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A Cost Function Analysis of Shigellosis in Thailand

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ABSTRACT

Objective: The purpose of this study was to develop a cost function model to estimate the public treatment cost of shigellosis patients in Thailand.
Methods: This study is an incidence-based cost-of-illness analysis from a provider's perspective. The sample cases in this study were shigellosis patients residing in Kaengkhoi District, Saraburi Province, Thailand. All diarrhea patients who came to the health-care centers in Kaengkhoi District, Kaengkhoi District Hospital and Saraburi Regional Hospital during the period covering May 2002 to April 2003 were tested for *Shigella* spp. The sample for our study included all patients with culture that confirmed the presence of shigellosis. Public treatment cost was defined as the costs incurred by the health-care service facilities arising from individual cases. The cost was calculated based on the number of services that were utilized (clinic visits, hospitalization, pharmaceuticals, and laboratory investigations), as well as the unit cost of the services (material, labor and capital costs). The data were summarized using descriptive statistics. Furthermore, the stepwise multiple regressions were employed to create a cost function, and the uncertainty was tested by a one-way sensitivity analysis of varying discount rate, cost category, and drug prices.
Results: Cost estimates were based from 137 episodes of 130 patients. Ninety-four percent of them received treatment as outpatients. One-fifth of the episodes were children aged less than 5 years old. The average public treatment cost was US$8.65 per episode based on 2006 prices (95% CI, 4.79, and 12.51) (approximately US$1 = 38.084 Thai baht). The majority of the treatment cost (59.3%) was consumed by the hospitalized patients, though they only accounted for 5.8% of all episodes. The sensitivity analysis on the component of costs and drug prices showed a variation in the public treatment cost ranging from US$8.29 to US$9.38 (–4.20% and 8.43% of the base-case, respectively). The public treatment cost model has an adjusted R^2 of 0.788. The positive predictor variables were types of services (inpatient and outpatient), types of health-care facilities (health center, district hospital, regional hospital), and insurance schemes (civil servants medical benefit scheme, social security scheme and universal health coverage scheme). Treatment cost was estimated for various scenarios based on the fitted cost model.
Conclusion: The average public treatment cost of shigellosis in Thailand was estimated in this study. Service types, health-care facilities, and insurance schemes were the predictors used to predict nearly 80% of the cost. The estimated cost based on the fitted model can be employed for hospital management and health-care planning.
Keywords: cost function, public treatment cost, shigellosis.

Introduction

A report made on shigellosis states that the global incidence of diarrhea has not declined through the years, although the same study reports that mortality resulting from it has declined. For children in developing countries under the age of five, the estimated annual mortality rate was 4.9 per 1000 children. Diarrhea caused by Shigella accounts for a high percentage of this mortality. It was reported that an estimated 164.7 million Shigella episodes happened annually worldwide. Sixty-nine percent of these episodes involved young children [1].

Thailand is an Asian country with 62.2 million population based from 2005 survey. Generally, its health problems have shifted from communicable diseases to noncommunicable diseases, with the notable exception of HIV/AIDS [2]. Based on the national reporting system, the incidence of acute diarrhea and dysentery was 1536 and 36 per 100,000 populations per year, respectively, in 2003. The causes of dysentery were unspecified pathogens (81%), culture-confirmed shigellosis (11%), and amoebas (8%) [3]. A

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population-based surveillance study conducted during 2000 to 2003 found that diarrhea incidence was 107.46 cases per 1000 population per year, while the annual incidence of shigellosis was 10.4 per 1000 population [4]. The disease is an alarming problem in children aged less than 5 years. Based on an active surveillance of this particular age group, the incidence rate was 64 cases per 1000 population per year [5]. It is noteworthy to mention that though several international studies have been published on the economic aspects of enteric infections [6–11], no similar research has been published from Thailand.

