นิพนธ์ต้นฉบับ

Unit costs of diagnostic imaging tests at the outpatient department of Chulalongkorn Hospital

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Dhanamun B, Hempisut P, Kamolratanakul P, Chotiwan P, Tungcharoensathien V. Hiransuthikul N. Unit costs of diagnostic imaging tests at the outpatient department of Chulalongkorn Hospital. Chula Med J 1996 Oct;40(10): 821-36

Objective : *To find out the unit costs of the diagnostic imaging tests at the outpatient department of Chulalongkorn Hospital in the fiscal year 1991 from the perspective of the service providers.*

Study design : *Descriptive study (prospective and retrospective survey)*

Setting : *The radiologic section, outpatient department, Chulalongkorn Hospital*

Subjects : *All labour cost, material cost and capital cost of the radiologic section, total cost from non-revenue producing cost centers and total number of diagnostic imaging tests requested from October 1, 1990 to September 30, 1991.*

Main outcome measure :

1. *The unit cost of each type of the diagnostic imaging test compared to the service charge.*
2. *The numbers of each type of the diagnostic imaging test compared to the break-even point.*

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Results : *It was found that the capital cost, material cost and labour cost had shares of 40.13%, 28.79% and 31.08% respectively of the total unit cost. Most of the service charges for diagnostic imaging tests were lower than the unit costs except for general X-rays, Endoscopic retrograde cholangiopancreatography (ERCP), hysterosalpingography, myelography, dacryocystography, ultrasound and tooth X-rays. Most of the test requested had costs that were lower than a the break-even point excepts for the ones mentioned above.*

Conclusions : *From the study of the unit costs of the diagnostic imaging tests at the outpatient department of Chulalongkorn Hospital in the fiscal year 1991, it was found that most of the service volume of the diagnostic imaging tests were lower than a break-even point and most of the service charges were lower than the unit cost. Result of this study may be beneficial for patient-service planning in order to increase the efficiency and forsetting new appropriate service charges which are justified from patients' perspective and by financial solvency. For generalization of this study, the effect of time on the calculated costs to the present value has to be considered.*

Key words : *Unit cost, Diagnostic imaging, Chulalongkorn Hospital, Labour cost, Material cost, Capital cost, Break-even point.*

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Received for publication. August 15,1996.

บดี ธนะมั่น, พินทุสร เหมพิสุทธิ์, ภิรมย์ กมลรัตนกุล, พรณรงค์ โชติวรรณ, วิโรจน์ ตั้งเจริญเสถียร, นรินทร์ หิรัญสุทธิกุล. ต้นทุนต่อหน่วยของการตรวจวินิจฉัยด้วยภาพถ่ายที่แผนกผู้ป่วยนอก โรงพยาบาลจุฬาลงกรณ์. จุฬาลงกรณ์เวชสาร 2539 ต.ค.;40(10): 821-36

วัตถุประสงค์ : *เพื่อคำนวณหาต้นทุนต่อหน่วยของการตรวจวินิจฉัยด้วยภาพถ่ายที่แผนกผู้ป่วยนอก โรงพยาบาลจุฬาลงกรณ์ จากมุมมองของผู้ให้บริการ*

ชนิดของการทำวิจัย : *การวิจัยเชิงพรรณนา (โดยการสำรวจไปข้างหน้าและย้อนหลัง)*

สถานที่ที่ทำวิจัย : *ฝ่ายรังสีวิทยา แผนกผู้ป่วยนอก โรงพยาบาลจุฬาลงกรณ์*

กลุ่มตัวอย่าง : *ต้นทุนค่าแรงต้นทุนค่าวัสดุและต้นทุนค่าเครื่องตรวจทางรังสีวิทยาทั้งหมดของฝ่ายรังสีวิทยา ต้นทุนทั้งหมดของฝ่ายที่ไม่มีรายได้ และจำนวนการตรวจวินิจฉัยด้วยภาพถ่ายทั้งหมด ที่ส่งตรวจระหว่าง 1 ตุลาคม 2533 ถึง 30 กันยายน 2534*

