RESEARCH ARTICLE

Hospital Cost Analysis in Developing Countries: A Methodological Comparison in Vietnam

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Abstract

Context: Health-care expenditure is increasing worldwide. To control costs and increase efficiency, health economics has been applied by hospital management. Determining the unit cost of medical services is essential for health economics analysis, including health-care financing. **Aims**: The aim of this study is, therefore, to explore the unit cost analysis of medical services in Vietnam as well as the effects of applying different costing methods. **Materials and Methods:** A standard costing approach was applied to calculate the unit cost of medical services in two provincial hospitals. During the unit cost calculation, the micro-costing method and the ratio of cost to charge (RCC) method were compared. For both hospitals, the total cost as well as the proportion of capital, labor, and material costs were calculated and compared. The unit cost analysis covered 776 services in Ha Nam Hospital and 2064 services in Thu Duc Hospital. **Results:** Although both hospitals offer the same level of service, they differ in terms of other characteristics. Hence, their costs are quite different. Comparing the results calculated using the micro-costing method and the RCC method, the unit costs of the same services were also found to be quite different. The present study should prove particularly valuable in relation to the methodological comparison of hospital service cost analysis in developing countries such as Vietnam. **Conclusions:** The micro-costing method proved to be the most accurate method when calculating the unit cost of medical services since it was best able to reflect the consumption of resources.

Key words: Medical services, micro-costing, ratio of cost to charge, unit cost, Vietnam

INTRODUCTION

Nowadays, the prices of medicine and health-care services are often so expensive as to be barely affordable, not only for the majority of low- and middle-income countries but also for a sizeable segment of the global population who do not receive adequate social protection or insurance such as that available in high-income countries.[1,2] As a consequence, both cost containment and efficiency management are considered to be urgent policy issues. For many countries, health economics is applied as a tool for providing information to policymakers.[3] As evidence-based policy making rarely relies on individual studies, policymakers and the researchers who support them typically attempt to make the best possible use of the various partially relevant studies that are already available.[4] Consequently, the standardized methods and reference values used in health economics studies are vital to the achievement of reliable and comparable results. In the field of health economics, the cost analysis of health-care

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services is necessary for the evaluation of the efficiency of routine services and intervention choices. In addition, it is also used in health financing in relation to both the government budget and the reimbursement of health insurance.

In recent years, the health status of Vietnamese people has been significantly enhanced. Many fundamental health indicators concerning the Vietnamese are higher when compared to those of other countries with an equivalent average income. However, some essential indicators have remained poor, while regional differences in terms of such health indicators persist. The Vietnamese population was estimated to be around 89.71 million in 2013.[5] The Vietnamese health-care system is comprised a highly unregulated group of both public and private medical facilities and services. The health-care establishments within the public system consist of four levels of hospital facilities, namely, central, provincial, district, and community facilities. Further, the public sector plays a leading role in providing inpatient health services in 1063 hospitals, with a total of 222,025 patient beds being available in 2014.[6] In developing countries, the government typically provides hospitals that account for more than 50% of all medical resources. In the case of Vietnam, this figure was 41.9% in 2010.[7,8]

According to the standard costing method, there are alternative calculation methods available for each step. These different methods result in a variation in the unit costs of medical services, which has been demonstrated in countries such as Canada,[9,10] the Netherlands,[11] India,[12] Thailand,[3] and the Philippines.[13] Therefore, the present study aims to explore a unit cost analysis of hospital medical services in Vietnam as well as the effects of different costing methods.

SUBJECTS AND METHODS

Study design

The economic cost of medical services was determined by the standard costing approach, which was performed from the hospital's perspective.[14] The unit cost of medical services was estimated by employing the micro-costing method and comparing it to the ratio of cost to charge (RCC) method.[15,16] The overall costs consist of the monetary value of the materials, labor, and capital assets used to provide the services.

Study hospitals

Two hospitals in different regions of Vietnam were selected on the basis of their willingness to participate in the study such as Ha Nam Hospital and Thu Duc Hospital. Ha Nam Hospital is located in Phu Ly City, Ha Nam Province, which is in the north of Vietnam some 60 km away from Hanoi. Ha Nam Hospital, which was established in 1954, is a Level II infirmary with a capacity of 662 beds, 124 inpatient admissions, and 540 outpatient visits per day as of 2012. Some 655 health-care staff are employed in 35 departments in Ha Nam Hospital. Meanwhile, Thu Duc Hospital is located in Ho Chi Minh City, which is the largest city in the South of Vietnam. Similar to Ha Nam Hospital, Thu Duc Hospital is a Level II infirmary with a capacity of 700 beds. In 2014, the numbers of visits and admissions per day were over 1,500 for outpatients and almost 100 for inpatients, respectively. The total number of hospital staff working in the 31 departments that comprise Thu Duc Hospital is 780. Furthermore, in 2012, the occupancy rate of Thu Duc Hospital was only 86%, while that of Ha Nam hospital was 123%.

Costing methodology

The term "cost" in this study refers to the economic cost, which is defined as the monetary value of the resources that are consumed to create goods or services.[17] The standard or conventional method of determining cost was employed in this study.[18-20] Figure 1 provides information about the analysis process concerning the unit cost analysis of medical services based on the standard costing methodology, which consists of six steps: (1) Study design and planning, (2) organization analysis and cost center classification, (3) direct cost of cost centers determination, (4) indirect cost determination, (5) full cost (FC) determination, and (6) unit cost of hospital services calculation.

Step one - study design and planning

This step requires the identification of the objectives, cost objects (or cost products), perspective, level of the organization involved, time horizon, and cost component.

Step two - Organization analysis and cost center classification

The structure of the relevant hospital organization is analyzed and then classified into two groups, namely, transient cost centers (TCCs), which are cost centers that support other cost centers, and absorbing cost centers (ACCs), which are cost centers that provide services that need to be calculated.

