ASSESSING THE EFFICIENCY OF HOSPITAL PHARMACY SERVICES IN THAI PUBLIC DISTRICT HOSPITALS

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Abstract. The purpose of this study was to assess the efficiency of hospital pharmacy services and to determine the environmental factors affecting pharmacy service efficiency. The technical efficiency of a hospital pharmacy was assessed to evaluate the hospital's ability to use pharmacy manpower in order to produce the maximum output of the pharmacy service. Data Envelopment Analysis (DEA) was used as an efficiency measurement. The two labor inputs were pharmacists and support personnel and the ten outputs were from four pharmacy activities: drug dispensing, drug purchasing and inventory control, patient-oriented activities, and health consumer protection services. This was used to estimate technical efficiency. A Tobit regression model was used to determine the effect of the hospital size, location, input mix of pharmacy staff, working experience of pharmacists at the study hospitals, and use of technology on the pharmacy service efficiency. Data for pharmacy service input and output quantities were obtained from 155 respondents. Nineteen percent were found to have full efficiency with a technical efficiency score of 1.00. Thirty-six percent had a technical efficiency score of 0.80 or above and 27% had a low technical efficiency score (<0.60). The average TE score increased in respect to the hospital size (0.60, 0.71, 0.75, and 0.83 in 10, 30, 60, and 90-120 bed hospitals, respectively). Hospital size and geographic location were significantly associated with pharmacy service efficiency.

INTRODUCTION

In Thailand, district hospitals under the Ministry of Public Health (MOPH) located in rural areas of Thailand have experienced pharmacist shortages for decades. District hospitals are located in districts or sub-districts of each province, with sizes ranging from 10 to 120 beds. They have the responsibility to provide primary and secondary levels of care. In 1989, the Thai government issued a mandatory public contract policy for new pharmacy graduates, which resulted in a dramatical increase in the number of pharmacists working in district hospitals.

It is now common to have two to four pharmacists working in a district hospital of 30-60 bed size, compared to one pharmacist at the same hospital a decade ago. Currently, the number of pharmacists at each hospital is comparable to or greater than the number of physicians. The number of outpatients and inpatients at district hospitals has also increased over time, especially after the implementation of the Universal Health Care Coverage Policy (UC) in 2001 (Wibulpolprasert, 2005).

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Like other developing countries, Thai hospital pharmacies have a major responsibility for drug distribution through drug dispensing, drug purchasing, and inventory control, both for inpatient care and outpatient care. Apart from these services, Thai hospital pharmacists perform community-oriented services through disseminating health-related information and education to consumers and conducting post-marketing surveillance on health product safety.

Concurrently, with the expansion of pharmacist manpower, several initiatives have been advocated by the Thai Pharmacy Council over the past decade to improve the patient-oriented skills of hospital pharmacists. All 12 pharmacy schools in Thailand have adjusted their core curriculums and continuing education programs to include the pharmaceutical care concept since 1995. Additional patient-oriented services have been widely integrated into the hospital setting. Most hospital pharmacists, even those in small district hospitals, provide patient-oriented services. Pharmacists educate patients with chronic diseases on the appropriate use of medications and lifestyle modification, screening for drug-related problems, and follow-up of patient compliance.

Efficiency is an indicator commonly used to evaluate an organization's performance; how well resources are used to produce the service outputs compared with similar organizations. In district hospitals, pharmacist efficiency has not been evaluated regarding the ability to provide the needed services. Pharmacist numbers allocated to work at each district hospital have been commonly estimated on the basis of population density. An efficiency measurement that provides information about the target level of inputs utilized to achieve the outputs required, or vice versa, may help planning for pharmacy departments, hospital administrators, and policy makers. The purpose of this study was to assess the efficiency of pharmacy services at district hospitals in Thailand and to determine the environmental factors affecting pharmacy service efficiency.

MATERIALS AND METHODS

In this study, the efficiency of pharmacy services was measured in terms of technical efficiency (TE). TE was assessed to reflect the hospital's capability in using the pharmacy manpower inputs to generate the maximal outputs of pharmacy services.