Recently, a health-care reform focusing on the health insurance system has been introduced in Thailand. Three major health insurance schemes operate in the country: the Social Security Scheme (SSS) for private employees, the Civil Servants Medical Benefit Scheme (CSMBS) for government servants, and the Universal Coverage of Health Care Scheme (UC) for the remaining two-thirds of the population. Payment methods for hospitals are capitation for the SSS and the UC, and fee-for-service for the CSMBS [12]. The newly introduced reform had an effect on hospital financing that resulted in unavoidable consequences to patient services. To have an appropriate management of the disease in Thailand, there is a need to focus on the economic outcome. Hence, to analyze the cost of an illness is pivotal. Other than the average cost, cost function provides information that may help a decision-maker to determine whether or not a service should be implemented and/or reimbursed [13]. Economic information can be applied in both treatment and prevention. Because of the widespread isolation of strains that are resistant to multiple antibiotics, there are few treatment options. A vaccine to prevent illness and death caused by Shigella would be a valuable public health tool with a strong impact. There are some shigella vaccines currently under development with promising outcomes [1,14]. Nevertheless, economic evaluation is essential to include a vaccine into the vaccination program. Therefore, this study aims to develop a cost function model to estimate the public treatment cost of shigellosis patients in Thailand. This economic information could be useful for hospital management and public health planning in the future.

Methods

This study was designed as an incidence-based cost-of-illness study with a bottom-up approach [15]. Bottom-up or microcosting approach is based on principles in which the actual services and then costs of individual patient are recorded and calculated. Costs were calculated from a provider perspective based on 2002 prices, and then adjusted to the 2006 prices using the medical care consumer price index [16]. The original Thai baht was converted to US$ at 38.084 baht per US$1 [17]. The costs in this study were economic (opportunity) costs, which are values of all resources used for producing services for the patients. The data were retrospectively collected. The study population was shigellosis patients from a surveillance project conducted on May 2002 to April 2003 [18]. The registered residents (39,594 males and 40,547 females) of Kaengkhoi District, Saraburi Province 108 km northeast of Bangkok were the study population. There were 5,686 children aged less than 5 years and 74,455 adults [4]. Samples were collected from all diarrhea patients from the Kaengkhoi District who visited community health-care centers, the Kaengkhoi District Hospital, and the Saraburi Regional Hospital. These study health service facilities all belong to the government. Public hospitals are major health service settings in Thailand [19]. Rectal swap specimens were tested through the conventional culture method and dot-enzyme linked immunosorbent assay (Dot-ELISA) for *shigella* detection [20]. The surveillance found that the incidence of diarrhea among children less than 5 years was 122 cases per 1000 population per year and 24.69 per 1000 population per year among the population 5 years and older. The incidence of diarrhea patients was 31.59, whereas the incidence rate of shigellosis was 1.96 per 1000 population per year [18].

All shigellosis patients detected during the study period were included in the study. The study included in and outpatients of both genders and all age groups. The variables included in this study were demographic characteristics (sex, age, and health insurance scheme), service utilization (hospital services, pharmacy cost, and other medical services for diagnosis and treatment), and direct medical cost or public treatment cost. Treatment costs also included complications and sequelae for up to 90 days after presentation [4], but did not include costs associated with comorbidity.

Descriptive statistics were used to summarize demographic characteristic, service utilization, and cost. Univariate sensitivity analysis was used to explore the uncertainty of the results [21]. Likewise, variations in discount rate, prices of drugs, and opportunity cost of land use were analyzed. The drug prices were the minimum and maximum prices reported to the Ministry of Public Health by public hospitals. The stepwise multiple regression analysis [22] was employed to analyze the relationship between the public treatment cost (dependent variable) and potential explanatory variables (independent variables). Assumption and model diagnostics were also explored. Independent variables with a probability value of F statistics ≤ 0.05 in the analysis were entered. To estimate the expected response on an untransformed scale after fitting a linear regression model of transformed scale, it needs to be adjusted by the smearing factor [23]. To retransform the predicted log of cost, the following equation was applied [24].

$$\mathrm{E(cost)} = \left[e_0^{(X\,\beta)}\right]\left[\frac{1}{n}\sum_{i=1}^{n} e^{S_i}\right] \quad (1)$$

$$\frac{1}{n}\sum_{i=1}^{n} e^{S_i} = \text{smearing factor} \quad (2)$$

where e^{Si} = antilog (exponential) form of the unstandardized residual.

