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Diabetes Cost Model of a Hospital in Thailand

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ABSTRACT

Objective: This study aims to formulate a cost model from a provider perspective regarding the direct medical costs for diabetic patients who received care in a 30-bed public hospital in Thailand during the fiscal year of 2001.

Methods: This study is a retrospective prevalence-based cost of illness study. Data were collected by reviewing the medical record of each patient for the whole year. The statistical analysis employed was the stepwise multiple regression method.

Results: The study covered 186 diabetic patients. It was found that the average cost of caring for a diabetic patient per year was 6331 Thai baht (THB) at 2001 prices (approximately 40 THB = US $1). A major portion of this cost was spent for pharmacy services, which accounted for 45% of the whole cost, followed by outpatient services (24%), inpatient services (16%), and laboratory investigation (11%). Regarding the model for forecasting the cost, the type of diabetes and its accompanying complications, i.e., hyperlipidemia, cardiovascular accident, hypertension, hyperglycemia, hypoglycemia, gangrene, and diabetic foot, were considered as significant predictor variables (adjusted $R^2 = 0.48$). The quantitative effects in monetary term of these significant predictors were also demonstrated.

Conclusions: The results could be beneficial in forecasting the economic burden of diabetes mellitus in Thailand. Furthermore, the results could be used as a financial tool for cost control and disease management at the community hospital level.

Keywords: cost model, diabetes mellitus, direct medical cost, hospital, Thailand.

Introduction

Diabetes mellitus is a chronic disease that occurs in people around the world, and the trend of the incidence rate has increased over time [1,2]. In relation to this, one study attempted to estimate the global prevalence of diabetes by using the data available from published prevalence studies and information on the demographic characteristics of each country around the world. The study forecasted that there would be about 220 million people, which is 3.2% of the world population, suffering from diabetes by the year 2010 [3]. Aside from health problems, diabetes also imposes a heavy economic burden because it affects not only individuals and their families, but also the entire society. Because of these consequences, studies on the economics of diabetes have been continuously done in different countries around the world [4–11].

In Thailand, diabetes was ranked fifth and third of the top 10 diseases among males and females, respectively, based on disability-adjusted life-years in 1999 [12]. In terms of prevalence, a national health examination survey done in 2004 revealed that the diabetes prevalence was 6.4% among males and 7.3% among females aged 15 years and above. People were characterized as having the illness if they had an increased blood sugar of greater than 126 mg/dL, or if they were currently taking oral antiglycemics or insulin [13].

Nevertheless, study about cost of illness is rarely conducted in Thailand. The researcher was aware of only one study conducted in seven government hospitals located in four regions of the country and in Bangkok [14]. Another study focused on patients' expenses as they used complementary and alternative medicine [15]. Nevertheless, these studies were focused on the patients' perspective and not on that of the providers. Hospitals in Thailand directly receive provider payments from the Social Security Office, the Comptroller General's Department and the National Health Security Office for private employees under the Social Security Scheme, civil servants under the Medical Benefit Scheme, and the rest of the population under the Universal Coverage of Health Care Scheme, respectively. Nevertheless, in the study year (2001), there was no Universal Coverage of Health Care Scheme. There were only health welfare schemes for the poor and the elderly. In addition, there were those who voluntarily procured health insurance for themselves, and those who had no insurance and welfare (out-of-pocket). With these in mind, the present study aimed to formulate a cost model of the direct medical

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costs [16] incurred by diabetic patients who received care at Ampawa Hospital, a 30-bed public hospital in Samutsongkram, a central province of Thailand.

Methods

Population

The target population consisted of patients with diabetes, defined as one who has plasma glucose at a level of at least 126 mg/dL by the fasting plasma glucose test [17]. A 30-bed public hospital in central Thailand was purposively selected based on convenience and acceptance of the hospital director. Diabetic patients belong to all age groups in both sexes and with either type 1 and type 2 diabetes, who received treatment during the fiscal year 2001 (October 1, 2000–September 30, 2001), were included in the study. Patients who had incomplete medical records or discontinuous treatment were excluded.

Research Hypothesis

Direct medical costs were associated with several independent variables. These included age, sex, payment scheme, type of diabetes, and type of complications.

Therefore,

$$\text{DMC} = f\ (\text{age, sex, payment scheme, type of diabetes, type of complications})$$

where

$$\text{DMC} = \text{direct medical cost}$$

Study Design

Since there was no standard unit cost of medical services, this study thus started with a calculation of the unit cost of the medical services given by the hospital. Afterward, the service utilization of each individual patient was collected to help calculate the direct medical costs. Finally, the cost model was formulated. Our calculation of the unit cost of medical service employed the standard costing approach [18,19]. The calculation was composed of five steps, i.e., organization analysis and cost center classification, direct cost determination, indirect cost determination, full cost determination, and calculation of the unit cost of medical services [20,21].

