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Development of a Practical Costing Method for Hospitals

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CAO, P., TOYABE, S. and AKAZAWA, K. *Development of a Practical Costing Method for Hospitals*. Tohoku J. Exp. Med., 2006, **208** (3), 213-224 —— To realize an effective cost control, a practical and accurate cost accounting system is indispensable in hospitals. In traditional cost accounting systems, the volume-based costing (VBC) is the most popular cost accounting method. In this method, the indirect costs are allocated to each cost object (services or units of a hospital) using a single indicator named a cost driver (e.g., Labor hours, revenues or the number of patients). However, this method often results in rough and inaccurate results. The activity based costing (ABC) method introduced in the mid 1990s can prove more accurate results. With the ABC method, all events or transactions that cause costs are recognized as "activities", and a specific cost driver is prepared for each activity. Finally, the costs of activities are allocated to cost objects by the corresponding cost driver. However, it is much more complex and costly than other traditional cost accounting methods because the data collection for cost drivers is not always easy. In this study, we developed a simplified ABC (S-ABC) costing method to reduce the workload of ABC costing by reducing the number of cost drivers used in the ABC method. Using the S-ABC method, we estimated the cost of the laboratory tests, and as a result, similarly accurate results were obtained with the ABC method (largest difference was 2.64%). Simultaneously, this new method reduces the seven cost drivers used in the ABC method to four. Moreover, we performed an evaluation using other sample data from physiological laboratory department to certify the effectiveness of this new method. In conclusion, the S-ABC method provides two advantages in comparison to the VBC and ABC methods: (1) it can obtain accurate results, and (2) it is simpler to perform. Once we reduce the number of cost drivers by applying the proposed S-ABC method to the data for the ABC method, we can easily perform the cost accounting using few cost drivers after the second round of costing. ——
medical costs; costing accuracy; volume based costing; activity based costing; simplified cost accounting
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Cost-savings is an important factor in hospitals management (Munoz et al. 1989; Scott and Thomas 1997; Shinohara et al. 1998; Wakai et al. 2005). Especially, the prospective payment system which fixes the amount of reimbursement for hospitals has been introduced in health care.

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Therefore, hospital managers have to reduce hospital costs while still maintaining the quality of care. Starting in April 2003 a Japanese prospective payment system (PPS) was introduced to a number of acute care hospitals in Japan. This Japanese payment system has a fixed daily reimbursement scheme based on a modified version of the case mix classification called the "diagnosis procedure combination (DPC)". The plan is to adopt the DPC/PPS system in all hospitals in the near future in Japan.

In traditional cost accounting systems, the volume-based costing (VBC) method is the most popular cost accounting method. In this method, the indirect costs are allocated to each cost object (services or units of a hospital [Chan 1993; Greger 2000; Klose and Bottcher 2002]) using a single indicator named a cost driver (e.g., Labor hours, revenues or the number of patients). Although the VBC method has advantages regarding its simplicity, it often gives rough and inaccurate results (Partovi 1991; Suneel 2001). In the mid 1990s, a new costing method was introduced to the health care fields which is named the activity-based costing (ABC) method (Ralph and Ramsey 1994; Baker and Boyd 1997; Lisa et al. 2002). With the ABC method, all events or transactions that cause costs are recognized as "activities", and a specific cost driver is prepared, whereby indirect costs are allocated is prepared to each activity. ABC can provide more accurate results. However, since the number of activities performed in hospitals is vast, data collection for these cost drivers is both time consuming and costly. In addition to its accuracy, the ABC method is much more complex than other traditional cost accounting methods (Robin 1988; Suneel 1996; Noah et al. 2000).

We herein propose a substitute method which provides a more convenient cost accounting method in comparison to the ABC. By this method, the data collection for cost drivers will become easier to perform by reducing the number of cost drivers. Simultaneously, this method avoids the inaccurate results that sometimes occur in cost accounting using the VBC method.

We further demonstrate the superiority of the proposed method in indirect cost accounting by comparing the costing results of three kinds of clinical examinations using ABC, VBC and the newly proposed method. Moreover, we evaluated the effectiveness of this new method using sample data from a physiological laboratory department.