The public treatment cost was calculated from the provider's perspective; in this case, the health facilities under the responsibility of the Ministry of Public Health. Saraburi Hospital has 680-bed and 1686 staff members providing tertiary hospital care on a provincial/regional level. Kaengkhoi Hospital is a 60-bed district hospital with 146 staff members providing secondary hospital care for the Kaengkhoi District. Health centers are public health-care facilities at the subdistrict level that provide primary health care, health promotion, and prevention (no inpatient service). The usual staff members include between two to six nurses and/or paramedics. All 19 health centers in the Kaengkhoi District participated in this project. The public treatment costs are defined as the direct medical costs at these health centers, as well as in Kaengkhoi Hospital and Saraburi Hospital. Cost analysis started from a calculation of the unit cost of the medical services of all facilities [25,26]. Unit cost analysis was calculated employing the same methods. The calculation consisted of five steps, organization analysis and cost center classification, direct cost determination, indirect cost determination, full cost determination, and calculation of unit cost of medical services [27,28]. The health service settings were categorized into patient care and nonpatient care cost centers. Direct cost determination of each cost center consisted of capital, labor, and material costs. Capital cost consists of two components, namely capital costs of capital items and opportunity costs of land and stocked materials. Capital costs of buildings and capital items were calculated as equivalent annual economic costs [25,29]. Following WHO recommendations, a 3% discount rate was selected [30]. A lifespan of 20 years for building and constructions and 5 years for the rest of the capital items were used [31,32]. Labor cost includes the sum of salaries, wages, incentives, and fringe benefits, such as accommodation, training expenses, health-care expenses, and education expenses. Materials covered were drugs, chemicals, office materials, and utilities. For the hospitals, the costs of all supporting departments or nonpatient care cost centers were allocated to production departments or patient care cost centers that employed a simultaneous allocation method [25]. Services or outputs of supporting cost centers were selected as allocation criteria for the allocation (e.g., number of staff for administration department). The average method [33,34] was used to calculate the unit cost of services of the departments producing one cost product or various homogeneous products in terms of resource consumption, such as outpatient visit, inpatient day, and drug dispensing. On the other hand, the microcosting method [34,35] was used for the unit cost calculation of the departments that had various cost products and consumed different resources (e.g., laboratory, radiology, physical therapy, operating room, emergency room). Microcosting is a method that allocates the cost of the production cost center to each unit of service. First, resources directly consumed by each unit of service were valued. Then, shared cost was allocated to the services in proportion to the direct cost of the services.

Results

The unit costs of medical services provide by Saraburi Hospital were higher than those of the Kaengkhoi Hospital except for some laboratory investigations (Table 1). For the health centers, consultation and drug dispensing were averaged to be the cost of outpatient service, which varied from US$1.21 to US$3.83. Some of these were higher than those of the Kaengkhoi Hospital. Regarding the drug cost, they were the hospitals' purchasing prices. Frequently used drugs are listed in

Table 1 Unit cost of some medical services (US$ at 2006 prices)

Service	Unit	Unit cost		
		Saraburi hospital	Kaengkhoi hospital	Health centers
Routine service: outpatient*	Visit	7.24	2.17	1.21–3.83
Routine service; female ward	Patient day	22.29	19.56	n/a
Routine service; male ward	Patient day	n/a	21.82	n/a
Drug dispensing for outpatient	Prescription	5.37	0.57	n/a
Drug dispensing for inpatient†	Prescription	1.65	n/a	n/a
Complete blood count (CBC)	Test	1.84	1.70	n/a
Blood urea nitrogen (BUN)	Test	0.54	3.60	n/a
Creatinine	Test	0.50	3.02	n/a
Stool exam	Test	0.46	1.60	n/a
Urine analysis (UA)	Test	0.70	2.03	n/a
Occult blood	Test	0.65	1.60	n/a

*For Saraburi Hospital, it is a service at the emergency room. For health centers, the cost per visit is presented as a range of all health centers included in the study.
†For Khaengkhoi Hospital, outpatients and inpatients receive drug dispensing from the same unit.

