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Benchmarking as a tool for the improvement of health services' supply departments

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This paper presents a benchmarking study carried out on the supply departments of Quebec's health services. The paper begins with the definition of a methodology to collect the information needed, both environmental (to enable institutions to be sorted into homogenous groups) and performance related. The analysis of indicators and the data envelopment analysis (DEA) models allowed classification of each hospital's performance and explained the operational approaches used, either at a general level or for each subprocess of the supply chain. It was observed that important economies of scale may be achieved with better co-ordination and with the regrouping of the supplying activities, both for purchasing management and central store management. The study showed that the best performance of central store services comes with flexible administrative structures, by receiving packages as small as possible and by using employees from the lowest range of the hierarchy. Purchasing services should employ highly qualified and well-paid staff. Although such services are relatively small with respect to their purchase volume, they show a higher activity rate. As a result of the discovered performing strategies, the possible economies range from 20% to 30% of the actual supply-chain management cost.

Introduction

The financial resources allocated to medical care are becoming increasingly limited in Western countries; health services managers must focus on mechanisms for the improvement of operations and on cost reduction in order to maintain the level of service required by the population.

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Varied literature can be found on Total Quality Management (TQM) projects on hospitals' medical structures (Omachonu, 1991; Brashier *et al.*, 1996), on physicians' performance (Chilingerian, 1995) or on cost-allocation strategies (Puig-Junoy, 2000). Even though there is no doubt that these projects allow important improvements in care, health services managers have neglected until recently an important part of the administrative structure, the supply chain.

To date, the managers in charge of supplying a hospital's products used different operational approaches developed throughout the years, but these working methods were just reactions to administrative and medical constraints instead of real strategies of a performing

service. In some cases, the reception docks, the product distribution mechanisms or central stores have been forgotten in the design of a new establishment, and the hospital administration has focused on the surgical units, research laboratories or patients' rooms. Only after the construction has been finished have they realized omission, consequently adapting the supply processes to the space rescued here and there. In this context, an optimized management of the supply chain becomes impossible.

This paper presents a benchmarking study carried out on the supply departments of Quebec's health services and presents a precise image of the supply departments. By studying the management processes and methods of 11 establishments, we were able to describe the approaches used and the relative performance of each one. The next section describes the methodology of the project, followed by an analysis of the benchmarking study, observing the performance of each establishment and the variables that justify it. The paper ends with suggestions for future work.

Project methodology

Benchmarking has become an essential tool for discovery of the best performing strategies and approaches. The managers implement different techniques for the performance analysis of best practice organizations and try to determine the reasons for this remarkable performance. According to the terminology established by Xerox Inc. — one of the first companies that used benchmarking under a methodological approach — this tool becomes the continuous process of measuring products, services and practices against the company's toughest competitors or those companies renowned as industry leaders (Camp and Tweet, 1994).

Benchmarking is a practical management tool. Thus, the development of a project may follow different approaches (Camp and Tweet, 1994; Kennedy, 1994; Mosel and Gift, 1994), all of them adequate depending on the situation or context. Benchmarking is an improvement methodology used in a multitude of fields and different authors have studied high-tech companies' supply chains (Cohen *et al.*, 1997), construction companies' supplies processes (Plemmons and Bell, 1995) or local governments' purchasing strategies (McCampbell and Slaich, 1995). Regarding the health sector, studies of supply processes have been centred more on costs perspectives (Egbelu *et al.*, 1998), on re-engineering (Connor, 1998) or on inventory management (Vollman *et al.*, 1998), but, to the best of our knowledge, there is no up-to-date global benchmarking project of different hospital supply departments.

The aim of applying this benchmark to health services' supply chains is, first, to increase the knowledge of the different operational approaches implemented by the managers, and second, to discover the best strategies and working methods in order to permit other establishments to implement them. The project methodology has been organized following three main steps: (1) detailed analysis of the different supply management strategies; (2) data collection and normalization; and (3) analysis of the data.

Study of the supply chain

In order to become familiar with the different supply management strategies, several visits to public healthcare services in Quebec, Ontario and Europe were carried out. The aim of these visits was to analyse current and future supply chain management approaches. Usually, healthcare organizations use the supply department to manage the purchases and the internal distribution of most of the products, whereas the department of pharmacy manages medication and pharmaceutics. In the province of Quebec, Regional Health Boards co-ordinate the contract negotiation of common products for all the hospitals in the region.

The departments dealing with the supplies replenishment are organized into two services. The purchasing service manages the contract negotiation specific to the type of care offered by the establishment, places the purchase orders and defines the operational characteristics for the products. The central store service has responsibility for receiving the merchandise at the docks, controlling the central store inventory, delivering the products to the final users, and, occasionally, managing the local storage units (LSU) — decentralized warehouses near the consumption place.

This working structure allows the implementation of quite different management strategies, although it is difficult to establish *a priori* which is the best performing. Several establishments

group all the supply activities in a unique department. Others prefer to reinforce purchasing management in order to negotiate more contracts — and in more detail — and place a higher number of purchase orders; or they prefer to emphasize central store management, internal product distribution and inventory control.[1]

Data collection and treatment

Among more than 100 Quebec health establishments, the Quebec hospital suppliers professional association (Association des gestionnaires des approvisionnements des établissements de santé du Québec (AGAESQ)) selected 30 establishments to participate in the study. The main criterion for their selection was their ability to collect the data. In the Association's opinion, several hospitals were not even able to collect the daily operational information needed, mainly due to technical development, managers' knowledge or even the nonexistence of proper administrative structures for supply management. Consequently, the 30 supply departments contacted may be regarded as the best performing and best managed.