Step three - direct cost determination

The direct costs of each cost center are determined by accumulating the values of its capital costs, labor costs, and materials costs. Then, the capital cost method and useful years are added.

Step four - indirect cost determination

In this step, the allocation criteria are used to rearrange and allocate the cost allocation. In this study, several allocation methods were considered, namely, direct allocation, step-down allocation, double allocation, and simultaneous allocation. However, simultaneous allocation, which is the most accurate method, was ultimately employed in this study. The allocation

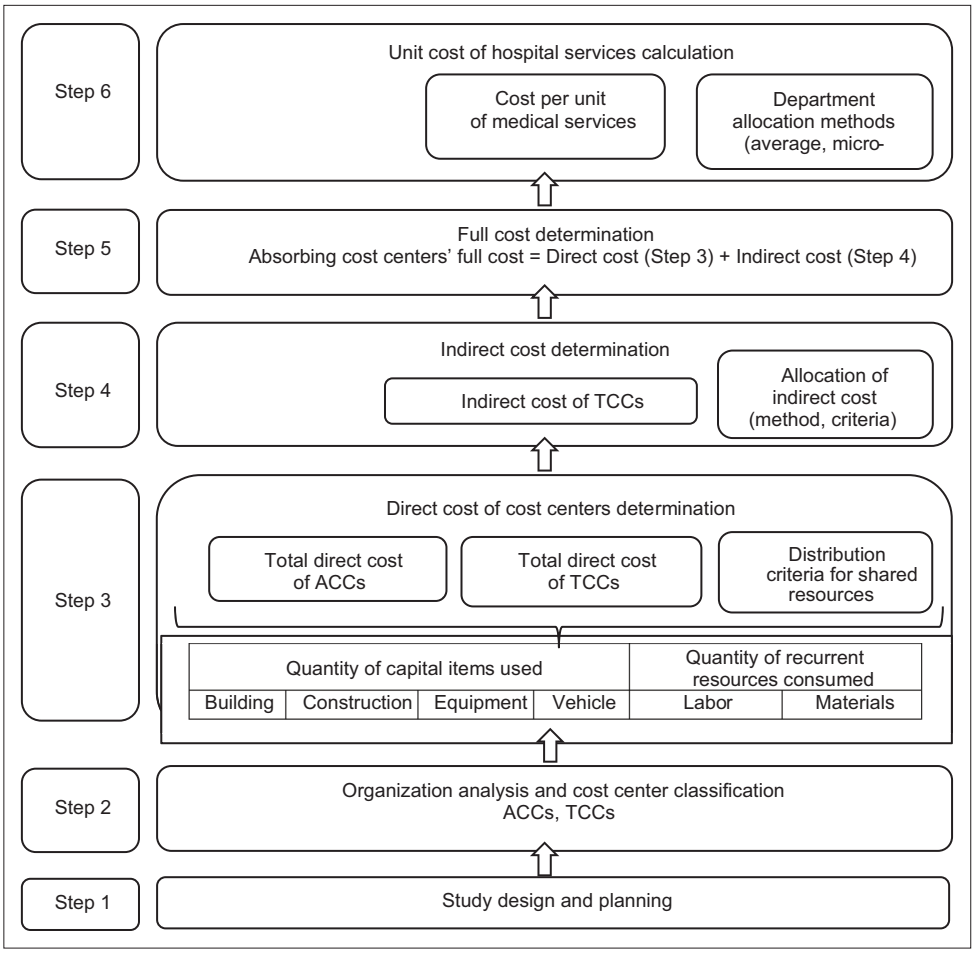

Figure 1: Analysis process based on the standard unit cost analysis of medical services.
ACCs - absorbing cost centers, TCCs - transient cost centers

criteria of TCCs (T1, T2, and T3) were applied as the full-time equivalents of the department of administration, personnel, and finance, respectively, while in the case of the amount of infectious garbage, the revenue was used to allocate the infection control cost center, including laundry (T6) and planning (T4).

Step five - FC determination

The FC of an ACC is calculated based on the summation of the total direct cost (TDC) and all indirect costs (IDCs):

FC = TDC + sum of indirect costs (IDCs)

Step six - unit cost of hospital services

In the unit cost analysis, the unit cost calculation is defined using multiple methods, including the average method, the micro-costing method, the relative value unit (RVU) or weight procedure method, and the RCC method.

In cases where the ACC produces only one output (a cost object) or a number of homogeneous outputs (e.g. an outpatient service), the average unit costs are used. For multi-product cost centers, a number of methods are available. The most accurate such method, which does require a greater workload, is the micro-costing method since it is based on actual resource use.[21] The micro-costing method first determines the direct cost of each service (that is, the amount of countable resources that are used during the provision of the service). The second utilized method is the RCC method.[22] This method is relatively less accurate, but it requires a lower workload. The RCC is computed based on historical records. It is used to estimate the cost of each service based on the relevant charge information obtained from patient bills.

In this study, we employed micro-costing as a base case, while the RCC method was used to explore the difference. Micro-costing is measured by the cost estimation that relates to "direct enumeration and costing out of every input consumed in service production." The time spent using equipment and the total working time of laborers (including doctors, nurses, and technicians) in practicing specific services were calculated as a proportion of the remainder of the cost. The costs are then calculated by assessing the average working time measured using the labor cost of doctors, nurses, and technicians or the capital cost. This calculation is considered

to be fairly simple. First, the total capital cost per department as multiplied by the total time spent using equipment for each service is determined. It is then divided by the total time spent using equipment per department, which results in the unit capital cost of a service.

Second, the unit labor cost of a service is calculated by multiplying the labor cost per department by the time spent working on each service, which is then divided by the total working time of laborers per department. Third, the unit materials cost of a service is calculated by multiplying the total materials cost per department by the unit price of the service and then dividing it by the total revenue per department. Finally, the unit cost of hospital services is the sum of the unit capital cost, unit labor cost, and unit materials cost.