ตัววัดผลที่สำคัญ : 1. *ต้นทุนต่อหน่วยของการตรวจวินิจฉัยด้วยภาพถ่ายแต่ละชนิด เปรียบเทียบกับค่าบริการ*
2. *จำนวนการตรวจวินิจฉัยด้วยภาพถ่ายแต่ละชนิด เปรียบเทียบกับจุดคุ้มทุน*

ผลการวิจัย : *พบว่า ต้นทุนค่าเครื่องตรวจด้วยภาพถ่าย ต้นทุนค่าวัสดุ และต้นทุนค่าแรง คิดเป็นสัดส่วนร้อยละ 40.13, 28.79 และ 31.08 ของต้นทุนต่อหน่วยตามลำดับ ค่าบริการของการตรวจวินิจฉัยด้วยภาพถ่ายส่วนใหญ่จะต่ำกว่าต้นทุนต่อหน่วย ยกเว้น การถ่ายภาพรังสีทั่วไป (General X-rays) การตรวจทางเดินน้ำดีและตับอ่อนด้วยกล้อง และฉีดสารทึบแสง (Endoscopic retrograde cholangio pancreatography) การตรวจมดลูกและปีกมดลูกด้วยการฉีดสารทึบแสง (Hysterosalpingography) การตรวจไขสันหลังด้วยการฉีดสารทึบแสง(Myelography) การตรวจทางเดินน้ำตาด้วยการฉีดสารทึบแสง (Dacryocystography) การตรวจด้วยคลื่นเสียง (Ultrasonography) และการถ่ายภาพรังสีฟัน จำนวนการส่งตรวจวินิจฉัยด้วยภาพถ่ายแต่ละชนิด ส่วนใหญ่จะน้อยกว่าจุดคุ้มทุน ยกเว้นการตรวจวินิจฉัยชนิดที่กล่าวแล้วข้างต้น*

สรุป : *จากการศึกษาต้นทุนต่อหน่วยของการตรวจวินิจฉัยด้วยภาพถ่ายที่แผนกผู้ป่วยนอก โรงพยาบาลจุฬาลงกรณ์ ในปีงบประมาณ 2534 พบว่าจำนวนการส่งตรวจวินิจฉัยด้วยภาพถ่ายแต่ละชนิดต่ำกว่าจุดคุ้มทุนและค่าบริการของการตรวจส่วนใหญ่จะน้อยกว่า ต้นทุนต่อหน่วย ผลจากการศึกษานี้จะเป็นประโยชน์ต่อการวางแผนในการให้บริการผู้ป่วยเพื่อเพิ่มประสิทธิภาพและกำหนดค่าบริการที่เหมาะสมขึ้นใหม่ ซึ่งเป็นธรรมในสายตาของผู้ป่วย และเหมาะสมในทางการเงิน อนึ่งการนำผลการศึกษานี้ไปใช้จะต้องพิจารณาถึง ปัจจัยเรื่องเวลาในการคำนวณต้นทุนเทียบกับมูลค่าในปัจจุบันด้วย*

