack_x, Sterile_x, Secondary Pack_x, Sterile Store_x, Inspect_x, Issue_x and Users_x. Moreover, Users_x stands for the operating rooms, the wards, and the nurse stations. Function areas such as packing, sterilization, and issuing areas are assigned to

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Figure 3 External supply chain reengineering

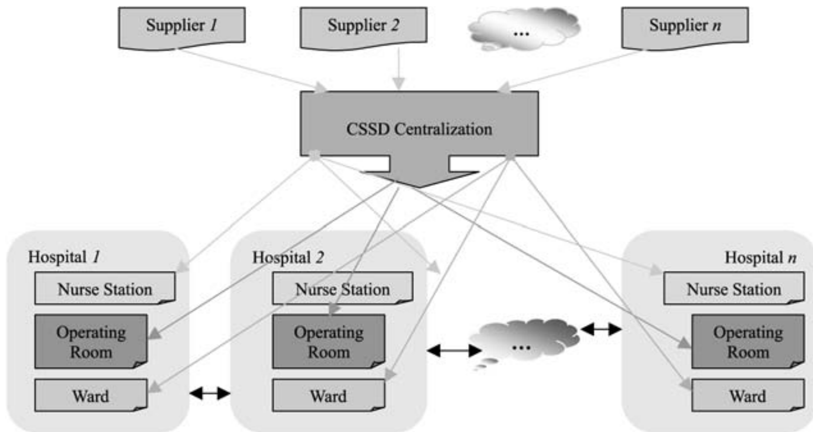
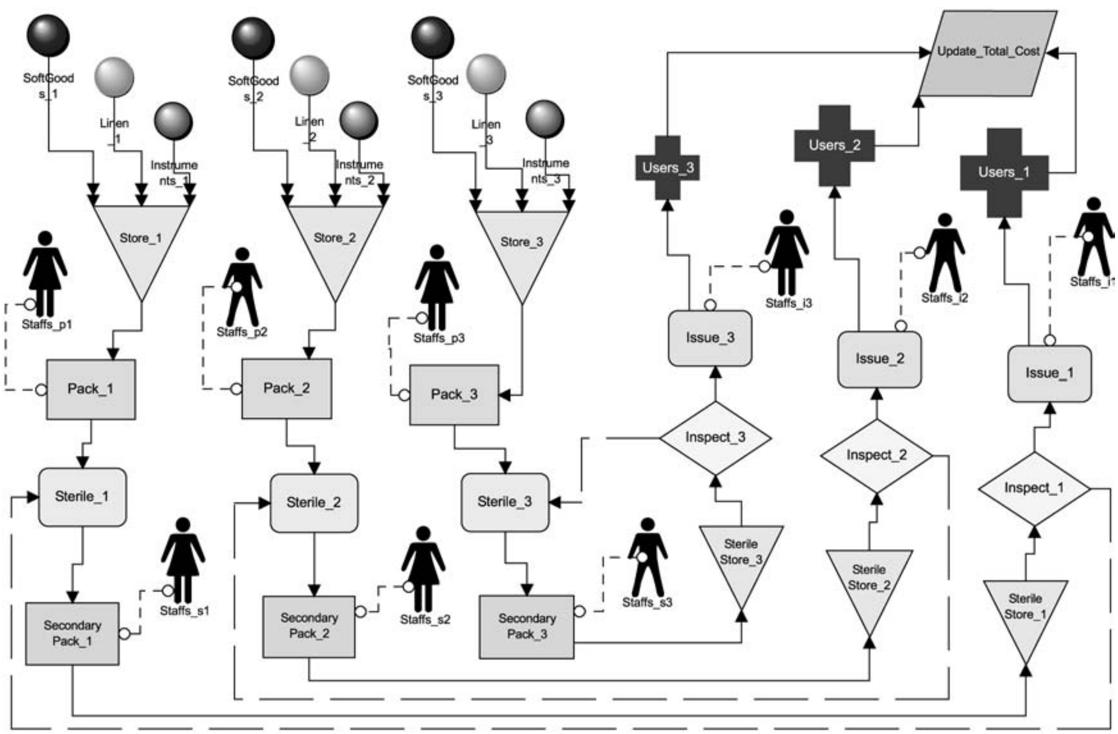


Figure 4 Existing supply chain



Activity. Resource is composed of the staff. The sequence is arranged on the basis of the conceptual models.

