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Measuring supply chain performance among public hospital laboratories

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Abstract

Purpose – The purpose of this paper is to investigate the efficiency levels of the decision-making units within the public hospital laboratories in using their supply chain towards meeting the satisfaction of doctors.

Design/methodology/approach – Data were collected from two senior laboratory administrators and 30 doctors of two hospital laboratories in Malaysia using two sets of structured questionnaires, which comprised of two dimensions, i.e. doctor satisfaction dimension (DSD) and supply chain inputs (SCI). The dimensions of DSD and SCI were developed and that SCI has been relabeled as hospital laboratory inputs (HLI) to suit the nature of current study. The resulting data were positioned on an importance-performance matrix. By using the data envelopment analysis software, the efficient frontier for both hospital laboratories was calculated under different scenarios.

Findings – Results reveal that one of the laboratories satisfies doctors efficiently using the present levels of HLI for each scenario while the other failed.

Research limitations/implications – The paper focuses only on two hospital laboratories.

Practical implications – The findings offer insights on the important dimensions of DSD and HLI that the hospital laboratories should concentrate on when measuring doctor satisfaction through the utilization of resources they possess. This will undoubtedly lead to better hospital-doctor-patient relationships.

Originality/value – Many prior supply chain studies have focused on patient satisfaction. This paper is probably one of the first attempts that comprehensively examines satisfaction from the perspective of doctors.

Keywords Customer service management, Hospitals, Laboratories, Customer satisfaction, Data analysis, Malaysia

Paper type Research paper

Introduction

Customer satisfaction is a psychological attitude which indicates a customer's positive or negative feeling about the value he or she receives as a result of using a particular firm's products or services (Homburg and Rudolph, 2001). It has been acknowledged as a core element in many organizational slogans and themes where the goal of

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100 percent customer satisfaction is one of the most frequently stated strategic goals for almost every organization. In fact, this concept continues to gain widespread recognition as a measure of quality even in many public sector services (Sajid and Baig, 2007) and the healthcare sector is no exception (Vukmir, 2006).

From the perspective of public hospitals, producing and delivering high-quality service at a reasonable cost has been one of the major goals in patient treatment efficiency (Haynes and Fryer, 2000). In fact, this is in tandem with the efforts of the Malaysian Ministry of Health to optimize the use of resources while at the same time enhancing healthcare delivery system. This is not difficult to understand as healthcare has been acknowledged as a very expensive service in most countries (Lanseng and Andreassen, 2007). This is consistent with a study conducted by Colletti (1994) who reveals that the cost of medical care in the USA has risen faster than consumer prices – by 35 percent in the past 40 years. A similar trend has been observed in Malaysia as evident from the increase in annual budget allocation for the Ministry of Health. The total budget allocation for the ministry has increased dramatically from RM10.0 billion in 2008 to RM13.70 billion in 2009 (Budget Report, 2008), compared with the RM8.99 billion and RM7.86 billion allocated in 2004 and 2005, respectively. This increasing allocation correlates with the rising operational and medical costs in addition to the increasing focus on emerging communicable and/or lifestyle diseases such as ischaemic heart diseases, cerebrovascular diseases and stroke, cancers, diabetes mellitus, HIV/AIDS, and other infectious diseases.

Consequently, significant consideration has also been rendered to the cost of laboratory testing and its consequences on the delivery of quality healthcare service. It was reported in the USA that laboratory testing makes up 10 percent of all hospital billings (Benge *et al.*, 1997). The rise in operational and medical costs has put public healthcare providers under tremendous pressure to significantly reduce their expenditure, with laboratory spending being one of the priorities. This inevitably poses noteworthy implications on the quality of medical care. This is in view of the fact that cost reduction may lead to reduced utilization of laboratory tests, which may lead to missed or delayed diagnoses and may even compromise patient outcomes. Worst, this could lead to higher costs for healthcare systems due to delayed decisions and prolonged hospital stays. These problems affect not only the satisfaction of patients but also the internal customers served by the healthcare providers such as the medical practitioners, which can be translated indirectly into the effectiveness and efficiency of the government in serving their constituents satisfactorily.

As healthcare services provided by government hospitals across the country are highly subsidized by the government, this triggers an alarm for the public hospital administrators to maintain their service delivery standards amidst the increasing cost. These issues point to the pivotal need for effective supply chain management (SCM) in terms of efficient resource utilization and at the same time improving customer satisfaction. Since one of the main goals of any health care organization is not only to meet but also to exceed the expectations of their customers, attempts to improve the levels of satisfaction of their customers and stakeholders are viewed as of paramount importance.

In the hospital laboratory industry, doctors are viewed as customers of the laboratory. This is because the doctors rely heavily on the laboratory test results for the diagnosis and clinical management of patients. It is therefore imperative for the laboratories to attend to the needs of the doctors to their satisfaction, as inequalities in the services provided will result in inefficiency in patient treatment, which eventually result in dissatisfaction to both the doctors and patients.

A literature search reveals that a considerable number of studies have attempted to examine patient satisfaction in various healthcare-related areas across different geographical locations (Akdag and Zineldin, 2009; Amyx *et al.*, 2000; Cameron *et al.*, 1994; Costello *et al.*, 2008; Li *et al.*, 2008; Mercer and Murphy, 2008; Papanikolaou and Ntani, 2008; Ramsaran-Fowdar, 2008; Tam, 2007; Trumble *et al.*, 2006; Vinagre and Neves, 2008). This is hardly surprising as satisfaction of patients has been acknowledged as an important criterion against which to judge the competency of any health system worldwide (Sajid and Baig, 2007). A general study on service climate within the context of service profit chain among the nurses has also been identified (Steinke, 2008). However, relatively few studies have examined doctor satisfaction. Those studies that are available are very general in nature (French *et al.*, 2006; Pillay, 2008).