Methods

ABC cost calculation

The total costs for each cost object are divided into direct and indirect costs; the direct costs mainly include direct labor costs, direct material costs and direct equipment costs, which can be accurately obtained from hospital information systems. The ABC method is a method that calculates the costs of indirect activities to each cost object. We assume that there are n indirect activities A_i ($i = 1, ..., n$), the corresponding total cost X_i of A_i, and m cost objects O_j ($j = 1, ..., m$). Under the ABC method, indirect costs C_{ij}, a component of the X_i is allocated to O_j based on the cost driver D_i. Herein, each activity corresponds to a cost driver. The total volume of the cost driver, D_i, is divided into the sub-volume for each cost object, d_{ij}. For example, assume that we want to calculate the indirect cost of the chemical test unit (O_j) in the clinical examination department. We can then assign the activity "receive test order" and the "number of order receptions" to A_1 and D_1, respectively. Consequently, d_{1j}, which is a part of D_1, is the number of order receptions for chemical tests. Fig. 1 shows the procedure for allocating the cost X_i of A_i to the cost objects O_j.

The indirect cost to be allocated to O_j from X_i, C_{ij}, is obtained by the following equation:

$$C_{ij} = X_i \times d_{ij}/D_i\,. \tag{1}$$

Finally, the total indirect cost, $C_{\cdot j}$, allocated to O_j is expressed as:

$$C_{\cdot j} = \sum_{i=1}^{n} C_{ij}\,. \tag{2}$$

VBC cost calculation

Table 2 shows the VBC cost accounting method. The traditional VBC method is applied when all cost drivers are common to A_i. This method allocates indirect costs to O_j using the following formula:

$$C_{\cdot j} = \sum_{i=1}^{n} X_i \times d_j/D,$$

where $C_{\cdot j}$ is the total indirect cost allocated to O_j, and D is the volumes of the only cost driver for all the indirect activities (Fig. 2).

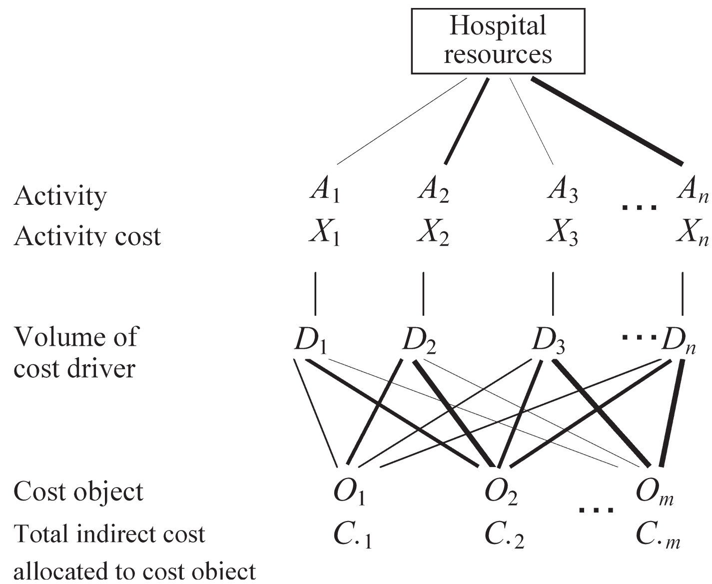

Fig. 1. The cost drivers using with the ABC cost accounting method. A specific cost driver is prepared for each activity.