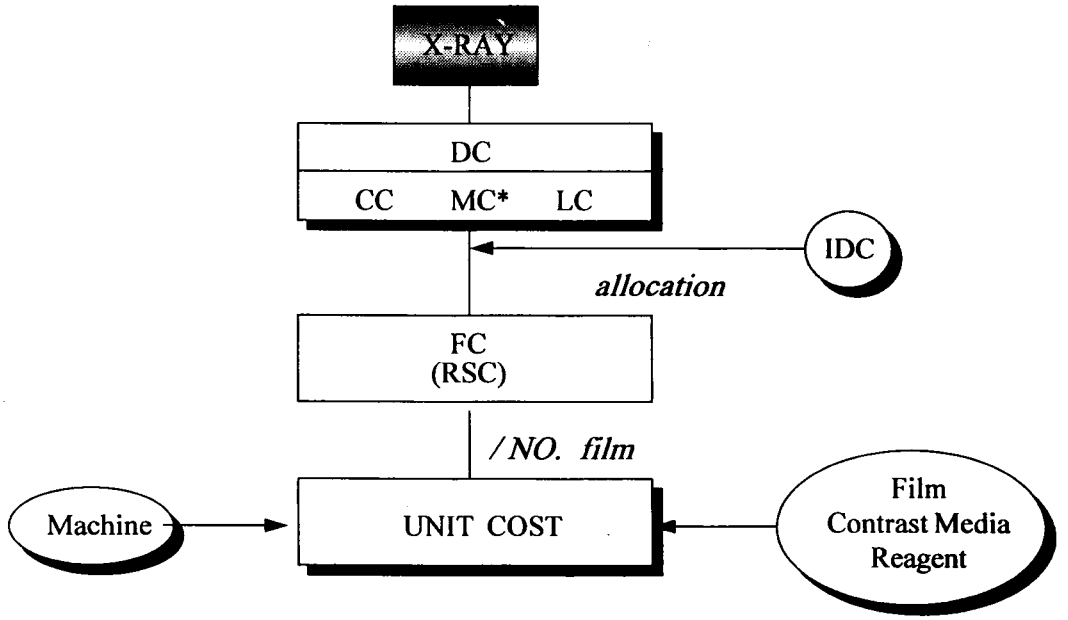
In providing health cares, a radiologic service is one of the most important medical services in diagnosis, follow-up of the progression of diseases and evaluation of management outcome. Therefore, a knowledge of the unit costs of the radiologic services will serve as a basic information in planning for an efficient medical service, and setting appropriate radiologic service charges. In addition, this information will be a supporting factor for a physician's judgement in choosing different kinds of the radiologic service with the highest efficiency.[1-3] Academically,this information can also be used as basic data for further studies in clinical economics such as studies of the unit costs of diagnosis related groups (for health social insurance), studies of cost-effectiveness of various health services, etc.

Therefore, this study had the objective of studying the unit costs of diagnostic imaging tests at the outpatient department of the Chulalongkorn hospital of in the fiscal year 1991. It includes both general and special diagnostic imaging tests and determines the break-even point of each imaging tests service and compare the calculated unit cost to the radiologic service charge.

Materials and Methods

This was a descriptive study to collect existing and new data by using prospective as well as retrospective surveys. All sections of the outpatient department were classified into three cost centre categories: patient service, revenue producing services (radiology, laboratory and pharmacy sections) and non-revenue producing services (administrative and supportive sections).[4] The total direct cost (TDC) of the radiologic section was calculated from a labour cost (LC), material cost (MC) and capital cost (CC) in each unit (see Fig.1). The total cost from the non-revenue producing cost centres was then allocated to the radiology section by the simultaneous equation method using appropriate allocation criteria.[5-8] Thus, the full cost of each radiology unit is the sum of the total direct costs in its section and the indirect costs which were allocated from the non-revenue producing cost centres. The unit cost of the diagnostic imaging was then calculated by dividing the full costs by the total number of types of tests requested during 12 months of observation (Oct 1,1990-September 30, 1991). We also had to add the cost of film, reagents, contrast media and the capital cost of the X-ray machines at the final step because these components of cost varied among the diagnostic imaging tests. Therefore, they were calculated separately for each diagnostic imaging test. The costing process of this study is shown in Fig.1. The break-even point of each imaging service was calculated by using the below formula.[9]

$$\frac{\text{Total Fixed Cost}}{\text{(Price/unit) - (Variable cost unit)}}$$



*Except cost of machine and reagent
LC = labour cost, MC = material cost, CC = capital cost, TDC = total direct cost, FC = full cost, DC = direct cost, IDC = indirect cost, RSC = routine service cost

Figure 1. Costing Process of X-ray

The fixed costs do not change with the volume of services provided, e.g.the cost of the X-ray machines. But the variable costs increase with the increasing volume of services.[10]

Results

In the analysis of the direct and total costs of the radiologic section, we found that the maximum component was the capital cost, followed in order by the labour costs and the materials costs. (Table 1)

Table 1. The direct cost, total cost, capital cost labour cost and material cost of radiology unit at the outpatient department of Chulalongkorn Hospital, 1991

Cost Categories	Direct Cost		Total Cost	
	Amount	%	Amount	%
Capital cost	3,449,770	39.44	3,826,715	40.13
Labour cost	2,858,718	32.68	2,964,576	31.08
Material cost	2,438,123	27.88	2,745,647	28.79
Total	**8,746,613**	**100.00**	**9,536,938**	**100.00**

Regarding the capital cost, it was found that the greatest cost (88%) was the medical instruments, while in the materials cost, X-ray films were the highest cost (62%) followed by the contrast media (17%).