As Grol (2001) puts it, a reliance on patient assessment of the healthcare services is in fact respecting the consumer sovereignty. There is ample theoretical and empirical evidence to suggest that many studies have been devoted to employee behavior and its impact on quality and customer satisfaction and that the interrelationships have been confirmed (Specht *et al.*, 2007), with strong evidence drawn from the medical field (Jaakkola and Halinen, 2006). Based on these predispositions, it is therefore imperative to measure the level of doctor satisfaction based on the services received from clinical laboratories. However, measuring the goal attainment of satisfaction is, and remains, a complex issue, more so in the healthcare sector. As such, Merry (2003) suggests that in order to know how well firms in a supply chain are catering to customer requirements and which improvement efforts should be focused upon, consideration should be given to assessing performance of the firms in the supply chain in terms of satisfaction of its customers.

It is against this backdrop that this study attempts to assess the performance of the closely linked decision-making units (DMU) within the public hospital laboratory supply chain by investigating how well the hospital laboratory supply chains supply chain inputs (SCI) are using their resources hospital laboratory input (HLI) toward achieving customer satisfaction, based on the customer satisfaction data collected through the use of appropriate doctor satisfaction dimensions (DSD). From the perspective of a hospital laboratory, the DMU are doctors who request clinical tests, while the hospital senior laboratory administrators are a source of data for HLI. The next section presents the literature pertaining to the topic under study.

Literature review

SCM of the healthcare industry

The concept of SCM has received significant attention as businesses across different industries have witnessed the values created through the integration and coordination of supply, demand and relationships in order to satisfy customers in effective and profitable manners (Simatupang *et al.*, 2004; Wong *et al.*, 2005). It is therefore not surprising to witness a considerable number of studies on this concept conducted in many different sectors, including manufacturing (Christensen *et al.*, 2007; Sha *et al.*, 2008; Sila *et al.*, 2006; Stevenson and Spring, 2009), agricultural business

(Aramyan *et al.*, 2007; O'Keeffe, 1998; Taylor and Fearne, 2006), aerospace (Michaels, 1999), retailing (Blatherwick, 1998; Hollis, 1996), construction (Briscoe and Dainty, 2005), steel (McAdam and Brown, 2001), automotive (Svensson and Baath, 2008), railway (Esposito and Passaro, 2009), banking and financial institutions (Fairchild, 2005; Keating *et al.*, 2008; Proenca and de Castro, 2005), textile (Cetindamar *et al.*, 2005), and even small- and medium-sized enterprises (Ciliberti *et al.*, 2009).

The majority of related studies recognize that an effective SCM is a powerful tool to achieve cost advantage and a more profitable outcome for all parties within and beyond any organization (Christopher, 1998; Lummus and Vokurka, 1999; Zsidisin *et al.*, 2000; Davis, 2008) and this includes the services setting (Vandaele and Gemmel, 2007). It is for this reason that a considerable number of studies related to SCM have been conducted on the healthcare industry even up to the recent years (Blanchard *et al.*, 2008; Kumar, A. *et al.*, 2008; Kumar, S. *et al.*, 2008; Pan and Pokharel, 2007).

Gattorna (1998) aptly describes that the healthcare business is provided by a variety of product and service organizations which include medical consumables, pharmaceuticals, catering, laundry cleaning, waste management, home-care products, information technology, vehicle fleet management, and general supplies which to a large extent are required by the clinical laboratories as well. Interestingly, it has been reported that the supply chain of the healthcare industry is different from the manufacturing sector in terms of the level of customization of services provided, the degree of participation of a partner or consumer and the uncertainty underlying the basic process (Pitta and Laric, 2004). As such, the healthcare providers are unable to predict patient mix and the demand for a particular item. This explains, why they are unable to control or project their production schedules (Jarrett, 1998). This is true enough in the current context where doctors request services from clinical laboratories according to the current needs of patients. All these make the healthcare value chain more dynamic and complex (Evans and Berman, 2001) and this significantly impacts on the performance measurement of the healthcare organizations.

Willmott (1989) therefore insists that there is a need to concentrate on single integrated supply chains within the healthcare industry. This is because improvements in the supply chain in hospitals can lead to excellent operating room and pharmaceutical management, better inventory management, enhanced vendor relationships, more satisfied patients, and more effective work flow for hospital employees (Burt, 2006), including serving the needs of internal customers (Swinehart and Smith, 2005) such as the doctors.

Performance measurement systems

Literally, performance measurement is the process of quantifying action, where measurement is the process of quantification and action which lead to performance (Neely, 1999). Measuring the performance of an entire supply chain is considered vital because it allows for "tracking and tracing" of efficacy and efficiency failures and leads to more informed decision making with regard to chain design (Aramyan *et al.*, 2007). In this context, numerous authors have proposed performance measurement frameworks, which prescribe which performance dimensions organizations should consider monitoring (Gulledge and Chavusholu, 2008; Kaplan and Norton, 1996).

For example, Hendricks (1994) opines that the attributes of performance measurement differ at different levels in the organizational hierarchy. At lower levels of the organization hierarchy, performance should be measured more frequently, and the measures should be more specific, with more emphasis placed on operational measures and less emphasis on financial measures. Financial measures such as return on investment or cash flow are important at the company or divisional level. At the departmental level, measures such as production schedule attainment, throughput time, scrap and downtime are imperative.

