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Effect of costing methods on unit cost of hospital medical services; A case of capital cost

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Abstract

Efficiency measurement is designed to compare the value of resources used in production in terms of unit cost. However, in practice, different valuing methods can result in difference in unit costs. Therefore, this study is aimed to provide evidence on effect of capital costing methods on unit cost of hospital medical services. The study was conducted in a regional hospital in Thailand employing standard costing methods. All costs were converted and adjusted to 2012 US dollars. There were 25,609 items valued which comprised equipment, furniture and vehicles. Twenty-six percent of the items valued had been used for more than their reference useful life. Capital costs was calculated using three methods, i.e., economic methods (3 % discount rate) with a fixed useful life (method 1), economic methods with extended useful year to study year in case when working time was over the reference useful year (method 2) and accounting method (method 3). Total capital cost from method 1, 2 and 3 was accounted for 16% (US$8,692,564), 13% (US$6,625,909) and 5% (US$2,607,947) of the total hospital cost, respectively. Ten out-patient clinics and 31 in-patients wards were selected for unit cost calculation. Generally, unit costs of method 1 were highest and those of method 3 were lowest. This study indicated significant effect of costing methods on hospital cost analysis. Using only the results from the analysis without considering costing methods would generally lead to an error in management. Therefore, standard costing guidelines should be developed for each country for effective analysis.

Keyword: Hospital cost analysis; Unit cost; Costing method; Capital cost

1. INTRODUCTION

Efficiency assessment of any workplace is an important tool to measure or evaluate the performance of the workplace. A producer will be considered efficient when there is optimal production with proper distribution of resources and gain outputs at minimum cost. There are two concepts of efficiency i.e. technical efficiency and allocative efficiency. Technical efficiency is concerned with how outputs can be maximized by given sets of inputs or resources used. A company is said to be technically efficient when they produce maximum outputs by using given minimum amounts of inputs like labor, capital. In allocative efficiency, resources are allocated in such a way so as to meet the people's demand using available resources. This can often also be termed as economic efficiency. Technical efficiency measurement is designed to compare the value of resources used in production in terms of unit cost. Resource value is defined as the product of the quantity of resources used and their associated value. Difference of unit cost is normally assumed to be due to difference in quantity of resources used. However, in practice, different valuing methods can cause there to be a difference in unit costs.

There are several hurdles in conducting the economic analyses including costing. Problems in costing may be categorized as controversial issues in concepts (e.g. including productivity cost), methods (*e.g.* human capital

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approach versus friction cost method), and reference values (e.g. discount rate). Normally, in costing process, general costing involves the identification, measurement and valuation of all resources consumed in the production of goods or services[1, 2]. In hospital cost analysis, standard costing method is composed of 6 steps, i.e., study design and planning, cost center classification, direct cost determination, indirect cost determination, full cost determination and unit cost calculation[3].

Based on the standard method aforementioned, there are some alternative costing methods, e.g., distribution criteria of shared direct cost, capital cost, indirect cost allocation, allocation criteria and unit cost calculation. There are some previous studies exploring this issue[4, 5]. Focusing on capital cost, which accounts for approximately 10-12% of the total hospital cost in Thailand after excluding the opportunity cost of land[6]. Capital costs are the costs of using capital assets, i.e., buildings, furniture, construction, equipment, vehicles and land. As land is non-depreciable its cost is based on its opportunity cost. For all other capital assets, depreciation needs to be considered. Such depreciation is assessed through either accounting or economic approaches. There are several methods of capital costing, for instance, straight line, reducing balance method, production unit method[4]. For straight line accounting, capital costs per year are defined as the purchasing cost divided by the useful life of the capital asset. If an economic approach were adopted, capital costs comprise both annual depreciation costs as well as the annual opportunity cost of purchasing the capital asset[7]. In this context, the annual opportunity cost of capital is generally calculated as the forgone interest income associated with the acquisition of the capital asset[8]. Such interest costs are calculated over the useful life of the capital asset and then converted to present values. Annuity factors are generally used to convert capital costs to a stream of annually occurring opportunity costs. In the calculation, other than the annuity factor, replacement cost is needed instead of original purchasing cost. This is because capital cost calculation is a process for resources use planning. Annual capital costs are accumulated to result in an amount of money for replacing the items at the end of their useful years. Using original purchasing cost in the calculation will understate the amount of money mentioned. In the calculation, replacement cost is resulted by adjusting original purchasing cost with consumer price index. In practice, we found that some capital assets have been used beyond their standard useful life. This might be due to the under estimation of the length of the useful life or when there has been any replacement or repairment of major parts of the asset with a new one. This would result in extension of the assets' standard useful life. In this case, there are two options to calculate useful life, i.e., using a fixed standard useful life or extending the useful life to be a period between its initial use and year of analysis.