With the co-operation of the AGAESQ and the supply managers, a detailed brochure was created and sent to each participant. This brochure included: (a) the questionnaire asking for the data needed; (b) the project planning description; (c) the hospital supply chain process description; (d) a confidentiality agreement; and (e) a terminology glossary giving the precise meaning of each concept used in the questionnaire.[2] After the questionnaire was received, the information was validated by means of telephone interviews and meetings among the participants. Out of the 30 hospitals contacted, 18 returned the questionnaire. However, once data normalization was carried out, only 11 supply departments were selected for analysis.[3]

[1]For a more detailed description of the operational processes and the actors in the supply chain see Dacosta-Claro *et al.*, 2002.

[2]If interested, please contact the corresponding author to receive the brochure, with the questionnaire and the documentation sent.

[3]The seven hospitals discharged were among the eight smallest.

Analysis of results

The data received can be analysed in various ways. However, the main goal of the project was to assess the performance of different supply strategies. Hence, the analysis chosen allowed us to determine: (1) the performance of each strategy; (2) the environmental factors that influenced strategy development; and (3) the operational aspects that determined the strategy.

Benchmarking study

Before starting to discuss the different approaches available to manage health services supplies, it is important to define performance. When can a supply management approach be considered to be performing well? What are the different concepts that influence the performance of a department? Are there different performances?

When applying Farrell's (1957) definitions of performance to our study, a health services supply department is technically efficient if, after an input reduction — with a given production function — only an increase in other inputs will allow the same level of output. If the input is missing the outputs will decrease. A department has allocated inefficiently if the combination of inputs used is not optimal, that is, the department could distribute the inputs using another allocation approach and expect to obtain the same outputs with fewer resources.

Following this definition of performance, it is important to define the outputs and inputs of the supply department. The main outputs of the department consist of: (a) the volume of transactions; and (b) the level of service offered to the customers. A glimpse of the volume of transactions comes with the purchase volume managed by the staff per year. Generally, a larger volume means more negotiations, more purchase orders, more receptions and more deliveries to the LSUs. The definition and treatment of this indicator is carried out according to the value of purchases in dollars, considering the purchase costs, the merchandise delivery costs, the order costs and even the return costs.

The second output of the department measures the level of service offered to the hospital's medical and administrative staff. Along with the volume of activity managed, the performance of a strategy depends on the service offered and on customers' satisfaction.

Some coherence problems may arise when measuring this aspect in different establishments since satisfaction depends on the customers' perception of the activities performed. To avoid such subjective comparisons, customer satisfaction is defined using two indicators: (1) the number of stock ruptures; and (2) the period for the treatment of an LSU replenishment order. The first indicator refers to the number of times per year a product is not available when requested by the customers. The period for the treatment of a replenishment order, in contrast, tries to measure the response time to customers' needs. In order to do so, two different concepts have been considered: (1) the time between the placement of a replenishment order with the central store and the product being received by the LSU; (2) the time between the purchasing service receiving the order and the placement of the purchase order with the provider.

In this definition of the delay of replenishment, the delivery period required by the suppliers has not been considered. Since the establishments' geographical location has an important impact on the suppliers' deliveries, its inclusion might penalize the region's remote hospitals for something that the managers have no control over.

This definition of the outputs may seem too limited at first sight. Therefore participants of the study suggested the inclusion of indicators based more on the employees' activity level, such as the number of purchase orders, the stock level, the number of LSUs managed by the department or the number of receptions performed. Even though these aspects of the supply chain are important to understand the work carried out and the approaches used by the managers, one should not confuse them with the outputs of the process. The number of purchase orders is a strategic choice in the hands of the department's manager. He/she may decide to regroup the orders, contacting the supplier only for orders higher than $3500, to reduce the delivery costs of the merchandise and the order costs paid to the providers. Or alternatively, the manager may encourage the placement of purchase orders of small quantities and reduce the inventory. Under these circumstances, the employees' activity level becomes an indicator of the strategy used and not of the output.

Two indicators measure the supply chain inputs: (a) the number of working hours; and (b) the financial expenses encountered to offer the service. This last indicator is measured in dollars and includes two types of expenses: (1) operational expenses; and (2) inventory costs. Operational expenses comprise salaries, information systems, furniture, and membership fees of the purchasing group.

Inventory costs depend on the inventory value of the hospital's central store and include: (1) the cost of space used in the hospital; (2) the cost of products that exceed their expiry date; and (3) the financial costs of immobilized resources. Considering that in private companies the inventory costs may reach 20–40% (Ganeshan, 1999), the managers establish a 15% rate of the value of inventory as more appropriate given that a part of the storage costs — central store's staff and furniture for operations — is already included in the operational expenses.

Short-term stay establishments (ST) have a medical environment different to that of long-term stay hospitals (LT). Thus, ST hospitals, even with a smaller number of beds, present higher hospital budgets and purchase volumes. Moreover, their production processes demand more expensive products, requiring different purchasing and storage processes. Therefore, the hospital medical orientation must be considered in the comparison analysis.