The unit cost of special diagnostic imaging at the outpatient department of Chulalongkorn Hospital are shown in Table 2 where each cost category (capital, material and labour cost) of each procedure is separated. Table 3 shows the unit costs of general imaging.

Table 2. Unit cost of the special diagnostic imaging at the outpatient department of Chulalongkorn Hospital, 1991.

Special Diagnostic Imaging	Cost Categories			Total unit cost
	C.C	M.C	L.C	
Barium enema	279.49	251.12	306.50	837.11
T-tube cholangiography	197.93	190.93	198.63	587.05
E.R.C.P.*	200.37	208.99	184.16	583.53
Hysterosalpingography	129.81	117.19	136.39	383.40
Fistulography	119.38	137.70	143.39	400.47
Venography	225.94	555.31	261.90	1,043.00
Cystography	235.76	318.67	266.71	821.14
Small bowel study	268.74	305.71	342.04	916.49
Upper GI study	562.89	204.45	204.67	972.01
Barium Swallow	601.57	182.34	204.08	987.99
Myelography**	305.45	124.05	142.74	572.24
Oral Cholecystography	512.06	228.11	194.05	934.22
Voiding cystourethrography	722.51	356.16	272.40	1,351.07
I.V.P.	222.10	275.97	297.56	795.62
Dacryocystography	49.09	32.66	40.92	122.68
Arthrography	466.89	339.57	407.90	1,214.35
Mammography	1,014.73	88.65	272.20	1,375.59
Ultrasound	123.42	63.31	80.30	267.03
Mandible(panoramic view)	304.54	60.58	61.39	426.51
Teeth	102.39	21.43	20.46	144.28
Temporomandibular Joint	203.47	41.00	40.92	285.39

*Endoscopic Retrograde Cholangio pancreatiography (Not include depreciation cost of endoscope)

**Not include labour cost of orthopedist and contrast media

Table 3. Unit cost of the general diagnostic imaging at the outpatient department of Chulalongkorn Hospital, 1991.

General Diagnostic Imaging	Cost Categories			Total unit cost
	C.C*	M.C*	L.C*	
Acute Abdomen	65.91	59.59	61.39	186.89
Abdomen	21.97	24.80	20.46	67.23
Ankle	21.97	21.66	20.46	64.09
Arm	21.97	17.10	20.46	59.53
Bone age	21.97	17.10	20.46	59.53
Bone Survey	53.79	106.93	143.23	403.95
Chest, Rib	43.94	42.20	40.92	127.06
Coccyx	43.94	22.80	40.92	107.66
Clavicle	21.97	17.10	20.46	59.53
C-Spine	87.88	38.19	81.85	207.92
Elbow	21.97	17.10	20.46	59.53
Esophagus	65.91	50.17	61.39	177.47
Foot	21.97	21.66	20.46	64.09
Femur	43.94	42.20	40.92	127.06
Gall Bladder	21.97	17.10	20.46	59.53
Forearm	21.97	17.10	20.46	59.53
Hand	21.97	17.10	20.46	59.53
Hip joint	43.94	35.92	40.92	120.78
Humanogram	21.97	24.80	20.46	67.23
Heart	87.88	76.99	81.85	246.72
Internal Acoustic canal	65.91	30.49	61.39	157.79
Knee	21.97	21.66	20.46	64.09
Leg	21.97	24.80	20.46	67.23
Larynx	43.94	22.80	40.92	107.66
Long bone	43.94	42.20	40.92	127.06

* C.C.= Capital Cost ; M.C. = Material Cost ; L.C. = Labour Cost

Table 3. (Cont.)

