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Applying activity-based costing to the nuclear medicine unit

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Previous studies have shown the feasibility of using activity-based costing (ABC) in hospital environments. However, many of these studies discuss the general applications of ABC in health-care organizations. This research explores the potential application of ABC to the nuclear medicine unit (NMU) at a teaching hospital. The finding indicates that the current cost averages US$236.11 for all procedures, which is quite different from the costs computed by using ABC. The difference is most significant with positron emission tomography scan, US$463 (an increase of 96%), as well as bone scan and thyroid scan, US$114 (a decrease of 52%). The result of ABC analysis demonstrates that the operational time (machine time and direct labour time) and the cost of drugs have the most influence on cost per procedure. Clearly, to reduce the cost per procedure for the NMU, the reduction in operational time and cost of drugs should be analysed. The result also indicates that ABC can be used to improve resource allocation and management. It can be an important aid in making management decisions, particularly for improving pricing practices by making costing more accurate. It also facilitates the identification of underutilized resources and related costs, leading to cost reduction. The ABC system will also help hospitals control costs, improve the quality and efficiency of the care they provide, and manage their resources better.

Introduction

Activity-based costing (ABC) has been implemented successfully in various manufacturing industries. Although ABC is not widely used in the health-care industry,[1] it can be applied in all types of organizations.[2] Cokins[3] states that health-care institutions are labour-intensive industrials where work activities represent most of their costs. There is a need to know what services actually cost and what activities are the most efficient. Thus, ABC is vital to the welfare of health-care organizations. West and West[4] note that ABC is now being used in numerous health-care organizations worldwide, including about 20% in the United States and Canada. Several studies apply the basics of ABC to health-care organizations.[1,2,4–18] According to these studies, ABC supports better pricing practices through more accurate costing, and can be used to identify underutilized

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resources as well as associated costs that can be reduced. In addition, the results show that this cost method allows a more effective planning and control method for hospitals compared with the traditional cost system.

According to Chan,[9] ABC can also be applied in the health-care sector in which procedures/patients are unique products themselves. This is because, under ABC, costs are accumulated for activities that consume resources and then are applied to products (procedures/patients) on the basis of the activities required in their production (treatment). Chan[9] points out that ABC provides more accurate cost information than do conventional costing systems for health-care industries. Combining ABC with the development of Standard Cost Profile per service unit and Standard Treatment Protocol per DRG allows health-care administrators to identify high-cost treatment protocols.

West *et al.*[19] compare the use of three costing systems in a renal dialysis clinic. The cost systems are the ratio-of-cost-to charges (RCC), relative value unit (RVU), and ABC. The result shows that ABC outperforms the RCC and the RVU in terms of accuracy in accounting for resource consumption. According to them, health-care administrators who have more accurate cost information can make effective decisions regarding resource allocation, cost containment, and incentives that drive the selection of treatment alternatives.

Dowless[1] applies ABC for a hypothetical patient care procedure over a 12-month period. The result alerts managers to areas in which maximum efficiency is not being achieved. According to Dowless, ABC facilitates an organizational focus on continued improvement. In addition, West and West[4] employ ABC to improve the operation of a dialysis clinic. The result indicates that ABC represents a significant contribution to health-care costing accuracy, enabling improved profitability analysis, and decision-making.

Objective

Previous studies have shown the feasibility of using ABC in hospital environments. However, most of the studies discussed benefits and implementation of ABC for health care in general. A few of these studies use the actual cost data to examine the difference between ABC and the traditional cost systems. There has been no study in the application of ABC to a nuclear medicine unit (NMU, radiology department). This research attempts to adapt ABC to the NMU at a teaching hospital. The NMU has been selected because over 85% of its costs represent variable costs which can be controlled and reduced. Therefore, there is significant opportunity for containing the cost of procedures.