Table 1 shows the indicators needed to compare the performance of the hospitals that participated.[4] When analysing the inputs and outputs, several conclusions on the structure of the two groups may be drawn. The eight ST hospitals present budgets between $34 million and $195 million, to satisfy the operational needs of between 156 and 851 beds. The average ST hospital spends $104 million on the management of 486 beds, from which $23 million is used for purchasing products and services. The supply departments' budgets vary from $265 000 to $1 410 000, the average being $780 000. They use 32 000 hours per year to accomplish supply tasks. The technological level, which measures the relationship between the hospital's purchases and the hospital's budget, varies considerably between 18% and 33%. Usually, a higher technological level reveals the use of more expensive products to accomplish the hospital's medical care services.

[4]All data correspond to one fiscal year's activities and are expressed in Canadian dollars.

Table 1 *Supply departments' performance measures*

	Short-term			Long-term		
	Average	Min	Max	Average	Min	Max
Hospital's budget	$104.5m	$34.40m	$195.0m	$89.27m	$66.20m	$121.6m
Number of beds	486	156	851	977	551	1545
Technological level	26%	18%	33%	17%	15%	20%
Department's budget	$782 834	$263 164	$1 405 880	$623 456	$288 051	$1 072 120
Value of stock	$639 194	$195 000	$1 611 375	$826 681	$457 400	$1 396 241
Total expenses	$878 713	$296 848	$1 526 905	$747 458	$356 661	$1 166 080
Working hours	32 162	11 882	56 692	24 094	15 022	32 520
Value of purchases	$23.58m	$4.97m	$49.25m	$14.66m	$10.00m	$20.98m
Stock ruptures	105	12	264	228	24	600
Repositioning period	3.86	1.00	10.50	1.58	1.00	2.50
Total cost per $1000	$44.47	$31.01	$64.01	$48.87	$35.67	$55.58

m, million

The three LT establishments present significantly lower budgets for the same number of beds—the average hospital has a budget of $89 million and 997 beds. By contrast, as far as the supply department's budget is concerned, the differences between the two groups disappear; their expenses to manage the supply activities are slightly lower than those of ST hospitals.

In order to compare the performance of the different hospitals at a financial level, the ratio between the value of purchases and the total expenses gives a quite interesting general overview (Figure 1). ST hospitals spend, on average, 10% less on the management of their purchases than LT hospitals. However, this analysis of average values is found to be too general since the differences within the groups are remarkable ($33 in the short term and $20 in the long term).

In the case of ST hospitals there are two different groups. The first five hospitals are the largest of the group with budgets ranging between $90 and $195 million. For these establishments, the management of $1000 purchases implies costs

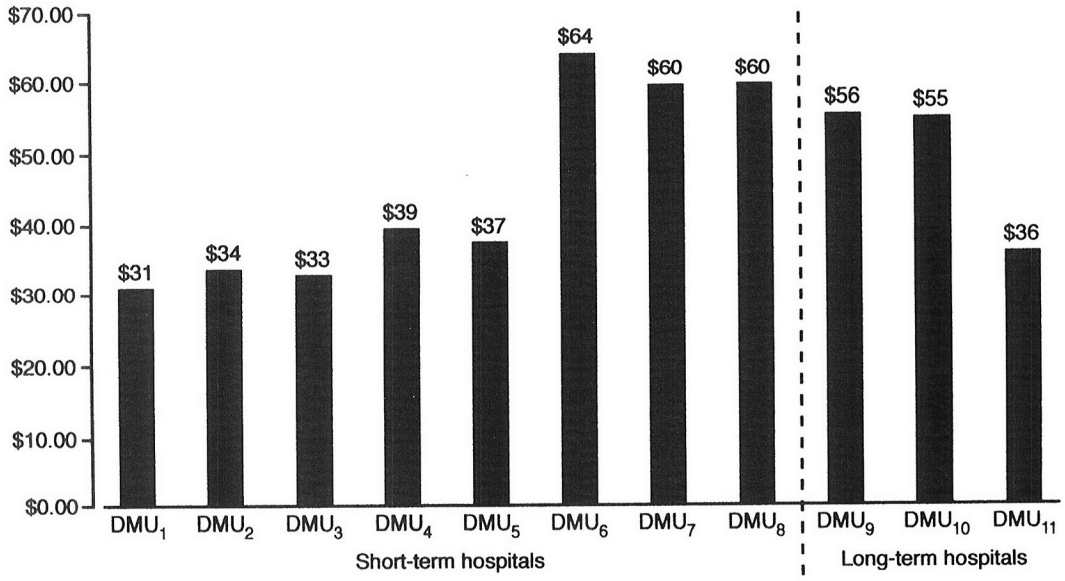

Fig. 1 *Total management costs per $1000 purchase. DMU, decision-making unit*

between $31 and $39. With regard to the environmental factors, two indicators must be studied before comparing these five hospitals. First, the technological level ranges between 23% and 33%, that is, the medical care demands relatively different products. Second, the involvement rate of the supply department, which measures the relation between the purchases managed by the supply department against the total hospital purchases. In four hospitals this varies between 71% and 80%, whereas the other is in charge of 100% of the purchases.

Regarding the small ST hospitals, the management costs of a $1000 purchase is double the costs of large ST hospitals, with figures ranging between $60 and $64. With budgets ranging from $34 to $78 million, two establishments use a unique department to manage all the purchases and the third establishment leaves 19% of the purchases for the department of pharmacy.

The higher management costs for LT hospitals do not necessarily entail a worse performance, since a part of the costs may depend on factors typical of long-term care. The most economical LT hospital, with a budget of $66 million, only spends $36 per $1000 purchase, figures comparable with the best-performing ST hospitals. The two largest LT hospitals have similar environmental variables but spend almost twice as much as the best-performing LT hospital.

