ECONOMIC BURDEN OF ROAD TRAFFIC INJURIES: A MICRO-COSTING APPROACH

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Abstract. This study aimed to determine the economic burden incurred from road traffic injuries in Thailand. It was designed as a prevalence-based cost-of-illness analysis from a societal perspective, employing a micro-costing bottom-up approach. It covered direct medical cost, direct non-medical cost, and indirect cost or productivity loss. Productivity loss covers the costs of work absence or death due to road traffic injuries suffered by persons of working age. We collected data on road traffic injuries and resource utilization which occurred in the fiscal year 2004. A simple random sampling was used to select 200 patients for analysis. The average cost of road traffic injuries per patient was USD 2,596 at 2004 prices. This can be divided into direct cost (USD 102, or 4%) and indirect cost (USD 2,494, or 96%). From these results, we can see that the indirect cost far outweighed the direct cost. To base decisions regarding road safety campaigns on savings of direct costs, particularly direct medical costs, is inadequate. Therefore, data on the complete cost of illness should be taken into account in the planning and creation of a road safety policy.

INTRODUCTION

In the past decade, road traffic accidents (RTAs) have become one of the top ten leading causes of fatality in Thailand (Sintuvanich, 1997). Deaths from RTAs per 100,000 population were 21.5, 20.4 and 19.8 in 2002, 2003 and 2004, respectively. Rates of admission to government hospitals (80.5% of total beds in the country in 2004) due to RTAs were 307.5, 331.1 and 334.2 per 100,000 population in 2002, 2003 and 2004, respectively (Alpha Research, 2006).

Numerous cost-of-illness studies have been conducted to assess the problem in terms of its economic burden. These studies were based on primary data collected at study sites, and on secondary data from hospital statistics reported to the Ministry of Public Health. The estimation was in the form of economic cost and cost at charge. We found three studies employing secondary data in estimating the national economic burden. One study (Tosutho, 1997) employed secondary data from the Ministry of Public Health and from previous studies. It covered six main losses, as follows: (1) loss due to medical treatment; (2) loss from damaged property; (3) opportunity loss cost for injured persons; (4) opportunity loss cost for disabled persons; (5) opportunity loss cost for family care; and (6) income loss due to death. The study showed the national economic loss was THB 6,951 million at 1985 prices.

During the following decade, Pitagpravej (1997) conducted another study on national

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economic losses due to transport accidents. This study used data from the Royal Thai Police, the Ministry of Public Health, the National Statistics Office, and previous studies. The study covered 1,618,714 victims of transport accidents in 1995. The covered cost aspects were similar to those of the aforementioned study, including expenditures for funeral ceremonies. The cost was THB 104,754 million. This was approximately 3% of the country's gross national product.

Recently, Suwanrada (2005) conducted a study using data from the Royal Thai Police, the Ministry of Public Health, the National Statistics Office, and previous studies. The cost aspects were similar to those of the 1985 study. Total losses amounted to 106,994 million THB. In short, Thai society lost more than THB 100,000,000,000 per year due to road traffic accidents.

At the hospital level, one study (Kunaratanapruk *et al,* 1995) demonstrated the treatment cost for road traffic injuries in ten provinces during a three-month period in 1993-1994. It found that the average medical expenditures (charges) per case for outpatients and inpatients were THB 286 and THB 10,167, respectively. A study at three public tertiary hospitals in Bangkok in 1995 (Sumiratana, 1998) indicated the average hospital cost per case was THB 29,004 to THB 39,875. For provincial hospitals, two other studies in 1996 and 1997 showed the average total treatment charge per case to be THB 10,852 and THB 11,606, respectively (Pulpanyawong, 1998; Munnae, 1999).

All these studies used secondary data, with some studies using primary data presented as charges. There was only one study that used primary data and presented it in the form of cost, but not including capital cost. Moreover, there was no study conducted from a societal perspective, employing primary data that covered both direct cost and indirect cost or productivity loss. Therefore, this study aimed to determine the cost of road traffic injuries from a societal perspective at a public district hospital in Thailand.