Nuclear medicine unit

This research was conducted at the NMU at a teaching hospital in South Florida. The hospital has 1567 beds and 1525 physicians on staff with over 60,000 admissions, nearly 12,000 deliveries, 340,000 outpatient visits, 102,000 emergency visits, 10,000 surgical procedures, and 300,000 radiology procedures per year. The study was based on a 12-month period (January 2001–December 2001). There were a total of 4877 procedures performed in 2001. Six major procedures (approximately 45% of total procedures) are considered for this research. They are bone scan – 557, Muga – 228, cardiac SPECT – 565, renal scan – 195, positron emission tomography (PET) scan – 487, and thyroid scan – 89.

Nuclear medicine is a specialized area of radiology that uses very small amounts of radioactive materials, or radiopharmaceuticals, to examine organ function and structure. Scans are used to diagnose many medical conditions and diseases. A nuclear medicine scan consists of three phases: tracer (radiopharmaceutical) administration, taking images, and image interpretation. The amount of time between the administration of the tracer and the taking of images may range from a few moments to a few days, depending on the body tissue being examined and the tracer being used. In addition, the time required to obtain the images may also vary from minutes to hours.

There are many different procedures performed in the NMU. Each procedure requires a specific set-up of machine and equipment, which are maintained by the maintenance department of the hospital. Once the machine is set up, the radiologist uses the materials and supplies delivered by the supply processing and distribution department to perform the procedures. As the procedures are performed, the clerks must complete the required documents and distribute the results to the appropriate party. Figure 1 presents an example of PET scan procedure at the NMU.