The RCC is calculated by establishing the total cost of the department, prices, and number of services produced. In the first step, the unit prices and the number of services practiced are used to compute the total expected charge. After that, the RCC equals the total cost divided by the total expected charge. Finally, the unit cost of each service is determined by multiplying that ratio and unit price. For instance, when the full charges are 200,000 VND (Vietnam dong), and the total costs are 50,000 VND, the RCC is computed as 0.25. Next, the RCC is applied to determine the costs of services. Then, the unit cost of each service equals the charge (unit price) for each service multiplied by the RCC (0.25), which is used to determine the cost of hospital services.

Data collection and management

The period of time spent collecting the data necessary for the research is defined as a year as well as the period of time during which the costs and outputs are to be considered. Normally, the unit cost analysis of a whole year is practiced so as to avoid the effect of seasonal variations in the number of patients, which might ultimately affect the cost per unit of the fixed cost. This study was conducted during the fiscal year 2012 for Ha Nam Hospital and in the fiscal year 2014 for Thu Duc Hospital.

All data were retrospectively collected. The utilized data collection tools were developed by the research team. The tools were piloted and tested in one hospital. In each of the studied hospitals, staff members with access to data and information concerning finance, equipment, and hospital activities as well as the ability to conduct calculations and use a computer (including representatives of each department) were selected for a 1-day training course regarding the methods of data collection. They were then responsible for collecting data at their hospitals. The two hospitals' activity and annual financial reports represent the main sources utilized from the medical record database, which includes information about outpatient visits, admissions, and inpatient days. In terms of the hospitals' annual accounting report, we retrieved the recurrent expenditures, for example, office materials, maintenance costs spent on equipment or the building and cleaning, electricity, telephone, mail, and internet.

Data analysis

All costs were obtained and presented in the monetary unit of Vietnam (VND), while the total cost of each hospital is presented together with the proportion of the cost component. The unit costs of all medical services derived using the two costing methods are presented with the percentage of the difference. The unit costs of services in Ha Nam Hospital in 2014 were calculated from the unit costs in 2012 by adjusting the consumer price index between 2012 and 2014 with the formula $\text{Cost}_{2014}=\frac{\text{CPI}_{2014}}{\text{CPI}_{2012}}.\text{Cost}_{2012}$ with $\frac{\text{CPI}_{2014}}{\text{CPI}_{2012}}=110.96$.[23,24]

RESULTS

Organization analysis and cost center classification

As shown in Table 1, the organizational structures of Ha Nam Hospital and Thu Duc Hospital were based on their functions as supporting departments or patient service producing departments. They were classified as either TCCs or ACCs. The overall cost centers proved similar, comprised eight TCCs for both hospitals as well as 23 ACCs for Thu Duc Hospital and 27 ACCs for Ha Nam Hospital. Each cost center was coded using either the letter "T" or "A" to indicate the group it belongs to TCCs or ACCs.

Direct costs

Table 2 displays the figures for the TDC obtained by multiple the different types of cost centers. From the information displayed in the table, it can be seen that the TDC (including drugs) can be determined by adding factors such as the capital cost, labor cost, and materials cost (drugs cost or other materials) together. At Ha Nam Hospital (in 2012), the value of the TDC without drugs was only 60,662,426,620 VND (2,910,761 USD), whereas the value of the TDC including drugs was 104,949,174,620 VND (5,039,092 USD). As seen in Table 2, the TDC without drugs for Ha Nam Hospital was divided between TCCs (15%) and ACCs (85%), while it was similarly divided between TCCs (17%) and ACCs (83%) for Thu Duc Hospital. Yet, the percentages of TCCs and ACCs were 9% and 91%, respectively, in the case of Ha Nam Hospital, whereas in the case of Thu Duc Hospital they were 14% and 86%, respectively. From the data, it is evident that the labor cost of Ha Nam Hospital and the material cost of Thu Duc Hospital accounted for the largest part of the ACCs cost. In Ha Nam Hospital, the labor cost comprised 46% of the

Table 1: Organization analysis and cost center classification

Ha Nam Hospital in 2012	Thu Duc Hospital in 2014
Transient cost centers - TCCs Administration (T1), Personnel (T2), Planning (T3), Finance (T4), Supply and Equipment (T5), Infection Control (incl. laundry) (T6), Nutrition (T7), Nursing (T8)	The same as for Ha Nam Hospital
Absorbing cost centers - ACCs Pharmacy (A1), Laboratory (A2), Pathology (A3), X-Rays (A4), Functional Probe (A5), Artificial Kidney (A6), Dental (A7), Examination (incl. OPD) (A8), Emergency (A9), Recovery–Toxic (A10), Surgery/Anesthesiology/Recovery (A11), Internal Medicine I (A12), Internal Medicine II (A13), Internal Medicine III (A14), Internal Medicine A (A15), Pediatrics (A16), Infectious Disease (A17), Surgery (A18), Urinary Surgery (A19), Maternity/Gynecology (A20), Trauma (A21), Rehabilitation (A22), Ophthalmological (A23), Ear-Nose-Throat (ENT) (A24), Dermatology (A25), Cancer (A26), Traditional Medicine (A27)	Pharmacy (A1), Laboratory (A2), Imaging (A3), Endoscopic (A4), Examination (incl. OPD) (A5), Emergency (A6), Trauma (A7), Artificial Kidney (A8), Recovery–Toxic (A9), Ophthalmological (A10), Ear-Nose-Throat (ENT) (A11), Dental (A12), Maternity/Gynecology (A13), Pediatrics (A14), Infectious Disease (A15), Endocrinology (A16), Surgery/Anesthesiology/Recovery (A17), Surgery (A18), Neurosurgery (A19), Internal Medicine I (A20), Internal Medicine II (A21), Internal Medicine III (A22), Traditional Medicine (A23)