MATERIALS AND METHODS

The study was conducted at Pattananikhom Hospital, a 60-bed public district hospital in Lopburi Province, 153 km north of Bangkok. Its location is 10 km away from the northern national highway. The hospital provides secondary level health services, including some surgery (*eg,* appendectomies). In the fiscal year 2004 (October 1, 2003 to September 30, 2004), there were five physicians, two dentists, three pharmacists and 167 staff at the hospital. The service output was 128.64 visits per day, and the hospitalization service had an occupancy rate of 83%. The average length of stay was 3.2 days. The study population was comprised of road traffic accident patients, both outpatient and inpatient, who received treatment during the fiscal year 2004. All patients had a definite diagnosis classified by the International Classification of Diseases, 10^{th} revision (ICD-10), code V01-V89 (WHO, 1992). Since Pattananikhom Hospital is a community hospital, there is inadequate equipment for treating severe conditions. Most patients were not severe cases; if patients had severe symptoms, they were referred to the nearest general hospital (Lopburi Hospital).

From hospital statistics, there were 1,505 cases of road traffic injuries in 2004. Sample size determination was based on limitations of time and budget (Kelley *et al,* 2003). Therefore, it was calculated at approximately 10% of the study population. To account for unresponsiveness, 250 patients were randomly sampled. Demographic characteristics and medical service utilization were covered. There was a limitation on the severity levels of the patients because routine medical records do not cover factors which evaluate severity.

The study was designed as a retrospective descriptive study. It was a prevalence-based cost-of-illness study (Kobelt, 2002). The prevalence-based approach measures the economic burden to each patient with a particular disease or injury within a given period, usually one year. This study analyzed the issue from a societal perspective, which is the broadest one, and included all costs incurred by all members of society: the public sector, the private sector, and private consumers (Kumaranayake *et al,* 2000).

The cost of road traffic injuries is composed of two major parts: direct and indirect costs (Kobelt, 2002). Direct medical costs are health-care-related costs directly spent for prevention, detection, treatment, continuing care, rehabilitation, and terminal care. The direct medical cost is calculated by multiplying the quantity of medical services consumed by their unit costs. There were some patients who received additional treatment from health facilities. Therefore in this study direct cost was classified into three parts: direct medical costs occurring at the study hospital; direct medical costs occurring at other health facilities; and direct non-medical costs. Indirect costs were classified into two parts: productivity costs lost due to absence from work; and productivity costs lost due to premature death. The indirect costs were calculated based on the human capital approach (Pritchard and Sculpher, 2000).

The productivity costs lost for an injured person refers to the wages lost over the period of illness. The wage rate used in this study was Thailand's minimum daily wage (USD 3.38). The productivity cost of disabled persons and victims of premature death were the present value of productivity loss of patients from the time of permanent disability or death until retirement (60 years of age). To calculate the cost, the age of each patient and the number of years lost between the age of permanent disability or death and 60 years were determined. The cost was calculated by finding Thailand's forecasted average per capita income (at the present value) for each year of disability until the age of 60. Yearly per capita income was calculated based on a 6% increase in income and a 3% discount rate from the present value (Suwanrada, 2005).

In this study, the unit cost of medical services was calculated by a standard method and a micro-costing bottom-up approach (Rigden, 1983; Kobelt, 2002; Drummond *et al,* 2005). The hospital's departments were classified into 13 supporting cost centers and 14 patient-care cost centers. The direct cost of each cost center was determined by the summation of its labor costs, material costs and capital costs.

The labor cost was a summation of salaries, wages, overtime pay, and fringe benefits, such as health-care expenses, education expenses, training expenses and travel allowances. For a person working for more than one cost center, the labor cost was distributed among the cost centers based on a self-estimated proportion of working time in each cost center.

Material costs covered drugs, medical material, office material, household material, gasoline, utilities, and maintenance costs. For utilities, the total cost of electricity was distributed based on the proportion of each cost center's area of operation. Mail and telephone costs were allocated to the hospital administration cost center. For other resources used, costs were collected according to the actual consumption of each cost center.