Pharmacy service inputs and outputs

Selection of the input and output parameters was based on a review of hospital efficiency literature (Chang, 1998; Lertiendumrong, 2003; Watcharasriroj and Tang, 2003; Pavananunt, 2004) and augmented by a session of focus group discussion consisting of 10 chief pharmacists who had working experience in the district hospitals for at least 10 years. For a parameter to be included in this study, it needed to be viewed as having the ability to reflect the production of pharmacy services, and the availability and reliability of data. A total of 12 variables, two inputs and ten outputs, was used to assess the technical efficiency (Table 1).

The labor inputs we selected for this study covered two types of pharmacy manpower: staff pharmacists and supportive personnel in full-time equivalent (FTE) units, whereby one FTE equals 40 working hours per week. The number of personnel allocated specifically to the four service dimensions of the hospital pharmacy (Table 1) was used as the input parameter for analysis.

The ten outputs selected are available in the monthly reports of hospital pharmacies. The outputs of drug dispensing services were quantified in terms of number of outpatient and inpatient prescriptions filled during the first quarter of the survey fiscal year (October-December 2004). The outputs of drug purchasing and inventory control were measured in

Table 1
Input and output parameters used for efficiency analysis.

Variables	Definitions	Unit of analysis
Input variables		
1) Number of FTE pharmacists	Number of FTE pharmacists spent on provision of four major services	FTE
2) Number of FTE supportive personnel	Number of FTE pharmacy technicians and supportive personnel spent on provision of four major services	FTE
Output variables		
1) Drug dispensing		
Number of outpatient prescriptions[a]	Number of outpatient prescriptions during normal work hours on weekdays (40 hours per week)	Prescription
Number of inpatient prescriptions[b]	Number of inpatient prescriptions during normal work hours on weekdays (40 hours per week)	Prescription
2) Drug purchasing and inventory control		
Value of purchased drugs	Monetary value of purchased drugs	Baht
Value of stocked drugs	Monetary value of stocked drugs	Baht
Value of drugs supplied	Monetary value of supplied drugs	Baht
3) Patient-oriented services		
Number of patients receiving drug counseling	Number of outpatients and discharged patients who received drug counseling	Patient
Number of patients receiving drug therapy monitoring	Number of outpatients and inpatients who received drug therapy monitoring	Patient
Frequency of ADR management, DIS and DUE	Total number of times of conducting ADR management for both outpatients and inpatients with ADRs, DIS for questions requested by health care professionals, and DUE for outpatient and inpatient prescriptions	Frequency
4) Health consumer protection		
Frequency of conducting health consumer surveillance	Total number of times of conducting health consumer surveillance at each setting including drugstores, private clinics, groceries, markets, and local food manufacturers	Frequency
Frequency of conducting education sessions	Total number of times of conducting health education sessions for drugstores, private clinics, groceries, markets, and local food manufacturers	Frequency

[a] The average number of drug items per outpatient prescription was 5 items.
[b] The average number of drug items per inpatient prescription was 6 items.
1 US dollar = 31.37 Thai baht
FTE= full time equivalent; ADR= adverse drug reaction; DIS= drug information service; DUE= drug use evaluation

terms of monetary values of the drugs purchased, stocked, and supplied over the whole fiscal year prior to the survey period (October 2003-September 2004). The numbers of patients receiving drug counseling and drug therapy monitoring, and frequencies of adverse drug reaction (ADR) management, drug information service (DIS), and drug use evaluation

(DUE) activities were taken as the outputs of patient-oriented services, and the data were collected in the same quarter as the dispensing service. The scope of each studied patient-oriented activity was clarified in the data collection form, and they were consistent with the definitions used in the literature (Helper and Strand, 1990; Raehl and Bond, 2000; Schumock *et al*, 2003). For health consumer protection, frequencies of post-marketing surveillance and health education activities spread over 12 months of the prior fiscal year represented the service outputs.

Data collection

A data collection form to record the quantities of studied inputs and outputs was generated and then modified after a pilot test for better clarification. The data collection forms with a covering letter and a stamped addressed envelope were mailed to the chief pharmacists at all the Thai public district hospitals (*N*=712) in January 2005. The chief pharmacists were asked to fill out the data collection form using the existing data in their monthly reports. Reminder telephone calls were made to the non-respondents one month after the initial mailing.