Table 2: Total direct costs by type of cost center

Group	TCCs (%)	ACCs (%)	Total cost (%)
Ha Nam Hospital (VND in 2012)			
Capital cost	2,319,862,385 (25)	16,845,313,547 (33)	19,165,175,932 (32)
Labor cost	4,577,357,434 (49)	23,543,449,254 (46)	28,120,806,688 (46)
Materials cost			
Drugs cost	-	44,326,748,000	-
Other materials	2,485,087,396 (26)	10,851,356,604 (21)	13,336,444,000 (21)
TDC (including drugs)	9,382,307,215 (9)	95,566,867,404 (91)	104,949,174,620 (100)
TDC (excluding drugs)	9,382,307,215 (15)	51,240,119,405 (85)	60,622,426,620 (100)
Thu Duc Hospital (VND in 2014)			
Capital cost	1,772,162,441 (5)	15,061,429,792 (8)	16,833,592,233 (7)
Labor cost	9,914,307,519 (25)	64,399,377,638 (32)	74,313,685,157 (31)
Materials cost			
Drugs cost	-	40,287,480,339	-
Other materials	28,426,131,369 (70)	122,598,749,157 (60)	151,024,880,526 (62)
TDC (including drugs)	40,112,601,328 (14)	242,347,036,926 (86)	282,459,638,254 (100.00)
TDC (excluding drugs)	40,112,601,328 (17)	202,059,556,587 (83)	242,172,157,915 (100.00)

TDC: Total direct cost

total ACCs cost, while the material cost accounted for 60%. The TDC (excluding drugs) was comprised three components, namely, the capital cost, labor cost, and materials cost, which are accounted for 32%, 46%, and 21%, respectively, in the case of Ha Nam Hospital. With regard to the TCCs cost, 49% was recorded as the cost of labor, while the values of the capital cost and labor cost in the TCCs accounted for 25% and 26%, respectively. However, the labor cost of the ACCs accounted for a higher proportion (46%) when compared to the capital cost (33%) and labor cost (21%) of those ACCs. In Thu Duc Hospital, differences were found in the proportions of each group (capital cost, labor cost, and materials cost). In terms of the total cost, the capital cost, labor cost, and materials cost contributed 7%, 31%, and 62%, respectively. The materials cost also accounted for the largest proportion of cost in both the TCCs and ACCs, representing 70% and 60% of the total cost, respectively. The labor cost accounted for the second largest proportion, representing 25% and 32% of the total cost related to TCCs and ACCs, respectively. The remaining cost (capital cost) of the TCCs accounted for only 5% of the total cost, while it accounted for 8% of the total cost of the ACCs.

Indirect cost determination

This step presents the indirect cost determination through the allocation criteria for the eight TCCs, which are coded from T1 to T8 for both Ha Nam Hospital and Thu Duc Hospital. The FC of all the TCCs was transferred to the ACCs, in

which the transferred cost is referred to as the indirect cost of the ACCs. The simultaneous method was used for the indirect cost allocation. In our study, the allocation criteria for each cost center were selected from one product provided by the TCCs. For example, full-time equivalent represents the allocation criteria for the cost centers of administration (T1), personnel (T2), and finance (T3). Both the nutrition (T7) and nursing (T8) cost centers are considered based on patient-day criteria. Moreover, the revenue, cost of supply, and amount of infectious garbage were allocated to the cost centers of planning (T4), supply and equipment (T5), and infection control (T6), respectively.

FC determination of ACCs without drugs

Table 3 displays the FC determination without drugs for the ACCs in Ha Nam Hospital (2012, VND). It can be seen that the values of the 27 ACCs were added together to determine the value of the FC of the ACCs (60,622,426,621 VND = 2,910,761 USD). After the direct and indirect costs were determined, the FC of the ACCs (6) could be determined through the sum of the indirect cost (5) and the TDC (4), which was derived by adding the values of the capital cost (1), labor cost (2), and materials cost (3). More specifically, the values that contributed to the TDC (4) were 21% (10,851,356,603 VND) for the materials cost, 33% (16,845,313,545 VND) for the capital cost, and 46% (23,543,449,257 VND) for the labor cost. As the summation needed to calculate the FC of the ACCs is already presented in the table, it is possible to see that the FC of the ACCs (60,622,426,621 VND) in Ha Nam Hospital (2012) was comprised two factors, namely, the TDC, which accounted for 85% (51,240,119,407 VND) of the total ACCs FC, and the indirect cost, which accounted for 15% (9,382,307,212 VND).

In terms of the FC of the ACCs, the three departments with the highest value cost (VND) were the pharmacy (A1), emergency (A9), and X-ray (A4) departments, which, respectively, accounted for 5,220,535,796 (9%), 6,444,992,766 (11%), and 7,396,739,810 (12%). However, the TDC ranged from 74% to 95%, with the former figure belonging to the cancer department (74%) and the latter to the X-ray department (95%). The percentage of the labor cost ranged from 12% to 83%, with the lowest percentage (12%) being seen for the X-ray (A4) department and the highest (83%) for the dental (A7) department. Despite of approximately vibration of relatively large value, 11 of the 26 cost center values were greater than 70%. In addition, the average capital cost and materials cost were 33% and 21%, respectively. The ranges of the capital and materials cost values were very similar, being between 3% and 85%.

