ประสิทธิผลของนโยบายภาครัฐด้านความปลอดภัยบนท้องถนน

THE EFFECTIVENESS OF THAILAND PUBLIC POLICY ON ROAD SAFETY

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As one of the top countries with the highest fatalities per capita in road traffic accidents, Thailand needs to raise public awareness about the social and economic losses creates by road accidents to improve the effectiveness of road safety policy. The aims of this study were as follows: (1) to estimate the productivity loss caused by the severe road traffic accidents in Thailand in 2017, and (2) to analyze the effectiveness of road safety policy in Thailand. Extensive data base from Road Accident Victims Prevention Co. Ltd. was used to calculate productivity losses due to traffic fatalities, permanent disabilities, and major and minor injuries. Furthermore, the cost-effectiveness analysis (CEA) method was used to evaluate the effectiveness of road safety policy such as: drunk-driving law, helmet use law, and seat belt use law. The data contained the costs and the amount of road traffic deaths between 2012 and 2017. The results showed that, the total amount of productivity losses were caused by road traffic accidents in Thailand in 2017 and cost approximately 121 billion Baht (45 billion for fatalities, 7 for disabilities, 67.5 for serious injuries and 1.5 for slight injuries). The number represented approximately 0.8 percent of the country's GDP. Moreover, people at in the sixteen to twenty-five age group represented the highest-burden group in all types of accidents. The value of productivity loss can be used as a campaign to install the awareness to the public, especially for teenagers and young adults, as well as sufficient knowledge of the effectiveness of policy and can improve road safety policy. The evaluating results of the road safety policy were as follows: (1) the drunk-driving law was effective in reducing fatalities caused by all types of motor vehicles accidents including motorcycles and bicycles; (2) the seat-belt use law was also effective in reducing the number of motor vehicle traffic fatalities; and (3) the helmet use law was considered ineffective, which was insignificant in terms of effort. The policy recommendation was a reduction in the number of deaths leading to the realization that the behavior of riders needed to be focused on safety education for motorcycle and law enforcement.

Keyword : Effectiveness, Public Policy in Thailand, Road Safety

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CHATURAPHAT CHANTITH

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CHAPTER 1

INTRODUCTION

Background

Despite raising awareness of road safety as national agenda, Thailand has been unsuccessful so far in reducing traffic accidents and ranked as of the top highest traffic fatalities countries with approximately 33 deaths per 100,000 people in the year 2018 (as shown in Table 1).

Table 1 top ten countries of road traffic fatality rate in 2010, 2015 and 2018

(Fatality rates per 100,000 inhabitants)

Ranking	2013		2015		2018	
	Country	Fatality rate	Country	Fatality rate	Country	Fatality rate
1	Niue	68.3	Libya	73.4	Liberia	35.9
2	Dominican	44.7	Thailand	36.2	Saint Lucia	35.4
3	Thailand	38.1	Malawi	36.0	Zimbabwe	34.7
4	Venezuela	37.2	Liberia	33.7	Mauritius	34.7
5	Iran	34.1	Congo	33.2	Dominican	34.6
6	Nigeria	33.7	Tanzania	32.9	Congo	33.7
7	South Africa	31.9	Central Africa	32.4	Venezuela	33.7
8	Iraq	31.5	Iran	32.1	Central Africa	33.6
9	Guinea-Bissau	31.2	Mozambique	31.6	Thailand	32.7
10	-		Togo	31.1	Guinea-Bissau	31.1

Source: (WHO, 2013), WHO (2015), and WHO (2018 A).

In contrast to National Agenda of Road Safety 2010 - 2019 ("Prevention and Reduction of Road Accidents"), Thailand has considerable number of policy and regulations in preventing accidents, controlling traffic, and campaigning for the road safety. The Budget of nearly 12.47 billion Baht was spent on policy and interventions for road safety in 2017 (Budget Bureau, 2019). It included budget for construction and maintenance of roadways, the treatment and rehabilitation of victims, policy and law enforcement, training and education program, and promotions and campaigns (the spending categories for road safety policy and prevention, see Table 2).

Table 2 the spending categories for road safety treatment and prevention in 2015 - 2017

(Unit: Baht)

List of Budgets for Road Safety Policy	2015	2016	2017
Direct Budgets			
1) budget for the highway network safety*	4,458,349,500	5,245,584,500	4,264,083,200
2) budget for the rural road network safety*	2,442,100,100	2,961,245,600	2,343,954,000
3) budget for the road safety prevention and reduction*	601,310,800	752,806,500	247,125,300
4) budget for road safety administration*			
5) budget for road accidents prevention and reduction during festivals and regular periods*	69,247,600	75,452,000	74,052,000
6) budget for training for disaster prevention and mitigation plan at the district/province level*	27,120,000	35,853,700	35,853,700
7) budget for traffic and road safety administration*	4,213,431,100	4,321,319,300	4,291,692,100
Indirect Budgets			
1) budget for road safety and disaster administration plans**	260,000,000	260,000,000	260,000,000
2) budget for road safety Thailand foundation***	819,238,215	865,145,947	951,515,436
Total	12,890,797,315	14,517,407,547	12,468,275,736

Source: Computed from Budget Bureau (2019).

From Table 2 above, Even Thai government spent more budget to reduce road traffic accident but the number of injuries, disabilities, and premature deaths did not decrease.

In 2017, seven years after the national agenda, “prevention and reduction of road accidents” has launched. The report of Thai RSC (2018) pointed out that the number of road crashes was not decreased, raised up by 68.31 percent compared to the year 2010 (the year before the program). There were 328,953 accidents with 10,544 fatalities, 376,020 injuries, and 1,589 disabilities (shown in table 3). Such report revealed that the road traffic accidents became one of the country’s biggest problems not only in health and social issues but also country’s productivity and foregone income due to the losses.

Table 3 the road accident insurance claimed, 2010 – 2017

(Unit: person)

Year	Number of Crashes	Number of Deaths	Number of Disabilities	Number of Injuries
2017	328,952	10,544	1,589	376,020
2016	299,961	10,577	1,212	342,284
2015	272,665	9,639	738	310,870
2014	251,126	9,832	910	283,670
2013	250,558	10,078	510	283,292
2012	251,942	10,561	433	287,537
2011	224,362	10,514	179	279,102
2010	195,447	8,822	398	223,651

Source: Thai RSC (2018).

The Together for Safer Road's report (Together for Safer Roads, 2015) showed that the cost of traffic crashes estimated at least 1-2 percent of gross domestic product (GDP), mostly in the developed country and in some countries, the damages had accounted for 3 percent of GDP, usually in the developing country. While the economic loss from road traffic accidents in Thailand during the year 2011–2013 was average at 6 percent of GDP (shown in table 4 below), the severe number, excess 2-3 times of world average (O-charoen, 2018).

Table 4 the value of economic loss due to deaths and injuries from road accidents

Year	Economic loss from Deaths (million baht)	Economic loss from Injuries (million baht)	Total economic loss (million baht)	Total economic loss after inflation rate adjusted by CPI (2011 = 100) (million baht)	Rate per GDP
2013	218,140	321,369	539,509	533,263	5.83%
2012	222,840	322,331	555,171	536,996	6.03%
2011	227,450	314,175	541,625	508,594	6.13%
Average	222,810	322,625	545,435	526,284	6.00%

Source: edited from O-charoen (2018).

Moreover, the TDRI (2017) research evaluated the value of economic damage due to road traffic accidents in Saraburi province by using willingness to pay method, found that more than one fourth of respondents did not realize the road safety issues as a significant problem, approximately one third paid moderate attention, and some respondents did not want to pay for the budget to reduce their risks. From this study we could implied that Thai people generality lacked awareness of the dangerous from road traffic accidents to themselves and the loss of the country as well. From the studies of Gul (2011), and DE LEON, Cal, and Sigua (2005) pointed that the knowledge about the harm of road traffic accidents to the economy was essential for the reduction in the number of road traffic accidents. Thereby, raising awareness to Thai people could be one of the strategies to reduce the socio-economic loss due to road traffic crashes.

The suggestions from WHO (2004), and Gitelman and Hakkert (2006) said that, to reach the objective of reducing the number of road casualties, it is necessary to implement effective and efficient of road safety measures, together with a better understanding of the socio-economic impacts of road traffic crashes-related deaths and injuries. The results from efficient assessment could stimulate more efficient priorities for road traffic safety policy and preventions, and will enable to employ available resources to achieve the target-reducing the number of road traffic accidents Baum, Hohnscheid, Evans, Perssons, and Wasemann (2000). Similar to the words of Elvik (2003), and Elvik and Amundsen (2000), the cost-benefit analysis of road safety policy could give the alternative strategies to save accident fatalities. Cronin (2005) studied the relationships between law enforcement and the reduction in the number of road traffic deaths, the results showed that the traffic safety law enforcement could reduce fatal traffic accidents. The studies by Sarawasee, Permpoonwiwat, and Fowles (2015), Permpoonwiwat and Kotrajaras (2012), and Kosalakorn (2001) implied that budget for motorcycle traffic accident preventions could reduce the motorcycle traffic fatalities. As mentioned above, the road safety measures evaluation is needed and uses those result for improving efficiency and effectiveness of the policy. The benefits of declining in road traffic accidents, decreasing in the number of victims, and reducing the value of productivity loss are worthwhile. The reduction of road traffic accidents and their consequences will give the great benefit to the society and the economy, the health prevention would shift the labor supply curve to the right-hand side, leading to high productivity due to a healthier population (Cohen & Henderson, 1988).

As you can see from the Thailand road traffic accident situation above, Questioning, do the Thai government efforts to reduce road accidents and their consequences? Many studies suggested that the effectiveness of road safety policies evaluation was imperative, together with a better knowledge of road accident effects. Consequently, this study examined the road safety policies by using the efficient assessment methods to analyze the efficiency and the effectiveness of Thailand road safety measures such as budgeting and law enforcement. It could provide significant results in helping policymakers and academic advisors for decision-makers processes to improve and stimulate efficient policies for traffic injuries and fatalities reduction.

Research Questions

1. What are the socio-economic effects due to road traffic accidents? And how much do those economic damage costs?

2. Would the road traffic safety policy and preventions have efficiency in reducing traffic fatalities, injuries, and disabilities due to road traffic crashes?

Research Objectives

The dissertation aims to reach the significant effects on the road safety policy and preventions in Thailand. The research objectives are as follows:

1. To estimate the value of productivity loss due to road traffic accidents.

2. To evaluate the road safety policy and preventions following the WHO recommended such drunk driving law, limited speed law, seatbelt law, and helmet law.