General Diagnostic Imaging	Cost Categories			Total unit cost
	C.C*	M.C*	L.C*	
K.U.B.	21.97	24.80	20.46	67.23
L-Spine	43.94	35.92	40.92	120.78
L-S Spine	43.94	35.92	40.92	120.78
Mastoid	43.94	22.80	40.92	107.66
Nasopharynx	43.94	26.80	40.92	111.66
Nasal Bone	43.94	22.80	40.92	107.66
Neck	43.94	22.80	40.92	107.66
Optic Foramina	43.94	22.80	40.92	107.66
Orbit	43.94	22.80	40.92	107.66
Patella	21.97	17.10	20.46	59.53
Pelvis	21.97	21.66	20.46	64.09
Paranasal Sinuses	21.97	17.10	20.46	59.53
Sacrum	21.97	17.10	20.46	59.53
Scapula	21.97	17.10	20.46	59.53
Shoulder	21.97	15.10	20.46	57.53
Sacroliac joint	65.91	30.49	61.39	157.79
Skull	65.91	36.49	61.39	163.79
Spinal cord	87.88	38.19	81.85	207.92
Sternum	43.94	26.80	40.92	111.66
Sternoclavicular	43.94	26.80	40.92	111.66
Styloid process	43.94	22.80	40.92	107.66
T-L Spine	43.94	35.92	40.92	120.78
Wrist	21.97	17.10	20.46	59.53
Zypomatic Arches	43.94	26.80	40.92	111.66
T-Spine	43.94	35.92	40.92	120.78

* C.C. = Capital Cost ; M.C. = Material Cost ; L.C. = Labour Cost

A comparison between the number of diagnostic imaging tests and the number of break-even point was shown in Tables 4 and 5. We found that the costs of most of the tests requested were lower than the break-even point, except for general diagnostic imaging tests, ERCP, hysterosalpingography, myelography, dacryocystography, ultrasound and tooth X-ray.

Table 4. The number of test requested and the break-even point of the special diagnostic imging tests at the outpatient department of Chulalongkorn Hospital, 1991.

Special Diagnostic Imaging	Break-even point (No. tests)	No.tests requested
Barium enema	936	557
T-tube cholangiography	28	15
E.R.C.P.	2	10
Hysterosalpingography	84	216
Fistulography	14	11
Venography	2	2
Cystography	14	5
Small bowel study	138	44
Upper GI study	4,457	1,426
Barium Swallow	63	17
Myelography	61	119
Oral Cholecystography	99	38
Voiding cystourethrography	113	39
I.V.P.	3,264	2,035
Dacryocystography	24	85
Arthrography	13	4
Mammography	619	198
Ultrasound	1,030	2,208
Mandible (panoramic view)	721	196
Teeth	109	123
Temporomandibular Joint	99	48

Table 5. The number of test requested and the break-even point of the general diagnostic imaging at the outpatient department of Chulalongkorn Hospital, 1991.

General Diagnostic Imaging	Break - even point (No. tests)	No. tests requested
Acute Abdomen	132	249
Abdomen	109	198
Ankle	222	410
Arm	64	125
Bone age	28	57
Bone Survey	11	21
Chest, Rib	36,303	24,727
Coccyx	15	14
Clavicle	47	92
C-Spine	433	795
Elbow	158	308
Esophagus	22	44
Foot	370	684
Femur	589	401
Gall Bladder	24	46
Forearm	149	291
Hand	392	766
Hip joint	772	583
Humanogram	0.56	1
Heart	5	11
Internal Acoustic canal	64	132
Knee	574	1,129
K.U.B.	776	1,375
Leg	311	627
Larynx	0.54	1
Long bone	8	12
L-Spine	151	292
L-S Spine	509	1,944
Mastoid	114	185

Table 5. (cont.)