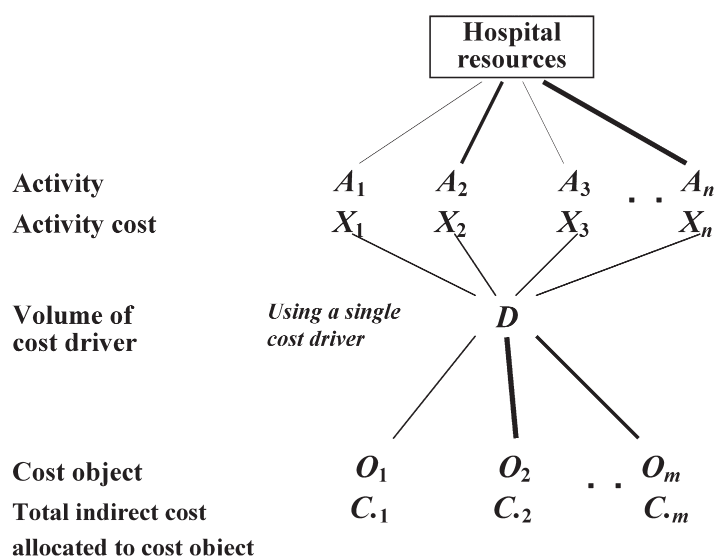

Fig. 2. The cost drivers using with the VBC method. In this method, the indirect costs are allocated using a single cost driver.

Simplifying cost accounting

In the processes of cost accounting, the data collection for the cost drivers is most time consuming and costly step, especially, when many activities and corresponding cost drivers exist. The obvious disadvantage of ABC is that the method is associated with the collection of a vast amount of data because it has more cost drivers. Moreover, the thorough collection of data used in ABC is almost impossible in some cases. A convenient cost accounting method to reduce the number of cost drivers without a loss in accuracy for estimations of the indirect costs in the ABC is thus needed. We herein propose a method for objectively selecting a representative cost driver from several cost drivers which have a high correlation. The detailed explanation for the calculation process of the cost driver selection is given below:

(a) For O_j, the rate of cost driver R_{ij} of d_{ij} to D_i with A_i is calculated by

$$R_{ij} = d_{ij} / D_i \times 100\%.$$

(b) With k-th A_i, A_k, the residual, $\mu_{ij}^{(k)}$, between R_{ij} ($i = 1, \ldots, n, i \neq k$) and R_{kj} for A_k is computed by

$$\mu_{ij}^{(k)} = | R_{ij} - R_{kj} | .$$

(c) We then define p as the critical value (can be adjusted by user). We select the cost drivers D_i and d_{ij} for A_k such that $\mu_{ij}^{(k)} \leqq p$. If there have not selected D_i and d_{ij}, the D_k and d_{kj} for A_k used in ABC are selected.

(d) In succession, we find the D_i that was simultaneously selected in each O_j. If there are several such D_i, then we define the best cost driver that obtained the least $\mu_i^{(k)}$ as the D_i'. $\mu_i^{(k)}$ is the sum of $\mu_{i1}^{(k)}$, …, $\mu_{im}^{(k)}$ with D_i shown as:

$$\mu_i^{(k)} = \sum_{j=1}^{m} \mu_{ij}^{(k)} .$$

(e) If the cost driver D_x of activity A_x is mutually selected for activity A_y, and the cost driver D_y of activity A_y is also selected for activity A_x, respectively, then the two cost drivers can be unified into one with a larger X_i. This proposition is easily proven as follows:

$$\sum_{j=1}^{m} | C_{yj}^{(x)} - C_{xj} | = X_x \sum_{j=1}^{m} | R_{yj} - R_{xj} |$$

$$\sum_{j=1}^{m} | C_{xj}^{(y)} - C_{yj} | = X_y \sum_{j=1}^{m} | R_{xj} - R_{yj} |$$

$$\sum_{j=1}^{m} | C_{yj}^{(x)} - C_{xj} | = X_x / X_y \sum_{j=1}^{m} | C_{xj}^{(y)} - C_{yj} |$$

If $X_x > X_y$, then the total deviation of costing using D_x in A_y is smaller than using D_y in A_x. Therefore, the cost driver D_x with a smaller costing deviation is a new cost driver common to the two activities.

(f) This new combination of cost drivers D_g ($g = 1, \ldots, f, f < n$) are the selected cost drivers obtained by the cost driver selection method.

Once we reduce the number of cost drivers by applying the cost driver selection method to the data for the ABC, from the second time of costing, we will then be able to use a simplified ABC (S-ABC) method that can easily perform both data collection and cost accounting.

Fig. 3 shows the procedure for allocating costs X_i of A_i to the cost objects O_j using the selected cost drivers.