Conceptual Framework

To estimate the social and economic loss, the costs of road accidents contained of three categories (Wijnen & Stipdonk, 2016): (1) direct economic costs consist of medical costs, property damage costs, and administrative costs, (2) indirect economic cost; the loss of productivity, and (3) intangible cost; human costs. This study aimed to analyze the indirect economic cost regarding social and economic damage as the value of productivity losses, and separate followed four causes include deaths, serious injuries, disabilities, and also slight injuries due to road traffic casualty. To prevent and reduce the social and economic loss, the road safety policy and preventions were raised up. From the literature reviews found that in Thailand there were four policies to prevent and reduce the socio-economic damages, included helmet law, seat belt law, limited speed law, and drunk driving law.

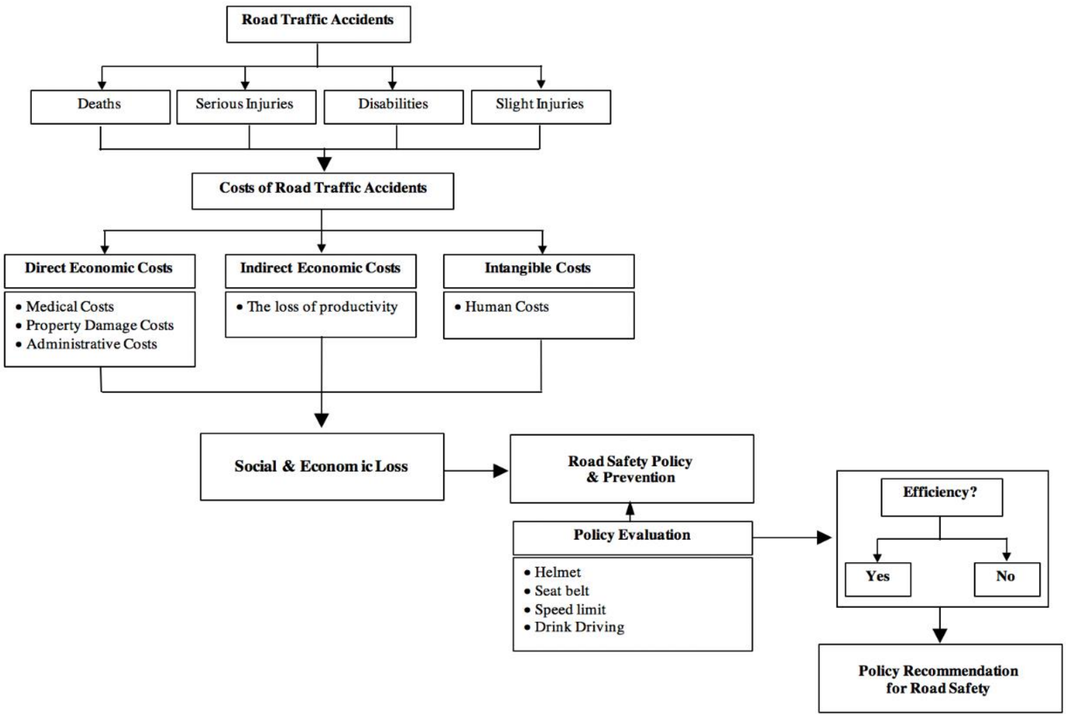

Figure 1 the conceptual framework

The efficient assessment is necessary for policy recommendations to improve the road safety measures. This study uses cost-effectiveness analysis (CEA) to assess the road safety policy. The CEA is for measure costs and benefits in a natural unit and allows the benefits to be compute in non-monetary terms, both number of death reduction and number of accident reduction. CEA is then calculated costs per outcome unit which indicates how many resources had to be paid to save one unit of outcome. This ratio is called CEA ration.

Significance of the Study

Thailand road traffic accidents are considered the productivity loss due to the reduction of human capital potential from injuries and disabilities, and premature death of labors. Even if Thailand has four policy by the WHO recommended included drunk driving law, limited speed law, seatbelt law, and helmet law in order to reduce and prevent road traffic crashes. But the trend also indicated that the number of deaths, injuries, and disabilities had been growing up more and more each year. Thus, the government sectors have to collaborate their means with the economists by evaluating their policy so that to get policy recommendation for improving the effectiveness and efficiency of the road safety policy to reduce and prevent road traffic accidents.

Scope and Limitation of the Study

The aim of this dissertation is to estimate the socio-economic damage in terms of the value of productivity loss due to severity injuries, slight injuries, disabilities, and premature deaths from road accidents. Moreover, to evaluate the efficiency of road safety policy and prevention. The scope and limitation of dissertation are defined as follow:

This dissertation is carried out the data in the year 2017 on a national level in Thailand, the number of victims is used data from Road Accident Victims Protection Company Limited, Royal Thai Police report, and the Ministry of Public Health report. The budget of road safety policy and preventions are used the data from the annual government statement of expenditure in 2017.

1. To answer the first objective. The study is to estimate the indirect economic costs as the value of productivity loss due to road traffic accidents only. The number of road accidents have a limitation because of there were not include all of victims, just used the data from three sources as mentioned above for the calculation.

2. The second objective is to evaluate the road safety policy and preventions, finding out the policy were efficiency or not. The scope of the study is focus on four road safety policy including drunk driving law, limited speed law, seatbelt law, and helmet law.

This study is organized as follows: Chapter 2 estimated productivity loss due to road traffic accidents in Thailand. Chapter 3 created the calculator for estimate socio-economic loss caused by road traffic accidents. Chapter 4 evaluated the cost–

effectiveness of road safety policy for preventing and reducing road traffic deaths. Finally, Chapter 5 concludes.

CHAPTER 2
MEASURE OF PRODUCTIVITY LOSS DUE TO ROAD TRAFFIC ACCIDENTS IN THAILAND

Abstract

As one of the top countries with the highest casualties per capita in road traffic accidents, Thailand needs to raise public awareness about the economic loss from road traffic crashes. This paper calculates the value of productivity loss due to road traffic accidents in Thailand in 2017. Extensive data collection and analyses enable to compute income losses over time in case of fatalities, permanent disabilities as well as major and minor injuries. The results reveal that, at the end of 2017, the total amount of productivity loss caused by road traffic accidents alone was approximately 121 billion Baht (45 billions for fatalities, 7 for disabilities, 67.5 for serious injuries and 1.5 for slight injuries), or close to 0.8 percent of the country's GDP, which is very significant. At-risk age groups are determined in each case and we see that the 16-25 age group is bearing the highest burden in all types of accidents. Future policies can then be targeted to types of casualties and to a specific public.

Keywords: Productivity Loss, Road Traffic Accidents, Thailand, Human Capital Approach

Introduction and Conceptual Framework

Thailand ranks among the top ten countries for road fatality rates in the world with approximately 33 deaths per 100,000 people in 2018 (WHO, 2018 A) and a large number of yearly injuries and disabilities. Road traffic accidents became one of the most significant problems in Thailand due to medical treatment, rehabilitation costs, property damage costs, loss of joy of life, and loss of human resources which, taken altogether, sum up to a considerable amount of money. This also impacts the productivity measure of the country as people killed in a road crash obviously cannot produce anymore, while those who are – or become – disabled and people who are injured cannot enjoy the same productivity as before.

As a response to this problem, the Thai government has followed the recommendations of WHO (2013) by setting up four main road safety policy and prevention measures, namely a speed limit policy, a drinking and driving policy, a compulsory motorcycle helmet policy, and a seatbelt policy. A large budget was also set aside for road safety policies. It included a budget for the construction and maintenance of roadways, the treatment and rehabilitation of victims, policy and law enforcement, training, education programs, promotions and campaigns.

On top of classical public policies aimed at road safety, various studies underline other important elements. For example, Gul (2011) found out that “a knowledge about the harm of traffic accidents to the economy is essential if measures to reduce road traffic accidents are to be identified and initiated.” Baum and Hohnscheid (Gitelman & Hakkert, 2006) pointed out that “A better knowledge of safety effects will stimulate more efficient priorities for road safety measures and will enable to employ available resources in such a way as to achieve the greatest possible benefits for society.” Thereby, the information of the socio-economic losses due to road traffic accidents may raise public awareness and an important strategy to reduce road traffic accidents should be coupled with the previously mentioned effective road safety measures. Unfortunately, a recent study by the Thailand Development Research Institute (TDRI, 2017) found that most people lack awareness of the danger of road traffic casualties.

Over the years, a few studies on the economic damage caused by road traffic accidents have been conducted in Thailand. They are summarized in Table 5.

Table 5 Studies in road traffic accidents and their economic impacts in Thailand

Previous Studies	Topic	Cost Components
TDRI (2017)	Road Safety Evaluation Project: Saraburi Province, Thailand	WTP (Willingness-To-Pay) for reducing and preventing Road Traffic Accidents
Ditsuwan, Veerman, Barendregt, Bertram, and Vos (2011)	The National Burden of Road Traffic Injuries in Thailand	Loss of Disability and Adjusted Life Years in 2004
Thanerananon et al. (2008)	The Study of Traffic Accident Costs in Thailand	Productivity Loss, Quality of Life Loss, Medical and Emergency Service, Long Term Care, Property Damage. Insurance Administration, Police Administration, Judicial System, Emergency Rescue Services, and Dept. of Transport
Thongchim, Taneerananon, Luathep, and Prapongsena (2007)	Traffic Accident Costs in Thailand	Productivity Loss, Quality of Life Loss, Medical and Emergency Service, Long Term Care, Property Damage. Insurance Administration, Police Administration, Judicial System, Emergency Rescue Services, and Dept. of Transport
Suwanrada et al. (2005)	Loss due to Road Traffic Accidents in Thailand	Loss of output by deaths, injuries, and disabilities, Loss of output by Care Taking, Medical Costs, Property Damage, Human Cost

As indicated in Table 5, some research has been conducted for Thailand, but information about damage costs and productivity loss due to road traffic crashes have not been updated or are simply missing. The measurement of productivity loss, as well as basic information to install awareness among Thai people seem to be a necessary first step to be implemented for reducing the number of road traffic crashes. On top of that, taking productivity loss into account, reducing car crashes could potentially increase economic growth according to the World Bank (2018), which estimated that reducing the number of road traffic deaths and injuries by 50 percent could potentially add 22 percent to GDP per capita in Thailand.

The contributions of this paper are the following. First, a few papers have already studied productivity loss due to road traffic accidents in the past but results have not been updated; using the most recent data available, this paper provides that important update. Second, the dataset used in this paper is more precise than before, even though it is far from perfect. As a matter of fact, almost all studies applied to Thailand estimated the number of road accident victims across the country from numbers collected from 5 hospitals in 5 provinces (out of the 76 provinces existing in Thailand at the time). The traffic accident data from this paper are taken from Thai Road Safety Collaboration (Thai RSC, 2018) and collected by the Road Accident Victims Protection Company in every province in Thailand, which enables to use more precise and accurate data. Third, the study concentrates on productivity loss only, that is, it aims at reflecting the value of indirect economic losses, that add up to the direct losses (property damage costs, medical costs, …) more easily grasped by the public so as to raise public awareness about the issue of traffic accidents and so as to have a more precise global picture. Hence, the purpose is not to compute the social costs of road traffic accidents but rather to shed light on indirect costs, that is on productivity loss.