The analysis previously carried out considers merely the economic perspective of supplies without taking into account the level of service offered. It could happen that a department spends more financial resources in order to reduce the number of stock ruptures or to respond faster to customers' needs. In order to take into account numerous variables — either in the inputs or in the outputs — Data Envelopment Analysis (DEA) methods may be used.

DEA models

Data Envelopment Analysis, initially developed by Charnes *et al.* (1978) is a mathematical technique that generalizes the approach of ratios single-input/single-output previously used in the multi-input/multi-output models, in order to evaluate the performance of many relatively homogeneous entities, called Decision-Making Units (DMUs).

The objective of DEA is to find a performance ratio, between 0 and 1, and a group of multipliers for the inputs and outputs (v and u, respectively) of each DMU. These multipliers try to maximize the ratio weighted output to weighted input provided that any other DMU does not reach an efficiency score higher than 1 with the same set of multipliers. The DMUs obtaining a ratio of 1 are defined as efficient and the DMUs presenting a ratio lower than 1 are classified as inefficient since, even in the most advantageous situation, they do not have a group of multipliers that would allow them to achieve the maximal performance ratio.

Hence, our model of ratios for the performance measurement of health services supply departments in the Charnes, Cooper and Rhodes (CCR) model may be presented as:

Maximize:

$$E_k = \frac{\sum_{r=1}^{R} u_{rk} * y_{rk}}{\sum_{i=1}^{I} v_{ik} * x_{ik}}$$

Subject to:

$$\frac{\sum_{r=1}^{R} u_{rk} * y_{rj}}{\sum_{i=1}^{I} v_{ik} * x_{ij}} \leqslant 1 \quad for\ j = 1, \ldots, N$$

$$u_{rk} \geqslant \varepsilon \quad for\ r = 1, \ldots, R$$

$$v_{ik} \geqslant \varepsilon \quad for\ i = 1, \ldots, I$$

Where:

E_k = the efficiency of establishment K (DMU_k)
y_{rk} = the output r produced by the DMU_k
x_{1k} = the input 1 used by the DMU_k
u_{rk} = the importance assigned to the output r in the DMU_k
v_{1k} = the importance assigned to the input 1 in the DMU_k
N = the number of DMUs
R = the number of outputs
I = the number of inputs

For their mathematical treatment, these equations must be transformed into their linear form, so methods of linear programming can be applied; however, its explanation does not concern the objectives of the present paper.[5]

Supply department

Under these circumstances, the DEA models can be applied to health services supply departments. The objective of this study has been to define the relative performance of the 11

[5]For more information on DEA and the different existing models, see Charnes *et al.*, 1997 or Cooper *et al.*, 2000.

Table 2 *Results of data envelopment analysis (DEA) models applied to the supply department*

		CRS		VRS	
		Rate	Benchmarks	Rate	Benchmarks
DMU_1	ST	1.0000	—	1.0000	—
DMU_2	ST	0.9758	DMU_1(0.92), DMU_3(0.01)	0.9789	DMU_1(0.89),DMU_3(0.04),DMU_{11}(0.07)
DMU_3	ST	1.0000	—	1.0000	—
DMU_4	ST	0.8040	DMU_1(0.19), DMU_3(0.16)	0.9373	DMU_3(0.20), DMU_{11}(0.80)
DMU_5	ST	0.8259	DMU_1(0.38), DMU_3(0.04)	0.8805	DMU_1(0.12),DMU_3(0.24),DMU_{11}(0.64)
DMU_6	ST	0.4844	DMU_1(0.28)	0.5333	DMU_1(0.09), DMU_{11}(0.91)
DMU_7	ST	0.5292	DMU_1(0.13), DMU_3(0.06)	0.7744	DMU_8(0.28), DMU_{11}(0.72)
DMU_8	ST	0.5188	DMU_1(0.10)	1.0000	—
DMU_9	LT	0.9692	DMU_{11}(2.10)	1.0000	—
DMU_{10}	LT	0.7894	DMU_{11}(1.30)	0.8029	DMU_9(0.27), DMU_{11}(0.73)
DMU_{11}	LT	1.0000	—	1.0000	—

departments that participated, trying to satisfy the current outputs of each establishment with the least amount of resources possible. Table 2 shows the results found when applying two DEA models: (1) the constant returns-of-scale (CRS); and (2) the variable returns-of-scale (VRS). For each model, the performance rate of each DMU and peer DMUs is indicated.[6] In order to avoid performance ratios of a difficult practical justification — due to the use of extreme groups of multipliers — a relationship between the multipliers assigned to the outputs has been defined, thus forcing the importance of the volume of transactions being higher than or equal to the other two outputs.

The analysis of the CRS model results confirms the existence of economies of scale in the supply management. Hence, the three ST hospitals with the highest performance are also the largest hospitals of the group. This conclusion seems to be intuitive. The contract negotiation, the placement of purchase orders and even the product reception and distribution leads to important fixed costs, regardless of the number of products treated. For example, a contract negotiation of 100 products or 1000 products may incur quite similar costs, giving rise to smaller unitary costs per product for the larger orders.

Taking into account long-term establishments, the CRS model considers DMU_{11}, the smallest one, as the most efficient either in terms of the internal cost or at the operational management level. It is important to note that DMU_9, the largest LT hospital, reaches an acceptable performance of 0.9692.