Fawcett and Cooper (1998) conducted a longitudinal survey and their findings suggest that higher performing firms have more information available and place greater emphasis on a broad-based set of performance measures. In their study, Fawcett and Cooper classified performance measurement into four dimensions:

(1) an improved measurement capability, especially with respect to total cost measurement;

(2) a process orientation that facilitates internal integration and external alignment;

(3) a benchmark that provides the impetus for continuous learning and improvement; and

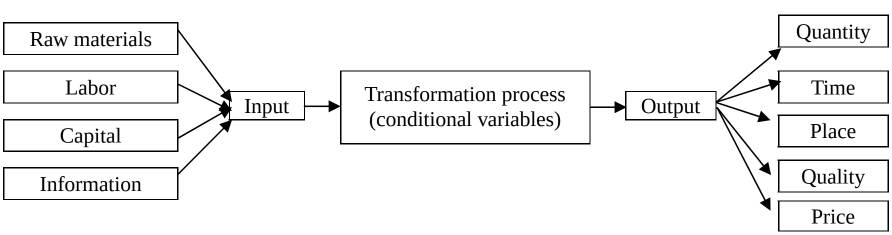
(4) the use of partner and supply chain scorecards to evaluate the role and performance of supply chain members and the overall supply chain.

They suggest that the designed measurement system should serve to align the firm's strategy with key customers' competitive requirements so as to enhance customer loyalty. In other words, measurement must help the firm to understand customers' real needs so that the firm can tailor its product or service packages to meet those needs. Ultimately, the measurement's value helps firms calibrate their capabilities and move forward via targeted continual improvement initiatives. From this perspective, performance measurement leads to better decision making and better value-added logistical processes (Fawcett and Cooper, 1998).

The NEVEM Workgroup (1989), on the other hand, presents its performance indicators and proposed a generic model for performance measurement which can possibly take place in three categories of process data: inputs, conditional variables, and outputs (Figure 1). The use of input-output ratios (also known as productivity or performance indicators) is common in logistics studies, and the use of such ratios has received extensive treatments in textbooks and other literature.

Importance/performance analysis

The concept of importance/performance analysis was developed by Martilla and James (1977). This method provides a formal way to assess both the performance of



Source: NEVEM Workgroup (1989)

Figure 1.
General model for performance measurement

a company's products and services and the importance attached to these products and services. Martilla and James (1977) employed the importance/performance analysis in their study as illustrated in the two-dimensional graph shown in Figure 2.

The analysis resulted in the importance/performance matrix (I-P matrix) which is divided into four quadrants, distinguishing between low- and high-importance and between low- and high-performance. Each quadrant can be interpreted as follows:

(1) *Top left: concentrate here*. Customers consider these dimensions to be important but they think that the companies' products and services are not performing well.

(2) *Top right: keep up the good work*. Customers consider these dimensions to be important and are satisfied with the way they are being performed.

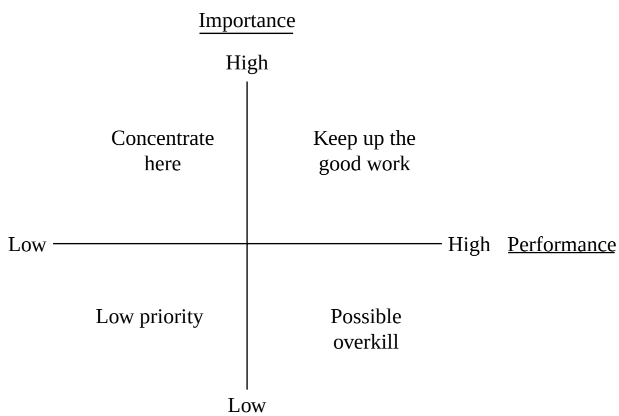
(3) *Bottom left: low priority*. Customers consider that these dimensions are neither performed well nor are important.

(4) *Bottom right: possible overkill*. Consumers consider that these dimensions are well performed, but they are not important.

The popularity of importance/performance analysis is evident from its successful adoption in a wide variety of service areas (Ford *et al.*, 1999; Hansen and Bush, 1999; Richardson, 1987; Weber, 2000). In addition, the model has also been used in a research on hospitals (Yavas and Shemwell, 1996).

Data envelopment analysis

Data envelopment analysis (DEA) is a measurement tool developed by Charnes *et al.* (1978) to evaluate the relative efficiency or productivity of the analyzed units (Wong and Wong, 2007). The units are DMUs which can be defined as a group of individuals who are brought together in order to purchase a product or service. These DMUs could be at the same level in the supply chain (i.e. company assembly facilities, product lines, branch offices, departments, or other comparable organizational units) or across two different levels of the supply chain (i.e. manufacturer and distribution warehouses, distributors, and retail outlets). The main point is that the DMUs are closely related



Source: Martilla and James (1977)

Figure 2.
Importance/performance analysis

and share many common customer satisfaction dimensions and types of resources used in production, product movement or service delivery (Sengupta, 2000).

DEA combines relevant performance ratio outputs and inputs into a single number that represents productivity or efficiency. It involves an application of linear mathematical programming to compare the observed outputs and inputs for all units of an organization, identifies the relatively best practice units to define an efficiency frontier, and then measures the degree of inefficiency of the other units relative to this frontier. Figure 3 shows an example of the DEA graphical analysis for an environment in which efficiency is evaluated in terms of two inputs and a single output. If there is only one output, the input amounts are divided by the output amounts to normalized input levels. The normalized input levels for the five DMUs are plotted in this graph. The positions on the graph represented by “A,” “B,” and “C” demonstrate superior performance in comparison to “D” and “E” because they are producing the same unit of output with lower levels of inputs.

The line segment shown in the plot is called the efficiency frontier. The frontier is a linear curve that is as far up and to the right as possible while still satisfying the condition that it is the lower envelop for all DMU in the set. It represents a standard of performance that the DMU not on the efficiency frontier could try to achieve. In DEA terminology, DMU “A,” “B,” and “C” are efficient, and DMU “D” and “E” are inefficient.