Hospital management has responsibilities to the community to provide healthcare services with great quality and at the least possible price. To achieve this, hospital managers must take into account each component of the hospital's capital structure when determining the hospital's overall capital cost[9]. Difference in valuing methods can cause the difference in unit cost. It is important to identify appropriate capital costing method which might help the managers to carefully allocate resources and direct or indirect costs to appropriate cost centres. Therefore, this study is aimed to provide evidence on effect of different capital costing methods on unit cost of hospital medical services.

2. MATERIALS AND METHODS

2.1 Study design

The study was conducted in a Thai public hospital that employed standard costing methods[7, 10, 11] using a hospital perspective.

2.2 Study site

The study was conducted in a public regional/tertiary hospital in Thailand with 809 beds. Total personnel were about 2,000 persons. Out-patient service was 1,792 visits per day. The hospital inpatient occupancy rate was 95% and average lengths of stay were 4.45.

2.3 Costing methods

Data were collected for fiscal year 2006. The study was designed to assess the economic costs of combining labor, materials and capital (excluding the opportunity cost of land) in order to yield hospital services. Costs associated with the activities of the hospital were exclusively and exhaustively assigned to one of 36 transient cost centers and 82 absorbing cost centers. In the process of direct cost determination, capital costs were calculated using the following equations[7, 8].

Equation 1: Equivalent annual economic cost
= Replacement cost in the year of analysis / Annuity factor

Equation 2: Replacement cost in the year of analysis
= Original purchasing cost x Inflation adjustment factor

Equation 3: Inflation adjustment factor
= Price index in the year of analysis/ Price index in the year of purchasing

Equation 4: Annuity factor = $[1 – (1 + r)^{-n}] / r$
r = discount rate
n = Useful life (years)

Equation 5: Equivalent annual accounting cost
= purchasing cost/ useful year

Theoretically, cost of capital asset must be subtracted by its scrap value. However, in practice, we assume zero value for its scrap. This is common assumption in many economic analyses[12].

The useful life of each capital asset was based on guidelines imposed by the Comptroller General Department of Thailand, i.e., computer 3 years, car 5 years medical equipment 5 years, electrical appliances and furniture 8 years and building 25 years[13]. A discount rate of 3% was used following standard guidelines in Thailand[14].

The study compared three methods, i.e., Method 1: Economic methods with a 3% discount rate and fixed useful life for capital assets; Method 2: Economic methods with extended useful life to study year in case of working time was beyond the reference useful life; and Method 3: Accounting methods with fixed useful life and no cost beyond the useful life. For instance in Method 2, an equipment with 5-year useful life has been used since 2007. A study calculated costs in 2012 value. This equipment has been used for 7 years. Therefore, seven years is for useful life in the capital costing equation. For indirect cost calculation, simultaneous equation methods were used[7]. The direct and indirect costs were summed to yield total costs. Unit costs for out-patient and in-patient cost centers were calculated using the average method[15].

2.4 Analysis

All costs were converted to 2012 prices by using the consumer price index[16]. and then were converted to US dollars[17]. The cost structure of the hospital indicating the proportion of costs associated with capital, labor and material costs were compared among 3 capital costing methods. Unit costs for out-patients (routine service cost per visit) and inpatients (hotel cost per admission and per patient day) for selected departments were calculated and compared among the capital costing methods.