Table 2 Cost of drugs per 100 units (US$ at 2006 prices)

Drug	Unit cost Base-case	Minimum	Maximum
Norfloxacin 100 mg tablet	1.68	0.84	11.49
Norfloxacin 400 mg tablet	2.74	1.57	6.43
Ciprofloxacin 250 mg tablet	9.84	2.80	9.84
Domperidone tablet	0.87	0.28	1.17
Hyoscine-n-butyl bromide tablet	4.08	1.40	4.08
Metoclopramide 5 mg tablet	0.50	0.39	0.70
Paracetamol 500 mg tablet	0.34	0.21	0.89
ORS adult sachet	7.55	2.80	13.42
ORS pediatric sachet	4.75	2.66	10.07
5% Dextrose in $^1/_2$ normal saline solution 1000 ml bag	44.74	41.75	71.31
Normal saline solution 1000 ml bag	46.14	38.87	167.51

Table 2. The minimum and maximum prices were the prices that the public hospitals reported to the Ministry of Public Health. Variations between the minimum and maximum prices were in the range of 1.7 (5% dextrose solution) to 13.7 times (norfloxacin 100 mg).

Patient Characteristics and Service Utilization

All shigella-positive cases were included. There were 137 episodes from 130 patients. Out of 140 outpatient visits, most patients received treatment at Kaengkhoi Hospital (94 visits), followed by 46 visits at the health centers. For the hospitalization treatment, there were nine and three admissions at Kaengkhoi Hospital and Saraburi Hospital, respectively. Nearly all patients (94.2%) received treatment as outpatients (Table 3), while 6% of patients were hospitalized. More than half of the patients were female (63.5%). Majority of the patients (61.3%) were aged more than 15 years. The largest percentage of patients was treated at Kaengkhoi Hospital (65%). The antibiotics used were norfloxacin, ciprofloxaxin, cotrimoxazole, and tetracycline.

Public Treatment Cost

Public treatment cost was defined as the sum of the cost of visit, cost of hospitalization, dispensing cost, drug cost, cost of medical devices, and laboratory cost. The average cost per episode was US$8.65. Hospitalizations consumed a major part of the overall costs of shigellosis treatment. There were only 5.8% of episodes that received hospitalization services, but they consumed more than half of the total public treatment costs. This was around 59.3% of the total cost (Table 4). Regarding the types of services, the routine service or hotel cost for inpatients consumed nearly half (46%) of the total cost. The routine service of outpatient and pharmacy cost (drug cost and drug dispensing cost) were approximately one-fourth (Table 4).

Sensitivity Analysis

To explore variations of the public treatment cost of shigellosis, some cost drivers (i.e., cost structure, discount rate, and prices of drugs) were varied in repeated calculations. The base case included opportunity of land used and a 3% discount rate. The following scenarios were employed in a one-way sensitivity analysis:

1. base case: 3% discount with cost of land use;
2. 3% discount rate for capital costing, excluding opportunity cost of land used (3%NoLand);
3. 6% discount rate for capital costing, including opportunity cost of land used (6%Land);
4. 6% discount rate for capital costing, excluding opportunity cost of land used (6%NoLand);

Table 3 Variables included in the regression analysis

Variable	Definition and characteristics	Codes and values
Dependent variables		
LNCOST	Natural Log of public treatment cost per episode	Number in Ln form of the cost
Independent variables		
ADULT	Age of patients	1 = adult; aged more than 15 years (61.3%), 0 = children; aged 1–15 years (38.7%)
Dummy variables for health providers; health centers (31.3%) as reference		
KH	Kaengkhoi Hospital (65%)	1 = Kaengkhoi Hospital, 0 = else
SR	Saraburi Hospital (1.5%)	1 = Saraburi Hospital, 0 = else
HCKH	Health center and Kaengkhoi Hospital (2.2%)	1 = Health center and Kaengkhoi Hospital, 0 = else
Dummy variables for service type; outpatient (94.1%) as reference		
IP	Inpatient (2.2%)	1 = Inpatient service, 0 = else
OPIP	Outpatient and inpatient (3.6%)	1 = Outpatient and inpatient service, 0 = else
Dummy variables for payment status; Universal Coverage Scheme (45.3%) as reference		
SSS	Social Security Scheme (21.9%)	1 = Social Security Scheme, 0 = else
CSMBS	Civil Servants Medical Benefit Scheme (4.4%)	1 = Civil Servants Medical Benefit Scheme, 0 = else
OOP	Out-of-Pocket (5.8%)	1 = secelf payment, 0 = else

Table 4 Descriptive data of public treatment costs by category of costs and services (US$ at 2006 prices)