Unit cost of hospital services

The unit cost analysis covers 776 services and 2064 services in Ha Nam Hospital and Thu Duc Hospital, respectively. Table 4 displays the relevant information regarding the sample unit cost (VND) of each service provided by the Laboratory (A2) cost center as calculated using the micro-costing method in Ha Nam Hospital in 2012 and 2014. In terms of the values of the unit cost, it is recognized that the values for the Cross-match in blood service were the largest during both surveyed years (16,789 VND and 18,672 VND). This was followed by the figures for the Test Coombs service and Blood Sedimentation (Handiwork) service, which were 13,764 VND and 15,271 VND for the Test Coombs service and 14,386 VND and 15,961 VND for the Blood Sedimentation (Handiwork) service in 2012 and 2014, respectively. Yet, the three lowest unit cost statistics, which had similar values at 1,239 VND (2012) and 1,375 VND (2014), belonged to the red blood cell count service, white blood cell count service, and platelet (Plt, quantitative, and machine) service, respectively. In terms of the TDC sector, there are a number of noticeable features, one of which is the value of the HBsAg (qualitative and quick test) service being 107,722,951 VND. Meanwhile, the HIV (quick test) service cost is slightly lower than the HBsAg service at 93,023,815 VND. Ultimately, the retic index (Handiwork) has the lowest cost, with a value of 3493 VND.

In terms of the cost allocation taken from the departments to their units of services, the unit costs of medical services in every department of the two hospitals were calculated using both the micro-costing and RCC methodologies. The latter method was computed by dividing the FC by the total revenue. The analysis of the RCC at Ha Nam Hospital revealed that the variation in the RCC ranged from 0.27 to 16.73 at 2.94 of the average of the RCC. Of the 27 ACCs (apart from the Pharmacy [A1]), seven cost centers had an RCC under 1.0, which renders the RCC the most profitable department. Most of the cost centers exhibited a current price of hospital services dissimilar to the real cost experienced in these services. The RCC of the artificial kidney (A6) department was 0.11, which indicated that the department made the largest profit. This was also proven by its unit cost per department, which was 400,352 VND, followed by the X-ray (A4) department at 125,578 VND. On the contrary, the Department of Surgery/Anesthesiology/Recovery (A11) had the highest RCC at 16.73. The results revealed that the average RCC in Thu Duc Hospital was 6.04 (range from 0.49 to 270), which means that the cost for practicing the service is higher than the current price of the service itself; hence, there is an unnecessary monetary loss. Of the remaining 23 cost centers, only the laboratory (A2) department's RCC was lower than 1.0 (0.49), meaning that providing the service in this department is profitable.

Comparison of the unit cost between the micro-costing method and the RCC method

Table 5 presents a comparison of the unit cost between the RCC method and the micro-costing method, which provides information about the unit costs (VND) of both Ha Nam Hospital and Thu Duc Hospital in 2014. The figures collected

Table 3: Full cost (FC) determination without drugs of ACCs in Ha Nam Hospital (2012, VND)

Cost center	Capital cost (%)	Labor cost (%)	Materials cost (%)	TDC (%)	Indirect cost (%)	FC of ACCs	Revenue	RCC
	(1)	(2)	(3)	(4) = (1)+(2)+(3)	(5)	(6) = (4)+(5)	(7)	(8)=(6)/(7)
A1	105,359,309 (3)	1,124,184,205 (28)	2,796,584,820 (69)	4,026,128,334 (77)	1,194,407,462 (23)	5,220,535,796	44,326,748,000	0.12
A2	525,141,436 (23)	1,047,209,297 (46)	720,280,282 (31)	2,292,631,015 (81)	543,277,745 (19)	2,835,908,760	10,508,510,000	0.27
A3	84,938,071 (19)	337,987,045 (74)	33,687,347 (7)	456,612,463 (78)	125,905,984 (22)	582,518,447	55,801,000	10.44
A4	5,423,887,361 (77)	832,107,614 (12)	760,871,919 (11)	7,016,866,893 (95)	379,872,917 (5)	7,396,739,810	6,061,787,000	1.22
A5	1,034,392,260 (51)	677,581,695 (34)	299,641,918 (15)	2,011,615,873 (89)	261,135,377 (11)	2,272,751,250	2,527,964,000	0.90
A6	66,389,164 (15)	-	377,784,925 (85)	444,174,089 (75)	149,021,006 (25)	593,195,095	5,464,400,000	0.11
A7	61,933,314 (6)	917,162,454 (83)	124,702,574 (11)	1,103,798,342 (84)	208,407,115 (16)	1,312,205,457	389,707,000	3.37
A8	1,089,388,060 (29)	1,978,951,928 (52)	716,097,818 (19)	3,784,437,806 (83)	748,361,310 (17)	4,532,799,117	3,892,598,000	1.16
A9	4,454,082,178 (74)	1,117,659,762 (18)	484,946,439 (8)	6,056,688,380 (94)	388,304,386 (6)	6,444,992,766	940,463,000	6.85
A10	235,758,023 (13)	1,329,852,008 (73)	243,761,022 (14)	1,809,371,053 (79)	493,523,399 (21)	2,302,894,452	827,706,000	2.78
A11	1,904,111,764 (44)	1,958,765,260 (46)	437,298,012 (10)	4,300,175,036 (91)	424,720,394 (9)	4,724,895,430	282,338,000	16.73
A12	94,860,665 (9)	750,924,680 (68)	258,418,900 (23)	1,104,204,245 (78)	316,251,627 (22)	1,420,455,872	856,409,000	1.66
A13	105,760,481 (10)	699,057,669 (67)	243,748,413 (23)	1,048,566,564 (79)	281,626,793 (21)	1,330,193,357	769,152,000	1.73
A14	93,440,039 (9)	697,411,774 (70)	202,872,020 (21)	993,723,833 (83)	197,316,256 (17)	1,191,040,089	571,277,000	2.08
A15	121,221,501 (15)	454,413,465 (58)	212,721,340 (27)	788,356,307 (82)	170,831,259 (18)	959,187,566	297,760,000	3.22
A16	505,940,484 (20)	1,464,898,533 (58)	567,834,282 (22)	2,538,673,299 (83)	535,541,393 (17)	3,074,214,691	2,187,803,000	1.41
A17	92,157,035 (10)	684,080,781 (71)	189,119,691 (19)	965,357,506 (83)	196,133,234 (17)	1,161,490,740	524,606,500	2.21
A18	85,437,686 (4)	1,436,582,032 (76)	377,222,738 (20)	1,899,242,457 (79)	510,083,459 (21)	2,409,325,916	2,915,144,000	0.83
A19	-	-	-	-	-	-	-	-
A20	315,940,194 (12)	1,668,956,605 (62)	690,498,370 (26)	2,675,395,169 (79)	705,569,375 (21)	3,380,964,545	3,558,754,000	0.95
A21	88,237,792 (5)	1,218,942,314 (74)	340,790,561 (21)	1,647,970,667 (80)	402,413,493 (20)	2,050,384,160	2,082,990,000	0.98
A22	53,610,696 (8)	472,764,282 (74)	111,132,768 (18)	637,507,747 (79)	171,213,584 (21)	808,721,331	312,333,000	2.59
A23	75,073,144 (11)	512,560,829 (72)	120,010,905 (17)	707,644,878 (77)	216,989,562 (23)	924,634,440	378,533,000	2.44
A24	88,632,530 (9)	758,633,513 (77)	137,813,378 (14)	985,079,420 (83)	205,865,246 (17)	1,190,944,666	618,721,000	1.92
A25	34,805,595 (7)	389,149,198 (78)	76,979,650 (15)	500,934,444 (84)	98,254,200 (16)	599,188,644	138,976,000	4.31
A26	53,663,883 (9)	403,032,658 (68)	132,307,634 (23)	589,004,175 (74)	210,378,920 (26)	799,383,095	349,132,500	2.29
A27	51,150,880 (6)	610,579,656 (71)	194,228,877 (23)	855,959,412 (78)	246,901,716 (22)	1,102,861,129	1,144,311,000	0.96
Total	16,845,313,545 (33)	23,543,449,257 (46)	10,851,356,603 (21)	51,240,119,405 (85)	9,382,307,215 (15)	60,622,426,620	47,657,176,000	1.27