To determine the representativeness of the study samples, a comparison between respondents and non-respondents was made. The 2004 data on the number of outpatient visits and inpatient admissions, and the number of pharmacists at each district hospital were obtained from the MOPH.

Technical efficiency analysis

In this study, Data Envelopment Analysis (DEA) was used to estimate the TE for each hospital pharmacy. DEA can incorporate several inputs and outputs with different units of measurement simultaneously. The basic DEA model helps to identify which hospital pharmacies are the most efficient or have actual good practice. It also helps to identify how much inputs may be reduced without reducing the current output levels, or alternatively, how much outputs should be increased with the current input levels in order to make inefficient hospital pharmacies efficient.

DEA was first developed by Farrell (1957), (Cited in Cooper *et al,* 2000). DEA has been used widely to measure efficiency in several types of health services (Hollingsworth *et al,* 1999), such as hospitals (Chang, 1998; Zere *et al,* 2006), nursing care (Nunamaker, 1983), nursing home care (Kooreman, 1994), dental clinics (Widsrom *et al,* 2004), health centers (Osei *et al,* 2005), and community pharmacy services (Färe *et al,* 1995; Lothgren and Tambour, 1999).

DEA is a mathematical linear programming technique that estimates the efficiency in terms of relative efficiency. This technique establishes a production possibility frontier based on efficient hospital pharmacies. The efficient hospital pharmacies which lie on the frontier are assigned a score of 1.0 (or 100%). The efficiency of a hospital pharmacy not located on the frontier, inefficient hospital pharmacy, is estimated by comparing its performance with the efficient hospital pharmacies with the most similar production characteristics. Inefficient hospital pharmacies are allocated a score that is less than 1.0. The higher the score, the greater the efficiency.

In DEA, efficiency is defined as the weighted sum of outputs to the weighted sum of inputs. To obtain a relative technical efficiency score, a linear programming formulation is calculated for each hospital pharmacy, as described below. The weights are chosen in a manner that assigns the best set of weights to each hospital pharmacy in order to maximize efficiency, under the restriction that no other hospital pharmacies, given the same weights, are more than 100% efficient.

Each hospital pharmacy, such as hospital pharmacy h_0, uses varying quantities of different inputs (x_i, i= 1,..., m) to produce varying quantities of different outputs (y_r, r= 1,..., p).

Objective function. The objective function is set up to maximize the sum of the weighted individual outputs for the hospital pharmacy being evaluated (h_0).

$$\text{Maximize:} \quad h_0 = \sum_{r=1}^{p} u_r y_{r0}$$

Subject to:

1). The sum of the inputs for the hospital pharmacy being evaluated must equal 1. 2). The sum of the individual outputs minus the sum of the individual inputs for each separate hospital pharmacy must be ≤0.

$$\sum_{i=1}^{m} v_i x_{i0} = 1$$
$$\sum_{r=1}^{p} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \leq 0, \; j = 1,\ldots\ldots, n$$
$$u_r > 0, \; r = 1,\ldots.p$$
$$v_i > 0, \; i = 1,\ldots.m$$

Where: y_{rj} = amount of output r produced by hospital j; x_{ij} = amount of input i used by hospital j; u_r = weight given to output r; v_i = weight given to input i; n= number of hospitals; p= number of outputs; m=number of inputs.

Pharmacy output production depends largely on the labor inputs used. In addition, most of the pharmacy activities depend largely on demands from outside hospital pharmacies and this is difficult to control. For model specification in this study, a constant returns to scale (CRS) model and input orientation were assumed for the DEA model. The CRS model assumes that an increase in unit inputs results in a proportional increase in its outputs. The input orientation model focuses on reducing input quantities without changing the quantity of outputs produced.

The software program used to compute relative efficiency scores in this study was IDEAS 6.1.x for Windows (Hollingsworth, 1999). In this study, the TE scores were categorized into three levels <0.6, 0.6-0.79, and ≥0.8 (low, moderate, and high levels, respectively) based on the consensus of the focus group discussion.