Capital cost consisted of two components: capital cost of depreciable assets, and opportunity cost of land and materials stock. The capital cost was calculated using an economic-based approach (Drummond *et al,* 2005). This approach covers both the depreciation cost (the rate at which the capital is "used up") and the opportunity cost (interest) of making the investment (Edejer *et al,* 2003). In this study, a 3% discount rate (Edejer *et al,* 2003) was used. The estimated useful life of buildings and structures was 20 years, while the estimated useful life of the rest of the capital items was five years (Creese and Parker, 2000; Tisayaticom *et al,* 2001). Opportunity costs for land and stocked materials were calculated using a 1% interest rate, which was the rate of a 12-month fixed deposit during the fiscal year 2004 (Bank of Thailand, 2004). The opportunity cost of stocked materials covered office materials, medical supplies, scientific materials, and drugs. The average value of 12 monthly stock amounts was used for the calculation.

After the direct cost was determined, the direct costs of all supporting cost centers were allocated to patient care cost centers employing the simultaneous equation method (Drummond *et al,* 2005). To calculate the unit cost of medical services, the average method was employed for cost centers producing one product or homogeneous products (Lerner *et al,* 1985; Suver and Cooper, 1988). A micro-costing method was used for cost centers producing heterogeneous products (*eg,* laboratory, radiology, operating room, physical therapy, emergency room, dental, health promotions, and sanitation) (Lerner *et al,* 1985). This method began by determining the direct cost of each service (the amount of countable resources directly used in providing such services). Then, the indirect cost of services (the full cost of each department minus the total direct cost for all services) was allocated to each service based on the proportion of direct cost for each service.

After the unit costs for medical services were computed, the treatment cost or direct medical cost was calculated. The direct medical cost included the costs of medical services, drugs, and medical supplies. Data were drawn from medical records. The cost of medical services received was calculated by multiplying the quantities of the services by their unit costs. Costs of drugs and medical supplies were calculated by the summation of the results from multiplying drug quantities and the number of medical supplies by their acquisition unit costs.

For direct non-medical costs and indirect costs, patients or their family members were interviewed. Direct non-medical costs are non-medical costs directly related to medical procedures (*eg,* transportation, meals, accommodation, home modifications, and informal care or care by relatives). Indirect costs are the costs that are not actually paid. They are defined as productivity loss due to illness. There are two forms of indirect costs: morbidity costs and mortality costs. Morbidity costs included the value of production lost by those who were sick, absent, unemployed, or restricted from working due to an illness. Mortality costs were calculated as the present value of lost production due to premature death caused by illness (Kobelt, 2002).

Descriptive statistics were used to present the demographic characteristics and costs. To analyze the robustness of the results from the sample data and the various methodologies, univariate sensitivity analysis was employed (Gold *et al,* 1996). Variations of material and capital costs were included.

RESULTS

The response rate for patient interviews regarding direct non-medical and indirect costs was 80%. Table 1 presents the demographic characteristics of the sample (200 respondents). Most of the patients were male (69%) less than 31 years old (64.5%). Most of the patients had only a primary education (50%) and worked as laborers (41%). In terms of payment schemes, most of the patients were under the Universal Health Coverage Scheme (44%). A large majority of patients (85.5%) were motorcycle riders (Table 2).

Table 1
Demographic characteristics of interviewed patients (n = 200).

	Characteristics	%
Gender	Male	69.0
	Female	31.0
Age group	1-12 years	14.5
	13-18 years	20.5
	19-30 years	29.5
	31-60 years	31.0
	>61 years	4.5
Education	Uneducated	10.0
	Primary education	50.0
	Secondary education	30.0
	Diploma	5.5
	Bachelor degree	2.0
	Others	2.5
Occupation	Unemployed	12.5
	Laborer	41.0
	Agriculturist	11.0
	State enterprise/Civil officer	7.0
	Merchant/Own business	3.5
	Student	21.5
	Others	3.5
Payment scheme[a]	UC	44.0
	MVAVPI	13.5
	SSS	12.0
	CSMBS	1.5
	Private insurance	2.5
	Out-of-pocket	26.5

[a]UC = Universal Health Coverage Scheme; MVAVPI = Motor vehicle accident victim protection insurance; SSS = Social Security Scheme; CSMBS = Civil Servants Medical Benefit Scheme

Total hospital costs were USD 1,039,208. (The average exchange rate in 2004 was USD 1 = THB 40.22) This consisted of labor costs (53%), material costs (32%), and capital costs (15%). The unit costs for some medical services are presented in Table 3. For the pharmacy cost center, the total cost was USD 189,820 and the drug cost was USD 136,455. Therefore, administration costs (total cost minus drug cost) was USD 53,366, resulting in a dispensing cost of USD 0.5 per prescription.