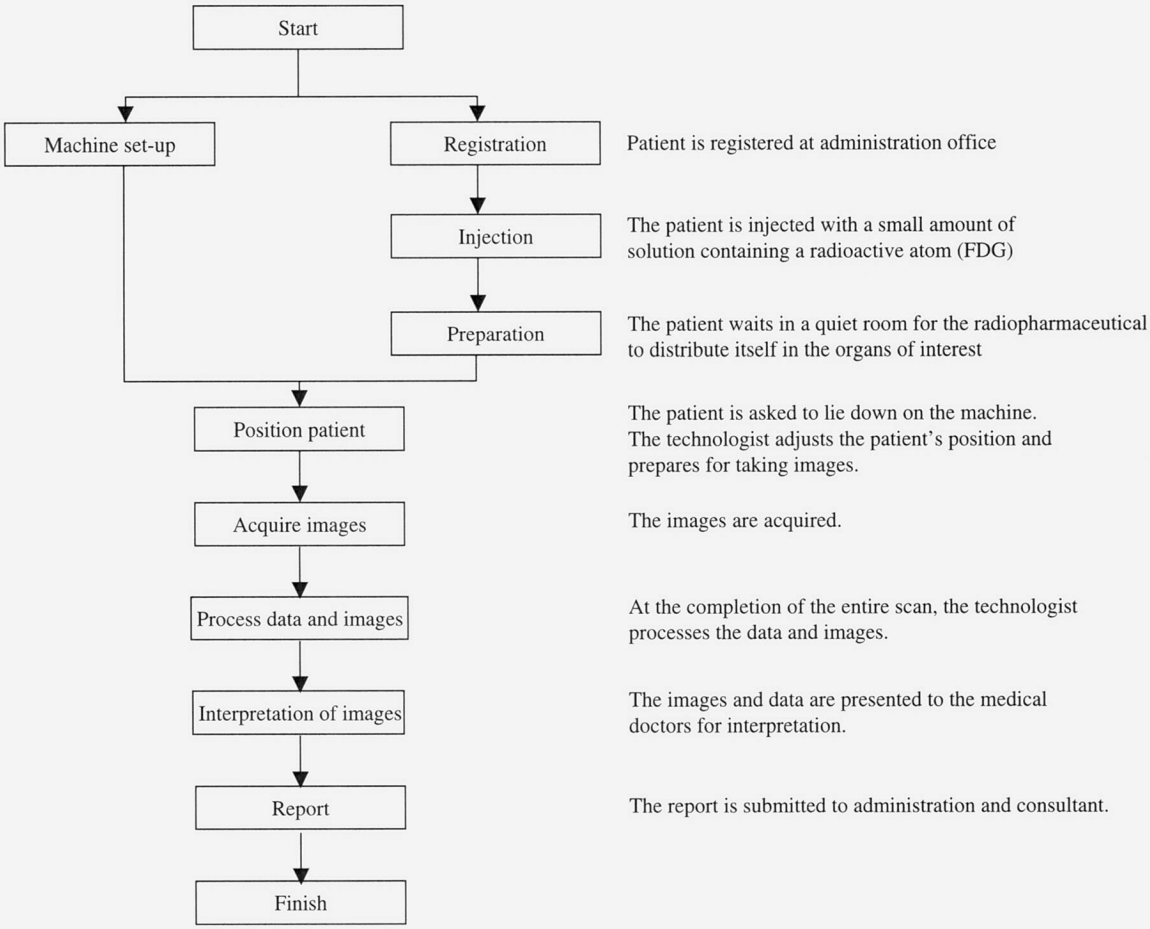


Figure 1 *PET scan procedures*

To better understand the nuclear medicine costs in general, an analysis and classification cost is developed (Figure 2). There are three major cost components: general overhead costs, indirect costs, and direct costs. The general overhead costs consist of collection and reporting costs, as well as administrative costs. Indirect costs consist of indirect supplies costs, indirect labour costs, and other indirect costs. Direct costs include equipment and tool costs, direct supplies costs, and direct labour costs.

Traditional cost system for the NMU

Figure 3 presents the traditional cost system for the NMU. The costs elements are broken down into fixed and variable costs. Both fixed and variable costs are assigned to each procedure using one base allocation (total fixed and variable costs divided by the number of procedures). The cost per procedure is expressed as follows:

$$\mathrm{CP}_i = \sum_{I=1}^{n} F_i + V_i$$

where CP = cost per procedure; F = fixed costs; V = variable costs; n = number of procedures per year; and $I = 1, 2, 3, \ldots, n$.

Based on the traditional cost system (Table 1), the cost of all types of procedures can be averaged to get the average cost per procedure (fixed costs and variable costs are divided by the total number of procedures). Thus, the average cost per procedure in this example is US$236.11 (US$1,151,518 ÷ 4877). The major problem of this approach is that it assumes that all procedures are alike. This is an unreasonable assumption, because the resources consumed by the procedure may