Factors associated with inefficiency

A Tobit regression model was used to determine the effect of hospital size, location, input mix of pharmacy staff, working experience of pharmacists at the study hospitals, and use of technology on pharmacy service efficiency. Regional dummy variables and distance from provincial city were used as the variables indicating location of hospitals. The ratio of pharmacists to other pharmacy staff was used to reflect labor input mix of staff. The TE score derived from the DEA was used as the dependent variable in the model by converting it into an inefficiency score: (1/Efficiency score)-1 (Chilingerian, 1995). The negative sign of a coefficient indicates an association with efficiency. These analyses were performed with STATA version 8.0.

RESULTS

Data on the pharmacy service inputs and outputs were obtained from 155 respondents, which represented 22% of all district hospitals. More than half (56%) were hospitals with 30 beds and almost a quarter (22%) were 60-bed hospitals. Comparison of respondents and non-respondents showed the distribution of hospital size, outpatient visits, inpatient admissions, and number of pharmacists were similar (Table 2).

Table 3 shows the distribution in the degree of efficiency based on the TE scores by hospital size. Of the 155 hospitals, 19% of the pharmacy services were fully efficient. Approximately one-third (36%) had a high TE score (0.80 or above), whereas 27% had a low TE score (<0.60). The majority (58%) of the 90-120 bed hospitals had pharmacy services at a high efficiency level, whereas in the 10-bed hospitals, the pharmacy services were mostly

Table 2
Characteristics of respondent hospitals compared with non-respondent hospitals[a].

	Respondents (*N*=155)	Non-respondents (*N*=557)
Hospital size, *N* (%)		
10-bed hospital	15 (27.8)	39 (72.2)
30-bed hospital	87 (20.8)	331 (79.2)
60-bed hospital	34 (21.0)	128 (79.0)
90-120 bed hospital	19 (24.4)	59 (75.6)
Number of outpatient visits, Mean (SD)		
10-bed hospital	35,831 (14,269)	34,721 (18,201)
30-bed hospital	59,309 (21,201)	63,857 (26,856)
60-bed hospital	100,217 (34,302)	97,398 (31,072)
90-120 bed hospital	133,040 (35,528)	159,472 (136,985)
Number of inpatient visits, Mean (SD)		
10-bed hospital	1,088 (340)	1,139 (570)
30-bed hospital	2,860 (1,202)	2,990 (41,231)
60-bed hospital	5,618 (2,177)	5,672 (1,627)
90-120 bed hospital	8,210 (2,204)	10,246 (7,402)
Number of pharmacists, Mean (SD)		
10-bed hospital	1.5 (0.7)	1.9 (0.9)
30-bed hospital	2.4 (1.1)	2.5 (1.1)
60-bed hospital	3.4 (1.4)	3.4 (1.5)
90-120 bed hospital	4.5 (2.1)	3.9 (2.6)

[a]There were no significant differences between respondents and non-respondents

Table 3
Efficiency of hospital pharmacies in Thai public district hospitals.

Efficiency	10-bed hospital (*N*=15)	30-bed hospital (*N*=87)	60-bed hospital (*N*=34)	90-120 bed hospital (*N*=19)	All hospitals (*N*=155)
Full efficiency (TE score 1.00), *N* (%)	1 (6.7)	14 (16.1)	7 (20.6)	7 (36.8)	29 (18.7)
TE score, Mean (SD)	0.60 (0.21)	0.71 (0.19)	0.75 (0.19)	0.83 (0.17)	0.73 (0.20)
Efficiency level, *N* (%)					
TE scores 0.80-1.00	3 (20.0)	28 (32.2)	13 (38.2)	11 (57.9)	55 (35.5)
TE scores 0.60-0.79	2 (13.3)	35 (40.2)	14 (41.2)	7 (36.8)	58 (37.4)
TE scores <0.60	10 (66.7)	24 (27.6)	7 (20.6)	1 (5.3)	42 (27.1)

TE= technical efficiency

(67%) at a low efficiency level. In the 30 and 60 bed hospitals, pharmacy services were mostly functioning at a moderate efficiency level.