For each inefficient DMU, DEA software identifies the level of inefficiency and tells the organization where to consider making changes. In order to move DMU “D” to the frontier, a line from the origin through point “D” to the frontier is drawn (Figure 4). The point where the line intersects the frontier is designated as “X”. X is called the “reference unit” for DMU “D,” and it represents the theoretical best possible performance that a DMU with the same dimension as “D” could be expected to achieve.

In a consistent manner, Cooper *et al.* (2000) state that one of the main purposes of using DEA is to project the inefficient DMU onto the production frontiers. There are three approaches that a DMU might choose to use to reach the efficiency frontier. One approach is called input-oriented, and it aims at reducing input amounts by as much as possible while keeping at least the present output levels. A second approach is called output-oriented, and it maximizes output levels under at most the present input consumption. There is a third choice that deals with input excesses and output shortfalls simultaneously in a way that seeks to maximize the ratio of weighted

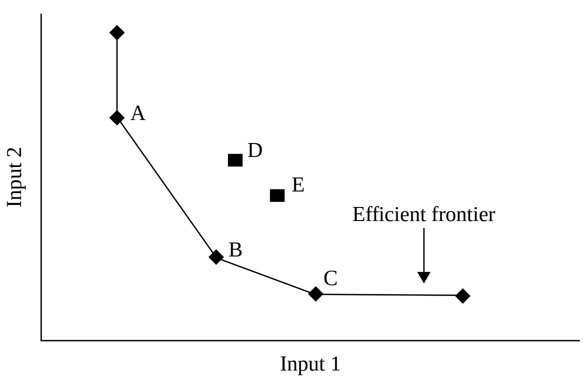


Figure 3. An example of DEA graphical analysis with two inputs and one output

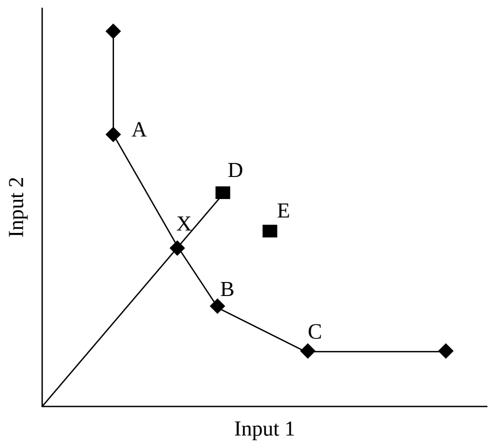


Figure 4.
Moving inefficient DMU "D" to the frontier in a DEA analysis

output levels to weighted input levels. In other words, in order to move towards point "X" on the efficiency frontier as shown in Figure 4, DMU "D" can pursue the following alternatives:

- increase the DSD outputs while keeping the SCI inputs constant;
- decrease SCI inputs while keeping the DSD outputs constant; and
- increase DSD outputs and decrease SCI inputs.

However, in reality there is no real DMU at "X". The best possible actual DMU to compare with "D" are the two efficient DMUs on either side of "X" which are "A" and "B". These are called the reference set for DMU "D". The reference set for any inefficient DMU includes efficient DMUs which have similar mixes of inputs and outputs.

DEA appears to be a popular and effective performance measurement technique even in the healthcare industry, judging from its application and the findings of prior research (Magnussen, 1996; Schinnar *et al.*, 1993; Ozcan and McCue, 1996).

Work flow and research process

Figure 5 shows the work flow (both input and output) in the hospital laboratory environment which sets the basis for this study to be conducted. First, the doctor requests an analysis to be conducted on a patient's sample. The sample then goes

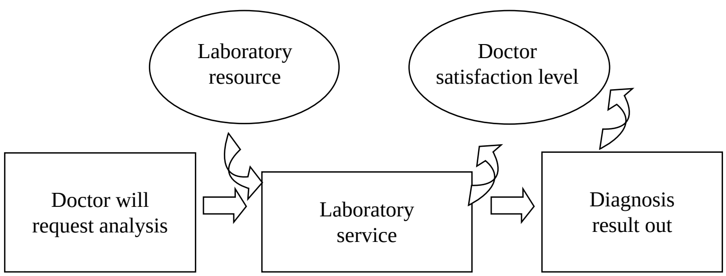


Figure 5.
Work processes (input and output) in hospital laboratory and research flow

through the analysis process in the laboratory and the diagnosis results will be returned to the doctor. Consequently, the hospital laboratory uses its resources to deliver its services to the doctor. During and at the end of the process, the doctor develops a feeling of satisfaction or otherwise based upon the service they received. As such, the laboratory services provided are considered inputs to the system, while the output comprises the level of the doctor's satisfaction based upon the service they received.

Based upon the work processes in Figure 5, the customer satisfaction performance measurement methodology can therefore be applied in assessing the efficiency of the laboratories in using their resources to satisfy the doctors.

Methodology

Two sets of structured, self-reporting questionnaires were developed for the purpose of data collection from the two groups of respondents, i.e. the DSD for doctors and the HLI for laboratory administrators. Two highly experienced laboratory administrators holding senior positions were determined as respondents, one each from the hospital laboratories, to provide data with respect to the HLI. About 30 doctors (15 each from the hospitals) who requested clinical tests and reports are identified as respondents on the part of the DSD questionnaire. The first step in developing the questionnaires entails the selection of appropriate sets of dimensions for the performance measurement inputs and outputs. In the hospital laboratory context, it involves asking the doctors, laboratory administrators and a team of experts in the hospital laboratories appropriate sets and definitions of DSD and HLI based upon the environments of the hospital laboratories under study. The definitions and constructs were then reviewed by a physician who has vast experience in the medical laboratory field. The questionnaires were piloted on five doctors and laboratory administrators. As such, face validity is achieved.