Human capital theory has been frequently used to estimate productivity loss due to road traffic accidents, as shown in Wijnen and Stipdonk (2016), Kasnatscheeuw, Heinl, Schoenebeck, Lerner, and Hosta (2016), the report of Italian Ministry of

Infrastructure and Transport in 2012 (International Transport Forum, 2013) and Ongkittikul et al. (2013). For example, Becker (2007) defined human capital as knowledge, information, ideas, skills, and he adds a special dimension to human capital: individual health. Therefore, the human capital method calculates the loss of output as the declining market value of a product produced by a person or the declining value of income for a certain period of time. In the case of death, the duration considered is consistent with the expected life expectancy of the individual, while in the case of injury, the duration and degree of disability must be considered and the discounted value of future income (Or production) if that person was not injured.

For the purpose of this study, productivity loss is defined as the value of lost income due to a decline in the potential human capital of an individual caused by temporary or permanent disability due to road traffic accidents, as well as the complete loss of production in the case of road traffic fatalities. More precisely, based on ideas coming from Thongchim et al. (2007), Boontarig (2006), and Suwanrada et al. (2005), and as shown later in Figure 1, productivity loss includes the following: (1) lost production in terms of income loss caused by fatalities; (2) lost production in terms of income loss from permanent disability; and (3) lost production in terms of income loss from injuries.

These computations seem necessary to gain a better understanding of the economic losses due to road traffic crash-related deaths and injuries as mentioned previously. Hence, the paper aims at calculating economic damage costs in terms of productivity loss due to the road traffic accident, for the purpose of stimulating more awareness of the public, an important strategy to reduce road traffic accidents.

This paper is organized as follows. Section 2 describes the methods used to evaluate the productivity loss caused by road traffic accidents and introduces the data used throughout this paper. Section 3 describes the results of all computations. Finally, Section 4 concludes.

Computing Productivity Loss due to Road Traffic Accidents in Thailand

1) Theoretical analysis

For the purpose of this paper, as depicted in Figure 2, we separate productivity loss in 3 categories; that is, income losses from fatalities, from being handicapped and from injuries. We draw on previous research and formulations from Wijnen, Schroten, and Hoen (2016), Boontarig (2006), Thanerananon et al. (2008), and Suwanrada et al. (2005).

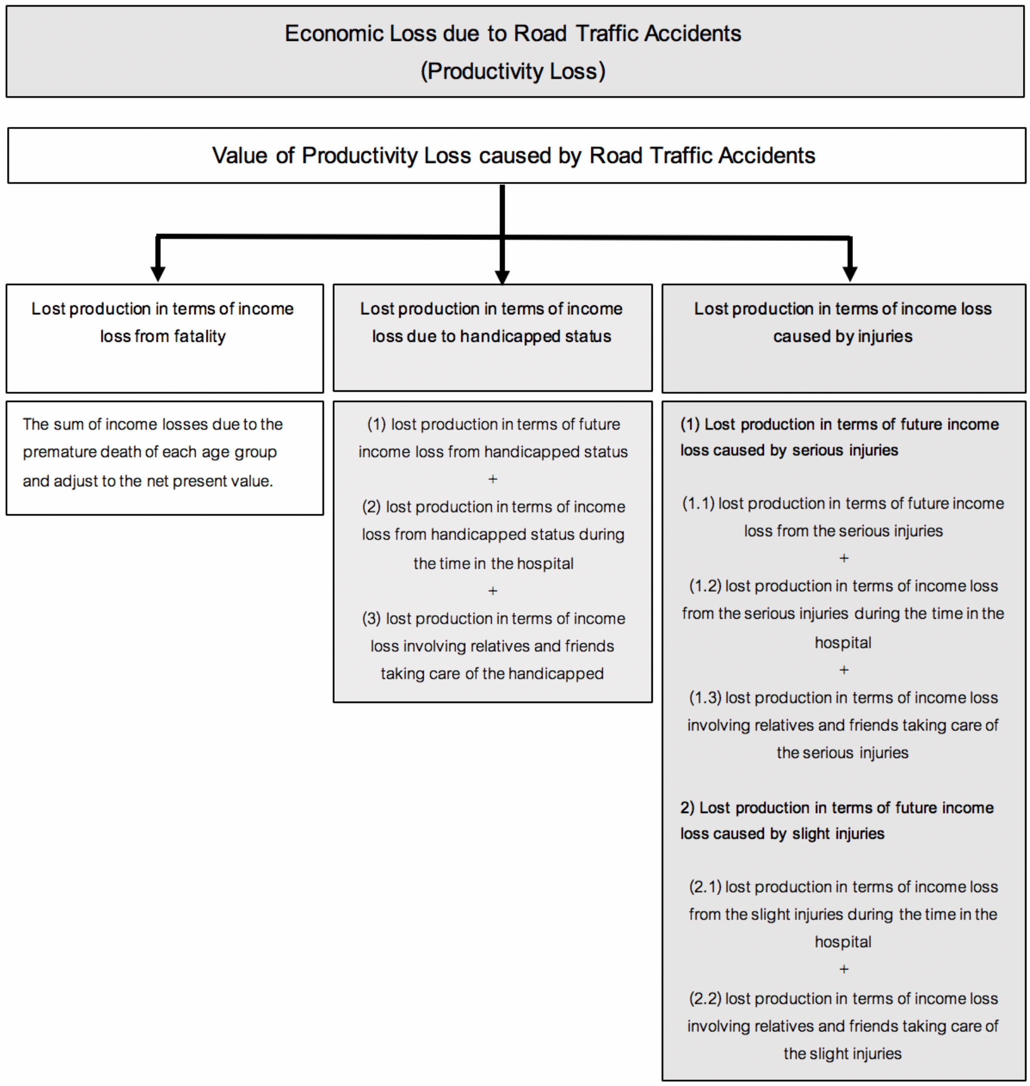

Figure 2 Conceptual Framework

The first category considers lost production in terms of income loss due to fatality. This calculation is based on the Net Present Value (NPV) of foregone income caused by premature deaths of each age group. The sum of these income losses of each age group represents productivity loss due to road traffic fatalities in 2017 and is formulated in Equation (1):

$$\sum_{k=1}^{n} LF_k = ND_k \sum_{i=1}^{e} \frac{Y_i}{(1+r)^i} \tag{1}$$

where $\sum_{k=1}^{n} LF_k$ represents lost production in terms of foregone income from fatalities, ND_k is number of deaths in each age group k, $\sum_{i=1}^{e} \frac{Y_i}{(1+r)^i}$ stands for the foregone income of individuals who have died (present value of income loss for year i (i = 1, 2, 3, … , e), Y_i means GDP per capita of year i (i = 1, 2, 3, … , e), i is time (year, where i = 0 is the year the person dies), e is the remaining number of years of work, and r stands for the discount rate.

The second step computes lost production in terms of income loss from handicapped status (the person cannot work anymore; she/he is permanently disabled). The purpose is to compute the NPV of income loss when handicapped persons are unable to work after their car accident, for each age group, to which ancillary losses during the time spent in the hospital, both for the victims and the persons taking care of the victims, are added. This is summarized in Equation (2).

$$\sum_{k=1}^{n} LH_k = NH_k \sum_{i=1}^{e} \frac{Y_i}{(1+r)^i}$$

$$+$$

$$L_{HH} = (\text{No. of handicapped}) \times (\text{No. of days in hospital}) \times (\text{Average wage per day})$$

$$+$$

$$L_{HCARER} = (\text{No. of handicapped}) \times (\text{No. of days to take care of the handicapped in hospital}) \times (\text{Average wage per day}) \tag{2}$$

Where $\sum_{k=1}^{n} LH_k$ represents lost production in terms of foregone income caused by disabilities, NH_k is number of disabled in each age group k, $\sum_{i=1}^{e} \frac{Y_i}{(1+r)^i}$ stands for foregone income due to handicapped status (present value of income loss of year i (i = 1, 2, 3, … , e)), Y_i is GDP per capita of year i (i = 1, 2, 3, … , e), L_{HH} is the income loss of the victims while in hospital, and L_{HCARER} represents income loss of relatives and friends taking care of handicapped in the hospital.

Two caveats can be noted in that computation. First, using the average daily wage to compute L_{HH} and L_{HCARER} is a strong approximation as the average wage may not be representative for the victims of an accident and their family. Second, heterogeneity in disabilities does exist as it may be conceivable that, for example, intellectual work may continue in spite of physical disability. These two caveats show that there is room for further data research but current data availability does not enable such refinements at present.

The last step considers lost production in terms of income loss caused by injuries. That computation is divided into two groups: serious injuries and slight injuries. In the case of serious injuries, the person can still work but it is assumed that his/her effectiveness is reduced by 30 percent (Thanerananon et al. 2008). This computation adds the NPV of foregone income of each age group to income losses of the seriously injured persons during the time spent in hospital and to income losses of the relatives taking care of the victim in the hospital. The sum of these income losses of each group represents productivity loss due to severe injuries in 2017 as shown in Equation (3).

$$\sum_{k=1}^{n} LSE_k = NSE_k \sum_{i=1}^{e} \frac{Y_i}{(1+r)^i} \times 0.3$$
$$+$$
$$L_{SEH} = (\text{No. of serious injuries}) \times (\text{No. of days in hospital}) \times (\text{Average wage per day})$$
$$+$$
$$L_{SECARER} = (\text{No. of serious injuries}) \times (\text{No. of days to take care of serious injuries in hospital}) \times (\text{Average wage per day}) \tag{3}$$

where $\sum_{k=1}^{n} LSE_k$ represents the value of lost production in terms of foregone income from serious injuries, NSE_k is number of serious injuries in each age group k, $\sum_{i=1}^{e} \frac{Y_i}{(1+r)^i}$ * 0.3 represents foregone income from serious injuries (present value of income loss of year i), L_{SEH} is lost production in terms of income loss from serious injuries during time spent in the hospital, and $L_{SECARER}$ represents lost production in terms of income loss of relatives and friends taking care of serious injuries in the hospital.

The second part of the computation concerns slight injuries. Those types of injuries do not have long term consequences. Hence, Equation (4) only takes into account income losses while in the hospital, both for the victim and the potential relatives or friends:

$$\begin{gathered} L_{SLH} = (\text{No. of slight injuries}) \times (\text{No. of days in hospital}) \\ \times (\text{Average wage per day}) \\ + \\ L_{SLCARER} = (\text{No. of serious injuries}) \\ \times (\text{No. of days to take care of slight injuries in hospital}) \\ \times (\text{Average wage per day}) \end{gathered} \tag{4}$$

where L_{SLH} is lost production in terms of income loss from slight injuries during time spent in the hospital, and $L_{SLCARER}$ represents lost production in terms of income loss of relatives and friends taking care of slight injuries in the hospital.