Practicality of the S-ABC method

To exemplify the practicality of the S-ABC method,

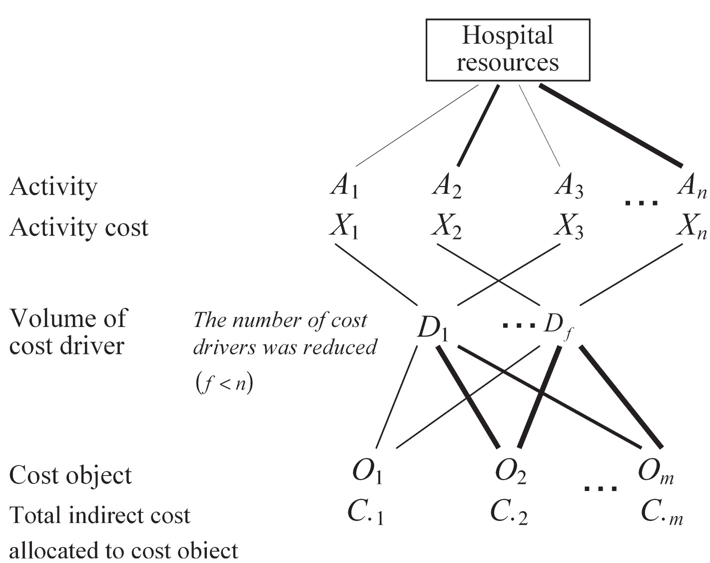

Fig. 3. Decreased cost drivers using with the S-ABC method. The number of cost drivers using in ABC method is reduced with the S-ABC method.

we performed the actual cost accounting of three kinds of laboratory tests namely biochemical, hematological and immunochemical tests, using the ABC, VBC and the S-ABC methods.

The activities necessary for test implementation in the laboratories of our hospital comprise eight factors: (1) Receiving test orders; (2) Taking blood samples; (3) Transferring reports; (4) Claiming remuneration; (5) Supplying materials; (6) Supplying reagents; (7) Maintaining SLAX (PREP-LAX system, Hitachi Medical Co., Tokyo); and (8) Maintaining STS (Sample transportation system, Hitachi Medical Co.). According to these activities, seven cost drivers (two activities, "Taking blood samples" and "Maintaining SLAX", use the same cost driver) and three cost objects (three tests) were thus constructed. Table 1 presents the total costs of each activity, the cost drivers, total volume of each cost driver and sub-volume of these cost drivers for each cost object with the ABC method. For simplification purposes, the hospital overhead costs such as building, water and light were excluded from this analysis.

Evaluation of the effectiveness of the S-ABC

We described an example from a physiological laboratory department to certify the effectiveness of the S-ABC. Table 4 shows the data list contained the values of activities A_i (i = 1, ..., 10), sum costs of each activity X_i, cost drivers $D_i(d_{ij})$ (j = 1, ..., 7) and cost objects O_j. There are ten activities and seven cost objects in the physiological laboratory department of our hospital. The information on labor time consumed by each activity was obtained by a time study. There are two aims of the evaluation containing (1) whether the new method is effective in the cost driver reduction, and (2) to show the relationship among the critical value p, the number of cost drivers and accuracy of costing.

Results

The indirect costs of the three laboratory tests with the ABC method

Indirect costs were allocated to each test using equation (1), and the total indirect costs for each of the three tests were calculated using equation (2). The results are shown in Table 1. The total indirect costs for the biochemical, hematological and immunochemical tests were $396,963, $27,868 and $16,393, respectively.

Cost estimation using VBC

We accounted the indirect costs of the three cost objects with the VBC method using the annual total number of order reception as the cost driver. The allocated indirect costs were estimated to be $419,363 for the biochemical tests, $15,248 for the hematological tests and $6,613 for the immunochemical tests (Table 2).