Cost	Mean	95% CI Lower	95% CI Upper	Median
Cost by category				
Routine service for outpatient	2.19 (25.1%)	2.04	2.34	2.17
Routine service for inpatient	4.01 (46.36%)	0.91	7.11	0.00
Drug dispensing cost	0.89 (10.29%)	0.47	1.31	0.57
Drug cost	1.06 (12.27%)	0.76	1.37	0.66
Medical devices	0.09 (1.00%)	0.02	0.15	0.00
Laboratory	0.41 (4.77%)	0.15	0.68	0.00
Total medical cost	8.65 (100%)	4.79	12.51	3.42
Cost by service (% of sample, % of total cost)				
Outpatient visit (91.3%, 37.0%)	3.51	3.21	3.81	3.35
Inpatient admission (1.5%, 10.7%)	63.25	−433.37	559.87	63.25
Outpatient + inpatient* (3.6%, 41.5%)	98.44	30.32	166.57	84.57
Multivisits (2.9%, 3.7%)	10.96	−3.52	25.43	6.60
Multiadmissions (0.7%, 7.1%)	84.04	n/a	n/a	n/a
Cost by age group (% of sample)				
Aged less than 5 years (20.4%)	6.22	0.255	12.19	3.20
Aged 5–15 years (18.3%)	9.24	−1.63	20.10	3.34
Aged more than 15 years (61.3%)	9.29	4.09	14.50	3.56
Total (100%)	8.65	4.79	12.51	3.42

*One visit and one admission.

5. 3% discount rate for capital costing, including opportunity cost of land used and substitution drug prices of base case by minimum prices (3%LandMinPrice); and
6. 3% discount rate for capital costing, including opportunity cost of land used and substitution drug prices of base case by maximum prices (3%LandMaxPrice).

Th total medical cost (or public treatment cost) ranged from US$8.29 per episode (–4.20%) to US$9.38 per episode (+8.43%) because of the different assumptions for drug prices. (Table 5).

Public Treatment Cost Function

Potential predictor variables included in the model tested are presented in Table 3. Because of the non-normal distribution of institutional costs, a log transformation [36] was applied and a linear relationship among variables was tested. For further assumption tests and model diagnosis, the scattered plot of residuals against the predicted values and all independent variables shows no funnel shape indicating homoscedasticity [22]. The condition index was 1 to 3.401. This meets the criteria of ≤ 30; hence, indicating no multicollinearity [22]. The final fitted model has a determination coefficient equal to the adjusted $R^2 = 0.788$, with a significance level = 0.000. The significant variables and regression coefficients are shown in Table 6. The smearing factor of the public treatment cost model was 1.0827.

Based on the fitted model, the predicted public treatment cost of a patient who received treatment at a health center as an outpatient and is not under CSMBS, is calculated as follows:

$$\text{LNCOST} = 0.877 + 2.970\text{opip} + 1.916\text{ip} + 0.453\text{kh} + 1.087\text{sr} + 0.406\text{csmbs} \quad (3)$$

$$\text{LNCOST} = 0.877 + 2.970 \times 0 + 1.916 \times 0 + 0.453 \times 0 + 1.087 \times 0 + 0.406 \times 0 \quad (4)$$

$$\text{LNCOST} = 0.877 \quad (5)$$

$$\text{Public treatment cost per episode} = e^{0.877} \times 1.0827 \quad (6)$$

$$\text{Public treatment cost per episode} = \text{US\$}2.60 \quad (7)$$

Based on the fitted model, the predicted public treatment costs of various scenarios were calculated as shown in Table 7.

Table 5 Results of sensitivity analysis; treatment cost per episode (US$ at 2006 prices)

Scenario	Average treatment cost	Variation from base case (%)
1. Base case; 3% Land	8.65	n/a
2. 3%NoLand	8.50	−1.78%
3. 6%Land	9.05	4.60%
4. 6%NoLand	8.74	1.05%
5. 3%LandMinPrice	8.29	–4.20%
6. 3%LandMaxPrice	9.38	8.43%

Discussion

In view of the general results of our study, we could state that the results could represent most shigellosis patients in Thailand. We selected two types of public hospitals that represent the majority of public hospitals in Thailand. This is important, considering that public hospitals are major health service settings in Thailand. The patient beds of public hospitals are approximately 80% of the total beds in Thailand [19].