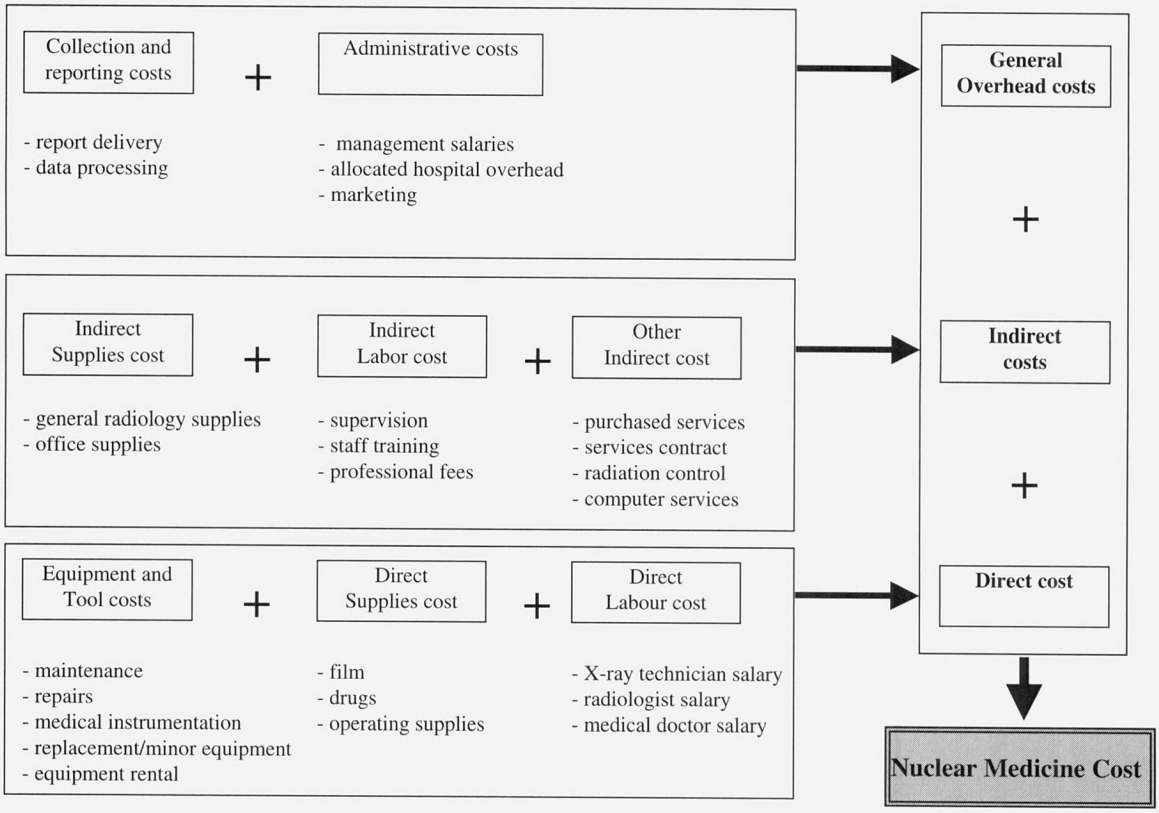


Figure 2 *An analysis and classification of the NMU*

significantly vary with each procedure. This may lead to inefficiency in making decisions due to less accurate information as well as unfair allocation of costs to patients.

Application of ABC in the NMU

To improve the traditional cost system, ABC is adapted for this research (Figure 4). The cost per procedure using ABC would be calculated as follows:

$$CP_i = L_i + S_i + \sum_{j=1}^{m} X_{ji}$$

where CP_i = cost per procedure for procedure i; L_i = amount of direct labour costs assigned to procedure i; S_i = amount of direct supplies costs assigned to procedure i; X_{ji} = costs associated with activity j assigned to procedure i; j = activity j associated with procedure i; $j = 1, 2, 3, \ldots, m$; and $I = 1,2,3,\ldots$

The steps for using ABC for the NMU

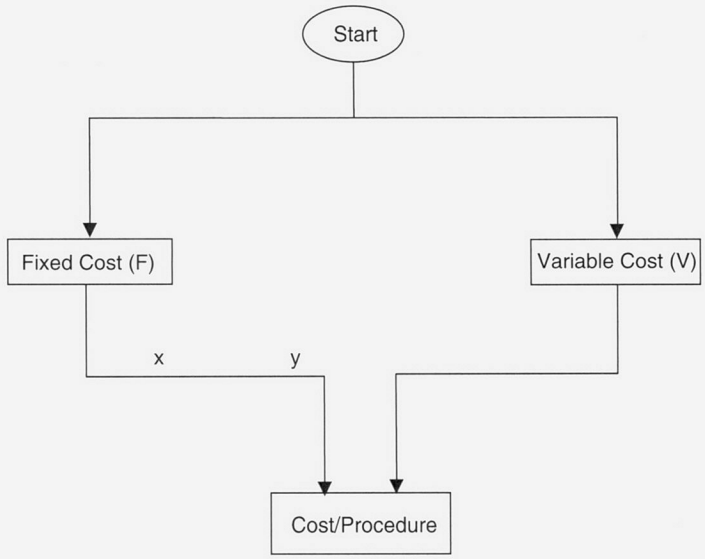
There are four steps involved in adapting ABC for the NMU.

Step 1. Identify procedures for analysis

The first step is to select procedures for analysis. The selection may be based on volume, quality assurance issues (high risk), financial impact (high cost, low profitability), special interests (new service), or variance measures (high variance from DRG estimation). For the purpose of illustration, only six major procedures (approximately 45% of total procedures) are considered for this research. They are bone scan, Muga, cardiac SPECT, renal scan, PET scan, and thyroid scan.