General Diagnostic Imaging	Break - even output (No. tests)	No. tests requested
Nasopharynx	84	151
Nasal Bone	18	29
Neck	192	305
Optic Foramina	4	7
Orbit	21	57
Patella	8	16
Pelvis	132	244
Paranasal Sinuses	654	1,277
Sacrum	0.89	3
Scapula	16	63
Shoulder	180	360
Sacroliac joint	42	73
Skull	503	923
Spinal cord	5	9
Sternum	2	5
Sternoclavicular	1	1
Styloid process	9	15
T-L Spine	316	612
Wrist	297	581
Zypomatic Arches	0.70	2
T-Spine	37	72

A comparison between the unit cost of diagnostic imaging tests and the service charges was shown in Tables 6 and 7. We found that most of the service charges for the diagnostic imaging tests were lower than the unit costs except for general diagnostic imaging tests, ERCP, hysterosalpingography, myelography, dacryocystography, ultrasound and tooth X-ray.

Table 6. Comparison between the unit cost of the special diagnostic imaging tests and service charge at the outpatient department of Chulalongkorn Hospital, 1991.

Special Diagnostic Imaging	Unit cost (฿)	Charge (฿)	Difference (Charge-Cost)
Barium enema	837.11	600.00	-237.11
T-tube cholangiography	587.05	400.00	-187.05
E.R.C.P.	593.53	2,000.00	+1,406.47
Hysterosalpingography	383.40	800.00	+416.60
Fistulography	400.47	350.00	-50.47
Venography	1,043.00	1,000.00	-43.00
Cystography	821.14	500.00	-321.14
Small bowel study	916.96	500.00	-419.96
Upper GI study	972.01	450.00	-522.01
Barium Swallow	987.99	400.00	-587.99
Myelography	572.24	1,000.00	+427.76
Oral Cholecystography	934.22	500.00	-434.22
Voiding cystourethrography	1,351.07	700.00	-651.07
I.V.P.	795.62	600.00	-195.62
Dacryocystography	122.68	350.00	+227.32
Arthrography	1,214.35	600.00	-614.35
Mammography	1,375.59	500.00	-875.59
Ultrasound	267.03	500.00	-232.97
Mandible(panoramic view)	426.51	160.00	-266.51
Teeth	144.28	160.00	+15.72
Temporomandibular Joint	285.39	160.00	-125.39

Table 7. Comparison between the unit cost of the general diagnostic imaging tests and service charge at the outpatient department of Chulalongkorn Hospital, 1991.

General Diagnostic Imaging	Unit cost (฿)	Charge (฿)	Difference (Charge-Cost)
Acute Abdomen	186.89	300.00	+113.11
Abdomen	67.23	100.00	+32.77
Ankle	64.09	100.00	+35.91
Arm	59.53	100.00	+40.47
Bone age	59.53	100.00	+40.47
Bone Survey	403.95	700.00	+296.05
Chest, Rib	127.06	100.00	-27.06
Coccyx	107.66	100.00	-7.66
Clavicle	59.53	100.00	+40.47
C-Spine	207.92	350.00	+142.08
Elbow	59.53	100.00	+40.47
Esophagus	177.47	300.00	+122.53
Foot	64.09	100.00	+53.91
Femur	127.06	100.00	-27.06
Gall Bladder	59.53	100.00	+40.47
Forearm	59.53	100.00	+40.47
Hand	59.53	100.00	+40.47
Hip joint	120.78	100.00	-20.78
Humanogram	67.23	100.00	+32.77
Heart	246.72	450.00	+203.28
Internal Acoustic canal	157.79	260.00	+102.21
Knee	64.09	100.00	+35.91
Leg	67.23	100.00	+32.77
Larynx	107.66	160.00	+52.34
Long bone	127.06	160.00	+32.94
K.U.B.	67.23	100.00	+32.77
L-Spine	120.78	200.00	+79.22
L-S Spine	120.78	360.00	+239.22
Mastoid	107.66	160.00	+52.34
Nasopharynx	111.66	160.00	+48.34

Table 7. (cont.)