Table 6 Regression model of public treatment cost

	Unstandardized coefficients				95% CI for *B*	
	B	Std. error	*t*	*Sig.*	Lower bound	Upper bound
(Constant)	0.877	0.058	15.075	0.000	0.762	0.992
Outpatient and inpatient	2.970	0.165	18.043	0.000	2.644	3.295
Inpatient	1.916	0.215	8.906	0.000	1.491	2.342
Kaengkhoi Hospital	0.453	0.072	6.315	0.000	0.311	0.595
Saraburi Hospital	1.087	0.300	3.623	0.000	0.493	1.680
Civil Servant Medical Benefit Scheme	0.406	0.170	2.388	0.018	0.070	0.742

Both selected hospitals had an indication of efficient production. The occupancy rates of inpatient beds were nearly 100%, even as World Health Organization guidelines recommend conducting cost analysis at 80% capacity utilization [30]. Another indicator of representativeness is resource utilization. The proportion of capital cost was 17.8% at Kaengkhoi Hospital and 23.47% at Saraburi Hospital, while studies in other hospitals were 14.73% to 15.38% in the district hospitals [37,38], and 15.89% to 22.21% in the regional hospitals [39,40], These are slightly less than those of the study hospitals because they were not included opportunity cost of the stocked materials. For the unit cost analysis, this study employed microcosting technique in the allocation of cost from the cost center to the individual service output. This method is the most accurate [27,41]. Nevertheless, the unit cost of similar medical services in varied settings can be different. There can be variation of unit cost estimates [41]. In this study, we have controlled costing methods by using the same methods among the study settings. In this way, variations can only happen as a result of the gap between the resources used and service outputs produced. In our study, the unit costs of some laboratory tests at Kaengkhoi Hospital were higher than those of the Saraburi Hospital. Generally, a district hospital provides secondary care while a regional hospital provides tertiary care. They have different equipments, as well as varying qualifications and number of staff members. Consequently, they vary in their capital and labor costs. In addition, they may provide a different number of services. In this situation, the unit costs of similar simple services can be different because of the unit fixed cost. Another factor that affects treatment cost is the prescribing pattern. We found that the antibiotics used in this study were similar to other studies [42]. Hence, the results from this study could be used in the estimation of the country cost.

In terms of hospital management, the information on cost structure is pivotal for cost management. Eight out of 137 episodes (5.8%) consumed a cost of 59.3% of the total treatment costs. This means that hospitalizations consumed a major part of the public treatment cost. Therefore, it is essential to control the number of admissions in order to contain the costs. Unfortunately, the number of inpatients was too small in this study to explore the factors leading to hospitalizations. Furthermore, the sensitivity analysis shows a considerable effect of drug prices on public treatment costs. Although drugs exclusive of dispensing costs accounted for only 12% of the public treatment cost (Table 4), drug prices affected the total cost in the range of –4.20% and +8.43% (Table 5). In Thailand, like in many low-income countries, drug prices vary considerably, and our findings may therefore be of wider interest. Therefore, the drug supply in hospitals is a target of cost containment. To know more about the details of cost drivers, the cost function method may be used to help provide such information [13]. The public treatment cost model with the adjusted R^2 of 0.788 was statistically significant as predicted by types of services (outpatient and inpatient), types of providers (health center, district hospital, regional hospital), and health insurance scheme. This fitted model

Table 7 Predicted public treatment cost from the fitted model (US$ at 2006 prices)

Scenario	Outpatient	Inpatient	HC	KH	SH	CSMBS	Cost	% change*
1	yes	no	yes	no	no	no	2.60	n/a
2	yes	no	no	yes	no	no	4.10	57%
3	yes	no	no	yes	no	yes	6.15	136%
4	yes	no	no	no	yes	no	7.72	196%
5	yes	no	no	no	yes	yes	11.58	345%
6	no	yes	no	yes	no	no	82.52	3070%
7	no	yes	no	yes	no	yes	123.80	4656%
8	no	yes	no	no	yes	no	52.44	1915%
9	no	yes	no	no	yes	yes	78.68	2923%

*% change from scenario one.
CSMBS, Civil Servants Medical Benefit Scheme; HC, Health Center; KH, Kaengkhoi Hospital; SH, Saraburi Hospital.

could be reliable because the model could explain the treatment cost by nearly 80%. The effect of the health service level on the treatment cost can also be explained. Generally, the unit costs per visit increased from the health centers to the district hospital and then to the regional hospital. In addition, there was no inpatient service at the health centers. Therefore, the average total cost of public treatment at the health centers was less than those of the hospitals.