The hospital's departments were categorized into 13 patient-service or production cost centers, and 14 nonpatient-service or supporting cost centers. For the direct cost determination of each cost center, the capital cost was computed as the equivalent annual economic cost [18,22] with a 3% discount rate as recommended by the World Health Organization guidelines [23]. Useful lives were 5 years and 20 years for capital items and buildings, respectively [24,25]. The indirect cost, which is the same as the cost of supporting cost centers, was distributed to the production cost centers through the simultaneous allocation method [18]. The services or outputs of the supporting cost centers were selected as allocation criteria for the appropriation, e.g., the number of staff for each administration department. The average method and microcosting of departmental allocation were employed for departments producing homogeneous and heterogeneous products, respectively [26,27]. Microcosting is a method to allocate the cost of production of the cost center to each unit of service. The first step was to value the resources directly consumed by each unit of service. Then the shared cost of the cost center was allocated to the services in proportion to the direct cost of the services.

For cost of illness, the study was based on the providers' perspective [28] employing the bottom-up, prevalence-based approach [16]. The research covered provider costs or direct medical costs including complications but not comorbidities [16].

Sample Size

The sample size for cost function analysis was calculated based on the following equation [29]:

$$\text{n (at least)} = 5 \times \text{IV}$$

where n = sample size, IV = number of independent variable.

From the hypothesis, there were 22 independent variables, so the minimum sample size was 110 cases. The study included 186 people with diabetes.

Variables

The variables included in this study were demographic characteristics, clinical status, types and quantities of medical services, drugs and medical supplies received (detailed in Table 1). The demographic characteristics included sex, age, and insurance scheme. Clinical status included the type of diabetes (type 1 or type 2) and the type of complications because these factors affect medical service utilization [17]. The types of medical services consisted of services from outpatient visits, inpatient stay, home health-care visits, pharmacy services, laboratory investigation, emergency services, and surgical services. The overall cost of drugs and medical supplies is composed of the acquisition cost and the dispensing cost. The total direct medical costs were calculated through a summation of medical service costs, and drugs and medical supplies costs. The medical service cost is the result of multiplying the number of services (e.g., outpatient visit, hospitalization service, drug dispensing, surgery and laboratory investigations) by their unit costs from the part of medical service cost calculation. The cost of drugs and medical supplies was calculated through the summation of the quotients produced by multiplying the quantities of each drug and medical supply by its acquisition unit cost.

Table 1 Description of variables (N = 186)

Variable and sample characteristics
Natural logarithmic of the cost: Thai baht (THB)
Sex: female = 62%
Age: mean = 62 years
Insurance schemes were recoded as dummy variables (reference = welfare scheme for poor, elderly, priest, 45.7%).
Civil servant medical benefit scheme: 28.5%
Social security scheme for private employees: 1.6%
Voluntary health insurance: 19.9%
Self-payment (out-of-pocket): 4.3%
Type of diabetes mellitus: type 2 = 95.7%
Types of complications
Hypertension: 41.1%
Neuropathy: 35.5%
Hyperlipidemia: 16.1%
Diabetic foot: 13.4%
Nephropathy: 7.0%
Ishemic heart disease: 4.3%
Cerebrovascular accident: 3.8%
Hyperglycemia: 2.7%
Hypoglycemia: 1.1%
Gangrene: 0.5%
Retinopathy: 0.5%

$$TC_n = \sum_{j=1}^{J} QS_{nj} \times US_j + \sum_{k=1}^{K} QD_{nk} \times UD_k + \sum_{l=1}^{L} QM_{nl} \times UM_l$$

where TC_n is the total direct medical costs for patient n, QS_{nj} is the number of medical service j used by patient n, US_j is the unit cost of medical service j, QD_{nk} is the number of drug k used by patient n, UD_k is the acquisition unit cost of drug k, QM_{nl} is the number of medical supply l used by patient n, UM_l is the acquisition unit cost of medical supply l.

Data Collecting Method

The resources consumed as well as the outputs produced by all of the hospital's departments during the fiscal year 2001 (October 1, 2000–September 30, 2001) were collected to calculate the unit cost of medical services. The medical history consisting of both outpatient and inpatient medical records was reviewed for the whole study year to record the patients' demographic characteristics, clinical status, types and quantities of medical services received, and the types and quantities of drugs and medical supplies used. As for records pertaining to the acquisition cost of drugs and medical supplies, they were collected from the pharmacy department and medical material department, respectively.