The DEA VRS model compares each establishment only with those found in its surroundings. Hence, the VRS ratios in Table 2 may indicate, given the establishment's external characteristics, the performance reached by the managers in their supply management strategies. According to the conclusions of this DEA model, DMU_1, DMU_3, DMU_8, DMU_9 and DMU_{11} are properly managed by their managers and they are located on the high efficiency frontier. Moreover, DMU_2 and DMU_4 may also be considered relatively well managed, and close to the high efficiency frontier. For the remaining DMUs, improvements in their management techniques are possible, observing a performance between 0.5333 and 0.8805.

This analysis is very general — even if the potential savings become important, the way to reach them is not indicated. In order to improve the activities, special attention should be paid to the different processes needed to replenish the establishment, the storage and distribution processes, and the purchasing processes.

Storage and distribution processes

The central store service is in charge of managing product reception at the institution's docks, to be later delivered to the LSUs in the case of direct purchase products, or to the central store for inventory products. The personnel

[6]Hospitals are sorted by budget. DMU_1 and DMU_8 represent the biggest and smallest ST hospitals and DMU_9 to DMU_{11} represent the LT hospitals.

Table 3 *Input data of the supply services department*

		Short-term			Long-term		
		Average	Min	Max	Average	Min	Max
Central store	Central store service budget	$356 488	$111 376	$569 021	$291 501	$111 916	$455 722
	Central store hours	19 108	6111	35 000	15 658	7210	20 404
	Costs per $1000	$18.32	$10.27	$27.55	$18.84	$11.19	$23.60
Purchase	Expenses purchasing service	$405 406	$142 255	$867 203	$247 940	$176 135	$388 353
	Purchase hours	13 055	5771	29 236	8436	5379	12 116
	Costs per $1000	$20.09	$13.67	$29.70	$16.64	$13.79	$18.51

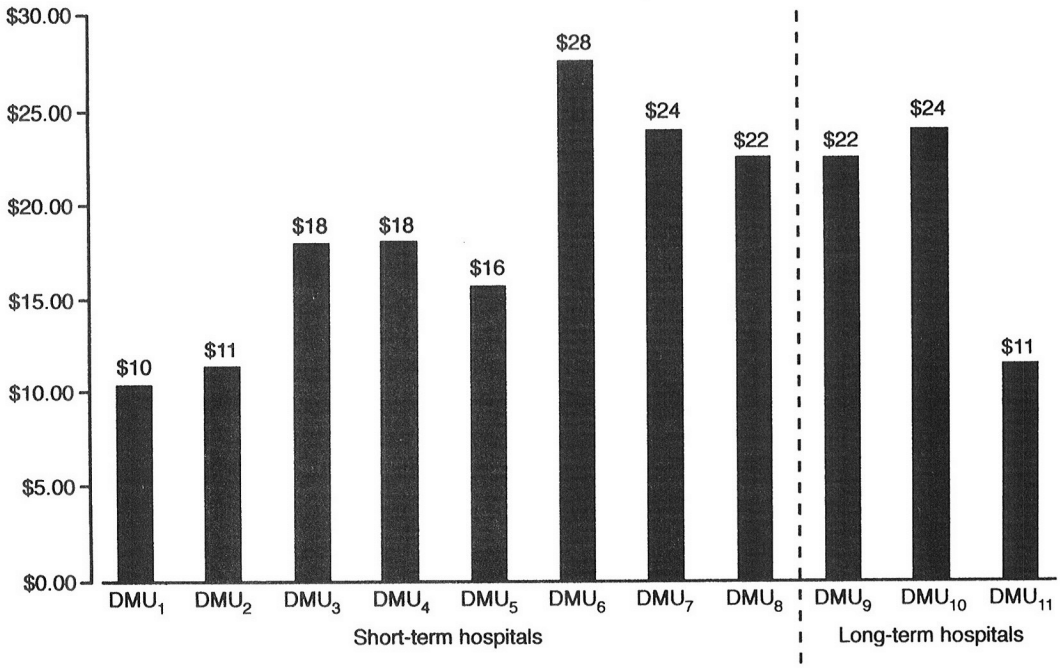

Fig. 2 *Management costs of the central store service. DMU, decision-making unit*

are also in charge of the followup of the inventory in the central store.

The average budget of the service is around $356 000 for ST hospitals and $291 000 for LT hospitals, although important differences can be observed within groups (Table 3). The personnel use 19 000 hours and 15 500 hours to accomplish the product reception and distribution tasks, respectively. The central store services, both in ST and LT hospitals, spend on average $18 for each $1000 purchase. By contrast, as shown in Figure 2, the large variations also found in the management costs per $1000 purchase suggest the existence of rather different working approaches.

In order to compare the performance when taking into account the different inputs and outputs, the CRS and VRS models are applied to the central store service data. The outputs of the central store service are the same as those of the supply department: (1) the volume of transactions; (2) the period for the treatment of a replenishment order; and (3) the number of stock ruptures. Regarding the inputs, a small variation is included for the service's expenses. This input only considers the operational expenses, such as the labour costs and the cost of furniture and leaves aside the costs of inventory and the information systems' expenses due to the impossibility of finding a clear and precise formula to split them. The number of working hours needed to accomplish the department's tasks measure the second input of the department. The performance ratios are shown in Table 4.

As was observed for the whole department, the existence of economies of scale for the ST establishments can be observed for the central store services — only DMU_1 obtains a performance rate of 1. In this analysis, the savings suggested by the CRS model start to be considerable, up to 28% of the total supply management cost.