Cost driver selection using S-ABC

Fig. 4 illustrates the procedures and result of the cost driver selection with the raw data and using A_1 as an example. The critical values p described in procedure (d) of the Methods section was set as 0.02. As a result, the cost driver D_2 and D_1 was selected for activity A_1 and A_2, D_8 and D_5 for A_5 and A_8, respectively. In accordance with procedure (f), with D_2 a larger "X_i" exists between D_1 and D_2, therefore, cost driver D_2 was used for both A_1 and A_2. In the same way, cost driver D_8 was used for A_5 and A_8. Because no other cost drivers were accepted, except D_3 and D_6 for A_3 and A_6, the D_3 and D_6 used in the ABC method were still used for A_3 and A_6. In A_4 and A_7, the D_2 was selected (D_7 was same with D_2).

Finally, the seven cost drivers used in the ABC method were reduced to four, D_2, D_3, D_6 and D_8, with the cost driver selection method.

Comparison of costing results between the S-ABC, ABC and VBC methods

We used the S-ABC method to perform cost estimations of three laboratory tests using the four cost drivers, D_2, D_3, D_6 and D_8. Table 3 shows the cost estimation results. The total indirect cost for the biochemical, hematological and immunochemical tests were $397,411, $27,133 and $16,680, respectively. The differences among the results of cost accounting by the ABC, VBC and S-ABC methods were assessed and are shown in Tables 2 and 3. The greatest difference of the S-ABC was less than 2.7% according to the hematological test. On the other hand, the differences between ABC and VBC showed significant discrepancies ranging from 6-60%.

Table 1. *The indirect cost accounting with the ABC method*

Activity (A_i)	Total cost ($) ($X_i$)	Cost driver	Total volume of cost drivers (D_i)	Sub-volume for each O_j (d_{ij})			Indirect costs (C_{ij})		
				B-test[3]	H-test[4]	I-test[5]	B-test	H-test	I-test
(1) Receiving test orders	44,608	Number of order receptions	2,143,412	2,037,214	74,071	32,127	42,398	1,542	669
(2) Taking blood samples	203,032	Number of tests requiring vacuum tubes[1]	2,128,262	2,023,073	73,366	31,823	192,998	6,999	3,036
(3) Transferring reports	25,100	Number of HIS[2] terminals	4	2	1	1	12,550	6,275	6,275
(4) Claiming remuneration	8,200	Time required	241	230	8	3	7,826	272	102
(5) Supplying materials	50,096	Number of bills	1,081	1,054	16	11	48,845	741	510
(6) Supplying reagents	45,659	Number of bills	133	85	34	14	29,180	11,672	4,806
(7) Maintaining SLAX[6]	10,632	Number of tests requiring vacuum tubes	2,128,262	2,023,073	73,366	31,823	10,106	366	159
(8) Maintaining STS[7]	53,897	Number of tests by transfer	2,069,341	2,037,214	0	32,127	53,060	0	837
Total	441,225						$396,963	$27,868	$16,393

[1] The number of tests in which a vacuum tube was required. $D_7 = D_2$.
[2] Hospital information system.
[3] Biochemical test.
[4] Hematological test.
[5] Immunochemical test.
[6] SLAX, the equipment system required for the vacuum tube preparation.
[7] STS, the equipment system required for the sample transfer.

TABLE 2. *The indirect cost accounting with the VBC method*

Total indirect costs	Cost driver	Total volume of cost drivers (D)	Sub-volume for each O_j (d_j)			Indirect costs (C_j)		
			B-test	H-test	I-test	B-test	H-test	I-test
441,225	Number of order receptions	2,143,412	2,037,214	74,071	32,127	\$419,363	\$15,248	\$6,613
			Difference with the ABC results (%)			5.64	45.29	59.66

(A_k)		A_1				A_2 A_3 A_4 A_5 A_6 A_8
Procedure		O_1	O_2	O_3		
(a)	D_i	d_{i1}	d_{i2}	d_{i3}		
D_1	2,143,412	2,037,214	74,071	32,127		
D_2	2,128,262	2,023,073	73,366	31,823		
D_3	4	2	1	1		
D_4	241	230	8	3		
D_5	1,081	1,054	16	11		
D_6	133	85	34	14		
D_8	2,069,341	2,037,214	0	32,127		

$$R_{ij} = d_{ij} / D_i \times 100\%$$

R_{i1}	R_{i2}	R_{i3}
95.05	3.46	1.50
95.06	3.45	1.50
50.00	25.00	25.00
95.44	3.32	1.24
97.50	1.48	1.02
63.91	25.56	10.53
98.45	0.00	1.55