Analysis

Descriptive statistics was used to summarize data on demographic characteristics, clinical status, and costs. The stepwise multiple regression analysis [30] method was also employed to analyze the relationship between the direct medical cost (dependent variable) and several potential explanatory variables (independent variables). These variables were selected based on expert opinion. A model was then formulated to estimate the direct medical cost of each patient. In the modeling, independent variables with a probability value of F statistics less than 0.05 on the analysis were entered. The statistic's assumptions and model checking were examined, i.e., normal distribution, multicollinearity, influential observations, and outliers [30].

Sensitivity Analysis

To analyze the uncertainty of the results due to the sample data, the one-way simple sensitivity analysis was used [31–33]. Drug prices in Thailand were highly varied among brand-name drugs and local-made generic drugs. So the maximum and minimum drug prices from the referent drug list in the fiscal year 2001 of the Ministry of Public Health were used for the sensitivity analysis.

Results

Unit Costs of Medical Services

In 2001, the total cost for the hospital was 28.4 million Thai baht (THB) at 2001 prices (approximately 40 THB = US $1). The cost can be broken down as 11% capital cost, 60% labor cost, and 29% material cost. The unit costs of an outpatient service (per visit) and hospitalization (per patient-day) were 125.00 THB and 993.94 THB, respectively. For a home health-care visit, the unit cost was approximately half of that of hospitalization day. The cost was relatively high because the number of service was relatively low. It spent approximately 1 day for one visit. As for the unit cost of pharmacy service, it was separated into two further divisions: the cost of dispensing and actual cost of the drugs. The details of the unit cost per medical service received by diabetic patients are demonstrated in Table 2.

Patient Characteristics and Service Utilization

There were totally 298 patients in the study year. One hundred twelve patients did not receive continuous

Table 2 Unit cost of medical services and drugs commonly used by diabetic patients

Medical services	Unit cost: THB (plausible range)
Routine service in outpatient clinics (visit)	125.00
Hospitalization, hotel cost with routine nursing care (day)	993.94
Home health care (visit)	570.78
Drug dispensing, not including drugs (prescription)	74.72
Fasting blood sugar (test)	50.54
Insulin NHH 10 cc	310.3 (150.70–310.30)
Insulin RI 10 cc	310.3 (274.31–310.30)
Glibenclamide 5 mg tablet	0.41 (0.10–1.61)
Metformin 500 mg tablet	0.54 (0.19–0.93)
Vitamin $B_{1\text{-}6\text{-}12}$ tablet	0.38 (0.18–2.65)
Vitamin $B_{complex}$ tablet	0.12 (0.11–0.20)

Table 3 Composition of direct medical cost (N = 186)

Medical services	Mean (THB)	95% CI; lower	95% CI; upper	Median
Pharmacy services	2803.99/45%	2440.91	3167.07	1927.78
Outpatient services	1528.21/24%	1471.30	1585.12	1499.98
Inpatient services	1020.65/16%	243.36	1797.95	0.00
Laboratory	712.95/11%	657.07	768.83	604.83
Emergency and surgical services	197.32/3%	78.25	316.40	0.00
Home health care	67.51/1%	20.73	114.30	0.00
Total	6330.64/100%	5300.70	7360.57	4257.45

treatment from the study hospital nor had incomplete medical record. One hundred eighty-six patients were included in the study. The patients were mostly females (61.8%) (Table 1). The mean age of those reviewed was 61.99 years. Ninety-six percent had type 2 diabetes, and about three-fourths of these patients had complication(s). Most of these complications included hypertension (41.4%), followed by neuropathy (35.5%). Additionally, the average hospitalization was 1.03 days and the average number of outpatient department visit was 12.23 (the visits covered diabetic wound dressing and some insulin injections). In Table 3, it is shown that the direct medical cost consisted of the cost of outpatient services, inpatient services, pharmacy, laboratory, emergency, surgery services, and home health care. The major cost was in pharmacy, because it included drugs and pharmaceutical services (an average of 2804 THB per person per year), followed by outpatient services (an average of 1528 THB per person per year). The total direct medical cost was 6331 THB per person per year. For home health care, the average cost per patient per year was less than its unit cost. This is because the average service utilization per patient per year was less than one.

Regarding sensitivity analysis, drug prices were considered. The prices of all drugs in the treatment of diabetes and its complication were recalculated. The maximum and minimum prices of drugs (Table 2) purchased were used in recalculating the total drug costs and average direct medical cost. The results indicated changes in drug costs and average direct medical cost. When the minimum and maximum prices of drugs were used in the recalculation, the total drug costs yielded between 172,053.98 THB (48.67% decrease) and 719,335.62 THB (114.59% increase), respectively. This affected average direct medical costs with a 14.91% decrease and a 23.30% increase.