The analysis of the VRS model ratios becomes more interesting. Only DMU_1, DMU_8, DMU_9 and DMU_{11} present a performance rate of 1, and even though DMU_2 maintains an acceptable performance (0.9098), the management of the rest of the departments could be considerably improved.

When analysing the characteristics of the DMUs located on the high efficiency frontier in the VRS model, several pertinent operational characteristics can be observed. The two performing ST hospitals, DMU_1 and DMU_8, allocate a much higher budgetary importance

Table 4 *Results of data envelopment analysis (DEA) models applied to central store services*

	CRS			VRS		
	Rate	Benchmarks	Savings	Rate	Benchmarks	Savings
DMU_1 ST	1.0000	—	—	1.0000	—	—
DMU_2 ST	0.9082	DMU_1 (0.93)	$47 552	0.9098	DMU_1(0.91), DMU_{11}(0.09)	$46 724
DMU_3 ST	0.7723	DMU_1 (0.65)	$129 566	0.8034	DMU_1(0.56), DMU_{11}(0.44)	$111 870
DMU_4 ST	0.6086	DMU_1 (0.29)	$101 225	0.7181	DMU_1(0.11), DMU_{11}(0.89)	$72 906
DMU_5 ST	0.6595	DMU_1 (0.41)	$106 032	0.6816	DMU_1(0.25), DMU_{11}(0.75)	$99 150
DMU_6 ST	0.3728	DMU_1 (0.28)	$234 067	0.4421	DMU_1(0.09), DMU_{11}(0.91)	$208 204
DMU_7 ST	0.5249	DMU_1 (0.17)	$97 210	0.7558	DMU_8(0.28), DMU_{11}(0.72)	$49 966
DMU_8 ST	0.4579	DMU_1 (0.10)	$60 377	1.0000	—	—
DMU_9 LT	0.7414	DMU_{11} (2.10)	$117 850	1.0000	—	—
DMU_{10} LT	0.4842	DMU_{11} (1.30)	$158 280	0.6708	DMU_9(0.27), DMU_{11}(0.73)	$101 020
DMU_{11} LT	1.0000		—	1.0000	—	—
Total			$1 052 160			$689 839

to the purchasing service, assigning up to 63% of the department's budget to this service. This relative reduction of the central store service's budget leads to salaries which are lower than the average for its employees, $16.87 per hour of work versus $18.31 in the other ST establishments.

When describing the operations of DMU_1, the department only assigns 20% of the purchase orders to products to be stored at the central store, close to the average of ST departments and far away from the limit distributions (6% and 37%). This inventory product consumption amounts to 13% of the total value of purchases, that is, the products stored at the hospitals' five central stores are less expensive than the average. It is important to notice that most of the ST hospitals prefer to store the most expensive products in the central store, in order to reduce the stocks of these products in the LSUs.

The inventory stored in DMU_1's central store is around $800 000, with a turnover rate of 8.26, less than the average rate (10.05). This increased inventory reduces the number of stock ruptures to 12 per year, which accounts for 10% of the problems found in the other hospitals. Two important indicators confirm the use of different approaches in DMU_1. First, the employees use only 0.56 hours to manage each $1000 purchase, which is half the time used in the rest of the ST hospitals (1.02 hours per $1000 purchase). Such considerable difference suggests the use of more flexible and faster working methods. And second, the 74 000 receptions performed at the docks of the hospital amount to an average value of $650 per reception, half of the average value of the rest of the group. Therefore, this hospital prefers smaller and more frequent deliveries in order to make it simpler and, at the same time, reduce the stock in the central store.

DMU_{11}, the only LT establishment found to be efficient in the CCR models, shows relatively similar financial results. Thus, this hospital presents quite low management costs, $11.19 for $1000 of purchases, quite similar to the central store service of DMU_1, although the volume of purchases and the department's budget is 2–3 times smaller. This department also allocates more financial resources to purchase management, 61%. The employees present the lowest cost per hour of the group, $14.99. This figure is lower only in hospital 2 ($11.86), whereas the remaining LT hospitals present costs between $15.85 and $20.95.

Purchasing processes

The purchasing service focuses on external activities such as relations with the providers and with the purchasing group, purchase order placement and contract negotiation for a hospital's particular products.

The ST hospitals' purchasing service presents a budget of $405 000 (Table 3), although important differences can be observed within the group, the largest service spends $850 000 whereas the smallest spends under $150 000. This service employs on average just 13 500 hours to manage and order all the products. For LT hospitals, with an average budget of $250 000, the differences observed are slightly smaller.