3. RESULTS

Total hospital cost associated with each capital costing method is shown in Table 1. Costs varied from US$54,251,245 for method 1 to US$ 48,166,628 for method 3. Capital costs as a share of total costs varied across the three methods from a high of 16% when method 1 was used to 5% when method 3 was used. For capital assets, there were 25,609 items of equipment, furniture and vehicle (Table 2). Twenty-six percent of these assets were used for longer than their reference useful life. 10 out-patient clinics and 31 in-patient wards were selected for unit cost calculation. Generally, unit costs from method 1 were highest while those associated with method 3 were lowest. Comparing methods 1 and 2, and methods 1 and 3, the average percent difference of cost per visit (routine service cost) was 2.71% and 9.68%, respectively (Table 3). For in-patient services (cost per admission and cost per patient-day), average percent difference was 3.08% and 11.18%, respectively (Table 4 and Table 5).

Table 1. Cost structure of the hospital (US$ in 2012 value)

Method	Capital cost	Labor cost	Material cost	Total cost
Method 1	8,692,564	20,313,095	25,245,586	54,251,245
	(16%)	(37%)	(47%)	(100%)
Method 2	6,625,909	20,313,095	25,245,586	52,184,590
	(13%)	(39%)	(48%)	(100%)
Method 3	2,607,947	20,313,095	25,245,586	48,166,628
	(5%)	(42%)	(53%)	(100%)
Difference between Method 2 and 1[a]	-24%	n/a	n/a	n/a
Difference between Method 3 and 1[b]	-70%	n/a	n/a	n/a

[a] (M2-M1)/M1 [b] (M3-M1)/M1

Table 2. Capital assets of the hospital (US$ in 2012 value)

	Equipment, furniture, vehicle	Building, construction	Total
Total items	25,609	28	25,637
Over useful year items*	6,739	8	6,747
Percentage of over useful year items	26.31%	28.57%	26.32%

*Use for more than reference useful years

Table 3. Unit cost of out-patient services; routine service cost per visit (US$ in 2012 value)

Cost center	Output (visit)	Method 1	Method 2		Method 3	
		A	B	(A-B)/A	C	(A-C)/A
Out-patient clinic; Ear nose and throat	8,905	16.80	15.95	5.07%	13.81	17.83%
Out-patient clinic; Gynaecology	44,600	3.97	3.87	2.38%	3.59	9.41%
Out-patient clinic; Internal medicine	189,025	4.06	4.01	1.35%	3.85	5.14%
Out-patient clinic; Ophthalmology	40,469	10.04	9.43	6.05%	8.13	18.99%
Out-patient clinic; Orthopaedics	31,998	9.36	9.20	1.66%	8.74	6.56%
Out-patient clinic; Pediatrics	23,392	7.94	7.75	2.32%	7.20	9.33%
Out-patient clinic; Psychiatry	16,608	15.34	15.01	2.18%	14.28	6.90%
Out-patient clinic; Surgery	70,250	7.16	7.06	1.41%	6.79	5.19%
Out-patient clinic; Medical Rehabilitation	15,500	11.22	11.00	1.97%	10.37	7.61%
Out-patient clinic; Accident and Emergency	76,096	13.44	13.07	2.75%	12.11	9.87%
Minimum		3.97	3.87	1.35%	3.59	5.14%
Maximum		16.80	15.95	6.05%	14.28	18.99%
Mean		9.93	9.64	2.71%	8.89	9.68%
Median		9.70	9.32	2.25%	8.44	8.47%
Standard deviation		4.38	4.19	1.58%	3.76	4.90%

Table 4. Unit cost of in-patient services; hotel cost per admission (US$ in 2012 value)