Because these losses are all measured in terms of a monetary metric, we can compute total productivity loss by adding all 3 components (as well as their sub-components). This also provides information about the indirect economic damage cost caused by road accident for raising awareness on road safety among Thai people

2) Data

The data used to estimate productivity losses detailed above are taken from various sources. For the number of deaths, disabilities, and injuries, this study uses data of the Road Accident Victims Protection Co., Ltd. from Thai RSC (2018). This is the most reliable data source that provides information about the number of victims. Injuries are separated into two categories: serious and slight injuries, the proportion of which can be estimated from the Bureau of Non-Communicable Disease (The National Statistical Office, 2018) that provides data about the severity of road accidents. GDP per capita comes from the World Bank (Fumagalli et al., 2017). Finally, the Social and Quality of Life Database System (The National Statistical Office, 2018) provides labor force participation rates for various age groups so as to compute the number of years individuals are expected to work. More precisely, labor force participation multiplied by the age span of each age group determines the years of attendance, that are then summed from that age group to the last one to determine the remaining numbers of years of work, as shown later in Table 3.

The last data used for this study are the following: the average exchange rate (from 2013-2017) is set at 33.39 Baht/1 US dollars (Bank of Thailand, 2018), the discount rate used here is 6.47 percent, as computed with data from The Global Economy (2018), the length of stay in hospital in case of disability is set at 25 days, the duration of hospital stay for serious injuries is 16 days while the number of days in hospital due to slight injuries is equal to 5 days as in Lee et al. (2016). Moreover, we assume the ratio of relative or friend to the victim is equal to 1; that is, only one relative or friend (per day) does take care of a victim for the entire duration of her stay in the hospital (Thongchim et al., 2007). And finally, the average wage per day in Thailand is equal to 465.71 Baht in 2017 (Trading Economics, 2018).

Results

1) Basic Information

As mentioned before the number of traffic victims in this study was collected from the Thai RSC (2018) and from The Office of the National Economic and Social Development Council (2018), and the Royal Thai Police (2018), which enables us to classify the severity of accidents by age group as shown in Table 6.

Table 6 severity of accidents by age group in 2017

Age Group	Fatalities	Serious injuries	Slight injuries	Disabled	Total
0 - 15	807	5,967	40,647	184	47,605
16 - 25	3,148	15,563	106,025	485	125,221
26 - 35	1,587	7,909	53,880	245	63,621
36 - 45	1,375	6,509	44,343	201	52,428
46 - 55	1,370	5,788	39,432	179	46,769
56 - 70	1,550	5,257	35,814	162	42,783
70+	666	1,141	7,772	33	9,612
Total	**10,503**	**48,134**	**327,913**	**1,489**	**388,039**

Source: own computations based on Thai RSC (2018), the office of the National Economic and Social Development Council (2018) and Royal Thai Police (2018)

The advantage of the Thai RSC database is that it is possible to disaggregate the severity of accidents from fatalities to slight injuries. Other organizations such as WHO (2018) publish reports on road traffic deaths. Their estimation for 2016 is much higher than our estimates from 2017 (21,745 versus 10,503) which means that the computations undertaken below should be seen as the lower bound of the productivity loss. We nevertheless decided to use the Thai RSC database because, even though it brings about different aggregate results than those of the WHO, it enables to consider various age groups and various types of accidents, which is important to our analysis. In any case, our estimations are probably conservative but they have the advantage of considering the per-age group costs of injuries and disabilities on top of fatalities.

Table 6 shows that adolescents and young adults (age 16-25) are in a much more severe situation than any other age group. They are followed by age group 26-35 and age group 36-45. This is true for all accident types, from the worst until the lightest. As these three age groups are considered the most important labor force of the country in terms of numbers, they will be the ones who will incur the largest income loss if they have car accidents and this will automatically result in the largest production loss for the country.

Computations of the remaining years of work come from data made available by the Social and Quality of Life Database System (The National Statistical Office, 2018) and is developed above in Section 2.2. Results are depicted in Table 7.

Table 7 labor force participation rate, years of attendance, and remaining years of work

Age Group	Age Range	labor force participation rate	Years of Attendance	Remaining Years of Work
0 - 15	15	0.1170	1.755	41
16 - 25	10	0.4733	4.733	40
26 - 35	10	0.8716	8.716	35
36 - 45	10	0.8764	8.764	26
46 - 55	10	0.8223	8.223	17
56 - 70	15	0.4652	6.978	9
71 - 75	5	0.3470	1.735	2

Source: calculated from Social and Quality of Life Database System (mentioned in the National Statistical Office, 2018).

As shown in Table 7, labor force participation is the highest between ages 26 to 55. However, about half of those between the ages of 16 and 25 do work and since Thailand has a large number of young adults, this group is not trivial. Since many accidents concentrate on the three age groups spanning from 16 to 45 years old, as shown in Table 2, we can see that potential income loss computations may quickly reach large numbers since remaining years of work are respectively of 40, 35 and 26 for these groups.

2) Productivity loss due to road traffic accidents in Thailand.

Cost of fatalities caused by road traffic accidents are computed from Equation (1) and detailed in Table 8.

Table 8 productivity loss in terms of foregone income from road traffic fatalities

Age Group	No of Fatalities	Cost of Fatalities (Dollar)	Cost of Fatalities (Baht)
0 – 15	807	136,425,691	4,555,253,822
16 – 25	3,148	526,850,602	17,591,541,601
26 – 35	1,587	250,292,959	8,357,281,901
36 – 45	1,375	184,805,913	6,170,669,435
46 – 55	1,370	138,918,164	4,638,477,496
56 – 70	1,550	96,410,729	3,219,154,241
71 – 75	666	13,254,745	442,575,936
Total	**10,503**	**1,346,958,803**	**44,974,954,432**

As expected, Table 8 shows that adolescents and young adults (age group 16-25) are hardly hit as the value of loss is around 17.6 billion Baht. This is followed by the age group 26-35 (almost 8.4 billion Baht) and the age group 36-45 (over 6 billion Baht) respectively. Those three groups account for more than 71 percent of the global cost of fatalities. In total, the value of lost production in terms of foregone income from road deaths approached 45 billion Baht in 2017.

Lost production in terms of foregone income from handicapped status is detailed in Table 5 and computed from Equation (2). Its total value was over 7 billion Baht in 2017.

Table 9 lost production in terms of future income loss due to handicapped people

Age Group	No of Handicapped	Cost of Handicapped (Dollar)	Cost of Handicapped (Baht)
0 - 15	184	31,645,351	1,056,638,270
16 – 25	485	81,649,793	2,726,286,588
26 - 35	245	39,134,653	1,306,706,064
36 - 45	201	27,446,971	916,454,362
46 - 55	179	18,413,856	614,838,652
56 - 70	162	10,258,848	342,542,935
71 - 75	33	712,174	23,779,490
Total	1,489	209,261,646	6,987,246,360

Here, we see that the large majority of the costs is borne by younger people. The first three age groups represent more than 70 percent of the total value of the cost of becoming handicapped after a car traffic accident.

The value for the other elements of Equation (2) reaches 17,336,055 Baht (1,489 $\times$ 25 $\times$ 465.71) for income loss while in the hospital. Income loss of relatives and friends taking care of the disabled person is of the same amount, that is, 17,336,055 Baht, since, by hypothesis, a friend or relative can stay for the entire duration of the hospital treatment.

Hence, income loss from disabilities in 2017 was 7,012,918,470 Baht (6,978,246,360 + 17,336,055 + 17,336,055) or more than 7 billion Baht.

The third cost relates to injuries, knowing that they can be serious or minor. Serious injuries concern persons who can continue working after their accident but with an effectiveness assumed to be reduced by 30 percent. This is estimated by Equation (3). Results are laid out in Table 6 and valued at 66,835,138,076 Baht or almost 67 billion Baht in 2017. (If the percent of effectiveness reduction changed from 30% to 40%, the total value of productivity loss of serious injuries is about 90.55 billion Baht, moreover, if there is a 20% reduction in work effectiveness, the productivity loss from serious injuries is almost 45.28 billion Baht)

Table 10 lost production in terms of future income loss caused by serious injuries

Age Group	No of Serious Injuries	Cost of Serious Injuries (-30%) (Dollar)	Cost of Serious Injuries (-30%) (Baht)
0 - 15	5,967	302,600,905	10,103,844,218
16 - 25	15,563	781,402,320	26,091,023,465
26 - 35	7,909	374,208,887	12,494,834,737
36 - 45	6,509	262,453,535	8,763,323,534
46 - 55	5,788	176,076,036	5,879,178,842
56 - 70	5,257	98,098,003	3,275,492,320
71 - 75	1,141	6,811,649	227,440,960
Total	**48,134**	**2,001,651,335**	**66,835,138,076**

As can be seen in Table 10, the age group between16-25 years old remains the worst group and it represents about 39 percent of the global value, with a productivity loss amounting to 26 billion Baht. It is followed by age group 26-35 (over 12 billion Baht) and the children group (over 10 billion Baht) respectively.

Calculations of foregone income from serious injuries during the time spent in hospital shows a value of 358,663,762 Baht (48,134 × 16 × 465.71) and so is the value of income loss of relatives and friends taking care of seriously injured patient.

Hence, total lost production in terms of foregone income from serious injuries was 67,552,465,600 Baht (66,835,138,076 + 358,663,762 + 358,663,762) or over 67.5 billion Baht in 2017.

Equation (4) now computes total lost production in terms of foregone income from slight injuries. It amounts to 1,523,770,520 Baht or over 1.5 billion Baht in 2017. Both terms show a value 761,885,260 Baht (327,913 × 5 × 465.71), the first one corresponding to the cost of the victim's stay in a hospital and the second, to care-taking by a friend or a family member.

Consequently, as shown in Table 11, total lost production in terms of foregone income from injuries was 69,076,236,120 Baht (67,552,465,600 + 1,523,770,520) or over 69 billion Baht in 2017.

Table 11 summarizes the value of productivity loss due to road traffic accident in 2017 as the sum of the various elements laid out in Figure 1. The total value reaches 121,064,109,022 Baht ((1) + (2) + (3)) or around 121 billion Baht. The average cost of a road accident per victim is therefore 311,990 Baht which corresponds to an average of 670 lost days of work per victim. This clearly shows that costs to society for road traffic accidents are very large and so is the impact on GDP for the country.

Table 11 the value of productivity losses in terms of foregone income caused by road traffic accident in 2017

Costs	Baht	No. of Victims	Cost per Victim
(1) The value of productivity loss from fatalities	44,974,954,432	10,503	4,282,106
(2) The value of productivity loss from becoming handicapped	7,012,918,470	1,489	4,709,818
(3) The value of productivity loss from injuries			
(3.1) Serious injuries	67,552,465,600	48,134	1,403,425
(3.2) Slight injuries	1,523,770,520	327,913	4,647
Total	**121,064,109,022**	**388,039**	**311,990**

Conclusion

This study estimated the economic damage caused by road traffic accidents in Thailand in 2017. The estimation process was carried out using the productivity loss of the human capital approach and updating previous national economic damage cost estimates.