The final version of the DSD reflects the concerns of doctors who receive laboratory services while the HLI version reflects the concerns of laboratory personals who provide the services. The first set of questionnaire contains 16 structured questions asking the doctors to rate both the importance and their satisfaction associated with each DSD (Table I). The second set of questionnaire comprises 11 structured questions for the senior laboratory administrators to rate the importance associated with each HLI (Table II). For both the DSD and HLI, a five-point Likert scale, ranging from 1 – very unimportant to 5 – very important, with three as neutral point, was used to indicate importance. In terms of satisfaction of doctors, a scale of 1 – very dissatisfied to 5 – very satisfied, with three as neutral point was adopted. Clear definitions of both DSD and HLI were provided on the questionnaires in order to avoid misinterpretation of the survey questions. The questionnaires were administered on the doctors and laboratory administrators through face-to-face interviews.

In order to determine the reliability of the instruments, Cronbach's alpha was employed to obtain the reliability coefficient. Both the questionnaires have been found to have considerably high coefficients (DSD = 0.8165; HLI = 0.7757).

In terms of selection of hospitals, one important criterion is the availability of adequate laboratory facilities in all major departments within the hospitals such as the biochemistry laboratory, hermatology laboratory, microbiology laboratory, and histology laboratory. Another criterion set forth is the distance of the hospitals where

No.	DSD	Importance (mean) SA	SI	Average	Satisfaction (mean) SA	SI	Average
D1	Getting medical results needed	4.44	4.00	4.22	3.89	3.30	3.60
D2	Quality of services given by the laboratory staff	4.20	4.20	4.20	3.50	3.50	3.50
D3	Time spent per patient sample	3.80	4.00	3.90	3.10	3.40	3.25
D4	Dependability of the results produced	3.90	3.80	3.85	3.20	3.30	3.25
D5	Conformance to the analysis requested	4.10	4.10	4.10	3.60	3.80	3.70
D6	Result recovery service	4.20	4.44	4.32	3.60	3.90	3.75
D7	Sample registration service	4.20	4.30	4.25	3.60	4.00	3.80
D8	Waiting time to get medical results	3.90	3.70	3.80	3.60	3.80	3.70
D9	Expertise of medical laboratory technicians (MLTs)	4.10	4.30	4.20	3.50	3.80	3.65
D10	Inquiry handling	3.40	3.60	3.50	3.60	3.50	3.55
D11	Availability of MLTs	4.33	4.44	4.38	3.40	4.10	3.75
D12	Sample transportation before each laboratory	4.00	4.10	4.10	3.40	3.50	3.45
D13	Communication with doctors	4.30	4.20	4.25	3.70	3.70	3.70
D14	Confidentiality of the results produced	4.10	3.80	3.95	3.60	4.00	3.80
D15	Safety of pathological samples	4.11	4.00	4.10	3.30	3.50	3.40
D16	Suppliers' capabilities	4.20	4.30	4.25	3.50	4.00	3.75
Total average		4.08	4.08	4.10	3.51	3.69	3.60

Table I.
Mean scores for both the importance and satisfaction of the DSD

No.	HLI	Importance (mean) SA	SI	Average
H1	Number of full-time equivalent laboratory staff	4.00	4.00	4.00
H2	Number of full-time equivalent registration staff	3.00	4.00	3.50
H3	Average years in medical service	3.00	5.00	4.00
H4	Hospital budget for diagnosis service per patient per year	5.00	5.00	5.00
H5	Cost of anti-infective agent disinfectants and other sanitization products per year	4.00	4.00	4.00
H6	Electrical power consumed per year	4.00	4.00	4.00
H7	Average number of patients per test per year	4.00	4.00	4.00
H8	Total number of medical records kept in the laboratory per registration staff	3.00	3.00	3.00
H9	Time spent by MLTs for a single test request	5.00	4.00	4.50
H10	Inventory of diagnosis reagent per patient per year	4.00	4.00	4.00
H11	Inventory of consumable products per patient per year	3.00	3.00	3.00
Total average		3.82	4.00	3.91

Table II.
Mean scores for importance of the items measuring HLI

locations within a 50 kilometre radius are preferred in order to allow the researchers to have sufficient time to carry out in-depth and extended research. This resulted in the selection of two public hospitals for this research. To preserve their anonymity, the hospitals are labelled to as Hospitals SA and SI, respectively.

Once the data on the DSD and HLI dimensions were gathered, they were positioned on an I-P matrix. In this study, the I-P matrix was re-labelled as importance and satisfaction, and classified into high- and low-importance and satisfaction for further analysis.

For the DSD, the responses were ordered and classified into four quadrants, distinguishing between low- and high-importance (vertical axes) and between low- and high-satisfaction (horizontal axes). Then, by pairing these two sets of rankings, each dimension is placed into one of the four quadrants of the matrix. The lines that separate both axes are calculated from averaging each total score. The placement of the DSD attributes on this two dimensional graph suggests a strategy for each quadrant, i.e. quadrant 1 signals maintaining attributes that are both important and lead to higher performance; quadrant 2 shows attributes that require special efforts or concentration; quadrant 3 determines attributes with low priority and therefore no additional resources is required; while quadrant 4 implies that a possible overkill has occurred. For the purpose of this research, special focus is given to quadrants 1, 2 and 4 as they create some opportunities, i.e. quadrant 1 (leverage opportunity); quadrant 2 (action opportunity); and quadrant 4 (resource transfer opportunity), while quadrant 3 requires no additional attention.