Cost center	Output (admission)	Method 1	Method 2		Method 3	
		A	B	(A-B)/A	C	(A-C)/A
In-patient ward; Ear nose and throat 1	2,229	184.48	178.40	3.29%	158.58	14.04%
In-patient ward; Ear nose and throat 2	2,235	170.66	164.80	3.43%	148.84	12.79%
In-patient ward; Gynaecology 1	3,893	126.91	123.56	2.64%	112.46	11.39%
In-patient ward; Gynaecology 2	2,590	141.79	138.59	2.25%	127.40	10.15%
In-patient ward; Gynaecology 3	2,415	165.58	162.14	2.07%	149.71	9.58%
In-patient ward; Internal medicine-female 1	3,764	144.54	140.83	2.57%	129.45	10.44%
In-patient ward; Internal medicine-female 2	3,964	139.70	136.23	2.48%	125.57	10.12%
In-patient ward; Internal medicine-male 1	985	568.89	554.37	2.55%	519.53	8.68%
In-patient ward; Internal medicine-male 2	3,948	134.75	131.58	2.35%	123.58	8.29%
In-patient ward; Internal medicine-male 3	3,969	125.78	122.64	2.50%	114.81	8.72%
In-patient ward; Medical rehabilitation	403	532.30	523.08	1.73%	489.05	8.12%
In-patient ward; Orthopaedics 1	2,285	174.02	170.14	2.23%	158.88	8.70%
In-patient ward; Orthopaedics 2	2,355	170.55	166.95	2.11%	156.19	8.42%
In-patient ward; Orthopaedics 3	1,958	186.74	182.99	2.00%	171.54	8.14%
In-patient ward; Pediatrics 1	2,889	97.47	95.16	2.37%	89.02	8.67%
In-patient ward; Pediatrics 2	3,832	114.28	111.47	2.46%	104.64	8.44%
In-patient ward; Pediatrics-newborn	1,933	185.96	172.81	7.07%	154.88	16.71%
In-patient ward; Surgery-accident	3,719	237.79	232.02	2.43%	215.50	9.37%
In-patient ward; Surgery-general	862	469.25	458.97	2.19%	432.89	7.75%
In-patient ward; Surgery-general-female	4,147	188.51	184.48	2.14%	168.52	10.60%
In-patient ward; Surgery-general-male	4,154	179.46	175.82	2.03%	160.50	10.57%
In-patient ward; Surgery-neurology	1,332	656.78	642.96	2.10%	592.43	9.80%
In-patient ward; Surgery-plastic	1,871	222.51	217.87	2.08%	198.49	10.80%
In-patient ward; Surgery-urology	2,855	215.33	211.09	1.97%	190.67	11.45%
Intensive care unit; Burn	107	2,314.97	2,244.95	3.02%	1,963.16	15.20%
Intensive care unit; Internal medicine	675	1,212.28	1,129.19	6.85%	969.29	20.04%
Intensive care unit; Pediatrics	309	1,507.17	1,401.65	7.00%	1,192.47	20.88%
Intensive care unit; Pediatrics-newborn	260	1,650.43	1,518.40	8.00%	1,307.08	20.80%
Intensive care unit; Surgery-general 1	500	1,510.30	1,433.68	5.07%	1,310.01	13.26%
Intensive care unit; Surgery-general 2	259	1,847.97	1,802.23	2.48%	1,693.92	8.34%
Intensive care unit; Surgery-general 3	518	447.97	439.50	1.89%	420.04	6.23%
Minimum		97.47	95.16	1.73%	89.02	6.23%
Maximum		2,314.97	2,244.95	8.00%	1,963.16	20.88%
Mean		516.94	495.76	3.08%	446.74	11.18%
Median		186.74	182.99	2.43%	168.52	10.12%
Standard deviation		612.87	583.39	1.74%	516.53	3.87%

Table 5. Unit cost of in-patient services; hotel cost per patient-day (US$ in 2012 value)