Two hundred patients were interviewed and included in the direct cost calculation. As seen in Table 4, the average cost per patient for road traffic injuries was USD 2,596 at 2004 prices. The largest part was indirect costs (96% of the total cost). The average direct cost was USD 102, of which 21% was direct non-medical costs. For informal care, the total days that a caregiver spent taking care of a patient ranged from 0.5 to 152. These numbers were multiplied by the minimum daily wage (USD 3.38) to establish the cost of informal care. The total number of days that a patient spent undergoing treatment, rehabilitation and recovery was between 1 and 365 days. The average was 21.5 days (Median =5).

After multiplying the time spent by the minimum daily wage, it was found that the average productivity cost of an injured person was USD 63. In this study, we did not find any person who was disabled due to a road traffic accident. However, there were three persons who died because of road traffic accidents. They were 18, 27 and 24 years old; therefore, the numbers of working years lost were 42, 33 and 36 years.

Total income lost due to deaths from road traffic accidents was USD 486,109 (range = USD 133,971-USD 198,486). The average cost among the three deaths was USD 162,036. When the cost was distributed to the study group (200 cases), the average cost was USD 2,431. In comparing the effect of insurance schemes and occupations on direct medical costs, the difference was not statistically significant (Tables 5, 6).

To analyze the robustness of the results due to the methodological method and sample data, one-way sensitivity analysis was employed. The cost of hospital services was recalculated by excluding capital costs. The

Table 2
Types of road traffic accidents.

	ICD-10	*n*	%
V01 - V09	Pedestrian	5	2.5
V10 - V19	Pedal cyclist	15	7.5
V20 - V29	Motorcycle rider	171	85.5
V30 - V39	Occupant of three-wheeled vehicle	3	1.5
V40 - V49	Car occupant	5	2.5
V50 - V59	Occupant of pickup truck or van	1	0.5
V60 - V69	Occupant of heavy transport vehicle	0	0
V70 - V79	Bus occupant	0	0
V80 - V89	Railway; streetcar	0	0
	Total	200	100

Table 3
Unit cost for some medical services (USD at 2004 prices).

Cost center	Full cost	Output	Unit cost
Pharmacy	53,365.6[a]	100,750 prescriptions (276 prescriptions/day)	0.5
Outpatient	91,707.9	46,954 visits (128 visits/day)	1.9
Male ward	148,928.7	6,152 patient-days (24 beds; 70% occupancy rate)	24.2
Female ward	126,272.1	10,827 patient-days (32 beds; 93% occupancy rate)	11.7

[a]Does not include the acquisition cost of drugs

Table 4
Cost of road traffic injuries (USD at 2004 prices).

Cost (*n* = 200)	Mean	Total cost (%)	Direct cost (%)	Median	SD
Direct cost	102.2	3.9	100	32.9	330.1
Direct medical cost	80.9			30.1	299.0
a) Direct medical cost at the study hospital	29.2		28.5	16.5	33.1
b) Direct medical cost at other health facilities	51.7		50.6	0.0	297.2
Direct non-medical cost	21.3		20.9	2.4	66.5
Indirect cost	2,493.8	96.1		20.3	20,015.7
Productivity cost of injured person	63.2			16.9	164.9
Productivity cost of death	2,430.5			0	20,021.7
Total cost of illness	2,596.0	100.0		57.9	20,169.5

Table 5
Direct medical cost classified by payment scheme (USD at 2004 prices).

Payment scheme	*n*	Mean cost
UC	88	28.0
SSS	24	30.6
CSMBS	3	12.5
MVAVPI	27	34.5
Out-of-pocket	53	28.9
Private insurance	5	27.4
Total	200	29.2

UC = Universal Health Coverage Scheme
SSS = Social Security Scheme
CSMBS = Civil Servants Medical Benefit Scheme
MVAVPI = Motor vehicle accident victim protection insurance
Test difference of the cost by Kruskal-Wallis test; p=0.65

Table 6
Direct medical cost classified by occupation (USD at 2004 prices).