The human capital approach used here computes monetary value of future lost production. Other techniques could have nevertheless been used. For example, the life-insurance approach uses the premium paid and the insured amount in the computations; however, not everyone is insured and additionally, this method does not provide information for friends or family taking care of injured or disabled victims in hospitals. The Value of Risk Change or the Willingness-To-Pay are two other approaches frequently used and worth considering but we felt that the human capital approach was the best method to exploit the data we collected and computed.

In undertaking this analysis, we divided the Thai population in 7 age groups and classified accidents according to their severity so as to have types of injuries per age group. We then computed the remaining years of work per group in order to determine the monetary value of productivity loss for each of the 28 cases (4 injury types and 7 age groups). Summing all of this provides the global indirect cost of road traffic accidents.

Some of the findings are pinpointed here. First, on a global scale, the value of productivity loss due to road traffic accidents included the following: (1) 45 billion Baht of productivity loss from road traffic fatalities with an average cost per death of 4.2 million Baht; (2) 7 billion Baht of productivity loss from becoming handicapped or 4.7 million Baht per person; (3) 67.5 billion Baht of productivity loss from serious injuries with approximately 1.4 million Baht per serious injury; and (4) over 1.5 billion Baht with 4,647 Baht per minor injury. The total amount of damage was approximately 121 billion Baht or nearly 0.8 percent of the country's GDP in 2017 (15,452 billions). Second, the age 16-25 was the worst group in each category: fatalities, handicapped, and injuries. Younger people therefore bear the largest share of the economic burden. This is so not only because they are the age group that has the largest remaining years of work, but also because, in absolute value, they outnumber any other age group in terms of number of fatalities, disabilities and injuries. These numbers are striking and those computations can be used to increase the awareness for better traffic policies.

There nevertheless remain various caveats in the analysis. First, we assigned pre-determined values to various parameters such as the discount rate, the duration of hospital stays and we used the average wage at the national scale and not wages that vary per region and/or per age group. Second, as always, data is limited. We tried to use and compute disaggregated data for considering various age groups and various accident types but a more detailed analysis would require additional data collection and this may be an avenue for further research. Third, the analysis is not dynamic as we concentrate on productivity loss for 2017. Finally, our computations may be considered as a lower bound of the total indirect costs of road traffic accidents. On the one hand, our estimation of fatalities is far below that of WHO but on the other hand, the productivity losses due to fatalities only account for 37% of the total output loss (45 out of 121 Million Baht).

In other words, this study is the early step in gathering and computing economic damage information and this could help policymakers raising public awareness about road traffic accidents. Computations undertaken here may have a trigger effect for both government officials in understanding the urgency to tackle the road accident issues and for citizens to understand the dangers (especially for certain age groups) and potentially change their behavior while driving.

Obviously, no policy can help reaching a zero-accident level. However, a maximum of 121 billion Baht could be saved each year with adequate policy measures. There is room for undertaking public policies aimed at reducing casualties. As shown in Table 6 and in the following Tables, those public investments should be targeted to teenagers and young adults who are those suffering the most in terms of fatalities, in terms of risks of becoming handicapped after an accident and in terms of injuries. The benefits – understood as reduced loss of productivity – of tougher policies and/or better awareness about the dangers of driving would likely outweigh the costs of setting up those policies.

It is important to further investigate prevention programs and programs aimed at reducing the burden of road traffic accidents. Education to promote awareness of potential income losses and the importance of controlling risky behaviors can be beneficial for health promotion activities. Such programs should also be targeted towards specific age groups, namely teenagers and young adults. And for the future cost of road traffic accidents calculation, the sensitivity analysis should be performed to identify the reduced efficiency of labor in terms of productivity loss from serious injuries.

CHAPTER 3
COMPUTATION FOR SOCIO-ECONOMIC LOSS DUE TO ROAD TRAFFIC ACCIDENTS IN THAILAND

Abstract

This study aimed to estimate the socio-economic damage caused by the severity of road traffic accidents to the victims in Thailand in 2017 by creating the road accident costs calculator. The evaluation is also updating previous national economic damage cost estimates by using the road traffic accident costs from so many related studies as a proxy to calculate the cost components. For the methods, the compensation payment approach was used to evaluate the direct economic cost included medical costs, property damage costs, and administrative costs. While the human capital approach was used to assess productivity losses, and the rule of thumb was used for estimating human costs (painful, sorrow, etc.). The initial results show that the road accident costs calculator can give the cost estimation quickly and clearly. There may be limitations in calculations since this study uses the average cost of previous studies for calculations; however, this calculation allows users to modify the value to reflect the actual cost. The study also recommends doing the valuation of road accident damage costs by gender or types of vehicles for future work.

Keywords: Road Traffic Accidents, Compensation Payment, Road Safety Thailand

Introduction

The data of road accident insurance claim from Road Accident Victim Prevention Company Limited indicated that the number of traffic accidents increased continuously, from 195,447 cases in 2010 to 328,952 cases in 2017 or raised by 68.31 percent (calculated from Thai RSC, 2018). That is caused a higher rate of road traffic deaths, disabilities, and injuries (as shown in Figure 3), leading to the loss of life, health, and property to the road traffic victims and those involved.

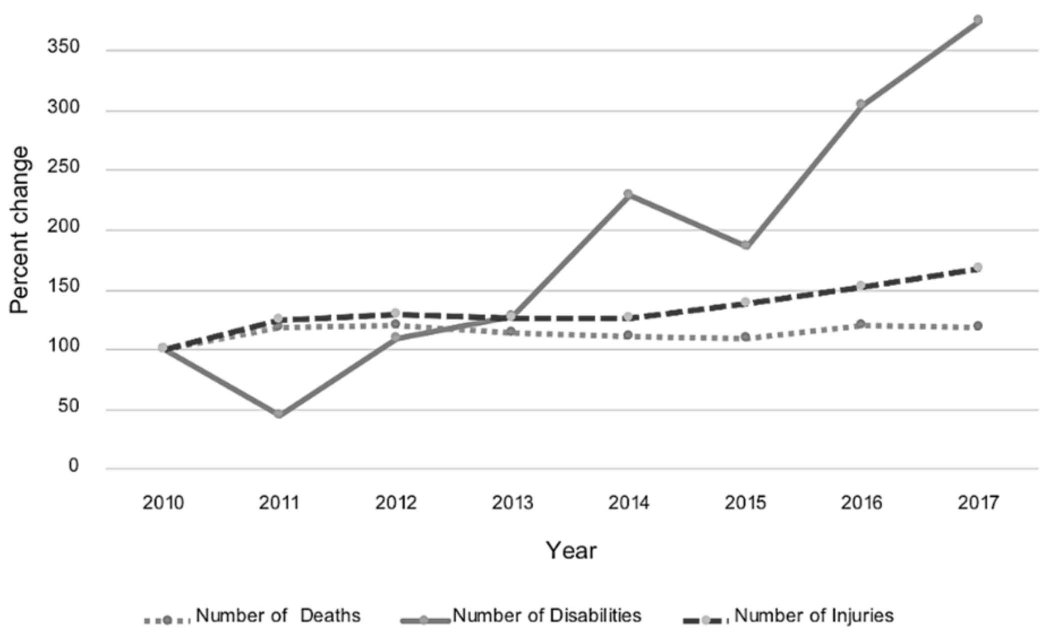

Figure 3 the percent change of the road accident insurance claim, 2010 – 2017

Source: Thai RSC (2018).

Thai law stated that the person who causes the road traffic accident (an accused) is subject to criminal action. The plaintiff and their relatives can file a claim for compensation to tort under the Civil and Commercial Code, section 420 "A person who, willfully or negligently, unlawfully injures the life, body, health, liberty, property or any right of another person, is said to commit a wrongful act and is bound to make compensation therefore" (Wiriyayuththanggul, 2013). However, even though the Thai law has provided the principle of determining compensation payment, there is no precise calculation method. The compensation payment is the discretion of the court and interprets the law in an attempt to reduce the claim for compensation. It can be seen that the current compensation claim is inappropriate (Sitthiprasert, 2018). If there are clear and correct loss assessment criteria, it will help to solve the problem of incorrect claim determination. Therefore, the guidelines for assessing the loss due to road traffic accidents are needed.

There were so many studies that summarized the cost components due to road traffic accidents, such as the final report of action by the European Commission, COST 313 (Alfaro, Chapuis, & Fabre, 1994). They studied the socio-economic costs of road traffic accidents in 14 European countries and mentioned that the cost-elements of road crash were medical costs, lost productive capacity, human costs, and other costs. Decade years later, the study of Trawén, Maraste, and Persson (2002) examined the international costs of road accident deaths in 1990 and 1999. They summarized that costs per road accident fatality as direct cost (health care, property damage, administrative), indirect cost (loss of productivity capacity) plus the value of safety per se (loss of value of statistical life, human costs). The recent study, Wijnen and Stipdonk (2016), examined the social costs of road traffic accidents from 17 countries of which ten high-income countries and seven low-middle income countries based on the publication of those countries can conclude those cost components as medical costs, production loss, human costs, property damage, and administrative cost. Therefore, five cost components of road traffic accident from international guidelines are:

1) Medical cost, this expense is incurred from first aid, transportation, emergency departments, inpatient hospitalization, outpatient hospitalization, outpatient treatment including assistants and electrical appliances (Boontarig, 2006; Trawén, Maraste, & Persson, 2001). The compensation method is used to calculate this cost. This method is to combine all medical expenses, and the current market price or proxy price will be used to pay attention to these costs if any. The effectiveness of medical fees depends on the availability and quality of the data source. (Kasnatscheeuw et al., 2016)

2) Administrative cost, this cost includes administrative expenses for insurance companies, police and court due to road accidents (Trawén, Maraste, & Persson, 2001) as well as medical expenses, methods of calculating administrative costs. Is the consolidation of all these expenses (Excluding the prevention of road crashes by police officers, transporting the dead to the hospital as part of Included in the cost calculation for property damage and will result in double counting) and the current market price or proxy price will be used to assess these costs if they exist. (Kasnatscheeuw et al., 2016)

3) Property damage cost, this cost includes damage to vehicles, public goods, roads and roadside objects (Wijnen & Stipdonk, 2016; Boontarig, 2006). The method of calculating property damage is to combine all these costs and assessed according to current market prices or proxy prices as well.