There are three separate processes in Figure 4 to embody the functions of the CSSDs, which are all from Store_x to Issue_x. The storages of Store_x are the places to receive recycled materials from the operating rooms, wards, and nurse stations, and to receive new materials, which are delivered separately to the CSSD in each hospital according to the orders and emergency needs. The entities of SoftGoods_x, Linen_x and Instruments_x represent these arrivals. The activities from Pack_x to Inspect_x are executed in every CSSD. Both one-time materials and recycled facilities are subject to the processes/activities of Pack_x, Sterile_x, and Secondary Pack_x. Then, packages are put into the storages of Sterile Store_x. The activity of Inspect_x is an unavoidable key and the last procedure in the internal supply chain, supported by the staff in the CSSD. Unqualified packages, which expire by deadline or are exposed accidentally to the air, are sent back to the activity of Sterile_x. After the sterilizing procedures in CSSD, items and facilities are dispatched to the nurse stations, operating rooms and wards, which is the function of the activity of Issue_x. Explicitly, the activities of User_x, which are shown by the crosses, indicate the nurse stations, operating rooms and wards in the hospitals. The sizes of these crosses indicate the scale of the facilities. Furthermore, total cost update can be invoked by iterative addition. Such calculation is completed by the activity of Update_Total_Cost according to the parameters set in the properties dialogs.

"To be" supply chain modeling

The redesigned supply chain model is shown in Figure 5. In the redesigned supply chain, the CSSD center is divided into several functional areas: reception, decontamination, sterile, packing areas, etc. Thus, in the simulation model, the supplies are delivered to the reception area and stored separately in terms of their types. Three storages are set as Instruments_Store, Linen_Store, and SoftGoods_Store. Specific rules exist that constrain the activity sequence. For example, everything cannot be sterilized before being packed; the customers can, however, order at any time during the process.

Performance evaluation

Three performance indicators are combined to analyze the supply chain system comprehensively. Performance evaluation is on the basis of the state and utilization graphs, and time series plots.

Model analysis of present status

This analysis is in line with the results from a 400 hour-simulation of the existing supply chain model. Figure 6 shows the percentage of time that each activity in the system is utilized. The activities and storage information are organized by logical locations. Figure 7 shows the percentage of time each resource is used and the relative amount of time each resource spends in a particular state.

The resources of Staffs_i1, Staffs_i2, Staffs_p1.1, Staffs_p1.2, Staffs_p1.3, Staffs_p1, Staffs_p2.1, Staffs_p2.1 and Staffs_p2 are almost fully in use.

Figure 8 illustrates a time series plot for the variable total cost value over the 400 hours' simulation. The x and y axes are time (in hours) and cost units. The existing system reaches a cost of 45,000 units over the run-time of 400 hours. The cost unit is not the practical cost in dollars, but the relative values used as performance measures of choice for many supply chain models. Therefore, it is important as a resource measure. The total cost here includes inventory and operating costs. The plot is a smooth straight line and is compared with Figure 9.

Model analysis of future perspective

This analysis is based on the results from a 400-hour-simulation of the "to be" supply chain model. Figure 10 shows the percentage of time that each activity in the system is utilized and all multi-capacity activities in the model. Only the multiple capacity activities of Hospital_1_inQ, Hopital_1_outQ, Hospital_2_inQ, Hopital_2_outQ, Hospital_3_inQ, Hospital_3_outQ, and Hospital_3 are almost empty, which may embody the philosophy of JIT. Other activities are utilized at different levels.

Figure 11 shows the percentage relative amount of time each resource spends in a particular state. All resources are used with varying rates, and the resource Staffs_i is fully in use.