The average TE score increased in respect to the hospital size (0.60, 0.71, 0.75, and 0.83 in 10, 30, 60, and 90-120 bed hospitals, respectively). These findings imply that inefficient hospital pharmacies in 10, 30, 60, and 90-120 bed hospitals could be technically efficient at their current output level by decreasing the inputs currently used by approxi-

Table 4
Percentage of input reduction among inefficient hospital pharmacies.

Efficiency score group	Percentage of input reduction, Median							
	10-bed hospital		30-bed hospital		60-bed hospital		90-120 bed hospital	
	FTE Pharmacist	FTE Supportive personnel	FTE Pharmacist	FTE Supportive personnel	FTE Pharmacist	FTE Supportive personnel	FTE Pharmacist	FTE Supportive personnel
Score 0.80-0.99	6.7	22.3	12.0	12.2	2.8	18.6	12.3	12.2
Score 0.60-0.79	18.1	43.8	32.4	33.5	36.0	24.8	36.8	30.3
Score <0.60	47.6	63.9	51.5	52.4	57.1	48.6	46.5	46.5

FTE= full time equivalent

mately 40, 29, 25, and 17%, respectively.

The magnitude of reduction of specific type of labor inputs, including FTE pharmacists and FTE supportive personnel, so as to achieve the efficient target was also estimated, as shown in Table 4. Inefficient pharmacy services may become fully efficient by reducing inputs according to their percentage of reduction.

Input and output characteristics of the pharmacy services by efficiency level and hospital size are presented in Table 5. Pharmacy inputs and outputs tended to increase with respect to hospital size. A wider variation in the scale of patient-oriented and health consumer protection activities was found within the same hospital size than for drug distributive functions.

As expected, the more efficient pharmacies had fewer pharmacists than the less efficient ones, given the same hospital size. The number of supportive personnel did not vary much across TE levels. The number of FTE pharmacists and FTE supportive personnel in the hospital pharmacies with high efficiency may be used as the most optimal numbers of pharmacy staff required to provide the four pharmacy activities for each hospital size. For example, in 10 bed hospitals, the optimal numbers of pharmacy staff required were 1 FTE pharmacist and 2.9 FTE supportive personnel.

For service output, the pharmacies with a high TE score tended to perform the distributive functions on a larger scale than the ones with a low TE score, except in the 90-120 bed hospitals. The magnitude of the outputs relating to patient-oriented services and consumer protection, however, did not correspond to the efficiency level except in 10- and 30-bed hospitals. This signals the potential for small hospitals to improve their service efficiency through non-distributive functions. The volume of outputs for patient-oriented services, including drug counseling and drug therapy monitoring, needed to help inefficient hospitals become fully efficient was estimated for each hospital size with varying numbers of pharmacy staff while other pharmacy outputs were obtained from the median values of pharmacy outputs for each hospital size. For example, pharmacies at 10 bed hospitals with 2 FTE pharmacists and 3 FTE supportive personnel which provide pharmacy outputs at a median level should provide drug counseling and drug therapy monitoring for 68 and 44 patients per day, respectively (Table 6).

Hospital size and geographical location were significantly associated with pharmacy service inefficiency, as shown in Table 7.

Table 5
Inputs and outputs of hospital pharmacies by efficiency level and hospital size[a].