4) Productivity capacity loss, this Cost is the loss of productivity and income due to temporary or permanent disability from road accidents and the complete loss of production of road traffic deaths (Wijnen & Stipdonk, 2016).The human capital approach is used to determine production losses to society resulting from road traffic deaths. The cost of production losses is an indirect accident expense. The human capital method is equal to the value of society and the discount market value of the products produced by an individual over a period of time. In the case of death, it corresponds to the expected life expectancy, while in the case of the injured must consider the duration and the level of disability. It evaluates the discounted value of future income. (Or production) that is otherwise recognized. The difference between primary production losses and net production losses Gross production losses include consumption losses, while net production losses do not take into account the value of future consumption losses. Initial production losses can be measured by adding value. Many indicators of production losses may be used, such as Gross Domestic Product per capita and income. (Kasnatscheew, A. et al., 2016; Wijnen and Stipdonk, 2016)

5) Human costs, the human costs are psychological costs such as pain, grief, and loss of happiness in life or quality of life (Wijnen & Stipdonk, 2016). This expense can be assessed with the Willingness-to-pay method. (WTP) Within the WTP guidelines, cost calculations are based on the amount that losers are willing to pay to avoid injury or death respectively to reduce the risk. In contrast to the WTP method, the willingness to accept the method of measuring the number of people willing to accept the increased risk. (Kasnatscheew et al., 2016; Ongkittikul et al., 2013)

In addition, the studies of Bahamonde-Birke, Kunert, and Link (2015) and Bickel et al. (2006) suggested to group the cost components into three families: 1) direct economic costs represent all direct expenditures related to road traffic casualty, including medical expenses, administrative costs, and police and property damage costs. 2) Indirect economic costs comprise social and economic losses due to production capacity loss caused by road accidents. And 3) intangible losses or human costs such as psychological costs such as suffering, pain, sorrow, and loss of joy of life or quality of life, etc. Besides, there are so many methods to estimate the cost depend on the severity of road traffic accidents. Ideally, a road traffic fatality is any person who is killed outright or dies within 30 days (Risbey, de Silva, & Tong, 2007), cannot consume anymore. While the severe disability led to complete or substantial permanent incapacity to work in the current occupation, caused to consume less. For injured people from road traffic crash may consume less as a result of their injuries.

The three families of cost components and their valuation methods were shown in Figure 4 below. The first two approaches constitute monetary amounts or refer to items that can be easily monetized while the willingness to pay approach is the intricate valuation of the intangible losses.

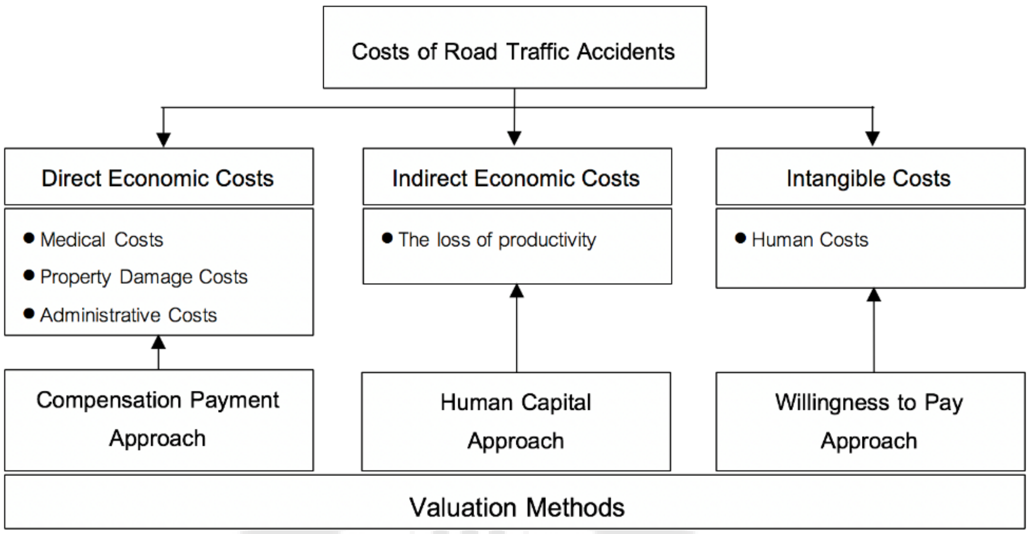

Figure 4 costs of road traffic accident and their valuation methods

Moreover, the recent study of Yudee and Nilbai (2019) suggested that the payment of compensation should be different, depends on the cost components from various accident severity levels. For example, in the case of fatal, the foregone income and property damage should be calculated as the claim for compensation. While in the case of injury, the payment to tort should consist of medical treatment cost, the present and future income losses, as well as property damage costs, etc.

As you can see, the accurate computation of road accident damages by the severity of road traffic accidents to the victims is significant and necessary. Therefore, this study aimed to create a calculation on road accident costs per person and classify these costs by the severity of the accident to the victims. In order to help the victims and their relatives, lawyers, mediators, judges, attorneys, polices, and related organizations to determine the compensation with not too much or too little claim. It can use as cost information for negotiating in the process of mediation in the court or before the trial to make the case quickly and fairly. Moreover, it believed that the measurement of road traffic accident costs might install awareness about road safety among Thai people as well.

This paper was organized as follows. Section 2 describes the methods used to create a calculation on the road accident damage costs and introduces the data used throughout this paper. Section 3 depicts the results of all computations and the manual of road traffic accident costs' calculator. Finally, Section 4 concludes.

Methods

For the purposes of this study, there were separated the severity of road traffic accidents to the victims into four categories: death, disability, serious injury, and slight injury, as shown in Figure 5. The study used previous research and formulas to create a calculation on the road accident damage costs per person, then to build the road accident costs calculator.

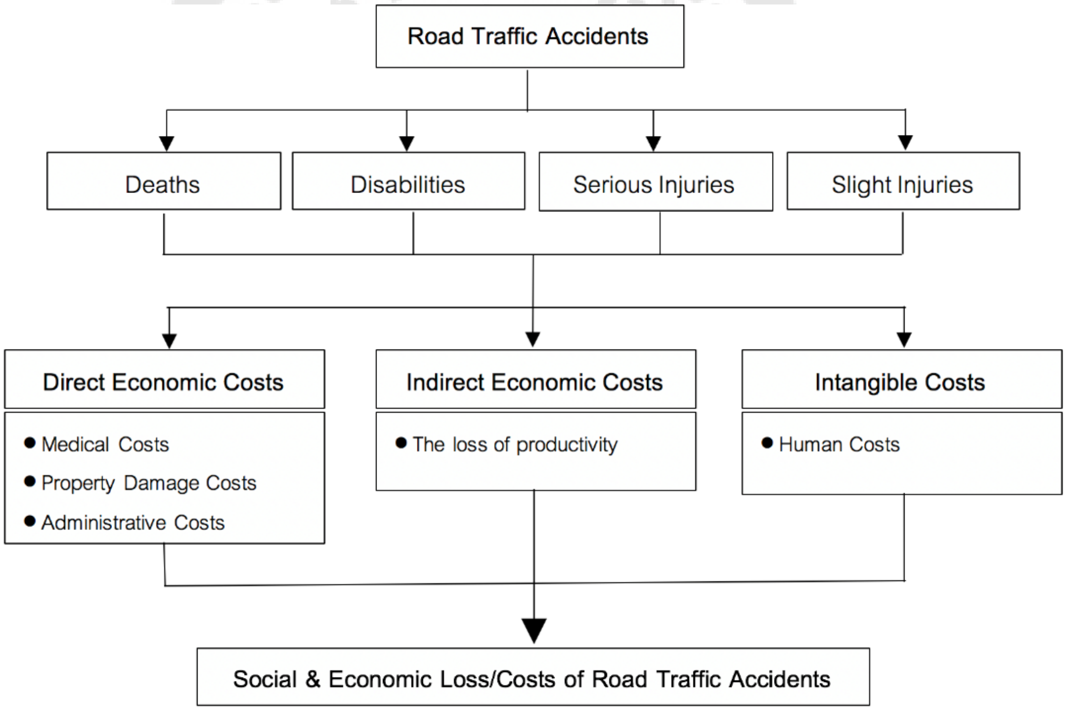

Figure 5 conceptual framework: estimating costs of road traffic accidents

1. Road Accident Costs Calculation Methods

The calculation of cost components is divided into three families, as mentioned earlier, the details and data used can be explained as follows:

1.1) Direct Economic Costs

1.1.1) Medical Costs

1.1.1.1) Medical Treatment Cost: MTC (Baht per Casualty)

$$MTC = \sum_{i=0}^{n} C_i$$

Where MTC is the medical treatment cost per person in 2017. C_i is the charge of care per day of day i (i = 0, 1, 2, …, n), n = 5 in case of slight injury, n = 16 in case of serious injury, and n = 25 in case of disabilities (the number of days in the hospital of road traffic victims has followed the study of Lee et al., 2016).

This study has used the charge of care per day data in 2013, from the study of Upakdee and Pannarunothai (2017) to calculate the average medical cost per victim by the severity of road accident to the victims. While the consumer price indexes in 2014 - 2017 from Bank of Thailand (2019) are used to adjust the charge of care per day into present value in 2017.

1.1.1.2) Long Term Care Cost: LTC (Baht per Casualty). For disability caused by road traffic accidents, there will be a cost of long-term care. The formula for calculating long-term care cost for each age group is:

$$LTC_A = \sum_{t=0}^{T} M \frac{(1+g)^t}{(1+r)^t}$$

Where LTC_A is the long-term medical cost of disability person at the age of A, M represents the average of medical cost per person in 2017, g is the annual increasing rate of medical cost, r means the discount rate, and T stands for the remaining number of years of work at the age of A (Thanerananon et al., 2008).

The long-term care costs have been used as healthcare costs for people with disabilities. It is assumed that the annual medical cost increase is 3.5%, according to a study by Thanerananon et al. (2008). While the discount rate was 2% or 5% or 6.47% (Bank of Thailand, 2019; CEIC, 2020; The Global Economy, 2018)

1.1.1.3) Emergency Medical Service: EMS (Baht per Casualty)

$$MSC = Prob._{EMS} \times C_{EMS}$$

Where MSC is the cost per casualty of emergency medical service, $Prob._{EMS}$ represents the probability of using emergency medical service, and C_{EMS} represents the average cost of emergency medical service.

The average emergency medical service cost was calculated from Raksakol Hospital (2019) set as 3,250 Baht per case in 2017 while the probability of using emergency medical service computed from the ratio of accidents to cases transferred by the emergency medical service unit by severity, was following the study of Thanerananon et al. (2008), as shown in Table 12.

Table 12 the probability of using emergency medical service by severity of road accident to the victims

The Probability of Using Emergency Medical Service by Severity			
Death	Disability	Serious Injury	Slight Injury
0.60	0.73	0.73	0.07

Source: Author’s calculation from Thanerananon et al. (2008).