from the two sites were calculated using both the MC and RCC methods. Later on, in terms of the MC and RCC results, the percentage of difference was determined by subtracting particular MC figures from their RCC counterparts, with the calculation of the percentage of difference (%dif) = ([cost by RCC method] - [cost by MC method])/(cost by RCC method). Comparing the results calculated using the ratio cost to charge method to those obtained using the micro-costing method revealed that generally the percentages of difference of Ha Nam Hospital and Thu Duc Hospital were decreased by 2245% and 96%, respectively, when calculating using the MC and RCC methods. Thus, there were a medium amount of cases with a %dif with negative results (eight cases) when compared to those with positive results (seven cases) in Ha Nam Hospital. Meanwhile, in the case of Thu Duc Hospital, the MC values were generally greater than the RCC values, resulting in a higher number of %dif cases with positive results (nine cases) than those with negative results (six cases). By taking a more detailed look at the figures, it is recognizable that in the case of Ha Nam Hospital, the X-Ray Cardiopulmonary (Straight) service and X-ray Lung (Tilt) service had a similar percentage of difference (44%), which were also the highest values in the %dif section. On the other hand, the lowest percentage of difference (2%) belonged to the LDL Cholesterol service. Meanwhile, in Thu Duc Hospital, the highest percentages of difference were those of the X-ray cardiopulmonary (straight), X-ray Lung (Tilt), and stool examination services, with the respective values being 285%, 512%, and 157%. Furthermore, the percentage of difference of the TSH service was the lowest in value (9%). For the whole hospital, the X-ray Lung (Tilt) service had the highest percentage of difference, with a value of 278%. In contrast, the HB1Ac service had the lowest %dif (1%). In addition, the %dif of the LDL cholesterol, TSH, and HB1Ac services were all lower than 10% (8% for LDL cholesterol, 4% for TSH, and 1% for HB1Ac).

DISCUSSION

TDCs of cost centers

In terms of the cost center groups, the TDCs of the ACCs, which were 51,240,119,404 VND (84.52%), were greater than those of the TCCs at 9,382,307,215 VND (15.48%) in 2012 in Ha Nam Hospital. With regard to the TDCs, the labor cost accounted for the largest proportion and the materials cost for the lowest proportion, being 28,120,806,688 VND (46.39%) and 13,336,444,000 VND (22%), respectively. In contrast, in Thu Duc Hospital (2014), the TDCs of the ACCs were greater than those of the TCCs, accounting for 202,059,556,587

Table 4: Sample unit cost of each service (VND) provided by the Laboratory cost center (A2) calculated using the micro-costing method in Ha Nam Hospital

Service	Direct cost				Indirect cost	Total cost	
	Labor cost	Capital cost	Materials cost	TDC		Unit cost in 2012	Unit cost in 2014
Retic index RI (handiwork)	2,533	-	960	3493	827	4320	4793
RBC count	422	237	343	1002	237	1239	1375
Anti-hepatitis C virus (qualitative, quick test)	1689	947	2947	5583	1323	6906	7662
Cross-match in blood	7599	4260	1714	13,573	3216	16,789	18,627
HbsAg (qualitative, quick test)	1689	947	2947	5583	1323	6906	7662
HIV (qualitative, quick test)	1689	947	2947	5583	1323	6906	7662
Prothrombin time (quick test)	844	473	206	1523	361	1884	2091
Test coombs	5066	2840	3222	11,127	2637	13,764	15,271
ABO test	422	237	685	1344	319	1663	1845
Rhesus test	422	237	1028	1687	400	2087	2315
WBC count	422	237	343	1002	237	1239	1375
Platelet (Plt, quantitative, machine)	422	237	343	1002	237	1239	1375
Osmotic fragility	1689	947	1302	3938	933	4871	5404
Platelet (quantitative, handiwork)	5066	-	1302	6368	1509	7877	8740
Saignement time	422	237	411	1070	254	1324	1469
Platelet - aggregation	2533	1420	617	4570	1083	5653	6272
ABO test (blood transmission: RBC, WBC)	422	237	823	1481	351	1832	2033
ABO test (blood transmission: Plt, plasma)	422	237	685	1344	319	1663	1845
Blood sedimentation (handiwork)	10,807	-	823	11,630	2756	14,386	15,961