Another predictor of the public treatment cost was the insurance scheme of patients. For example, CSMBS patients tended to receive drugs with higher cost (they take brand name drugs instead of generic drugs) and longer hospitalization. The CSMBS is a fee-for-service payment scheme, while the other insurance schemes are capitation schemes. This results to a scenario of unequal treatments among patients with different payment schemes. This is related to the issue of equity in health and needs to be further investigated.

Based on the stepwise method that was used, we concluded that there is no difference in the treatment cost between adults and children. Because admission is a significant factor, we tested and found that there is no statistically significant difference in the rates of admission between adults and children (Fisher's exact test; $P = 0.297$). Another factor that might have affected the difference in the public treatment costs of adults and children was drug cost. Nevertheless, Table 4 shows that drugs exclusive of dispensing costs accounted for only 12% of the public treatment cost. This proportion might not be big enough to affect the public treatment cost. Various scenarios according to service types, providers, and health insurance schemes show high variations in cost. As shown in Table 7, for the same condition, patients treated at health centers were able to save as much as US$1.5 per episode in comparison with those treated at the district hospital (scenario 1 versus 2 in Table 7). The treatment cost increased to 2,923% from that of the health center. The treatment cost function is useful because it provides an estimated quantity of cost difference among the various scenarios. In the future, this would be applicable in feasibility studies on health interventions. Nevertheless, the consequences for the quality of treatment should be further investigated.

Based on the results of this study and the overall incidence of shigellosis in 10.4 per 1000 population per year [4], the annual cost because of shigellosis in Thailand is estimated at US$5.60 million. Bearing this in mind, the priority setting of the country's public health planning could be affected. Furthermore, costing studies can be applied to the design of interventions. Generally, the cost and outcome of interventions should be estimated during planning. The economic outcome is one of the most important factors to take into consideration. Cost-benefit is an alternative evaluation method. The number of illness that could be avoided with information on the cost of illness can be used in the calculation of savings to compare the intervention cost. In the same district where this study was conducted, another study was done on the risk factors of shigellosis. This particular study showed that hygiene behaviors such as regular hand washing, a clean household and environment, and the availability of water to flush the toilet were associated with a reduced risk for shigellosis in the multivariate model [43]. If an intervention such as hand washing is targeted to reduce shigellosis by 10%, this can produce a savings of US$0.56 million. In terms of the project design, the cost of the intervention should not be higher than the amount of the expected savings.

Another interesting intervention is vaccination. The information from our studies and others similar to it could be useful for vaccine development. The success of vaccination does not solely depend on the development of a vaccine, but also on its wide coverage. One of the factors that affect vaccination compliance is affordability. If we have information on an affordable price, it could have an effect on the development of a production technique that relates to the targeted prices. Currently, there are some shigellosis vaccines under development [1,14]. Information on treatment cost from this study and previous epidemiological studies, including further estimation of vaccine delivery cost, can be used in a modeling design of cost-effectiveness analysis (CEA) [44] for a shigella vaccine. The analysis can be performed for all age groups or high-risk groups whose age are less than 5 years old [5]. The fitted model provided an estimated cost of treatment at various settings. This can be useful for a CEA in a specific geographic area. For example, we may implement the vaccination only in a high-incidence area. This area may have a different proportion of treatment among health center and the hospital. Based on the costs between the health center and the hospital, as shown in Table 7, we can calculate the weighted average treatment cost in that area for the CEA. In addition, the threshold analysis [45,46] method may be used to show the break-even price of the vaccine. This price can be one of the targets for vaccine development.

Conclusion

The average public treatment cost of shigellosis in Thailand was determined to be US$8.65 per episode. Approximately 6% of these episodes consumed 60% of the total cost. Service types, health-care facilities, and insurance schemes were predictors of nearly 80% of the cost. The estimated cost can be employed for hospital management and health problem priority setting and planning. The fitted cost model was useful in estimating the treatment cost of various scenarios.

These estimated costs can be applied in a feasibility study of health interventions. Furthermore, it can be useful information for vaccine development.

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