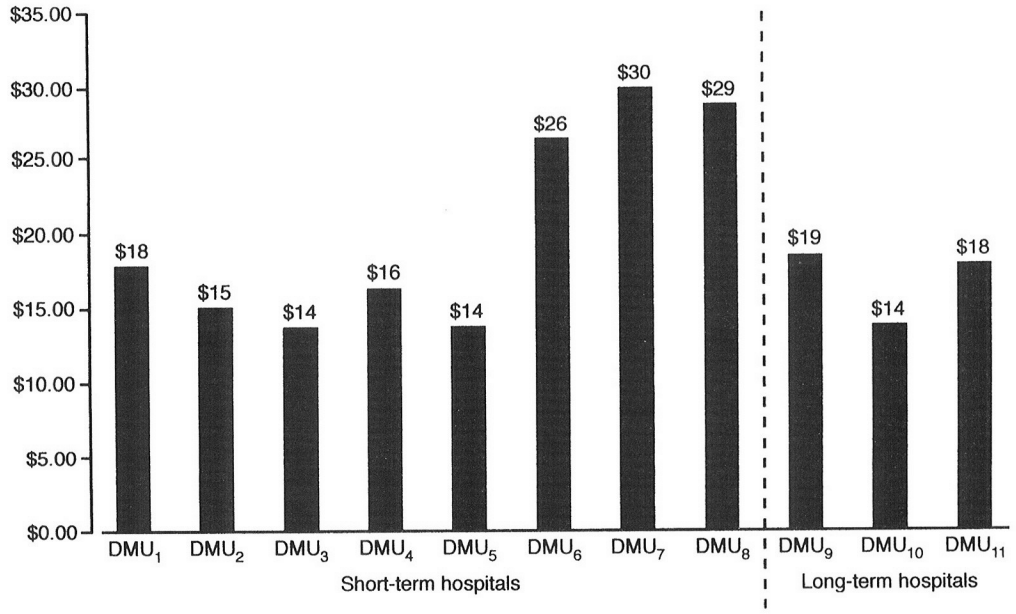

Fig. 3 *Management costs of the purchasing service. DMU, decision-making unit*

Table 5 *Results of data envelopment analysis (DEA) models applied to purchasing services*

	CRS			VRS		
	Rate	Benchmarks	Savings	Rate	Benchmarks	Savings
DMU_1 ST	0.7765	DMU_3(1.54)	\$193 820	1.0000	—	—
DMU_2 ST	0.9351	DMU_3(1.43)	\$43 483	1.0000	—	—
DMU_3 ST	1.0000	—	—	1.0000	—	—
DMU_4 ST	0.8482	DMU_3(0.45)	\$35 361	0.8544	DMU_3(0.08), DMU_{10}(0.92)	\$33 917
DMU_5 ST	0.9716	DMU_3(0.63)	\$7994	0.9751	DMU_3(0.37), DMU_{10}(0.63)	\$7009
DMU_6 ST	0.5199	DMU_3(0.42)	\$171 091	0.5241	DMU_3(0.03), DMU_{10}(0.97)	\$169 594
DMU_7 ST	0.4604	DMU_3(0.27)	\$137 820	0.6226	DMU_8(0.55), DMU_{10}(0.45)	\$96 392
DMU_8 ST	0.4775	DMU_3(0.16)	\$74 328	1.0000	—	—
DMU_9 LT	0.7453	DMU_{10}(1.61)	\$98 914	1.0000	—	—
DMU_{10} LT	1.0000		—	1.0000	—	—
DMU_{11} LT	0.7832	DMU_{10} (0.77)	\$38 186	1.0000	—	—
Total			\$800 998			\$306 913

Regarding the management costs, as shown in Figure 3, the best performing hospitals are not necessarily the largest ones. This fact may also be observed when analysing the results of the DEA models[7] in Table 5.

[7]DEA models for the purchasing service follow the same approach as in the case of the central store service. It considers three outputs: volume of purchases, period for the treatment of a replenishment order, and number of ruptures; and two inputs: number of hours and service's operational expenses, such as the labour costs, costs of furniture and regional health board's membership fees.

The best performing ST purchasing service in the CRS model is DMU_3, presenting a purchase volume of \$32 million. This establishment is neither the biggest nor manages the largest volume of transactions, however it is the hospital that, having a minimum size, has succeeded in implementing a different and efficient management approach. Moreover, confirming the same hypothesis, the two ST hospitals with ratios between 93% and 97%, have relatively large budgets but they are not the largest hospitals. In LT hospitals, the same conclusions

can be drawn; DMU_{10}, presenting an average volume of transactions, has the best performing purchasing service.

Continuing with the conclusions of this analysis, the purchasing services of different hospitals could be merged in order to respond better to the physicians' and nurses' needs. By employing outsourcing models, the hospital would be able to delegate the following responsibilities: (i) communication with customers; (ii) negotiation of contracts with the providers; (iii) placement and followup of the purchase orders; and (iv) definition of the supply policies, for all the establishments. This structure would become a regional purchasing group with increased responsibilities, such as maintaining customer relations and placing purchase order. A large size does not guarantee a remarkable performance in purchase management, it is also important to decode the operational reality that allows remarkable performance.

When analysing the operational characteristics of DMU_3, it can be observed that its purchasing service, with a budget of just 43% of the department's total expenses, spends more per hour of work than all the group. The service's cost per hour is \$43, well above the average (\$29) and significantly more than the ST hospital with the second highest cost per hour (\$35). Under these circumstances, the employees use just 0.32 hours to manage \$1000 purchases, half of the 0.75 hours that the other hospitals use. The service's employees work 10 100 hours — less than the average (13 500 hours) — to manage 30% more purchases. This indicates that the better-paid employees have developed more flexible and efficient management mechanisms.

Regarding the operational context, the differences between DMU_3 and the rest of the hospitals increase. The number of purchase orders placed (38 000) is double the average, placing close to four purchase orders per hour whereas the other hospitals do not reach 1.5. The average value of the orders (\$984) is 30% lower than the rest of the group. It is important to note that this purchasing service places most of the purchase orders for the direct purchase products, leaving just 7% for the inventory products (the average of ST hospitals is 25% of the purchase order in inventory). The department reduces the inventory size in the central store by using more receptions and internal distributions, which is apparently detrimental to the central store service performance (as seen in Table 4), although the central store service of DMU_1 also uses a similar strategy, encouraging the reception of smaller packages.