Step 2. Identification and classification of activities (activities analysis)

All activities associated with the procedures are identified and classified. The activities are



x: Fixed costs are equally assigned to each procedure using one suitable base (total fixed cost divided by the number of the procedures)

y: Variable costs are equally allocated to each procedure using one suitable base (total variable cost divided by number of the procedures)

V : Variable costs

F : Fixed costs

Figure 3 *Current cost system for the NMU*

further categorized into direct activities and indirect activities. Direct activities are those that are clearly and directly associated with the cost objects (procedures). Indirect activities are those that are not directly associated with the cost objects (procedures). To optimize the decision-making efficiency, the direct activities are further grouped into two major categories: direct labour and direct supplies. This is because the labour and supplies, altogether, account for more than 50% of the total cost. The information for ABC is presented in Table 2.

Step 3. Determine the cost drivers

The cost drivers trace and reassign activities to their cost objects (procedures) in direct proportion to the objects' consumption of the activities. As the indirect activities of operating the NMU are identified, they are applied to the procedures on the basis of the activities undertaken in performing each specific procedure. For illustration, determining the cost of equipment maintenance by using the number of procedures is an inappropriate method. A more accurate calculation can be obtained by using the number of machine hours. The machine hours are more appropriate for applying costs of repairs and maintenance, equipment rental, medical instrumentation, as well as minor equipment. This is because the more one uses machines, tools, and equipment, the more the amount of maintenance, rental, and replacement one would require. In addition, direct labour hours are appropriate for applying costs of administration, purchased services, professional fees, recruitment, and employee training, because these activities are associated with direct labour. The cost drivers for the indirect activities are presented in Table 3.

Table 1 *Nuclear medicine costs 2001*

	Variable costs	Fixed costs	Total costs
Labours			
Staff	253,502		
Temporary	14,853		
Overtime	21,572		
Benefits	76,306		
Total salaries	366,233		366,233
Supplies			
Operating supplies	1,385		
CSR	10,740		
Pharmacy	1,633		
Film	2,371		
Office supplies	4,339		
Cost of drugs	574,414		
Special functions	683		
Total supplies	595,565		595,565
Other contracts, supplies, fees			
Purchased services	2,640		
Data-processing services	41,351		
Telephone		5512	
Physical plant		570	
Repairs and maintenance		211	
Service contracts		102,103	
Professional fees	13,671		
Medical instrumentation	1,228		
Radiation control		17,080	
Replacement/minor equipment		280	
Equipment rental	34		
Recruitment		3,414	
Computer services	1202		
Employee training		424	
Total contracts, supplies, fees	60,126	129,594	189,720
Total expenses	1,021,924	129,594	1,151,518
Number of procedures			4877
Average cost per procedure			236.11

Step 4. Allocate all activities to procedures

Finally, all activities are assigned to the procedures using different cost drivers in order to obtain the final costs.

Results

With the use of ABC, the standard costs for the bone scan, Muga, cardiac SPECT, renal scan, PET, and thyroid scan are US$114, US$183, US$302, US$463, US$292, and US$114, respectively (Table 4). As illustrated in the nuclear medicine example, various cost drivers can be chosen for applying indirect costs to the procedures under ABC, as long as a cause–effect relationship is evident. Traditional costing, on the other hand, uses one volume-related allocation base (number of procedures per year) in cost application. For example, the current cost averages US$236.11 for all procedures, which is quite different from the costs computed by using ABC. The difference is most significant with PET scan, US$463 (an increase of 96%) as well as bone scan and thyroid scan, US$114 (a decrease of 52%).