Similarly, the items for the HLI were classified into two main classes, high in importance and low in importance. The scores greater than or equal to three were assigned to the high in importance category and the scores lower than three were assigned to the low in importance category. In this methodology, only the attributes that are rated high in importance by the laboratory administrators were given due attention.

Finally, the three scenarios were analyzed using DEA through the use of commercial software, i.e. Frontier analysis, to measure performance. One main advantage of DEA over the traditional linear models is that it is not necessary to subjectively assign weights to the input/output factors. The DEA allows each DMU, in this case each doctor that requests clinical test from the hospital laboratory to adopt the most advantageous set of weights to the determined input/output criteria factors. The DEA will find an efficiency frontier for each of the three scenarios. A hospital laboratory that has an efficiency score equal to 1 is considered efficient while an inefficient hospital laboratory has an efficiency score less than one. The next section presents the results.

Results

Table I shows the mean scores for both the importance and satisfaction ratings obtained from the doctors of Hospitals SA and SI. It is interesting to note that almost all the dimensions have a mean rating of 3.50 and above, implying that all the DSD are perceived as either important or very important. In terms of satisfaction, the items were rated on an average of between 3.30 and 3.80, indicating that the responses range from neutral to somewhat satisfied. This corroborates the total mean average of 3.60.

Table II indicates the mean scores in terms of importance of the HLI as rated by the laboratory administrators. The average score for each of the items for both the hospitals ranged from neutral (mean = 3.00) to very important (mean = 5.00).

Based on the average scores, the DSD for Hospitals SA and SI are positioned on the I-P matrix for further analysis into four categories, i.e. "keep up the good work," "concentrate here," "low priority," and "possible overkill." Figures 6 and 7 show the resulting matrix. Similarly, the average scores for items measuring HLI were positioned on the matrix, categorized into high and low in importance as shown in Figure 8. The numbers shown on the figures correspond with the items numbered in Tables I and II. Of the 11 items, eight were classified as high in importance. These include number of full-time-equivalent laboratory staff, average years in medical service, hospital budget for diagnosis service

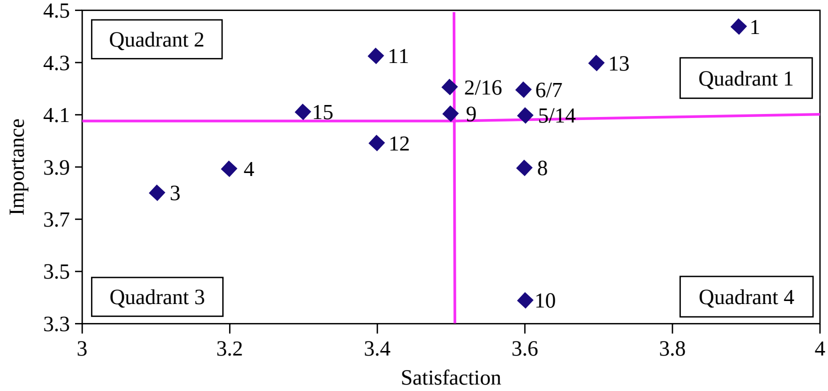


Figure 6.
I-P Matrix for Hospital SA laboratory

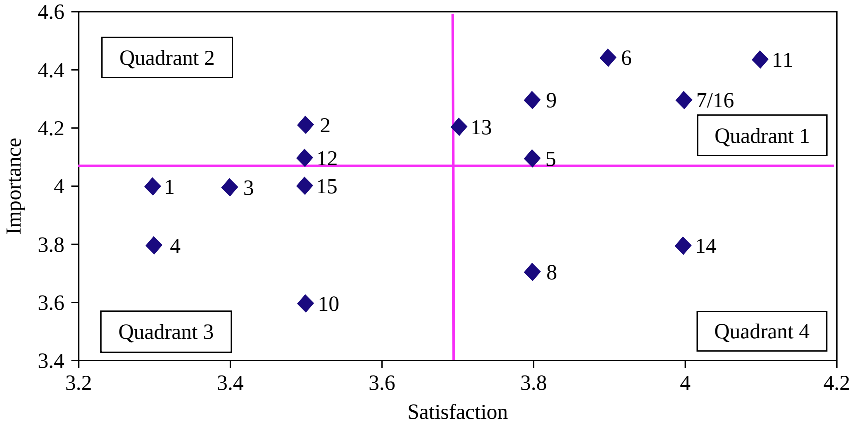


Figure 7.
I-P Matrix for Hospital SI laboratory

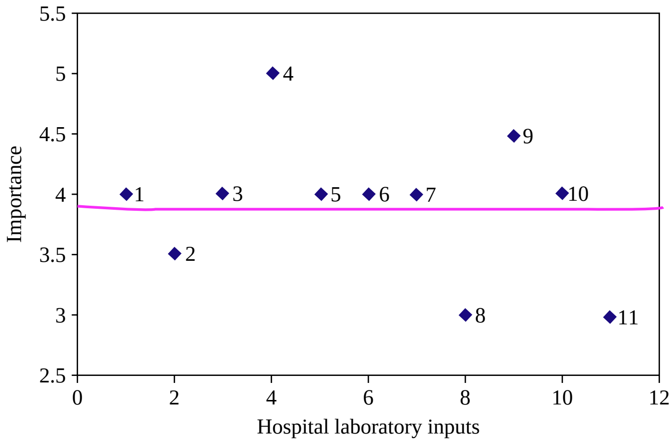


Figure 8.
Classification of HLI

per patient per year, cost of anti-infective agents disinfectants and other sanitization products per year, electrical power consumed per year, average number of patient per test per year, time spent by a MLTs on a single test request, and inventory of diagnosis reagent per patient per year. Figure 8 shows the matrix for the items measuring HLI.

Table III summarized the results based on the I-P matrix of both the hospital laboratories.