The VRS models point out several purchasing services managed in a performing way — DMU_1, DMU_2, DMU_3, DMU_5 and DMU_8 for ST hospitals and the three LT hospitals. Such a high number may reveal that the purchasing services remain the most important activity, or, at least, that they receive more attention from the managers than central store management or product distribution. As mentioned by the participants, negotiation and ordering processes, with large volumes and many different products, demand the implementation of capable and rather complex management mechanisms. Moreover, due to the increased complexity in purchasing activity, better purchase management leads to more important savings than focusing on central store management, and therefore must receive prioritized attention. Also, inappropriate management might give rise to additional risks. This conclusion is confirmed by the potential savings shown by both DEA models. The potential economies of a better purchasing service management will reduce the service budget by only 8% and, with the structural reorganization suggested previously, the savings will reach 20%.

Conclusion

The optimized management of health services supply departments may lead to considerable savings and cost reductions for health services — up to 30% — allowing the level of medical care to be maintained or improved upon. The supply chain accounts for over 20% of the hospital's expenses, although this percentage may occasionally increase up to 40%, with resources that amount to 1% of the total budget. Consequently, the choice of the best purchasing approach, inventory control or product distribution, may lead to important reductions in the hospital's expenses with relatively low implementation costs.

By contrast, before changing the departments' approaches and operations, it is important to analyse current performance. In this context, the present study has shown the operational and performance characteristics of 11 Quebec health services. By observing the working processes currently used by the managers, pertinent operational characteristics, environmental variables, and different perfor-

mance approaches have been documented. Central store services present important economies of scale in the management of transaction volumes of $50 million. Since the services' tasks are mainly mechanic (reception, inventory control, package distribution), the well-performing structures are those succeeding in achieving an important flexibility in the operations with lower salaries than the average.

For the purchasing services, the equation is slightly modified. The providers' negotiation and management demand an increased knowledge and training; the performance does not depend on the quantity but on the quality of resources. Hence, the best-performing purchasing services are those who, with less well-paid employees, manage to implement a flexible structure.

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References

Brashier, L. W., Sower, V. E., Motwani, J. and Savoie, M. Implementation of TQM/CQI in the healthcare industry: a comprehensive model. *Benchmarking for Quality Management and Technology* 1996; **3**: 31–50

Camp, R. and Tweet, A. Benchmarking applied to healthcare. *Journal on Quality Improvement* 1994; **20**: 229–238

Charnes, A., Cooper, W. W. and Rhodes, E. Measuring the efficiency of decision-making units. *European Journal of Operational Research* 1978; **2**: 429–444

Charnes, A., Cooper, W. W., Lewin, A. Y. and Seiford, L. M. *Data Envelopment Analysis: Theory, Methodology and Applications*. Boston: Kluwer Academic Publishers, 1997

Chilingerian, J. A. Evaluating physician efficiency in hospitals: a multivariate analysis of best practices. *European Journal of Operational Research* 1995; **80**: 548–574

Cohen, M. A., Zheng, Y.-S. and Agrawal, V. Service parts logistics: a benchmark analysis. *IIE Transactions* 1997; **29**: 627–641

Connor, L. R. Re-engineering healthcare material management. *Journal of the Society for Health Systems* 1998; **5**: 74–89

Cooper, W. W., Seiford, L. M. and Tone, K. *Data Envelopment Analysis: A Comprehensive Text with Models, Applications, References and DEA-Solver Software*. Boston: Kluwer Academic Publishers, 2000

Dacosta, I. C., Lapierre, S. D., Fontaine, J. and St-Laurent, G. *Des indicateurs de performance pour les services d'approvisionnement des établissements de santé*. CRT-2002-47, Montreal: Centre for Research on Transportation, 2002

Egbelu, P. J., Harmonosky, C. M., Ventura, J. A., O'Brien, W. E. and Sommer III, H. J. Cost analysis of hospital material management systems. *Journal of the Society for Health Systems* 1998; **5**: 1–10

Farrell, M. J. The measurement of productive efficiency. *Journal of the Royal Statistical Society Series A* 1957; **120**: 253–281

Ganeshan, R. Managing supply-chain inventories: a multiple retailer, one warehouse, multiple-supplier model. *International Journal of Production Economics* 1999; **59**: 341–354

Kennedy, M. Being benchmarked against: what can organizations expect? *Journal on Quality Improvement* 1994; **20**: 294–298

McCampbell, A. S. and Slaich, L. L. Purchasing efficiency and staffing benchmarks: a county government study. *International Journal of Purchasing and Materials Management* 1995; **4**: 30–36

Mosel, D. and Gift, B. Collaborative benchmarking in healthcare. *Journal on Quality Improvement* 1994; **20**: 239–249

Omachonu, V. K. *Total Quality and Productivity Management in Healthcare Organizations*. Milwaukee: American Society for Quality Control, 1991

Plemmons, J. K. and Bell, L. C. Measuring effectiveness of material management process. *Journal of Management in Engineering* 1995; **6**: 26–32

Puig-Junoy, J. Partitioning input cost efficiency into its allocative and technical components: an empirical DEA application to hospitals. *Socio-economic Planning Sciences* 2000; **34**: 199–218

Vollman, K., Sprung, P., Posa, S., Ladin, D. and Kachhal, S. K. Strategies for reducing material cost through implementation of clinical guidelines. *Journal of the Society for Health Systems* 1998; **5**: 69–73