The result of ABC analysis indicates that the operational time (machine time and direct

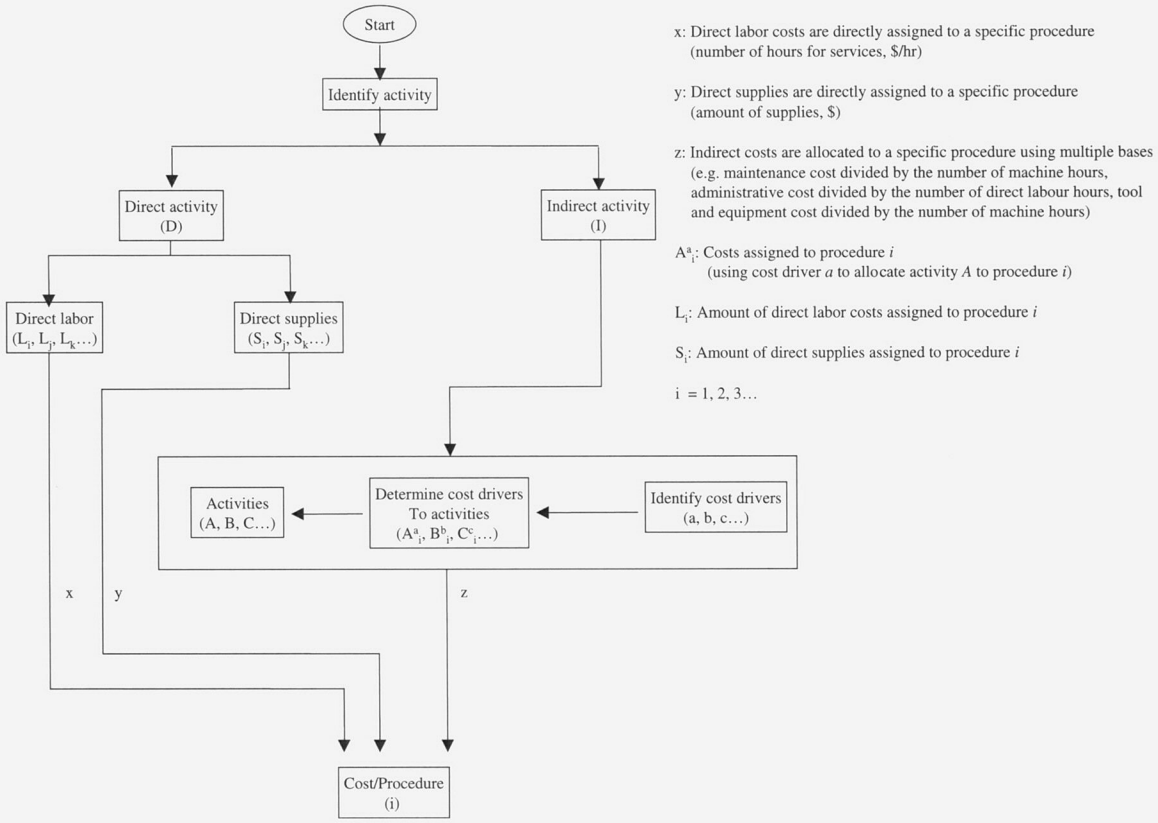


Figure 4 *ABC for the NMU*

labour time) and the cost of drugs have the most influence on cost per procedure. For example, the time to perform a renal scan and cardiac SPECT is 120 min, while it takes 60 min to perform bone scan and thyroid scan. In addition, the cost of drugs per procedure for PET scan, cardiac SPECT, renal scan, bone scan, and thyroid scan is US$350, US$135, US$125, US$10.95, and US$10.95, respectively. Thus, the costs per procedure for PET scan (US$463), cardiac SPECT (US$302), and renal scan (US$292) are much higher than for bone scan (US$114) and thyroid scan (US$114). Clearly, to reduce the cost for the NMU, the reduction in operational time and cost of drugs should be analysed.

Discussion

Although the merits of ABC costing are not fully clear, attempts to apply the concept provide a realistic basis for understanding cost drivers. Additionally, applications of ABC costing concepts in health care are limited, therefore making its value questionable. By applying ABC, a health-care organization can identify non-value-added activities, which consume resources without adding value to patient services. It assists management in effectively reducing the cost by focusing on non-value-added activities. While eliminating waste may not reduce hospital costs in every case, it can improve the quality of services provided.