*Inflation: Adjusted values from the cost in 2012, RBC: Red blood cell, WBC: White blood cell

Table 5: Comparison of unit cost between the ratio of cost to charge (RCC) method and the micro-costing method

Service	Unit cost (VND) in 2014						
	Ha Nam Hospital			Thu Duc Hospital			
	MC	RCC	% difference	MC	RCC	% difference	Average of the % difference
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
HBsAg (qualitative)	7662	12,875	40	20,484	29,488	31	36
CT scanner-32 Slice (not including drugs)	547,566	586,200	7	489,880	1,299,318	62	34
Ferritin	6345	8,683	27	24,491	36,860	34	30
PSA	14,498	17,366	17	25,025	41,775	40	28
Glucose (quantitative)	5028	4,491	−12	8,304	5,898	−41	−26
X-ray cardiopulmonary (straight)	101,088	70,398	−44	320,242	83,156	−285	−164
X-ray lung (Tilt)	101,088	70,398	−44	318,242	51,973	−512	−278
LDL cholesterol	5216	5,090	−2	8,838	10,812	18	8
FT4	12,804	11,976	−7	18,881	29,488	36	15
Uric acid test	5028	4,491	−12	8,464	31,945	74	31
T3	12,804	11,976	−7	4,456	29,488	85	39
TSH	12,334	10,479	−18	26,895	29,488	9	−4
Doppler color ultrasound (heart/fetus)	78,725	114,709	31	614,850	389,795	−58	−13
Stool examination	4574	7,186	36	11,349	4,423	−157	−60
HB1Ac	11,069	17,965	38	8,249	5,898	−40	−1
Average of 15 medical services			3			−47	−22
Average of all healthcare services			−2245			−96	−1171

(3) = [(2)-(1)]/(2), (6) = [(5)-(4)]/(5)

VND (83.44%). Considering the TDCs, the labor cost accounted for the largest proportion and the materials cost for the lowest proportion, being 151,024,880,526 (62.36%) and 16,833,592,233 (6.95%), respectively. Considering the direct cost, the golden ratio of labor cost to materials cost to capital cost was 20:50:30. It was, therefore, found that many departments had an acceptable cost ratio. The departments often had a low labor cost ratio and low capital cost ratio (about 14 departments had an acceptable percentage value). However, two departments, namely, the Imaging and Surgery/Anesthesiology/Recovery Departments, had labor cost rates and capital cost rates that were too high. These two departments did not achieve an appropriate proportion of costs.

Unit costs of medical services

The most important information required to determine the unit costs of medical services is complete and accurate cost data. These data include the standard practice guidelines and detailed records of the resource consumption involved in performing such services. Further significant information includes the amount of time spent on each activity by worker(s) to calculate the labor cost. Similarly, information regarding the time spent using equipment is needed for the depreciation cost calculation. A record of the materials used is also very important. It is vital that all the outputs should be counted since they are all very significant in relation to the cost analysis. The remainder (FC of the ACCs - TDC of all services) was the shared cost or the indirect cost of an individual service, which was allocated based on a selected criterion. In reality, micro-costing often results in difficulties when collecting the hospital data required for the cost analysis. Said data include information about the amount of time spent on each activity, the cost/value of materials used per activity, and the time spent using each capital item, which are needed to calculate the depreciation in the cost per service. Thus, a lot of time needs to be spent gathering information. Another key problem concerns the skill of the staff tasked with collecting the data. In addition, some errors cannot be prevented due to the staff members' individual

ways recording data (i.e., if they pay attention to detail, the direct cost will be higher than expected).

According to the RCC methodology, it is the less complicated method in practice, since it is easy to use and requires only data concerning the charges for medical services when calculating the unit cost of those medical services. This is also useful when analyzing the rate of return, which is important in terms of financial or business management. However, the charge or price setting should reflect the actual unit costs. Therefore, this method should be employed following price standardization based on the unit cost derived from the micro-costing method.

Analysis of variation of the unit cost of some services between the two hospitals: RCC methodology versus micro-costing methodology

To determine how the unit cost of hospitals is analyzed, Tracey *et al*.[25] conducted a literature review, which showed that the proportion of hospitals using each cost derivation method consisted of the RCC method alone or a combination of the RCC method and other costing approaches (66%), actual cost (12%), RVU (9%), actual cost and RVU (3%), and other methods, or no method (10%). However, recent developments in the field of costing studies of health-care interventions have led to renewed interest in the micro-costing method, the use of which is widespread in various countries to inform efficient resource allocation. In a study conducted by Riewpaiboon,[3] it was found that the micro-costing method has been proven to be reliable.

From the results of the present study, it can be seen that almost all the services supplied by Ha Nam Hospital had a unit cost that is higher than that seen for Thu Duc Hospital according to both the MC and RCC methods. For instance, the unit costs of the T3 Test and CT scanner-32 Slice (not including drugs) in Ha Nam Hospital are higher than those in Thu Duc Hospital at 187.34% and 11.78%, respectively. When using the RCC method, the unit costs of all services exhibited a positive decrease, except for the X-ray lung (Tilt), and stool examination services, which exhibited increases of 35.45% and 62.47%, respectively, between Ha Nam Hospital and Thu Duc Hospital. The average percentages of difference between the two methods in Ha Nam Hospital and Thu Duc Hospital are minus 3.44% and 46.97%, respectively, while the average of the percentage of difference is 21.77%. Riewpaiboon *et al*.'s[14] analysis of the RCC method revealed that the variation in the unit costs of medical services was high, ranging from −85% to +32%, which suggested that the existing prices (charges) of the medical services were not related to the real costs of those medical services.