The findings were then subject to DEA analysis with the objective of evaluating the performance of each hospital laboratory and to find an efficiency frontier for each of the three scenarios. A hospital laboratory that has an efficiency score equal to 1 is considered to be efficient while an efficiency score of less than 1 is considered inefficient. Tables IV-VI present the results for each of the quadrants 1, 2 and 4. It can

I-P matrix quadrant classifications	DSD SA	SI	HLI
Quadrant 1 (keep up the good work)	Getting medical result needed Conformance to the analysis requested Result recovery service Sample registration service Communication with doctor Confidentiality of the result produced	Conformance to the analysis requested Result recovery service Sample registration service Expertise of MLTs Availability of MLTs Communication with doctor supplier's capability	Number of full-time-equivalent laboratory staff Average years in medical service Hospital budget for diagnosis service per patient per year Cost of anti-infective agents disinfectants, and other sanitization products per year Electrical power consumed per year Average number of patient per test per year
Quadrant 2 (concentrate here)	Quality of services given by the laboratory staff Expertise of MLTs Availability of MLTs Safety of pathological samples Supplier's capability	Quality of services given by the laboratory staff Sample transportation before reach laboratory	Time for a MLTs to spend for a single test request Inventory of diagnosis reagent per patient per year
Quadrant 3 (low priority)	Time spent per patient sample Dependability of result produced Sample transportation before reach laboratory	Getting medical result needed Time spent per patient sample Dependability of result produced Inquiry handling Safety of Pathological Samples	
Quadrant 4 (possible overkill)	Waiting time to getting medical results Inquiry handling	Waiting time to getting medical result Confidentiality of the result produced	

Table III. Summary of the three scenarios to be used in measuring performance using DEA

Table IV.
Summary of DEA results for both hospital laboratories under Scenario 1

Laboratory	Efficiency															
Hospital SA	1	D1	D5	D6	D7	D13	D14	H1	H3	H4	H5	H6	H7	H9	H10	
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Hospital SI	0.9812	D5	D6	D7	D9	D11	D13	D16	H1	H3	H4	H5	H6	H7	H9	H10
		0.8152	0.6946	0.3607	0	0.2815	0.7781	0.8213	0.2314	0.5412	0.7124	0	0.2241	0.3612	0.2311	0.7524

Laboratory	Efficiency													
Hospital SA	1	D2	D9	D11	D15	D16	H1	H3	H4	H5	H6	H7	H9	H10
		0	0	0	0	0	0	0	0	0	0	0	0	0
Hospital SI	0.9615	D2	D12	H1	H3	H4	H5	H6	H7	H9	H10			
		0.9537	0.2632	0	0.6127	0.5521	0.3665	0.8821	0.8771	0.2114	0.9241			

Table V.
Summary of DEA results for both hospital laboratories under Scenario 2

be observed that Hospital SA's laboratory has efficiency scores equal to one in all three scenarios while the Hospital SI's laboratory has an efficiency score of less than one in all three scenarios. In all the instances, Hospital SA lies in the efficiency frontier in terms of satisfaction of its doctors and the resources it utilized compared to Hospital SI.

The results on each quadrant are briefly explained in the following sub-sections.

Scenario 1 – "keep up the good work"

The efficiency scores in Table IV indicate that Hospital SA's laboratory lies on the efficiency frontier while the Hospital SI's laboratory lies under the frontier (efficiency = 0.98), implying that Hospital SI's laboratory is inefficient by 2 percent compared to Hospital SA. Table IV demonstrates that Hospital SA's laboratory efficiently satisfies doctors in the dimensions of "getting medical result needed," "conformance to the analysis requested," "result recovery service," "sample registration service," "communication with doctor" and "confidentiality of the result produced," using the HLI they consume. However, the situation was otherwise for Hospital SI's laboratory where it does not efficiently utilize its resources to generate satisfaction among doctors under Scenario 1.

Scenario 2 – "concentrate here"

Table IV suggests that Hospital SA's laboratory has an efficiency score equal to one while Hospital SI's laboratory has an efficiency score of 4 percent less (efficiency = 0.96). Hospital SA's laboratory which lies on the frontier is shown to efficiently satisfies doctors under this scenario for dimensions of "quality of services given by the laboratory staff," "expertise of MLTs," "availability of MLTs," "safety of pathological samples," and "supplier's capability" using the HLI they consume.

Scenario 3 – "possible overkill"

Again, under Scenario 3 of quadrant 4, Hospital SA's laboratory lies on the efficiency frontier while Hospital SI's laboratory lies under the frontier in view of the efficiency score of less than one (efficiency = 0.98). The doctors utilizing the services of Hospital SA's laboratory considered two dimensions, namely "waiting time to get medical results" and "inquiry handling" as important, while dimensions of "waiting time to get medical results" and "confidentiality of the results produced" were considered important by the doctors using the services of Hospital SI's laboratory.

Discussion and implications

Overall, it appears that the DMU of Hospital SA's laboratory is 2-4 percent more efficient and satisfying compared to Hospital SI's laboratory under the three scenarios. The results also suggest that 11 out of 14 dimensions are considered important that

Table VI. Summary of DEA results for both hospital laboratories under Scenario 3

Laboratory	Efficiency										
Hospital SA	1	D8	D10	H1	H3	H4	H5	H6	H7	H9	H10
		0	0	0	0	0	0	0	0	0	0
Hospital SI	0.9782	D8	D14	H1	H3	H4	H5	H6	H7	H9	H10
		0.1132	0.6060	0.8824	0.3214	0.8724	0.5645	0	0.2356	0.2784	0.1401

satisfy doctors which require attention from the hospital laboratory administrators. They include "getting medical results needed," "conformance to the analysis requested," "result recovery service," "sample registration service," "communication with doctor," "confidentiality of the results produced," "quality of services given by the laboratory staff," "expertise of MLTs," "availability of MLTs," "safety of pathological samples," and "suppliers' capabilities."