The ability to identify indirect activities and trace them to each procedure based on the consumption of activity-related resources represents an important step in the containment of costs. This can facilitate the generation of more accurate cost data, thereby reducing faulty pricing decisions and enhancing optimal capital budgeting decisions. For example, the cost of a bone scan using the traditional cost system is US$236.11, while the cost under ABC is US$114. In this case, the hospital can enhance profit while leaving the patient at a disadvantage.

Table 2 *A summary of data for the ABC for the NMU (2001)*

Procedure types	Number of procedures per year (*n*)	Direct labour per procedure (min)	Machine hours per procedure (min)	Direct suppliers per procedure: Direct supplies (US$)	Direct suppliers per procedure: Cost of drugs (US$)
Bone scan	557	60	45	20	10.95
Muga scan	228	90	45	20	53.5
Cardiac SPECT	565	120	60	30	135
PET scan	195	60	25	30	350
Renal scan	487	120	75	30	125
Thyroid scan	89	60	45	20	10.95
	Procedures per year (*n*)	**Direct labour hours per year (min)**	**Machine hours per year (min)**	**Direct supplies per year (US$)**	**Cost of drugs per year (US$)**
	4877	458,651	266,581	16,812	574,414

Overhead: Expense per year (US$) – administrative: 16,459; clerk: 90,941; office supplies: 4339; purchased services: 2640; data processing: 41,351; telephone: 5512; physical plant: 570; repairs and maintenance: 211; service contracts: 102,103; professional fees: 13,671; medical instrumentation: 1228; radiation control: 17,080; replacement/minor equipment: 280; equipment rental: 34; recruitment: 3414; computer services: 1202; employee training: 424.

Table 3 *Cost drivers for the NMU*

Activity cost pool	Activity cost driver	Proportion	Cost per unit (US$)
Administrative	Direct labour hours	16,459/458,651	0.036 per direct labour hour
Clerk	No. of procedures	90,941/4,877	18.647 per procedure
Office supplies	No. of procedures	4,339/4,877	0.890 per procedure
Purchased service	Direct labour hours	2,640/458,651	0.006 per direct labour hour
Data processing	No. of procedures	41,351/4,877	8.479 per procedure
Telephone	No. of procedures	5,512/4877	1.130 per procedure
Physical plant	Direct labour hours	570/458,651	0.001 per direct labour hour
Repairs and maintenance	Machine hours	211/266,581	0.001 per machine hour
Service contracts	Direct labour hours	102,103/458,651	0.223 per direct labour hour
Professional fees	Direct labour hours	13,671/458,651	0.030 per direct labour hour
Medical instrumentation	Machine hours	1,228/266,581	0.005 per machine hour
Radiation control	Direct labour hours	17,080/458,651	0.037 per direct labour hour
Replacement/minor equipment	Machine hours	280/266,581	0.001 per machine hour
Equipment rental	Machine hours	34/266,581	0.0001 per machine hour
Recruitment	Direct labour hours	3,414/458,651	0.007 per direct labour hour
UM computer services	No. of procedures	1,202/4,877	0.246 per procedure
Employee training	Direct labour hours	424/458,651	0.001 per direct labour hour

However, competitor hospitals can take advantage of a hospital's poor decisions based on inaccurate cost information (higher than actual) by reducing pricing for the bone scan. PET scan, on the other hand, costs US$463 based on the ABC system, but costs US$236.11 using the traditional system. The patient will realize cost-reduction benefits, while the hospital will carry the excess cost.

ABC can also be used to determine the profitability of the nuclear medicine procedures. Based on this analysis, the hospital seems to obtain a profit from bone scan, Muga, and thyroid scan, while it may experience a loss from cardiac SPECT, PET scan, and renal scan. Cooperative arrangements between hospitals may produce opportunities for maximizing the cost effectiveness.