Occupation	*n*	Mean cost
Unemployed	25	17.4
Laborer	82	30.6
Agriculturist	22	41.5
State enterprise/Civil officer	14	39.1
Merchant/Own business	7	23.3
Student	43	25.6
Others	7	23.2
Total	200	29.2

Test difference of the cost by Kruskal-Wallis test; p=0.38

results indicate a decrease in the total cost for the study hospital, average direct medical cost at the study hospital, and average cost for road traffic injuries by 14.7%, 14.3%, and 0.2%, respectively.

To explore the uncertainty due to the discount rate, capital and indirect costs were reanalyzed using variations of the discount rate (0% and 6% instead of 3% for the base case). After recalculation using discount rates of 0% and 6%, the depreciation cost for buildings changed by decreasing 25.6% and increasing 29.7%, for discount rates of 0% and 6%, respectively; while the depreciation cost for durable goods decreased by 8.4% and increased by 8.7%, for discount rates of 0% and 6%, respectively. The total cost of the study hospital decreased by 3.0% and increased by 3.4%, at discount rates of 0% and 6%, respectively. Similarly, the average direct medical cost at the study hospital decreased by 2.7% and increased by 3.1%, at discount rates of 0% and 6%, respectively. The indirect cost due to death increased by 105.5% and decreased by 45.2%, at discount rates of 0% and 6%, respectively. Finally, the average cost of road traffic injuries increased by 96.3% and decreased by 41.2%, at discount rates of 0% and 6%, respectively.

To test the effect of drug price variation on the study results, the minimum and maximum prices from purchasing reports of public hospitals were used in the recalculation (Drug and Medical Supplies Information Center, 2004). The results indicate changes in total direct medical costs. When the minimum and maximum prices of drugs were used in the recalculation, costs decreased by 8.4% and increased by 38.6%, respectively, the average direct medical costs at the study hospital decreased by 4.5% and increased by 10.7%, respectively, and the average costs of road traffic injuries decreased by 0.1% and increased by 0.1%, respectively.

DISCUSSION

For a representation of the study hospital, the cost structure of the hospital was considered. The percentages for labor, material, and capital costs of the hospital were 53.6, 31.7, and 14.7%, respectively. The proportion for labor cost had the highest percentage (about 50%), followed by material and capital costs. This proportion was similar to previous cost studies in community hospitals (Kongsawatt, 1997; Riewpaiboon *et al,* 2007a,b).

The characteristics of the study patients were similar to those of previous studies. The patients were predominantly male (about 70%), as was the case in previous studies of road traffic accidents (Pitagpravej, 1997; Piyayothai, 1997; Munnae, 1999; Nuake, 2001; Suwanrada, 2005). The majority of patient were young (less than 30 years old) (Pitagpravej, 1997; Sumiratana, 1998; Munnae, 1999; Miller and Blewden, 2001; Nuake, 2001; Suwanrada, 2005). As to education and occupation, half of the study patients had only a primary education, and 41% of the study patients worked as laborers (Sumiratana, 1998; Munnae, 1999).

While the average cost per patient was USD 2,596, Thailand's per capita gross domestic product (GDP) in 2004 was USD 2,513 (Office of the National Economic and Social Development Board, 2007). Thus, the cost outweighed the income. Road traffic injuries therefore have a significant effect on the country's economy.

The indirect costs estimated in this study accounted for 96% of the total costs of road traffic injuries. Productivity costs lost due to premature death (mortality cost) were accountable for 94% of the total cost. The indirect cost was much greater than the direct cost, as is the case with other illnesses (Pitagpravej, 1997; Sumiratana, 1998; Al-Masaeid *et al,* 1999; Miller and Blewden, 2001; Suwanrada, 2005; Garcia-Altes and Perez, 2007). The proportion of indirect costs was relatively greater than with other illnesses. This is because road traffic deaths occur mostly in teenagers, resulting in longer periods of productivity loss. This indicates that the indirect costs due to death are a major part of the economic burden in road traffic accidents.