Cost center	Out put	Method 1	Method 2		Method 3	
	(patient-day)	A	B	(A-B)/A	C	(A-C)/A
In-patient ward; Ear nose and throat 1	8,882	46.30	44.77	3.29%	39.80	14.04%
In-patient ward; Ear nose and throat 2	9,035	42.22	40.77	3.43%	36.82	12.79%
In-patient ward; Gynaecology 1	10,763	45.91	44.69	2.64%	40.68	11.39%
In-patient ward; Gynaecology 2	8,239	44.57	43.57	2.25%	40.05	10.15%
In-patient ward; Gynaecology 3	7,067	56.58	55.41	2.07%	51.16	9.58%
In-patient ward; Internal medicine-female 1	13,882	39.19	38.18	2.57%	35.10	10.44%
In-patient ward; Internal medicine-female 2	13,510	40.99	39.97	2.48%	36.84	10.12%
In-patient ward; Internal medicine-male 1	5,178	108.22	105.46	2.55%	98.83	8.68%
In-patient ward; Internal medicine-male 2	14,415	36.91	36.04	2.35%	33.85	8.29%
In-patient ward; Internal medicine-male 3	15,074	33.12	32.29	2.50%	30.23	8.72%
In-patient ward; Medical rehabilitation	3,885	55.22	54.26	1.73%	50.73	8.12%
In-patient ward; Orthopaedics 1	11,004	36.14	35.33	2.23%	32.99	8.70%
In-patient ward; Orthopaedics 2	11,634	34.52	33.80	2.11%	31.62	8.42%
In-patient ward; Orthopaedics 3	1,044	350.22	343.20	2.00%	321.71	8.14%
In-patient ward; Pediatrics 1	5,059	55.66	54.34	2.37%	50.84	8.67%
In-patient ward; Pediatrics 2	10,858	40.33	39.34	2.46%	36.93	8.44%
In-patient ward; Pediatrics-newborn	11,323	31.75	29.50	7.07%	26.44	16.71%
In-patient ward; Surgery-accident	10,216	86.56	84.46	2.43%	78.45	9.37%
In-patient ward; Surgery-general	7,068	57.23	55.97	2.19%	52.79	7.75%
In-patient ward; Surgery-general-female	20,656	37.85	37.04	2.14%	33.83	10.60%
In-patient ward; Surgery-general-male	21,724	34.32	33.62	2.03%	30.69	10.57%
In-patient ward; Surgery-neurology	11,177	78.27	76.62	2.10%	70.60	9.80%
In-patient ward; Surgery-plastic	10,735	38.78	37.97	2.08%	34.59	10.80%
In-patient ward; Surgery-urology	14,720	41.76	40.94	1.97%	36.98	11.45%
Intensive care unit; Burn	1,906	129.96	126.03	3.02%	110.21	15.20%
Intensive care unit; Internal medicine	3,596	227.56	211.96	6.85%	181.94	20.04%
Intensive care unit; Pediatrics	2,186	213.04	198.13	7.00%	168.56	20.88%
Intensive care unit; Pediatrics-newborn	3,254	131.87	121.32	8.00%	104.44	20.80%
Intensive care unit; Surgery-general 1	2,858	264.22	250.82	5.07%	229.18	13.26%
Intensive care unit; Surgery-general 2	2,897	165.21	161.12	2.48%	151.44	8.34%
Intensive care unit; Surgery-general 3	2,833	81.91	80.36	1.89%	76.80	6.23%
Minimum		31.75	29.50	1.73%	26.44	6.23%
Maximum		350.22	343.20	8.00%	321.71	20.88%
Mean		86.66	83.46	3.08%	75.97	11.18%
Median		46.30	44.77	2.43%	40.68	10.12%
Standard deviation		79.11	75.63	1.74%	68.71	3.87%

4. DISCUSSION

There is a similar study in the literature that demonstrated the effect of costing methods in previous study[12]. This study indicates that costing method chosen should meet two criteria: present value method to yield economically correct results and constant value for each year to be consistent with the evaluation of the project by examining annual costs. This study compared results of capital cost from equation with opportunity cost (discounting) (as in Equation 1 mentioned above) and without opportunity cost (accounting approach; purchasing price/ useful years). The results from the method without opportunity cost are less than that of with opportunity by 8.4% to 33% when using 3% discount rate and 15% discount rate, respectively. Another study was conducted in Thailand[18]. This study was conducted in a district hospital. It was found that total annualized capital cost of buildings and capital items calculated by the accounting approach (method 3) was 13% less than that of the economic-based approach (method 1). Results of this previous study and this current study are in same direction. However, the proportion of difference cannot be directly compared due to difference in level of settings and useful life used in the analyses. The previous study used 20 years and 5 years for building and other capital assets, respectively. In addition, capital cost beyond useful life was ignored. In previous study, there was no analysis of effect on unit cost of services. Therefore, there is no comparison. However, in this study, the maximum percent difference was 21% in case of cost per admission which is quite considerable. The difference is dependent on inputs of capital assets or medical equipment. The hospital's overall capital cost must be the mixture of costs of different sources of capital. It is a fact that consumption of equipment, drugs, labor and other ancillary resources are significantly different among wards, for instance, cardiology patients generally require higher clinical inputs as compared to general medical patients may be due to much costly instruments involved in cardiac patients.