Table 4 *The ABC for the NMU*

Procedures	Bone scan (US$)	Muga scan (US$)	Cardiac SPECT (US$)	PET scan (US$)	Renal scan (US$)	Thyroid scan (US$)
Direct labour	33	49.5	66	33	66	33
Direct supplies	20	20	30	30	30	20
Drugs	10.95	53.5	135	350	125	10.95
Overhead						
Administrative	2.15	3.23	4.31	2.15	4.31	2.15
Clerk	18.64	18.65	18.65	18.64	18.65	18.64
Office supplies	0.89	0.89	0.89	0.89	0.89	0.89
Purchased service	0.35	0.52	0.69	0.35	0.69	0.35
Data processing	8.48	8.48	8.48	8.48	8.48	8.47
Telephone	1.13	1.13	1.13	1.13	1.13	1.13
Physical plant	0.08	0.11	0.15	0.08	0.15	0.08
Repairs and maintenance	0.04	0.04	0.05	0.02	0.06	0.04
Service contracts	13.35	20.04	26.71	13.35	26.71	13.35
Professional fees	1.78	2.68	3.58	1.78	3.58	1.78
Medical instrumentation	0.21	0.21	0.28	0.21	0.35	0.21
Radiation control	2.35	3.35	4.47	2.35	4.47	2.35
Replacement/minor equipment	0.05	0.05	0.06	0.03	0.08	0.05
Equipment rental	0.01	0.01	0.01	0.00	0.01	0.01
Recruitment	0.45	0.67	0.89	0.45	0.89	0.45
Computer services	0.25	0.25	0.25	0.25	0.25	0.25
Employee training	0.06	0.08	0.11	0.06	0.11	0.06
Total cost per procedure	114	183	302	463	292	114

Labour cost=direct labour time × rate per minute (e.g. bone scan=0.55 × 60); Administrative cost=direct labour time × rate per minute (e.g. bone scan=0.36 × 60); Purchased service cost=direct labour time × rate per minute (e.g. bone scan=0.006 × 60); Physical plant cost=direct labour time × rate per minute (e.g. bone scan=0.001 × 60); Service contract cost=direct labour time × rate per minute (e.g. bone scan=0.223 × 60); Professional fee cost=direct labour time × rate per minute (e.g. bone scan=0.03 × 60); Radiation control cost=direct labour time × rate per minute (e.g. bone scan=0.037 × 60); Recruitment cost=direct labour time × rate per minute (e.g. bone scan=0.007 × 60); Employee training cost=direct labour time × rate per minute (e.g. bone scan=0.001 × 60); Repair and maintenance cost=machine time × rate per minute (e.g. bone scan=0.001 × 45); Medical instrument cost=machine time × rate per minute (e.g. bone scan=0.005 × 45); Replacement/Minor equipment=machine time × rate per minute (e.g. bone scan=0.001 × 45); Equipment rental cost=machine time × rate per minute (e.g. bone scan=0.0001 × 45).

There are numerous challenges in implementing the ABC system in a hospital. First, collecting the data needed to establish the ABC system is time consuming and expensive. The ABC system is much more complex and detailed than a traditional cost system because costs are allocated to different activity pools and each of these pools is further broken down into several separate activities. This requires detailed analysis of financial accounting records, as well as interviews to identify and gather costs and other information regarding specific activities. Also, the statistical analysis required to allocate costs is much more complex for the ABC system.

Conclusion

ABC provides a more accurate basis for understanding cost information than the traditional costing system. It allows health-care administrators to identify costly and unprofitable procedures. Once the costly procedures are identified, other techniques such as time and motion study can be applied to either reduce or eliminate the non-value-added activities of such procedures. Integrating ABC with case management, critical path analysis, and other hospital control processes might offer significant opportunity for cost containment. ABC provides a structured approach to analysing

activities, cost services, reducing costs, and improving quality. The ABC system is also a time-consuming, labour-intensive process, and its success depends on the total participation of every unit of an organization.

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