It appears that Hospital SI only possesses seven of these dimensions compared to Hospital SA. The dimensions of "getting medical results needed," and "safety of pathological samples," albeit being important, were given low priority and that "sample transportation before reaching laboratory" was given more focus although the dimension requires lower priority. However, both the hospitals agree that dimensions of "time spent per patient sample" and "dependability of results produced" should not be prioritized. The "wrong" focus of Hospital SI's laboratory, coupled with the presence of excess resources which have not been properly utilized may be the reason for its underperformance.

The I-P matrix quadrants indicate action to be taken when developing management plans to enhance the satisfaction of doctors. Specifically, the results in Scenario 1 suggest that Hospital SA's laboratory performs well on the various dimensions deemed to be important by the doctors that warrant improvements. As such, it should continue to use these amounts of HLI to maintain or even increase its output. However, improvements are needed for Hospital SI's laboratory to be efficient on various DSD such as "conformance to the analysis requested," "result recovery service," "sample registration service," "expertise of MLTs," "availability of MLTs," "communication with doctor," and "supplier's capability."

Similarly, in Scenario 2, the results imply that Hospital SA's laboratory should concentrate on the dimensions identified through the current utilization level of HLI in order to maintain the satisfaction of doctors. Frequent performance monitoring on these DSD is needed. Similarly, Hospital SI's laboratory should devote extra attention to these DSD, particularly on two important areas such as "quality of services given by the laboratory staff" and "sample transportation before reaching laboratory."

In Scenario 3, however, it is important to note that the findings under this quadrant are in the reverse trend of the former two scenarios. Since the DSD in this scenario are rated low in importance, the laboratory that lies on the frontier (Hospital SA) efficiently satisfies doctors in dimensions that the doctors think insignificant to their satisfaction. The DSD include "waiting time to get medical results" and "inquiry handling." The results suggest that these dimensions were given significant attention but in actual fact, they are perceived as not worth the level of attention they are presently being given. It implies that the Hospital SA's laboratory should keep their current level of resources devoted to these dimensions and instead pay more attention on other DSD. Alternatively, the laboratory could use some form of promotion to make the doctors realize the importance of these DSD. This will allow competitive advantage to be gained by Hospital SA and its laboratories because they are able to perform well on these as well as all other dimensions.

On the other hand, while the Hospital SI's laboratory is considered inefficient, they could be viewed as desirable under this scenario. They do not perform well in DSD that are rated low in importance. It is suffice to say that the Hospital SI's laboratory is not wasting its resources on dimensions that are low in importance and satisfaction. This suggests that the Hospital SI's laboratory should continue using its existing levels of HLI to satisfy doctors with respect to the measures under Scenario 3 such as "waiting time to getting medical result" and "confidentiality of the result produced."

The results suggest that the Hospital SA's laboratory has the potential to serve as a reference set to Hospital SI's laboratory in many ways. As such, the DMU of Hospital SI should benchmark and adopt the methods of operations undertaken by Hospital SA in many of the dimensions surveyed in order to improve its efficiency and subsequently its performance.

This study does not consider DSD that fall into the quadrant of "low priority" as the dimensions are considered to be not as important and do not reflect the performance of the hospital laboratories. As a result, no additional action is required and resources initially devoted to these dimensions should be redirected to areas of higher importance. Notwithstanding, these dimensions should not be permanently eliminated from consideration. It is important to be aware of doctors' bias and latent needs of patients. The doctors may not recognize that the dimensions are important even though in reality they are. It is therefore imperative for future studies to explore these dimensions.

Conclusion and limitations of the study

This study has achieved its objective of evaluating the supply chain performance of the DMUs of the two hospital laboratories under study. The contribution of this study is two-fold. From the theoretical perspective, the results contribute to the existing body of knowledge on the important role played by SCM in terms of efficient utilization of resources by the hospital laboratories while at the same time satisfying doctors in an effective and efficient manner. In the context of this study, the efficiency frontiers for both the hospital laboratories under the three different scenarios based on the use of the DEA have been aptly identified, which helped to provide insights of how well the DMU in a hospital laboratory supply chain is performing. In other words, DEA helps supply chain managers to monitor the performance of a DMU with respect to doctor satisfaction and subsequently helps in determining areas and ways that warrant improvement. Equally important is the eight HLI determined in this study which can be used to inform decisions regarding the significant areas a hospital should concentrate on particularly when measuring satisfaction.

From the practical context, the laboratory administrators of both hospitals under study benefit from the importance of identifying the DSD, particularly those which fall under the quadrants of "keeping up with the good work," "concentrate here" and "possible overkill," which would allow them to focus on the most important dimensions of doctors' satisfaction *vis-à-vis* the resources they possessed.

While the findings illustrate some common themes, the results reported in this study need to be interpreted cautiously due to a number of limitations that call for future research possibilities. The primary limitation is the small sample size which might not portray the actual scenario of the topic researched. Because of the fact that the survey was conducted only in the state of Johor, most of the supply chain transactions are usually accomplished within a confined area in a relatively short span of time. Therefore, improvements in time-related delivery activities such as reduction in lead time and on-time delivery may not significantly impact on the doctors' satisfaction. Notwithstanding, while interesting findings have been obtained, it raises the question as to whether the results can be generalized to the same or different cultural contexts. Further, there are possibilities that other satisfaction dimensions and HLI that are important but not covered in this study. Future research is therefore warranted to address these gaps so that the issues covered in this study can be generalized and appropriately addressed.

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