Impact of Implementation of Case-mix System on Efficiency of a Teaching Hospital in Malaysia

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Abstract

University Kebangsaan Malaysia Medical Center (UKMMC) is the first government hospital in Malaysia which has taken the initiative to implement the case-mix system since July 2002. Established in 1997, this 873 bed teaching hospital provides tertiary level services to around 600,000 people in two southern districts of Federal Territory Kuala Lumpur.

The objective of this research is to assess the impact of implementation of case-mix system on efficiency of clinical services provided by UKMMC using Stochastic Frontier Analysis.

The hypothesis for this study is that the implementation of case-mix system has improved the level of efficiency at UKMMC.

Results of SFA models proved that implementation of case-mix system have decreased the technical inefficiency 1.93 percent yearly during study period at UKMMC.

Keywords: Technical efficiency, Stochastic frontier analysis, Teaching hospital, Case-mix, UKMMC

1. Introduction

The demand for health care services and medical costs has been observed to be on the increasing trends worldwide, while governments in most countries have limited ability to continue providing subsidy for such services. Increasing health care cost is one of the most hotly debated policy issues in developed and developing countries in recent years. Most of the debates revolved around issues related to how best to control costs while sustaining the provision of services. Measures such as rationing, effective management of waiting lists, human resource management, global capping on budgets and capitation through managed care has been suggested in that regards. However, these measures have often resulted in negative publicity for governments and purchasers of health care.

The most important approach dealing with this problem is to introduce an efficient healthcare administrative and financing system. Effective and efficient health care service will result in good quality service and cost containment. Therefore, an effective and resilient system is required to achieve this target.

With regards to this, case-mix system seems to be a good option for achieving this efficient system. Case-mix is a generic term that describes the mixture of patients present within a healthcare setting. Case-mix system also facilitates implementation of quality enhancement programs in line with the original objective of classification. Case-mix system has many applications including hospital payment system (prospective payment mechanism), performance monitoring and quality assurance.

In Malaysia the work on case-mix system based on Diagnostic Related Groups (DRG) was initiated in 1996, with the establishment of a case-mix research team consisting of representatives from Ministry of Health, University of Malaya, University of Kebangsaan Malaysia and University of Science Malaysia. This team conducted a research project involving 12 public hospitals in Malaysia including three university hospitals (Zafar, 2005). University Kebangsaan Malaysia Medical Center (UKMMC) is the first hospital in the country to fully implement the case-mix system since July 2002.

According to Freisner *et al*. (2006) research on efficiency measurement in health care has focused on three key issues. One issue is the approach used to generate efficiency scores. The two most commonly used approaches are Data Envelopment Analysis (DEA) and Stochastic Frontier analysis (SFA) (Hollingsworth, 2003). Efficiency is measured relative to the best practice (or efficient) frontier. Deviations from this frontier give measures of (relative) efficiency. Some has developed comparing the two existing techniques (DEA & SFA) and examining their statistical properties. The second major area of research used one of the two approaches (DEA or SFA) to look at efficiency in a single area of health care production. Such studies have covered almost every area of health care, including hospitals, nursing homes, dental services, pharmacies, organ procurement, stroke treatment and neonatal care. These studies look for systematic differences in efficiency across firms, patients or other decision-making units(DMUs), and try to identify the factors causing (or correlated with) those differences. A third area of research used a mixture of different efficiency calculations to measure other aspects of health care practice. A broad literature used technical efficiency calculations to form Malmquist indices of technological change (Hollingsworth, 2003).

The research question in this paper is, has the efficiency of UKMMC improved by implementation of case-mix system?

The remainder of the paper is organized as follows. The next section discusses about technical efficiency. Section 3 provides the methodology has used in this study. Section 4 contains the result and section 5 and 6 present the discussion and conclusion.

2. Technical efficiency

The history of microeconomic efficiency began in 1950 when Koopmans defined technical efficiency for production possibilities as a situation in which it is impossible to increase any more output without simultaneously increasing the input. Debru (1951) is the first economist to measure efficiency while Farrell (1957) defined a simple measure of firm efficiency that could account for multiple inputs within the context of technical, allocative and productive efficiency.

Technical efficiency of hospitals can be measured by parametric and non-parametric methods that permit simultaneous comparison of the inputs and outputs of a hospital's production process and produce concise indicators of efficiency. Technical efficiency shows the capability of production units to transform inputs into outputs. In this sense, hospitals are perceived as efficient if they produce the maximum possible outputs given their available inputs, or equivalently, if they utilize a minimum level of inputs to produce a given amount of outputs. This study has focused on technical efficiency analysis.

3. Methodology

For this research, UKMMC data were obtained from Medical Record and Human Resource department. Data from 1998 to 2006 were analysed and subjected to SFA model.

The variables for inputs were number of beds as a representative of capital, and number of doctors, nurses, non-medical staff as representatives of labour. The output variable was number of inpatient discharged from each clinical department. Case-mix effect is labelled as dummy variable in the analysis. This variable is allocated as value of 0 for the period before the introduction of case-mix system and given value of 1 after that period.