The time series plot (Figure 9) for the variable total cost value shows the history of the variable over 400 hours of simulation. The plot is similar to Figure 8, where the existing system reaches the cost of 45,000 units, while the redesigned system results in a cost of 12,000 units, a reduction of approximately 75 percent. Although the latter is only a result of simulation, the virtual cost reduction is impressive. Cost has emerged as the most important competitive attribute in supply chain management. Not only the hospital itself but

Figure 5 "To be" supply chain

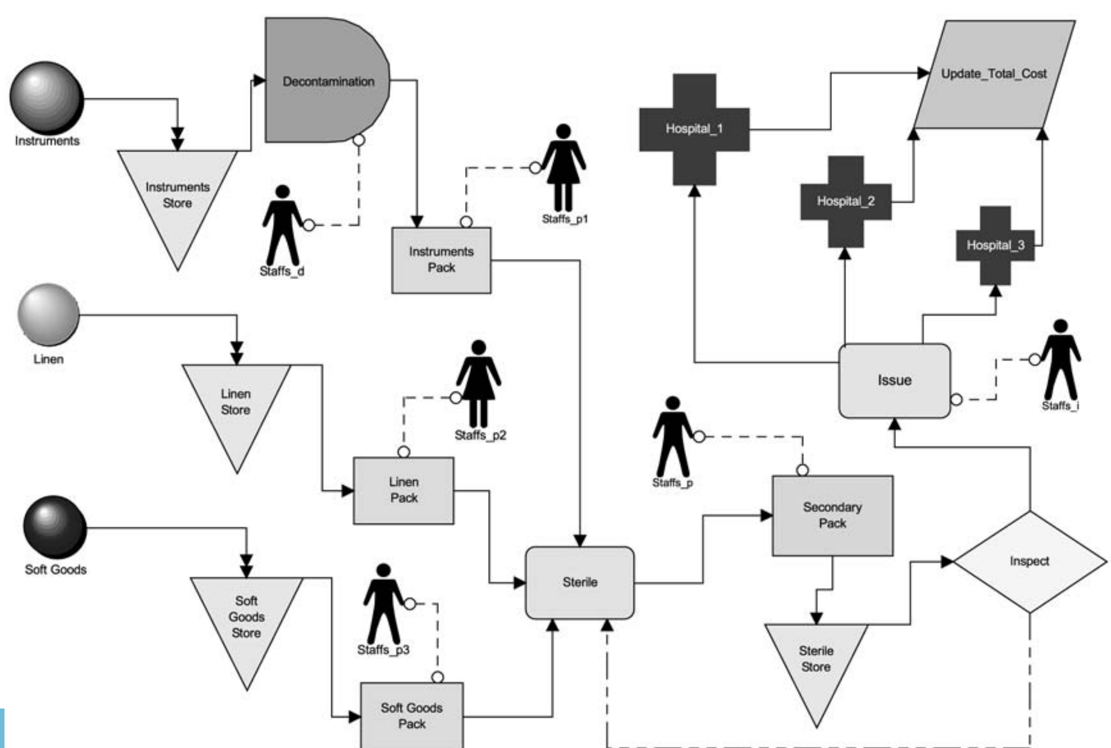


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Figure 6 Activity utilization (I)

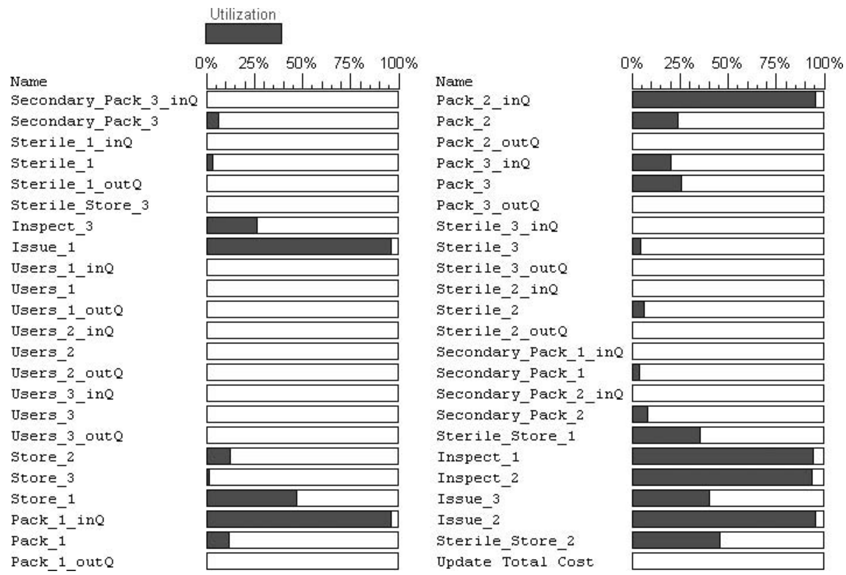
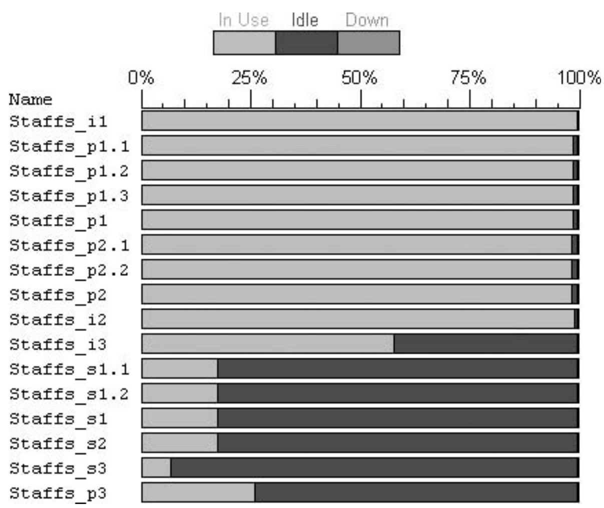