1.1.2) Property damage cost

1.1.2.1) Average Vehicular Damage Cost: VDC (Baht per Crash). The average vehicle damage costs from the study of Kazmi and Zubair (2014) were adjusted into Baht, and the consumer price indexes in 2008 - 2017 from Bank of Thailand (2019) used to improve costs as shown in Table 13 to the current value in 2017.

Table 13 the average vehicle damage costs by severity of road accident to victims in 2008

(Bath per crash)

The Average Vehicular Damage Cost by Severity			
Death	**Disability**	**Serious Injury**	**Slight Injury**
212,406	120,180	120,180	4,509

Source: edited from Thanerananon et al. (2008).

1.1.2.2) Average Non-Vehicular Damage Cost: NDC (Baht per Crash).

The average cost of non-vehicle damage was approximately 3,021 baht per crash in 2014 (Pradubboon, Phannaen, & Prathumsutra, 2014). The consumer price index between 2014 - 2017 from Bank of Thailand (2019), is used to adjust this cost to present value in 2017.

1.1.3) Administrative costs

1.1.3.1) Police Administration Cost: PAC (Baht per Crash).

The report of Sugiyanto (2017) pointed out that the administrative cost is minimal compared to other cost components. No matter how, the PAC was included in this study, and set at 500 Baht per crash as mentioned in the survey of Luathep and Tanaboriboon (2005)

1.1.3.2) Insurance Administration Cost: IAC (Baht per Crash)

The insurance administration cost was adopted from Thanerananon et al. (2008), equal to 1,302 Baht per crash for all severity levels. And the probability of the number of crashes referred to the number of insurance claims was set at 0.82.

1.1.3.3) Judicial Administration Cost: JAC (Baht per Crash)

$$JAC = Prob._{JAC} \times C_{JAC}$$

Where JAC is judicial administrative cost per crash, $Prob._{JAC}$ represents the percentage of number of cases referred to court, C_{JAC} represents the average judicial administrative cost due to road traffic accident

The judicial administration cost was adopted from Thanerananon et al. (2008), set at 34,333 Baht per crash for all severity levels. And the probability of number of crashes referred to court was set as shown in Table 14:

Table 14 the probability of number of crashes referred to court by severity of road accident to the victims

The probability of number of crashes referred to court by severity			
Death	**Disability**	**Serious Injury**	**Slight Injury**
0.88	0.55	0.55	0.005

Source: Author's calculation from Thanerananon et al. (2008).

1.2) Indirect Economic Costs

1.2.1) Loss Production in terms of Foregone Income Loss: $LFI^{A}_{severity}$(Baht per Casualty)

$$LFI^{A}_{severity} = \sum_{i=1}^{e} \frac{Y_i}{(1+r)^i}$$

Wherein $LFI^{A}_{severity}$ represents lost production in terms of future income by severity levels at the age of A , $\sum_{i=1}^{e} \frac{Y_i}{(1+r)^i}$ stands for the foregone income of individuals who have died (present value of income loss for year i (i = 1, 2, 3, … , e), Y_i means Gross Regional Product per capita (GRP per capita) of year i (i = 1, 2, 3, … , e) from DGA Open Government License (2020), i is time (year, where i = 0 is the year the person dies or injured), e is the remaining number of years of work, and r stands for the discount rate. In addition, for the case of serious injuries assume effectiveness reduced by 30% (Thanerananon et al., 2008). This calculation is not included in the case of slight injuries.

1.2.2) Loss Production in terms of Income Loss of the victims while they were in the hospital: $LFH_{severity}$ (Baht per Casualty)

$$LFH_{severity} = (\text{No. of days in hospital}) \times (\text{average wage per day})$$

Wherein $LFH_{severity}$ is the income loss of the disabilities or serious injuries or slight injuries while they were in the hospital.

1.2.3) Loss production in terms of income loss involving those relatives and friends who take care of the injured and the disabled: $LRF_{severity}$ (Baht per Casualty)

$$LRF_{severity} = (\text{No. of days to take care}) \times (\text{average wage per day.})$$

Wherein $LRF_{severity}$ was the sum of loss of production in terms of carer's income loss while taking care the disabilities/serious injuries/slight injuries in hospital and assumed the number of carers to victim, 1:1 (Thongchim et al., 2007).

The data used to assess the value of productivity losses detailed above are taken from various sources. For the GRP per capita comes from the Bank of Thailand (2020). The discount rate used here is divided into three levels: the low level is 2% (the official rate mentioned in CEIC, 2020), the medium level is 5% (the most frequently used rate), and the high level is 6.47% (computed from Bank of Thailand, 2019 and The Global Economy (2018). The length of stay in hospital in case of disability is set at 25 days, the duration of hospital stay from serious injuries is 16 days while the number of days in hospital due to slight injuries is equal to 5 days as in Lee et al. (2016). Moreover, only one relative or friend (per day) can take care of a victim during the stay in hospital (Thongchim et al., 2007). And finally, the average wage per day in Thailand is equal to 465.71 Baht in 2017 (Trading Economics, 2018).

1.3) Intangible Cost

Human Cost: HC (Baht per Casualty)

Human cost was calculated by the rule of thumb (Wijnen & Stipdonk, 2016), as 15 percent of total cost (social & economic loss). This calculated the total cost by summation the amount from direct cost, and indirect cost together and used the rule of thumb to estimate this number.

2) Road Traffic Accident Costs' Calculator

The study used the cost components and their evaluation methods from above to build the road traffic accident costs' calculator. The conclusion of the cost components of each severity level shown in Table 15 below:

Table 15 the cost components by the severity of road traffic accidents to the victims

The Cost Components	Death	Disability	Serious Injury	Slight Injury
1) Medical Costs				
1.1) Medical Treatment Cost		✓	✓	✓
1.2) Long-Term Care Cost		✓		
1.3) Emergency Medical Service Cost	✓	✓	✓	✓
2) Property Damage Costs				
2.1) Average Vehicle Damage Cost	✓	✓	✓	✓
2.2) Average Non- Vehicle Damage Cost	✓	✓	✓	✓
3) Administrative Costs				
3.1) Police Administrative Cost	✓	✓	✓	✓
3.2) Insurance Administrative Cost	✓	✓	✓	✓
3.3) Judicial Administrative Cost	✓	✓	✓	✓
4) Loss Production in terms of Foregone Income Loss				
4.1) Loss Production in terms of Foregone Income Loss of the victims	✓	✓	✓	
4.2) Loss Production in terms of Income Loss of the victims while they were in the hospital		✓	✓	✓
4.3) Loss production in terms of income loss involving those relatives and friends who take care of the injured and the disabled		✓	✓	✓
5) Human Cost	✓	✓	✓	✓

Results

1. Road Accident Costs by Severity of Road Traffic Accidents

1) Medical costs

1.1) Medical treatment costs

The medical treatment costs of each severity level of road accidents to victims were shown as Table 16 below:

Table 16 the medical treatment cost

(Baht per Casualty)

The Medical Treatment Cost by Severity in 2017		
Disability	Serious Injury	Slight Injury
58,424	52,543	5,821

1.2) Long-term care cost (LTC)

The results of calculation are partly presented for 20 years as shown in Table 17 below:

Table 17 the accumulated long-term care cost

(Baht)

Long-Term Care Cost in 2017 (growth rate = 2%, CPI = 6.47%)			
Year	Accumulated LTC	Year	Accumulated LTC
1	58,424	11	560,127
2	115,218	12	602,926
3	170,428	13	644,531
4	224,098	14	684,976
5	276,271	15	724,292
6	326,988	16	762,512
7	376,291	17	799,665
8	424,218	18	835,783
9	470,808	19	870,892
10	516,099	20	905,023

1.3) Emergency medical service costs

The emergency medical service costs by severity in 2017 were shown in Table 18 below:

Table 18 the emergency medical service cost by severity of road accident to the victims

(Baht per Casualty)

The Emergency Medical Service Cost by Severity in 2017			
Death	Disability	Serious Injury	Slight Injury
1,950	2,373	2,373	228

2) Property damage costs

2.1) Average vehicular damage costs

The average vehicular damage costs by severity of road accident to victims were indicated in Table 19.

Table 19 the average vehicular damage costs by severity of road accident to the victims

(Bath per crash)

The Average Vehicular Damage Cost by Severity in 2017			
Death	Disability	Serious Injury	Slight Injury
221,505	156,568	156,568	4,706

2.2) Average non-vehicular damage costs

The average non-vehicular damage costs by severity of road accident to victims were indicated in Table 20.

Table 20 the average non-vehicular damage costs by severity of road accident to the victims

(Bath per crash)

The Average Non-Vehicular Damage Cost by Severity in 2017			
Death	Disability	Serious Injury	Slight Injury
3,338	3,338	3,338	3,338

3) Administrative costs

3.1) Police administration costs

The police administrative costs by severity of road accident to victims were indicated in Table 21.

Table 21 the police administrative cost by severity of road accident to the victims

(Bath per crash)

The Police Administrative Cost by Severity in 2017			
Death	Disability	Serious Injury	Slight Injury
500	500	500	500

3.2) Insurance administration cost

The insurance administrative costs by severity of road accident to victims were shown in Table 22.

Table 22 the insurance administrative cost by severity of road accident to the victims

(Bath per crash)

The Insurance Administrative Cost by Severity in 2017			
Death	Disability	Serious Injury	Slight Injury
1,768	1,768	1,768	1,768

3.3) Judicial administration cost

The judicial administrative costs by severity of road accident to victims were shown in Table 23.

Table 23 the judicial administrative cost by severity of road accident to the victims

(Bath per crash)

The Judicial Administrative Cost by Severity in 2017			
Death	Disability	Serious Injury	Slight Injury
50,039	31,274	31,274	284

4) Loss production

4.1) Loss production in terms of foregone income loss by region and whole country.

The results of estimation of loss production in terms of foregone income loss were partly presented as shown in Table 24.

Table 24 the loss production in terms of foregone income loss

(Baht per Casualty)

Loss Production in terms of Foregone Income by region (base year 2017)								
Year	Northeastern	Northern	Southern	Eastern	Western	Central	Bangkok & Vicinities	Whole Country
0	80,352.46	103,760.29	148,066.67	500,675.77	149,826.83	267,162.27	449,881.18	228,398.33
1	155,648.73	203,458.29	289,609.63	976,802.04	292,522.24	532,742.52	848,052.13	439,442.37
2	229,093.69	300,471.63	426,767.38	1,439,509.55	430,931.33	790,473.58	1,230,518.15	644,285.20
3	300,634.28	394,758.42	559,550.20	1,888,670.95	565,048.11	1,040,328.68	1,597,717.63	842,901.14
4	370,230.75	486,291.81	687,983.31	2,324,223.91	694,883.12	1,282,313.29	1,950,093.62	1,035,290.56
5	437,855.20	575,058.23	812,105.02	2,746,163.69	820,461.49	1,516,461.31	2,288,091.75	1,221,476.75
6	503,490.28	661,055.98	931,965.04	3,154,536.39	941,821.11	1,742,831.56	2,612,158.20	1,401,503.19
7	567,128.06	744,293.74	1,047,622.97	3,549,432.77	1,059,010.98	1,961,504.68	2,922,738.02	1,575,430.96
8	628,768.91	824,789.39	1,159,146.91	3,930,982.66	1,172,089.72	2,172,580.21	3,220,273.62	1,743,336.48
9	688,420.52	902,568.82	1,266,612.17	4,299,349.89	1,281,124.23	2,376,174.01	3,505,203.45	1,905,309.39

Noted: For the case of serious injuries assume effectiveness reduced by 30% and this calculation is not included in the case of slight injuries.