The cost models were formulated as a forecasting model, and the total direct medical cost as a dependent variable was not normally distributed. Therefore, a natural logarithmic transformation was undertaken. The potential predictor variables were reviewed in Table 1. The fitted model is shown in Table 4 with an adjusted $R^2 = 0.480$ ($R^2 = 0.50$), and the probability of F-test = 0.000. The significant predicting variables were the type of diabetes and its complications. For assumption tests and model diagnosis, a scatter plot of residuals against predicted values and all independent variables showed no funnel shape indicating homoscesdasticity [30]. Regarding the test of independence of the residual, the Durbin-Watson value was 1.938. This indicated that the model met the assumption of independence of the residual (the criteria was 1.5–2.5) [34]. The condition index was 12.499. This met the criteria of less than 30 which indicates no multicollinearity [30]. Cook's Distance had a range of 0.000–0.190. This met the criteria of less than 1 which indicates no influential observation [30].

The estimation of the expected response on the untransformed scale after fitting a linear regression model of the transformed scale needs to be adjusted (multiplication) by means of a smearing factor [35]. The smearing factor is the mean of anti log (exponen-

Table 4 Fitted explanatory direct medical cost model (N = 186)

	Unstandardized coefficients				95% CI for B	
	B	SE	*t*	Sig.	Lower bound	Upper bound
Constant	9.099	0.170	53.440	0.000	8.763	9.435
Type of diabetes mellitus (type 2 = 1)	–0.913	0.169	–5.417	0.000	–1.245	–0.580
Hyperlipidemia	0.358	0.093	3.836	0.000	0.174	0.542
Cerebrovascular accident	0.948	0.177	5.357	0.000	0.599	1.297
Hypertension	0.149	0.069	2.174	0.031	0.014	0.285
Hyperglycemia	0.729	0.215	3.391	0.001	0.305	1.154
Gangrene	1.201	0.453	2.653	0.009	0.308	2.095
Diabetic foot	0.633	0.101	6.282	0.000	0.434	0.832
Hypoglycemia	0.893	0.344	2.597	0.010	0.215	1.572

Adjusted $R^2 = 0.480$, probability of F-test = 0.000. SE, standard error.

Table 5 Predicted cost of various clinical statuses (N = 186)

Clinical status	Cost (THB)	Cost increase (THB)*	Percentage increase
1. Diabetes type 2, no complication	4,036.97	—	
2. Diabetes type 2 with hypertension	4,685.60	648.63	16.07
3. Diabetes type 2 with hyperlipidemia	5,774.75	1,737.78	43.05
4. Diabetes type 2 with diabetic foot	7,602.63	3,565.66	88.33
5. Diabetes type 2 with hyperglycemia	8,368.66	4,331.69	107.30
6. Diabetes type 2 with hypoglycemia	9,860.08	5,823.11	144.24
7. Diabetes type 2 with cerebrovascular accident	10,417.57	6,380.61	158.05
8. Diabetes type 2 with gangrene	13,416.62	9,379.65	232.34
9. Diabetes type 1, no complication	10,059.27	6,022.30	149.18

*Clinical status 1 is a base-case.

tial) form of the unstandardized residuals [36]. The smearing factor of the fitted model was 1.1244. In forecasting for a simulated patient with type 2 diabetes with no complications, the predicted cost was 4036.97 THB. To explore economic effect of the complications, treatment costs of patients with various complications were estimated as presented in Table 5. The treatment cost for a patient with type 2 diabetes without complication was approximately 4000 THB. The patient with hypertension consumed an additional 16% of cost of the patient without complication. The cost increased up to 232% for the case of gangrene.

Discussion

The study found that the annual average treatment cost of diabetic patient was 6331 THB or approximately US $158 at 2001 prices (40 THB = US $1). The highest proportion of the treatment cost was related to pharmacy services (45%), and the proportions of outpatient services, inpatient services, and laboratory investigation were 24%, 16%, and 11%, respectively. The forecasting cost model demonstrated that type of diabetes and its accompanying complications (i.e., hyperlipidemia, cardiovascular diseases, hypertension, hyperglycemia, hypoglycemia, gangrene, and diabetic foot ulcer) were significant predictor variables (adjusted $R^2 = 0.48$).