Figure 7 Resource states (I)



also the customer benefits from reduced costs, as benefits are mutual.

In the existing model, utilization rates are zero for 20 activities, and less than 25 percent for 22 activities related to crucial procedures such as Pack and Sterile, and around 95 percent for only six activities. Thus, most of the activities are underutilized.

In the redesigned system, more than half of the activities reach the utilization rate of 50 percent. Several significant activities are almost fully used. Comparing resource utilization, the staff in the large and medium hospitals seems to be busy; however, in the small hospital, staff are idle. The reengineering model provides a more efficient solution with reduced staff. Staffs_i is fully used, implying that staff are busy delivering and distributing materials to terminals.

Conclusions

With the help of a survey questionnaire, the current status of IT implementation, outsourcing opportunities, inventory

Figure 8 Total cost value-plot (400 hr) (I)

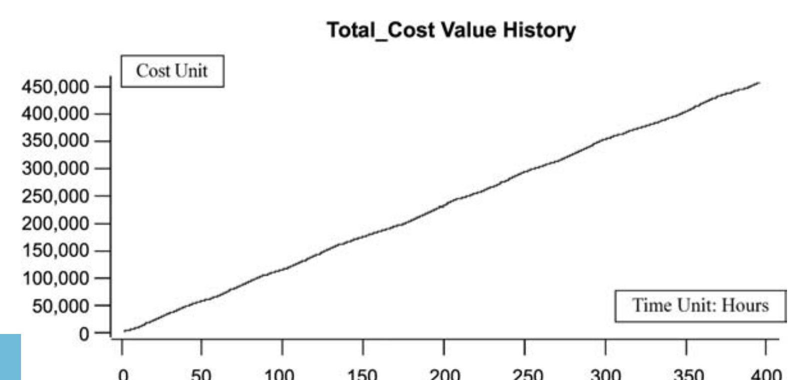


Figure 9 Total cost value-plot (400 h) (II)

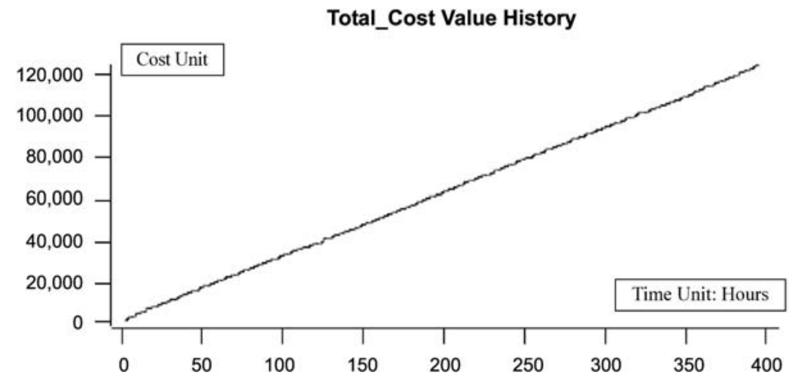


Figure 10 Activity utilization (II) (II)