Variables	10-bed hospital				30-bed hospital			
	TE score <0.60 (*N*=10)	TE score 0.60-0.79 (*N*=2)	TE score 0.80-1.00 (*N*=3)	Overall (*N*=15)	TE score <0.60 (*N*=24)	TE score 0.60-0.79 (*N*=35)	TE score 0.80-1.00 (*N*=28)	Overall (*N*=87)
Pharmacy manpower inputs								
1) FTE pharmacists	1.7 (1.4-1.8)	1.2 (0.9-1.6)	1.0 (0.5-2.0)	1.7 (0.9-1.8)	2.3 (1.8-2.6)	2.5 (1.8-2.8)	1.9 (1.7-2.7)	2.3 (1.8-2.7)
2) FTE supportive personnel	2.6 (2.4-3.0)	2.8 (2.7-3.0)	2.9 (1.5-3.0)	2.6 (2.5-3.0)	3.0 (2.4-3.6)	3.0 (2.6-3.8)	3.0 (2.3-4.4)	3.0 (2.5-3.8)
Pharmacy service outputs								
1) Drug dispensing								
Outpatient prescriptions per month	2,188 (1,310-2,486)	2,517 (1,980-3,054)	2,074 (1,848-4,357)	2,112 (1,848-2,514)	3,073 (2,144-3,745)	3,960 (2,640-4,735)	5,191 (3,381-6,391)	3,722 (2,676-4,895)
Inpatient prescriptions per month	186 (157-229)	225 (176-273)	154 (79-242)	186 (154-242)	330 (176-498)	440 (242-550)	572 (424-689)	440 (258-659)
2) Drug purchasing and inventory control (in thousand baht)								
Value of purchased drugs per year	1,723 (762-2,666)	3,205 (3,124-3,285)	2,075 (1,684-2,170)	2,075 (912-2,830)	2,686 (2,167-3,988)	4,115 (3,073-4,814)	5,458 (3,536-7,850)	3,817 (2,800-5,499)
Value of stocked drugs per month	339 (245-518)	711 (453-970)	613 (316-633)	453 (299-613)	639 (436-878)	882 (606-1,261)	1,546 (934-1,974)	905 (610-1,431)
Value of drugs supplied per month	164 (116-182)	258 (248-267)	139 (121-204)	175 (124-204)	265 (202-349)	370 (257-476)	429 (303-649)	350 (251-498)
3) Patient-oriented services								
Patients receiving drug counseling per month	57 (23-121)	22 (7-37)	142 (4-147)	52 (23-142)	117 (26-161)	106 (24-205)	153 (32-258)	119 (29-211)
Patients receiving drug therapy monitoring per month	24 (4-46)	117 (3-231)	120 (0-161)	30 (3-87)	22 (4-53)	69 (19-197)	44 (17-245)	43 (11-118)
Frequency of ADR management, DIS and DUE per month	10 (8-19)	7 (3-12)	1 (0-63)	9 (4-18)	8 (6-16)	13 (7-22)	10 (6-21)	10 (6-21)
4) Health consumer protection								
Surveillance frequency per year	66 (38-108)	196 (77-314)	22 (19-82)	70 (22-92)	54 (32-121)	110 (46-205)	112 (25-399)	96 (38-206)
Education sessions per year	23 (5-144)	69 (62-76)	82 (41-209)	41 (6-82)	25 (14-63)	88 (18-184)	82 (44-337)	58 (18-184)