RECOMMENDATIONS

Before the conducting of the present study, the micro-costing method was considered the most accurate method in terms of calculating the unit cost of medical services, since it can best reflect the consumption of resources. Indeed, the micro-costing method was found to be most suitable for calculating the unit costs of medical services. However, in the future, a standard cost list should be developed in the Vietnamese context based on the results of the micro-costing method. Similarly, the RCC method should prove efficient after the prices have been adjusted based on the results of the micro-costing method.

CONCLUSIONS

The present study is particularly valuable due to comparing different costing methods for hospital service cost analysis in a developing country that is Vietnam. In addition, a number of potential avenues for future investigations using the same methodologies have been identified in this study. It is expected that the method described in this study will prove valuable in terms of conveying costs for researchers in many countries as well as a topic publicly open for valuation. Thus, the present study serves to validate and expand this methodological area.

To cover the expenses of various hospitals as well as their multiple levels (which range from central to provincial and district), a considerable amount of work must be performed. More information regarding the unit cost of health-care services would be helpful in relation to establishing a reference unit cost list for accurate health economics evaluations. As far as hospital financial management is concerned, the results regarding the unit cost of hospital services are needed when implementing and planning the operational and financial regimes that are applicable for public health non-business units. Further, they are also relevant to the prices of medical examinations and treatment services, as well as to the treatment establishments found in Vietnamese hospitals.

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REFERENCES

1. WHO. Health Action International. Medicine Prices-A New Approach to Measurement. 2003 edition. Working Draft for Field Testing and Revision. Geneva: WHO; 2008.
2. OECD. Pharmaceutical Pricing Policies in a Global Market. Paris: OECD; 2009.
3. Riewpaiboon A. Standard cost lists for health economic evaluation in thailand. J Med Assoc Thai 2014;97 Suppl 5:S127-34.
4. Anderson R. Systematic reviews of economic evaluations: Utility or futility? Health Econ 2010;19:350-64.
5. HPG VMoH. Joint Annual Health Review 2014. Strengthening Prevention and Control of Non-Communicable Disease. Hanoi, Vietnam: Medical Publishing House; 2015.
6. General Statistics Office. Number of Patient Beds by Items, Health Establishments and Year 2014; Cited 2014. Available from: https://www.gso.gov.vn/default_en.aspx?tabid=783. [Last accessed on 2017 May 12].
7. Barnum H, Kutzin J. Public Hospitals in Developing Countries: Resource Use, Cost, Financing. Baltimore: Johns Hopkins University Press; 1993.
8. Chinh LD. Hospital Activities in Vietnam. Vietnam: Ministry of Health of Vietnam; 2016.
9. Jacobs P. A National List of Provincial Costs for Health Care. Canada: 1997/8. Canada: Institute of Health Economics; 2004.
10. Jacobs P, Roos NP. Standard cost lists for healthcare in Canada. Issues in validity and interprovincial consolidation. Pharmacoeconomics 1999;15:551-60.
11. Oostenbrink JB, Koopmanschap MA, Rutten FF. Standardisation of costs: The dutch manual for costing in economic evaluations. Pharmacoeconomics 2002;20:443-54.
12. Chatterjee SL, Laxminarayan R. Unit cost of medical services at different hospitals in India. PLoS ONE 2013;8:e69728.
13. Tsilaajav T. Costing Study for Selected Hospitals in the Philippines. Manila, Philippines: Final Report in Technical Assistance to the Health Sector Policy Support Programme In the Philippines (EC-TA HSPSP); 2009.
14. Riewpaiboon A, Malaroje S, Kongsawatt S. Effect of costing methods on unit cost of hospital medical services. Trop Med Int Health 2007;12:554-63.
15. Suver JD, Cooper JC. Principles and methods of managerial cost-accounting systems. Am J Health Syst Pharm 1988;45:146-52.
16. Finger SA. The distinction between cost and charges. Ann Intern Med 1982;92:102-9.
17. Creese PD. Cost Analysis in Primary Health Care: A Training Manual for Programme Managers. Geneva: World Health Organization; 2000.
18. Drummond MF, Sculpher MJ, Torrance GW, O'Brien BJ, Greg LS. Methods for the Economic Evaluation of Health Care Programmes. 3rd ed. Oxford: Oxford University Press; 2005.
19. Rigden MS. Health Service Financial and Accounting. London: Heinemann; 1983.
20. Cleverley WO. Product costing for health care firms. Health Care Manage Rev 1987;12:39-48.
21. Lerner WM, Wellman WL. Pricing hospital units of service using microcosting techniques. Hosp Health Serv Admin 1984;30:7-28.
22. Cooper JC, Suver JD. Product line cost estimation: A standard cost approach. Healthcare Financ Manag J Healthcare Financ Manage Assoc 1988;42:60, 2, 4 passim-, 2, 4 passim.
23. Nam GS. Consumer Price Index Gold and USD Price Indexes, Whole Country; 2013. Available from: https://www.gso.gov.vn/default_en.aspx?tabid=625&ItemID=13842. [Last accessed on 2017 May 25].
24. Nam GS. Consumer Price Index, Gold and USD Price Indexes; 2014. Available from: https://www.gso.gov.vn/default_en.aspx?tabid=625&ItemID=14183. [Last accessed on 2017 May 25].
25. Orloff TM, Littell CL, Clune C, Klingman D, Preston B. Hospital cost accounting: Who's doing what and why. Health Care Manage Rev 1990;15:73-8.

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