These findings may also provide concern on using costing data in efficiency management, financing management and health economic evaluation. For efficiency management, we are concerned with how resources are used in production by comparison in terms of monetary unit reflecting quantity of resources. Therefore, if the difference of the monetary cost comes from different costing methods, this can be misinterpreted. In case of financing management, price or reimbursement rate setting is normally based on cost. Inaccurate cost will affect the income of provider and budget of payer. These could, then, affect sustainability of the organizations.

In addition, in economic evaluation of health intervention, normally, results are based on effectiveness of the intervention, costing data and evaluation methods. When effectiveness of intervention and evaluation method are considered to be constant, the intervention can be cost-effective or not from costing parameter. Cost-effectiveness is based on incremental cost effectiveness ratio (ICER) or cost of additional unit of effective output unit comparing to willingness to pay or cost-effectiveness threshold. ICER is calculated by difference on cost of compared interventions divided by difference on effectiveness of compared interventions. Cost of each alternative is sum of cost of the intervention activity and cost of studied illness. Unit cost of hospital medical services is used in cost of studied illness and cost of intervention activity in case of hospital related intervention. If estimated unit cost from different methods used in the CEA makes change on the ICER across the cost-effective threshold, this results in policy decision makers accepting the intervention. The society will then either lose opportunity of using the cost-effective intervention or likewise waste their resources on using non cost-effective intervention.

Based on the significant effect of capital costing methods aforementioned, we have to be careful while selecting an appropriate method suited to individual context. According to economic concept, costing method 3 i.e. accounting technique using fixed useful life

and considering no cost beyond the useful life is not quite relevant. This is in fact based on economic definition of cost, which states cost as the value of resources used to produce goods or services. Therefore, once the resources are used, the cost cannot be considered zero. However, Method 1 (i.e. Economic method with a 3% discount rate and fixed useful life for capital assets) is applied based on a concept of accurately estimating useful life. Useful life period of any resources is estimated based on actual usage of capital asset without any repairment (except some routine maintenance).[1] Some capital assets that seem to be in proper working condition even after extending its useful life are due to the fact that they may have received a repair with major part(s) change. Therefore, these items may seem brand new after the repair while in fact the useful life is still fixed as the reference. Method 2 (i.e Economic methods in which useful life of a resource is extended up to the year of the cost analysis being conducted; only just in case if the goods still functions beyond the reference useful life) is actually applied when there is underestimation of period of useful life. This assumes that there is no repairment. Cost of routine maintenance is classified as material cost and not included in this analysis. We may have seen different producers producing similar capital assets with different quality, which is why their periods of useful life are also different. The items that are used longer than the reference period are never repaired but have better quality than the reference. The selection and implementation of Method 1 or 2, it solely based on individual context. In developing countries, due to very limited budget, there has been a trend to continuously keep using capital assets as long as possible with constant repairing. Therefore, it may seem practical and relevant to adopt Method 1 in developing countries.

5. CONCLUSION

The selection of the best costing method involved in estimation of hospital capital cost is very crucial in order to gain financial stability. When it comes to capital cost analysis, the useful life of all the capital assets needs to be thoroughly reviewed or standardized as it might considerably have an effect on estimation of overall hospital capital cost. The work reported in this manuscript has demonstrated that hospital capital costs are sensitive to the costing methods adopted. Since the findings from hospital cost analysis affect the estimation of budget, it would ultimately affect the hospital financial management. Using the analysis results without consideration of costing methods would lead to an error of management and wrong policy. Therefore, standard costing guidelines should be developed for each country for better sustainability of the country's national schemes.

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