General Diagnostic Imaging	Unit cost (฿)	Charge (฿)	Difference (Charge-Cost)
Nasal Bone	107.66	160.00	+52.34
Neck	107.66	160.00	+52.34
Optic Foramina	107.66	160.00	+52.34
Orbit	107.66	250.00	+52.34
Patella	59.53	100.00	+40.47
Pelvis	64.09	100.00	+35.91
Paranasal Sinuses	59.53	100.00	+40.47
Sacrum	59.53	160.00	+100.47
Scapula	59.53	180.00	+120.47
Shoulder	57.53	100.00	+42.47
Sacroliac joint	157.79	250.00	+92.21
Skull	163.79	270.00	+106.21
Spinal cord	207.92	350.00	+142.08
Sternum	111.66	250.00	+138.34
Sternoclavicular	111.66	100.00	+11.66
Styloid process	107.66	160.00	+52.34
T-L Spine	120.78	200.00	+79.22
Wrist	59.53	100.00	+40.47
Zypomatic Arches	111.66	270.00	+158.34
T-Spine	120.78	200.00	+79.22

Discussion

The capital cost was the largest portion of the total costs of the radiologic imaging tests at the outpatient department of Chulalongkorn Hospital, because of the expensive X-ray machines. The procurement of advanced X-ray machines increased the fixed cost of service at the outpatient department. In order to reduce the impact of this high cost, it is necessary, therefore, to increase the service volume.

The average unit cost of the radiologic imaging tests in the OPD was 198 baht. This was higher than unit costs of large general hospitals,i.e 101 baht, from the Kanong-Yud et at study in 1983.[11] Although these two numbers could not be compared directly, they implied that the unit costs of the imaging tests at Chulalongkorn Hospital were higher than a general hospital. This may be attributed to Chlalongkorn Hospital being a teaching and tertiary-care hospital.

Based on this study, the unit costs of the radiologic imaging tests at the outpatient department of Chulalongkorn Hospital were related to several factors such as number of X-ray films being used, the amount of contrast media, a number of test requested and the experience of the personnels.

The service volume of most diagnostic tests did not provide break-even, probably because most of them were provided only during office hours, except for the general X-ray. The service volume for general X-ray is higher than the break-even point. Another factor may come from the fact that during the time of the study, services at radiologic department was not fully operated at the new outpatient department. In addition, service charges for the imaging tests were below their cost, so these charges should be readjusted.

This study may be beneficial for patient-service planning in order to increase efficiency, and for setting new and appropriate service charges which are justified from the patients' perspective and by financial solvency. Moreover, this in formation may serve as important input for managing the utilization of 20 diagnostic imaging equipments and for future studies in clinical economics, such as study of the unit costs of diagnostic related groups, that will support the health services related to social health insurance in the future. Generalization of this study, ones have to consider the effect of time on the calculated cost to the present value.

References

1. Kamolratanakul P. Clinical economic I. Chula Med J 1987 Oct; 31(10): 769-74
2. Kamolratanakul P. Clinical economic II. Chula Med J 1987 Nov; 31(11): 851-61
3. Kamolratanakul P. Clinical decision analysis. Chula Med J 1989 Aug; 33(8): 575-83
4. Metha NH, Maher DJ. Hospital Accounting System and Controls. New Jersy : Prentice-Hall, 1977.
5. Kennamer DB. A Hospital Unit Cost Model, Ph.D. Dissertation, Department of Industrial Engineering. Knoxville : University of Tennessee, 1986.
6. Balachandran V, Dittman DA. Cost allocation for maximizing hospital reimbursenment under third party cost contracts. Health care Manage 1978; 3: 61-70
7. Berman HJ, Weeks LE, Kikla SF. The Financial Management of Hospital. Ann Arbor, Michigan: Health Administration Press, 1986: 117-38
8. Meeting DT. 4 cost-financing mathods. Which one is best? Hosp Finan Manage 1978; 33: 34-9
9. ชาญวิทย์ โคธีรานุรักษ์. การบริหารระดับปฏิบัติการ. Package Program on Health Service and Hospital Management. กรุงเทพมหานคร: โครงการ Mini MBA in Health, 2532: 57-59.
10. Kaewsonthi S, Kamolratanakul P. Health Economics : Research Principles and Procedures for Evaluation of Health Services. Bangkok : Chulalongkorn University Press, 1994.