The Stochastic Frontier Analysis was independently proposed by Aigner, Lovell and Schmidt as well as Meeusen and Broeck in 1977. Their approach in estimating production function involved the specification of the error term which is made up of two components: one from normal distribution and another from one-sided distribution. Thus the Stochastic Frontier Analysis model has the advantage compared to the other approach such as Data Envelopment Analysis because it is able to decompose the two sources of error into random noise and efficiency (Dor, 1994). The model used in this study is based on the Battes and Coelli (1995) approach which uses a stochastic frontier model to estimate efficiency. In its original form, as outlined in following equation;

$$Y_i = \beta x_i + \varepsilon_i \qquad (1)$$

Where Y_i is the production (or the logarithm of the production) of the i^{th} firm;

x_i is a kx1vector of (transformations of the) input quantities of the i^{th} firm;

β is a vector of unknown parameters and;

$$\varepsilon_i = v_i - u_i$$

v_i is two-sided error term representing statistical noise, which is assumed to be independently and identically distributed as $N(0,\sigma_v^2)$ and independent of u_i;

u_i is the one-sided error term representing technical inefficiency and satisfies $u_i \geq 0$

Parameter u_i is assumed to be truncated normally with variance σ^2 and the mean $u_i = \delta_i Z_i$ is represented as a linear combination of the inefficiency variable

The inefficiency determinant function following the general model is:

$$U_i = \delta_i + \delta_i Z_i + w_i \qquad (2)$$

Where Z_i is a vector of factors affecting the efficiency level, case-mix effect,

δ_i is a vector of parameters and w_i is error term.

Following Battes and Corra (1977) and Battes and Coelli (1993) variance terms are parametrized by replacing σ_v^2 and σ_u^2 with $\sigma^2 = \sigma_v^2 + \sigma_u^2$ and $\gamma = \sigma_u^2/(\sigma_v^2 + \sigma_u^2)$.

The maximum likelihood estimation procedure is proposed for the simultaneous estimation of the parameters of the Stochastic Frontier model and technical efficiency model. The likelihood function and its partial derivatives with respect to the parameters of the model are presented in the Battes and Coelli (1993)

4. Results

Table 1 shows the simple output input ratio at clinical departments in UKMMC. Number of inpatient discharged from each department was considered as output and number of doctors, number of nurse, number of beds and number of nonmedical staff were considered as inputs. The ratios were calculated in two different time period (before and after 2002).

Table 2 shows the results of Stochastic Frontier Analysis. In this table, logarithmic form of number of inpatient discharged from each department was considered as output and logarithmic form of number of bed, doctors, nurses, and non medical staff was considered as inputs.

The signs of the all variables (bed, doctors, nurses and non-medical staff) are positive and also expected.

The Table 3 shows the result for inefficiency model. The sign of case-mix effect variable is statistically significant.

Table 4 presents the statistical summary of above model.

5. Discussion

The mean value of single output to single input ratio was higher after the introduction of case-mix system in most clinical departments in the study.

On the other hand in the stochastic frontier model, positive signs for number of beds, number of doctors, number of nurses, and number of non medical staff suggest that a one unit increase in each of these variables results in an increase in the inpatient discharged in each department. (Table2)

As shown in table 3 the sign in the inefficiency model was also expected. The result for case-mix effect suggests that if a clinical department in the case-mix environment, it reduces the inefficiency effect by 1.93 percent

To test the goodness of fit for the model, the generalized likelihood ratio test for the null hypothesis that the γ parameter and the $\sigma2$ parameter are jointly equal to zero was calculated by using the value of the log likelihood function estimating the frontier model. (Stevenson 1984). The likelihood ratio test for null hypothesis that $\gamma=0$ and $\delta0=\delta1=0$ with 1 degree of has been rejected.

The γ parameter lies between zero and one, and its value provides a useful test of relative size of the inefficiency effects. If $\gamma=0$, this would indicate that deviation from the frontier are due to entirely to noise and if $\gamma=1$ however, this would indicate that all deviations are due to entirely to economic inefficiency. Since the estimation of γ is close to 1(here is 0.78), we conclude that the most of variation in the total error, comes from the inefficiency component

6. Conclusion

The outcome of the study clearly demonstrates that by adopting case-mix system in 2002, UKMMC is able to mobilize the resources in the hospital to improve efficiency. UKKMC did not use case-mix system for reimbursement of services provided by the physicians, since all heath workers in public hospitals in Malaysia is on salary scheme and social insurance has yet to be implemented in the country (Aljunid, 2008). It is likely that the gain in efficiency is achieved through internal competition created by providing regular feedback to the clinicians in all the departments on the unit cost of their services as well as outcome of care. Both results of using single output to single input ratios and the SFA models proved that introduction of case-mix system has enhanced efficiency of clinical services provided by UKMMC

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Tabel 1. Simple input-output ratio by Clinical Departments in UKMMC*

DEPARTMENTS		#IPDIS / #BED	#IPDIS / #DOC	#IPDIS / #NRS
Department A	Before 2002	38.65	125.92	294.3
	After 2002	52.32	125.42	445.78
Department B	Before 2002	38.23	234.88	235.17
	After 2002	45.09	243.52	270.04
Department C	Before 2002	56.13	156.9	117.23
	After 2002	54.32	167.04	139.56
Department D	Before 2002	67.91	310.18	707.42
	After 2002	68.28	375.4	123.3
Department E	Before 2002	52.23	189.6	249.3
	After 2002	61.27	204.24	197.25
Department F	Before 2002	13.24	66.09	211.36
	After 2002	16.23	59.35	273.54

#IPDIS : number of inpatient discharges

#DOC : number of doctors

#NRS : number of nurse

*Clinical departments are anonymised.

Table 2. Results of Stochastic Frontier Analysis

Explanatory variables (*ln*)	Coefficients	Standard Error	p value
Constant	2.56	0.46	0.073
no. of bed	0.02	0.26	0.043
no. of doctors	0.42	0.36	0.018
no. of nurses	0.11	0.04	0.071
no. of non-medical staff	0.74	0.22	0.011

Table 3. Result of Analysis of Inefficiency

Variable	Coefficient	Std. Error	p value
Constant	0.26	0.033	0.03
Case-mix Effect	-1.93	0.328	0.02

Table 4. Statistical Summary

Statistics	Coefficients	St. error	p value
Log Likelihood Function	-101.45		
σ^2	0.38	0.051	0.03
est γ	0.78	0.016	0.0415