Pharmacy manpower inputs								
1) FTE pharmacists	4.3	4.3	3.2	3.7	5.3	5.3	4	4.8
	(3.7-4.9)	(3.3-6.5)	(2.3-3.6)	(2.8-4.5)	(-)	(4.5-7.3)	(3.6-5.9)	(3.8-5.9)
2) FTE supportive personnel	5	4.6	5.5	5	6.8	6.7	6	6.6
	(4.0-6.2)	(3.9-6.8)	(4.9-6.0)	(4.0-6.2)	(-)	(6.6-8.0)	(5.3-6.9)	(5.8-7.1)
Pharmacy service outputs								
1) Drug dispensing								
Outpatient prescriptions per month	4,649	5,735	6,161	5,570	5,134	8,206	6,999	7,392
	(3,866-5,471)	(4,163-7,847)	(4,806-8,010)	(4,319-7,827)	(-)	(6,661-11,502)	(6,037-9,070)	(6,167-9,618)
Inpatient prescriptions per month	660	880	1,303	880	920	1,523	1,884	1,644
	(520-850)	(780-1,286)	(770-1,650)	(660-1,320)	(-)	(1,320-2,222)	(1,350- 2,456)	(1,320-2,222)
2) Drug purchasing and inventory control (in thousand baht)								
Value of purchased drugs per year	5,991	8,377	8,500	7,863	7,107	10,068	10,423	10,409
	(4,728-7,259)	(5,918-13,400)	(6,784-11,700)	(6,186-11,400)	(-)	(8,181-12,600)	(8,679-12,200)	(8,181-12,200)
Value of stocked drugs per month	1,007	1,409	1,790	1,369	2,773	2,099	2,244	2,244
	(744-1,096)	(1,087-2,253)	(1,188-2,748)	(1,072-2,273)	(-)	(1,595-2,743)	(1,831-2,800)	(1,831-2,773)
Value of drugs supplied per month	490	762	682	668	990.5	845	885	853
	(415-688)	(468-1,070)	(558-1,052)	(471-937)	(-)	(729-1,230)	(792-1,469)	(792-1,230)
3) Patient-oriented services								
Patients receiving drug counseling per month	146	101	262	134	631	103	583	449
	(7-406)	(33-228)	(57-581)	(37-411)	(-)	(16-449)	(12-1,060)	(16-920)
Patients receiving drug therapy monitoring per month	70	46	66	63	151	62	57	62
	(7-191)	(17-317)	(26-374)	(17-250)	(-)	(6-150)	(6-723)	(6-508)
Frequency of ADR management, DIS and DUE per month	14	20	9	14	35	25	25	25
	(10-34)	(11-29)	(6-40)	(7-29)	(-)	(20-25)	(10-37)	(14-42)
4) Health consumer protection								
Surveillance frequency per year	141	326	145	147	74	45	159	86
	(64-390)	(92-650)	(65-448)	(77-471)	(-)	(31-135)	(68-338)	(45-237)
Education sessions per year	175	134	122	138	187	38	105	79
	(63-403)	(50-740)	(55-164)	(57-432)	(-)	(19-107)	(50-216)	(38-187)

[a]Data are expressed as median (25^{th}-75^{th} percentiles).

1 US dollar = 31.37 Thai baht

Table 6
Target outputs of patient-oriented services for becoming efficient pharmacy services by hospital size.

	FTE pharmacist	FTE supportive personnel	Target number of patients receiving per day	
			Drug counseling	Drug therapy monitoring
10 bed hospital	2	3	68	44
30 bed hospital	3	3	102	68
	3	4	114	74
60 bed hospital	4	5	55	34
	5	5	57	36
90-120 bed hospital	5	7	85	45
	6	7	89	51

Table 7
Factors associated with inefficiency of pharmacy services.

Explanatory variables	Coefficient estimate	*t*-ratio	p-value
Hospital size			
90-120 Beds	Reference		
10 beds	0.697	3.610	<0.001
30 beds	0.349	2.540	0.012
60 beds	0.274	1.760	0.081
Geographic location			
Northeastern	Reference		
Central	0.117	1.020	0.307
Northern	-0.071	-0.490	0.625
Southern	0.366	2.660	0.009
Distance from the provincial city greater than 40 kilometers	0.029	0.320	0.749
Ratio of pharmacists to pharmacy technician and supportive personnel	0.055	0.440	0.661
Proportion of pharmacists who worked at the hospital ≤ 3 years	0.193	1.220	0.226
Use of computer for OP, IP dispensing services, and drug inventory service	-0.049	-0.540	0.592
Constant	-0.102	-0.500	0.615

Y variable= inefficiency
OP= outpatient; IP= inpatient

Hospital pharmacies in large hospitals were more technically efficient in the use of resource inputs than smaller hospitals. Hospital pharmacies in southern Thailand functioned less efficiently than hospital pharmacies in northeastern Thailand. No other factors were found to be significantly associated with pharmacy service inefficiency.

DISCUSSION

This study assessed the efficiency of pharmacy services provided by district hospitals in Thailand. There existed differences in efficiency which depended primarily on hospital size, and geographical location. The DEA model permitted estimation of the optimal number of pharmacy staff required to become fully technically efficient, which could be used as a benchmark for staffing levels at each size of hospital. This study used the DEA model to estimate the target volumes for drug counseling and drug therapy monitoring for each hospital size.

The influence of hospital size on efficiency may be related to the location of larger district hospitals in urban areas. Regarding geographic location, this may result from the lower population density in southern Thailand, which may reduce the demand for health care services. This finding was consistent with a previous study which also showed southern Thailand had the lowest workload for hospital pharmacists (Tangcharoensathien and Patcharanarumol, 2001).