$$\mu_{ij}^{(k)} = \left| R_{ij} - R_{kj} \right|$$

(d)

$$\mu_i^{(k)} = \sum_{j=1}^{m} \mu_{ij}^{(k)}$$

(b)	$\mu_{i1}^{(1)}$	$\mu_{i2}^{(1)}$	$\mu_{i3}^{(1)}$	$\mu_i^{(1)}$
D_2	0.01	0.01	0.00	**0.02**
D_3	45.05	21.54	23.50	90.09
D_4	0.39	0.14	0.25	**0.78**
D_5	2.46	1.98	0.48	4.91
D_6	31.14	22.11	9.03	62.27
D_8	3.40	3.46	0.05	6.91

$\mu_{ij}^{(k)} \leq p$ (p=0.02)

I	**D_2, D_4**	**D_2, D_4**, D_5	**D_2, D_4**, D_5, D_8	D_2

(e) $D_i' = D_2$ — D_1 D_3 D_2 D_8 D_6 D_5

(f) Selected cost drivers D_g: D_2 D_3 D_6 D_8

Fig. 4. The cost driver selection and result for A_1 to A_8 using A_1 as the sample.

TABLE 3. *Indirect cost accounting using the new cost drivers of S-ABC method*

Activity (A_i)	Total cost ($) ($X_i$)	Simplified cost driver	Total volume of cost drivers (D_g)	Sub-volume for each O_j (d_{gj})			Indirect costs (C_{ij})		
				B-test	H-test	I-test	B-test	H-test	I-test
(1) Receiving test orders	44,608	Number of tests with vacuum tubes	2,128,262	2,023,073	73,366	31,823	42,403	1,538	667
(2) Taking blood samples	203,032						192,998	6,999	3,036
(4) Claiming remuneration	8,200						7,795	283	123
(7) Maintaining SLAX[1]	10,632						10,106	366	159
(3) Transferring reports	25,100	Number of HIS[3] terminals	4	2	1	1	12,550	6,275	6,275
(6) Supplying reagents	45,659	Number of bills for reagents	133	85	34	14	29,180	11,672	4,806
(5) Supplying materials	50,096	Number of tests by transfer	2,069,341	2,037,214	0	32,127	49,318	0	778
(8) Maintaining STS[2]	53,897						53,060	0	837
Total	441,225						$397,411	$27,133	$16,680
			Difference with the ABC results (%)				0.11	2.64	1.75

[1] SLAX, the equipment system required for the vacuum tube preparation.
[2] STS, the equipment system required for the sample transfer.
[3] Hospital information system.

Note: According to the S-ABC method, the costs of the activities (1) Receiving test orders, (2) Taking blood samples, (4) Claiming remuneration and (7) Maintaining SLAX were allocated to the tests using the unified cost driver "Number of tests with vacuum tubes". The costs of activities (5) Supplying materials and (8) Maintaining STS were allocated to the tests using the unified cost driver "Number of tests by transfer".

TABLE 4. *The real data from the physiological laboratory department*

Activities (A_i)	Total cost for each A_i (X_i)	Cost driver	D_{ij}	d_{i1}	d_{i2}	d_{i3}	d_{i4}	d_{i5}	d_{i6}	d_{i7}
Schedule appointments	11,346	Time required (1)	2,800	235	235	235	482	553	478	582
Patient check in	7,092	Time required (2)	1,715	245	245	245	245	245	245	245
Patient education	8,036	Time required (3)	8,507	1,758	535	1,453	878	1,585	1,253	1,045
Provision of testing	8,509	Time required (4)	7,584	1,857	725	993	785	1,204	885	1,135
Handling of equipments	4,727	Time required (5)	7,520	1,534	558	782	1,123	2,140	658	725
Patient check out	3,782	Time required (6)	2,585	635	325	325	325	325	325	325
Handling of reports	14,182	Number of tests	20,313	791	12,791	3,966	1,300	934	114	417
Billing and administration	7,563	Time required (7)	4,109	587	587	587	587	587	587	587
Handling of materials	5,673	Time required (8)	6,691	1,477	358	559	575	1,875	1,089	758
Others	5,200	Time required (9)	2,605	552	320	320	320	453	320	320