With regard to indirect cost estimation, there is still controversy about which is the most appropriate method; although the most recent method proposed, friction cost, is claimed to be the most accurate (Koopmanschap, 1996). However, the data required for this method was not available in Thailand at the time of the study. Therefore, in this study the traditional human capital approach was selected to calculate the cost. Although this approach has some weak points, it does reflect the economic burden due to the illness to a certain degree. It has been applied in other studies related to the cost of road traffic injuries (Elvik, 1995; Trawen *et al,* 2002; Garcia-Altes and Perez, 2007).

In this study, the productivity cost lost by the patients was calculated by multiplying the minimum daily wage and the morbidity absence period (days). Some previous studies have employed a minimum daily wage (Pornlertwadee, 2002), or the GDP (Youngkong *et al,* 2002); or the average income of the population from their surveys (Tosutho, 1997; Sumiratana, 1998; Al-Masaeid *et al,* 1999; Global Road Safety Partnership, 2004; Suwanrada, 2005; Garcia-Altes and Perez, 2007) for their calculation. In 2004, the minimum daily wage in Thailand was USD 3.38, while the per capita GDP was USD 5.85 per day. The average income of Thai private workers from a 2002 survey (Planning and Information Group, Labor Standard Development Bureau, 2002) was USD 7.28. Based on the consumer price index (CPI) adjustment, the average income in 2004 was USD 7.42. In the case of an approximately 6% increase, the average income in 2004 was USD 8.18. The minimum daily wage used in the study was the lowest cost; therefore, the calculation based on the minimum daily wage resulted in the lowest opportunity cost. The minimum daily wage was used because most of the patients in this study (41%) were laborers.

The income lost was calculated by the summation of the forecast for Thailand's average per capita income at the present value for each year of disability or death until age 60 years (retirement). The per capita income was formulated from the earning function, including gender, age, education, and occupation variables (Tosutho, 1997; Suwanrada, 2005). It was calculated by using a 6% annual increase and a 3% annual discount rate. This could be more accurate than the estimated per capita income used in previous studies (Pornlertwadee, 2002; Youngkong *et al,* 2002).

Focusing on the aspect of inequity in health care, the direct medical costs were compared for various insurance schemes and occupations (Tables 5 and 6). The payment method for the primary insurance scheme, CSMBS, was fee-for-service, while the other schemes were based on capitation methods. With the fee-for-service schemes, providers tended to offer more services. Patients under the Social Security Scheme (SSS) or Universal Health Coverage (UC) incurred lower costs than those under the CSMBS. This could be due to the effect of the health financing methods. Public hospitals in Thailand receive a fixed per capita budget (per person registered with the SSS). Physicians are urged to control expenditures for these patients. This phenomenon has been demonstrated in other studies (Chaikledkaew *et al,* 2005; Riewpaiboon *et al,* 2007b). Similar results occurred with road traffic injury patients (Munnae, 1999). However, the differences in direct medical costs among the insurance schemes and occupations in this study were not statistically significant. Therefore, inequity in road traffic injury care is still a controversial matter. Inequity in road traffic injury care actually may have little chance to occur because the treatment is of an emergency nature, and is provided in a short time, whereas with chronic or non-acute care, physicians have more treatment options.

In this study, there were no persons disabled due to road traffic accidents. It is possible that most of the patients were not severe cases, because the percentage of outpatients was 88.6%. Therefore, the cost of the injuries at a higher-level hospital should be greater than the cost obtained in this study, because more severely injured patients need more complicated treatments, and there is a higher probability of disability and death. The cost of road traffic injuries could be much higher if the study also covered long-term follow-up and consequences (Maraste *et al,* 2003).

In conclusion, the economic cost of road traffic injuries at a public district hospital in Thailand was USD 2,596 per case at 2004 prices. This amount included direct medical costs, direct non-medical costs, and indirect costs. The direct medical cost was composed of material, labor, and capital costs for patient care and supporting departments. Direct costs represented only 4%, while productivity loss due to work absence or death resulted in indirect costs accounting for the vast majority (96%) of the total cost. Direct medical costs occurring at the study hospital comprised approximately one-third of the direct costs, and 1% of the total cost of the illness. Therefore, regarding public policies and planning for road safety campaigns, the complete cost-of-illness data should be taken into account instead of only direct medical costs.

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