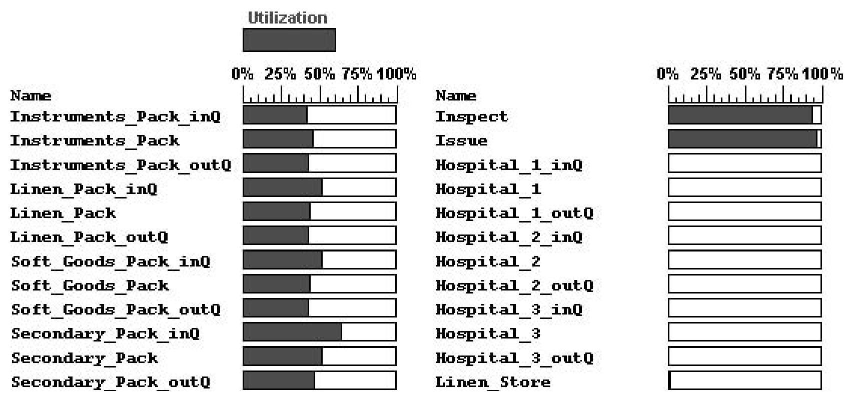
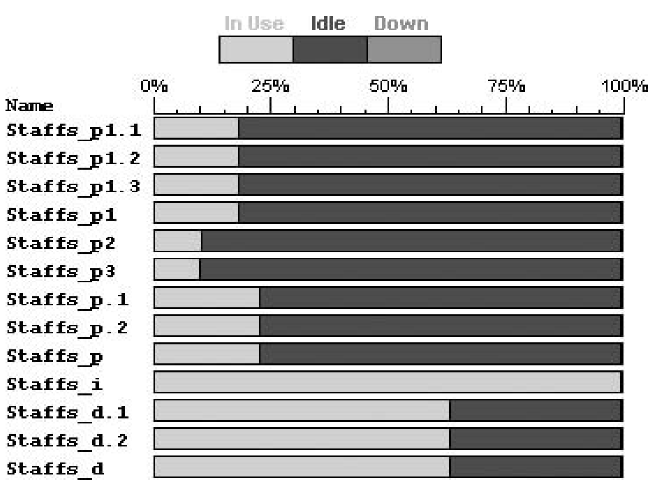


Figure 11 Resource states (II)



reductions, just-in-time applications, and restructuring are identified for the healthcare industry in Singapore. It is found that almost all supplies are retrieved through local agents, so daily delivery is possible and even JIT purchasing is feasible. At least a safety stock for four days of most supplies (65 percent) can be eliminated. Further, outsourcing is the potential area for integrating sterile supplies with other hospitals, leading to process reengineering. Each hospital has more than six suppliers and their cooperation and coordination will assist in outsourcing implementation. The most paramount problem in IT implementation in healthcare systems is the high initial cost, followed by a lack of expertise. IT implementation or using electronic means with suppliers is in its early stages.

The establishment of the conceptual model of the proposed centralized coordination mechanism is on the basis of the survey, the tours and the information collected. The opportunities of process reengineering have also been proposed and described, which leads to just-in-time philosophy. The simulation study has addressed the concept of process orientation and the advantages of process-oriented supply chain management. In the redesigned system, more than half of the activities reach a utilization rate of 50 percent. Several significant activities are almost fully occupied, but the activities of Store have space for improvement. The reengineering model provides a more efficient solution with fewer staff, resulting in a cost reduction of 60 percent. Singapore hospitals still need to have full confidence that integrating logistics concepts in their systems would result in reduced costs.

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About the authors

Arun Kumar is an Associate Professor of Systems and Engineering Management at Nanyang Technological University, Singapore. Prior to joining Nanyang Technological University, he was employed as an Associate Professor of Decision Sciences at the State University of New Jersey. He obtained his PhD in Operations Research from Virginia Tech. His research interests are in reliability, logistics and health care systems. Arun Kumar is the corresponding author and can be contacted at: makumar@ntu.edu.sg

Linet Ozdamar is an Associate Professor of Systems and Engineering Management at Nanyang Technological University, Singapore. She obtained her PhDdegree in Operations Research from Bogazici University, Istanbul. Her research interests are in global optimization, health care systems, logistics and uncertainty.

Chun Ning Zhang is a research staff member at the Singapore Institute of Manufacturing Technology. She obtained her MEng degree in Engineering Management from Nanyang Technological University, Singapore. Her research interests are in health care systems and supply chain management.