To improve efficiency, inefficient hospital pharmacies may use excess FTE pharmacists to improve the quality of patient care, which would be of benefit for the patients. The first option is an expansion of drug counseling and drug therapy monitoring to cover a larger proportion of inpatients and outpatients, since a great variation in the volume of drug counseling and drug therapy monitoring among hospitals was found in this study. Several studies have shown that drug counseling and drug therapy monitoring have a positive impact on economic benefits besides improving patient outcomes (Schumock *et al,* 2003).

The second option is extending the role of pharmacists regarding patient care to include more community service. A collaborative health care team, including health care workers, pharmacists and physicians can provide care for patients with chronic diseases at primary care units (PCUs) to help decrease the chance of unplanned hospital visits and increased physician workloads at hospitals. In the health care team, pharmacists can provide medication therapy management and provide education to patients regarding prevention of complications. These activities would then need to be included in the model of efficiency assessment when they are widely integrated into all district hospitals.

Two previous studies in Thailand have used DEA for measuring hospital efficiency and to examine the effect of hospital size, information technology (Watcharasriroj and Tang, 2004), and UC policy (Puenpatom and Rosenman, 2006) on hospital efficiency. Input variables commonly used were the number of hospital staff, including physicians, nurses, and ancillary professional care providers and the number of beds. The number of inpatients, outpatients, and surgery cases were used as outputs for the hospital services.

Other methods commonly used to measure efficiency are simple ratio analysis, regression analysis, and stochastic frontier analysis (SFA). Disadvantages of the simple ratio analysis are that it is limited to representing the overall aspects of an organization, and it cannot identify the appropriate set of comparators for a particular observation. Regression analysis uses the mean of observations to create an efficient unit which differs from DEA which uses the best-practices to create the frontier of efficient units (Cooper *et al,* 2000). Measuring TE based on SFA requires choosing a functional form to describe the production technology. For DEA, the selection of an appropriate functional form (*eg* translog) is not a primary consideration (Coelli *et al,* 1998).

This study does have certain limitations. The relatively low response rate may reduce the generalizability of the results, although we found that the characteristics of hospitals which did not respond did not differ from those of the respondents. Capital inputs were not included, given that the typical pharmacy services in public hospitals are labor intensive and that the majority of the recurrent costs incurred by material inputs have been captured as the output of drug purchasing and inventory control. The efficiency evaluation in this study focused on the quantity dimensions of pharmacy services. The quality of outputs was taken to be similar among hospital pharmacies. This is justified for the following reasons. The system for quality assessment and assurance of pharmacy services under hospital accreditation has developed over several years. Minimum requirements for quality indicators were set including rate of medication errors, rate of repeated ADRs, number of preventable adverse drug events resolved by pharmacists, turnover rate of drug inventory, and number of expired drugs. Another factor which may influence efficiency, but which cannot be captured in this study, is non-productive time due to the need to undertake multiple tasks and shift between tasks. Increasing job specificity is more likely to occur in hospitals with larger staff. Although we required chief pharmacists to report working hours of their pharmacy staff spent on each pharmacy activity, they may report working hours spent on each pharmacy activity in which non-productive time was also included. Finally, this study provided information regarding efficiency over one time period. Repeated measures of efficiency over time would provide information that would be useful for long-term monitoring and decision making.

At a national level, transferring excess pharmacists to hospitals which are understaffed would be another option for decreasing inefficiency and balancing work load for pharmacy services. The model we have developed could be used for improving resource management by regular monitoring of efficiency. It uses routinely collected data for both inputs and outputs which can be easily obtained from existing monthly reports. Development of an online database for efficiency monitoring would be useful to keep updated on the current efficiency status of hospital pharmacies.

In conclusion, this study demonstrated the variations in efficiency of pharmacy services in Thai public district hospitals. Approximately one-third of district hospitals had relatively low efficiency in pharmacy services, especially in the 10 and 30 bed hospitals. Pharmacy services in the small hospitals and hospitals located in southern Thailand should focused on efficiency improvement.

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