Cost objects (O_j)		Total costs allocated from activities with ABC ($C_{.j}$)
O1	Electroencephalogram (EEG)	11,590
O2	Electrocardiogram (ECG)	15,064
O3	Respiratory function tests	10,381
O4	Holter ECG	8,972
O5	Electromyogram (EMG)	12,149
O6	Test for peripheral circulation	8,738
O7	Treadmill test	9,216

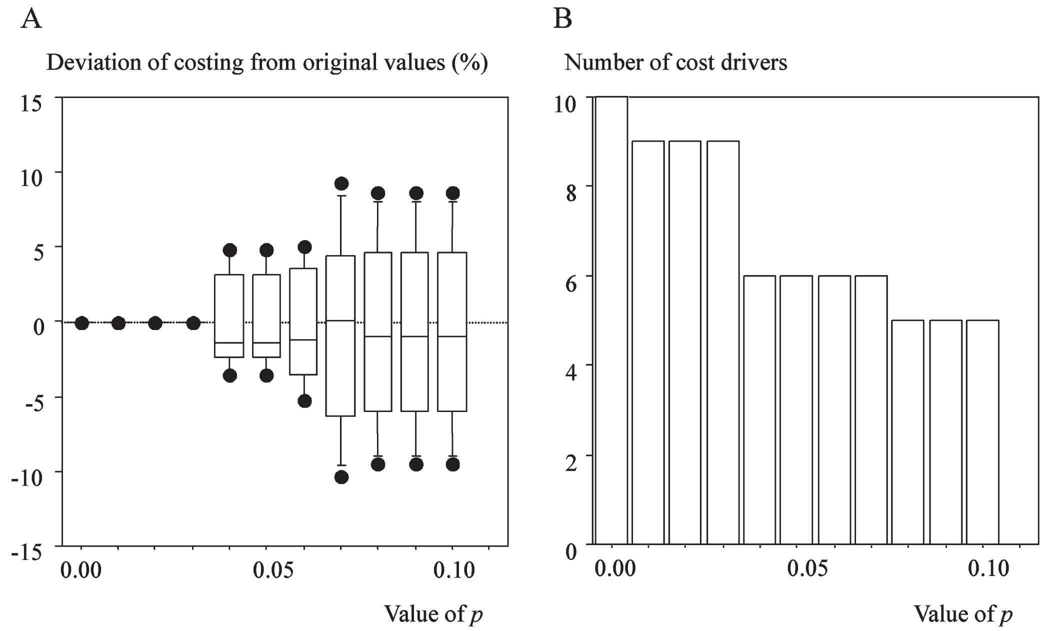

Fig. 5. A: Cost deviance rate from original value by change in the value of p.
B: Number changes of cost drivers by change in the value of p.

Application of S-ABC to physiological laboratory data

We evaluated the effect of p value on cost driver selection. The p value was changed from 0.0 to 0.1 (Table 4). The changes in the number of selected cost drivers and the deviation of costing results from original values calculated by the ABC method are shown in Fig. 5. The cost drivers were the most efficiently reduced from ten drivers to six without losing the accuracy of costing (the deviation of costing results from the ABC values were showed as −1.44, 4.83 and −3.57 percent at median, max and min) when p value was 0.04-0.05.

Discussion

There are two major advantages with the S-ABC method in comparison to the VBC and the ABC methods when used in routine cost accounting at hospitals. First, the S-ABC method provides accurate costing results, and the accuracy of costing is achieved by the appropriate usage of cost drivers. The second advantage is that the data collection and costing procedures in S-ABC are simpler than those in the ABC method. The simplicity of costing with our method is achieved by the reduced number of cost drivers compared with the ABC method. The pertinent reduction in the cost driver numbers does not significantly influence the accuracy of costing as shown by the laboratory examinations. The results of cost driver selection using S-ABC was similar to those using the cost driver reduction method, which is an alternative method to reduce cost driver and simplify the cost estimation (Cao et al., in press).