Regarding the cost comparison, Ettaro et al. [5] stated in the review article titled "Cost-of-illness studies in diabetes mellitus" that:

> Healthcare components considered in the direct cost calculations vary between the studies. Nearly all of the studies included costs associated with hospital care, physician services and prescription drugs, but there are marked discrepancies with respect to inclusion of long-term care, emergency department services, home healthcare and other services.

Based on the review aforementioned, this study covers complete components of direct medical costs of diabetic care.

The results of the sensitivity analysis indicated considerable changes in average direct medical costs. The variation range was 38.21% (23.30 increases and 14.91 decreases). In Thailand, hospitals have their own purchasing unit. In addition, there are many producers for each drug, both local and original, which create price variations. Based on the sample in Table 2, the price differences are approximately 1 to 15 times in the cases of insulin RI and vitamin $B_{1\text{-}6\text{-}12}$, respectively. Because price variations generally occur in other countries [37], the administrators or researchers who aim to use the results of this study for comparison should thus keep in mind the differences of prices of drugs between hospitals.

The forecasting of the direct medical cost model showed significant predictor variables consisting of the type of diabetes and its complications. For the type of diabetes, the result showed that the cost of patients with type 1 diabetes was more than the cost of those with type 2 diabetes, when other explanatory variables were constant. This could be explained by the fact that patients with type 1 diabetes used insulin in exact amounts, even if most of them were unable to inject themselves. Thus, they had to go to the hospital for insulin injections every day. Because of this, direct medical costs would increase because of the high cost of insulin injection and hospital services. There are studies confirming the higher cost of type 1 than type 2 diabetes [38,39].

Regarding complications, the actual economic burden of diabetic care without covering the cost of complications was underestimated [40–42]. This study confirmed such findings. Gangrene was the highest economic burden among all of the complications because it requires surgical treatment. Preventing the occurrence of gangrene created savings of nearly 10,000 THB per patient-year (232% of the case without complications; see Table 5). Studies in India showed that the treatment expenditure of diabetic patients with foot complications was significantly higher than those without the complications [43,44]. Similarly, many studies showed that diabetic patients with diabetic foot ulcer had significantly higher health-

care costs [40,45–49]. Costs due to the complications attribute to the largest fraction of diabetic care [50]. Based on the economic effects of these complications, it would be quite challenging to conduct complication-preventing measures.

To compare the cost models with those of other studies, one study conducted a cost model of patients with type 2 diabetes from a large group-model health maintenance organization during the period between 1987 and 1995 in the United States [51]. The potential explanatory variables were age, sex, stages of renal complication, and stages of cardiovascular complication. The result indicated that sex, all stages of renal complication, and all stages of cardiovascular complication were in fact significant explanatory variables. The results of our study were consistent with such a study indicating that costs were positively associated with complications.

Considering generalizability, the characteristics of the setting have an effect on the direct medical costs of the patients. Therefore, the characteristics of the hospital should be evaluated. Ampawa Hospital, for example, has no specialists for treating diabetes and its complications (such as an ophthalmologist). The diabetic drugs used were not advanced, were locally made, and were available only in a limited number. The hospital had no special health-care team to care for diabetic patients neither. This kind of situation might affect direct medical costs. If the characteristics of the hospital changed, the direct medical cost would also change. Bigger hospitals naturally have specialists of diabetes, more types of drugs (some of which are brand-name drugs), and a health-care team caring for diabetic patients. Thus, the average direct medical cost of caring for patients at tertiary services, e.g., provincial hospitals, was expected to be higher than that of patients at Ampawa Hospital.

In attempt to extrapolate the country cost based on this study, the similarity of the proportions of cost between the study hospital and other same level hospitals was considered. When comparing the proportions of labor (60%), material (29%), and capital (11%) costs obtained from this study with those from the study performed at 17 community hospitals [52], which are of the same hospital level, the proportions of labor (53%), material (38%), and capital (10%) were not quite different. In addition, the annual average cost from the study hospital could also be used to represent as the cost of all community hospitals in Thailand. Based on the study estimating diabetic outpatient charges of one regional hospital (900 beds) and 17 community hospital covering 900,000 outpatient visits, it was found that charge per visit of the regional hospital was 3.48 times of those of the community hospitals (mean = 1180.6 THB and 339 THB at 2002 prices, respectively) [53]. This ratio and the cost of diabetes resulting from the study hospital can be applied for estimation of average treatment cost of diabetes in regional hospitals.

Conclusions

Bigger hospitals naturally have specialists of diabetes, more types of drugs (some of which are brand-name drugs), and a health-care team caring for diabetic patients. In addition, the study demonstrated cost-effectiveness of prevention/screening of complications. Nevertheless, there might be limitations on the generalizability of the model because of differences in facility characteristics resulting in different resource utilization pattern.

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