The data collection for cost drivers is not always easy. For example, supposing that an indirect labor cost is allocated to each cost object using labor hours as the cost driver, we have to perform a time study to determine how long each member of staff has spent on each cost object. However, labor hours are difficult and troublesome to measure, especially in healthcare practices, because staff are often simultaneously engaged in several activities (e.g., performing a treatment, involved in a meeting of inquiry, data recording or taking reports) or working for several different cost objects. These procedures are not only difficult and troublesome to compute but also costly. Moreover, thorough data collection is almost

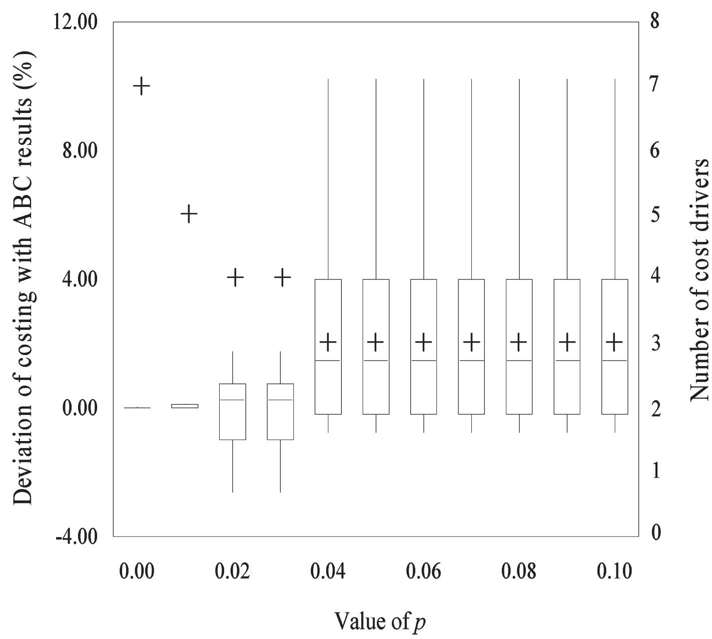

Fig. 6. The simulation results using the data shown in Table 1. Changes in the number of cost drivers and costing deviances with the ABC results based on the change in the *p* value in cost calculations for three laboratory tests. The costing deviances between the simulated results and the ABC results are shown by a box-and-whisker plot, and the number of cost drivers are indicated by a cross mark.

impossible in some cases. For example, supposing that the costs for a surgical operation are estimated using the ABC method, the number of activities and thus cost drivers would be enormous. The enormity of data and complexity of data collection for surgical operations is beyond comparison with that required for laboratory examinations, which was used as an example in our study. The strict application of such ABC method in usual cost estimation is therefore difficult to realize. Therefore, we have to simplify the procedure of data collection for the cost estimation that may be required at anytime in hospitals.

On the other hand, the number of cost drivers can be adjusted using the S-ABC method. This adjustment can be performed by adjusting the *p* value. If we want to obtain accurate cost data while not taking into account the labor required for data collection, we will decrease the *p* value. On the other hand, the *p* value increases when we want to obtain the cost data quickly. However, there is a drawback in that the accuracy of costing may be lost when the number of cost drivers is reduced too much. The great advantage of the S-ABC method is the ability to adjust the balance between the accuracy and simplicity depending on the purpose of specific cost accounting. For three laboratory tests, Fig. 6 showed the simulation results of the change in the number of cost drivers and costing deviation with the ABC results by change the *p* value from 0.0 to 0.1. The cost drivers were the most efficiently reduced from seven drivers to four without losing the accuracy of costing (the deviation of costing results from the ABC values were showed as 0.11, 1.75 and −2.64 percent at median, max and min) when the *p* value was 0.02-0.03. We therefore selected 0.02 as the *p* value in this study.

Once we reduce the number of cost drivers by applying the proposed S-ABC method to the data for the ABC method, we can easily perform the cost accounting using few cost drivers after the second round of costing. The proposed S-ABC method can be generally used throughout all hospitals.

A patent on this S-ABC method is currently under review at the Japan Patent Office (No. 3483705).

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