4.2) Loss production in terms of income loss of the victims while they were in the hospital

The results of estimation of loss production in terms of income loss of the victims while they were in the hospital, as shown in Table 25.

Table 25 the loss production in terms of income loss of the victims while they were in the hospital

(Bath per crash)

The Loss Production in terms of Income Loss of the victims while they were in the hospital in 2017		
Disability	**Serious Injury**	**Slight Injury**
11,643	7,451	2,329

4.3) Loss production in terms of income loss involving those relatives and friends who take care of the injured and the disabled

The results of estimation of loss production in terms of income loss involving those relatives and friends who take care of the injured and the disabled were shown in Table 26.

Table 26 the loss production in terms of income loss involving those relatives and friends who take care of the injured and the disabled (Bath per crash)

The Loss Production in terms of Income Loss of involving those Relatives and Friends who Take Care of the Injured and the Disabled in 2017		
Disability	**Serious Injury**	**Slight Injury**
11,643	7,451	2,329

5) Intangible Cost

The human cost Human cost was set at as 15 percent of total cost (Direct + Indirect economic costs).

2. Manual of Road Traffic Accident Costs' Calculator

The study has been deployed the road accident costs calculator as an excel sheet to allow easy access for users, and they can be able to edit data for calculations in the case of more update data provided to make the computation closer possible to reality. The manual of the road accident costs calculator was shown in Figure 6 below:

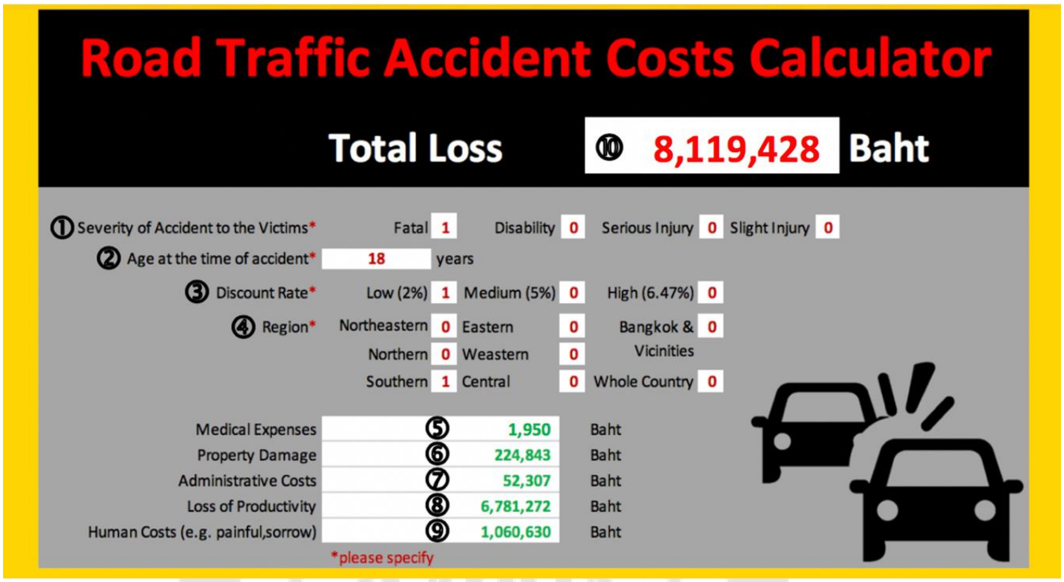

Figure 6 road traffic accident costs calculator

1) The user will not be able to proceed without specifying the severity of road traffic accidents to the victims in①, and the details are as follows:

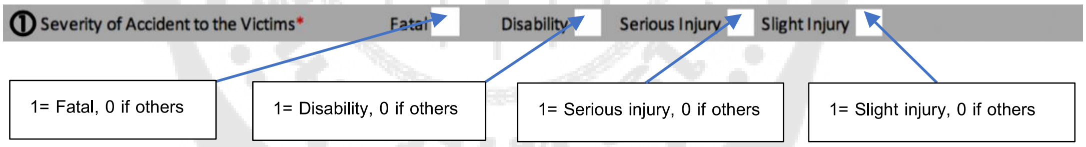

Figure 7 specifying the severity of road traffic accident

2) The user must specify the age of the victim at the time of accident in②.

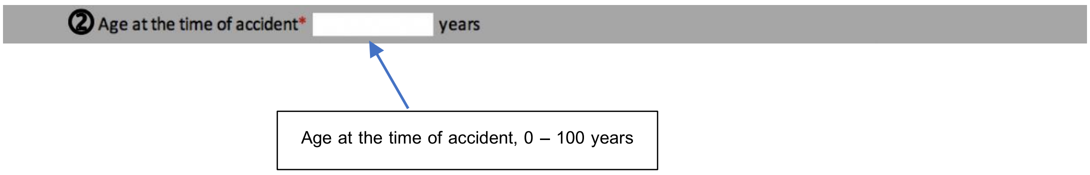

Figure 8 specifying the age of the victim at the time of the accident

3) The user will not be able to proceed without specifying the discount rate in③, and the details are as follows:

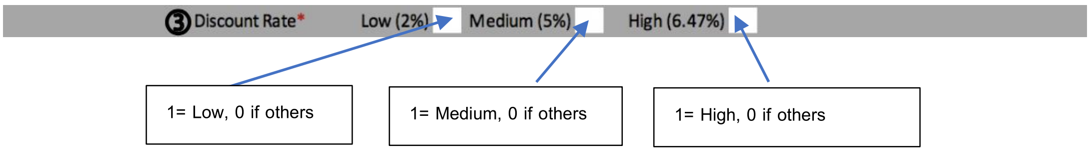

Figure 9 specifying *the discount rate*

4) The user must specify the region of the victim in ④, and the details are as follows:

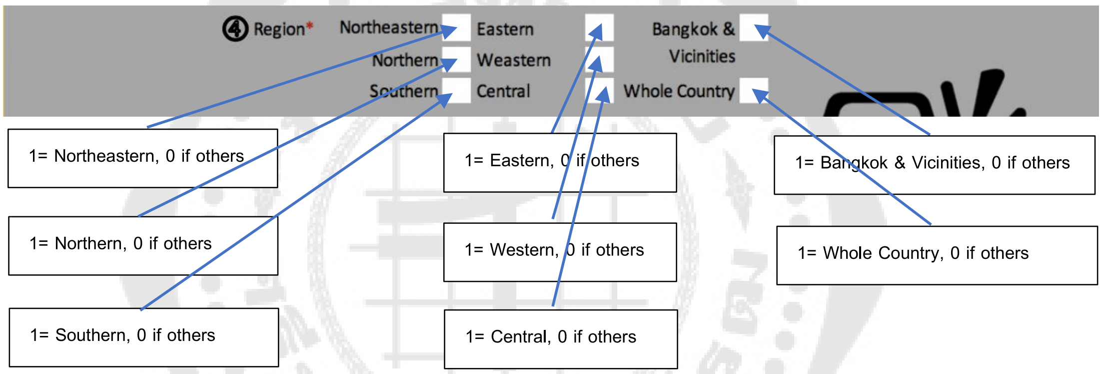

Figure 10 specifying the region of the victim

5) Then the calculator will sum up all the medical costs (⑤), the property damage costs (⑥), the administrative costs (⑦), and the productivity loss (⑧) automatically.

6) The calculator will compute the human cost (⑨) as 15% of the cost in item 3 above (⑨ = [(⑤ + ⑥ + ⑦ + ⑧)*0.15]).

7) The calculator will sum up the road accident costs in ⑩ (⑩ = ⑤+⑥+⑦+⑧+⑨).

Conclusions

This research is significant to the field of law economists, especially as it relates to the compensation payment of the road traffic accident costs. The road accident costs calculator could help to determine the compensation payment and for negotiating in the process of mediation in the court to make the case quickly and fairly. It is believed that the calculation would give rise awareness among Thai people about road safety as well.

The results of road accident costs estimation by the severity of road traffic accidents were as follows: for example, the study supposes the victim at the age of 18 years old was killed by road traffic accidents. Once a user is filled and successfully specifies into the calculator, a user can then see the costs of a road traffic accident, as depicted in Figure 6 above. The road traffic accident costs of the 18 years old fatality were comprising of medical cost (1,950 Baht per head), property damage (224,843 Baht per head), administrative cost (52,307 Baht per head), and Loss of productivity (6,781,272 baht per head). The human cost was set at 15% of the summation of medical expend with property damage and with administrative cost, equal to 1,060,630 Baht per head. The total cost was 8,119,428 Baht per head.

However, this accident calculation is still based on the value of road traffic damages from previous studies. If users want to edit the data to match the actual cost, they can change the data for calculations at the database sheet. It will lead to an assessment that reflects the accurse value of road accident losses in each case and could access to a broader group of people. The following activities are planned for future work: 1) the valuation of road traffic losses classified by gender, and 2) the valuation of road traffic losses by types of vehicles.

CHAPTER 4

COST-EFFECTIVENESS OF ROAD SAFETY POLICY FOR PREVENTING AND REDUCING ROAD TRAFFIC FATALITIES IN THAILAND

Abstract

This paper aimed to analyze the effectiveness of road safety policy in Thailand. The cost-effectiveness analysis (CEA) was the method used to evaluate the policy involved in road safety; Drunk-Driving Law, Helmet Use Law, and Seat Belt Use Law. The data contained costs and the amount of road traffic deaths between 2012 and 2017 were collected. The evaluating results of the road safety policy were as follows: (1) the drunk-driving law was effective in reducing fatalities caused by all types of motor vehicles accidents including motorcycles and bicycles; (2) the seat-belt use law was also effective in reducing the number of motor vehicle traffic fatalities; and (3) the helmet use law was considered ineffective, which was insignificant in terms of effort. The policy recommendation was a reduction in the number of deaths leading to the realization that the behavior of riders needed to be focused on safety education for motorcycle and law enforcement.

Keywords: Cost-effectiveness, Public Policy in Thailand, Traffic Fatalities

Introduction

Since 2011, Thailand has established the "Prevention and Reduction of Road Accidents" as a national agenda and has set goals to reduce the number of road traffic deaths to less than 10 deaths per 100,000 of the population (Road Accident Victim Prevention mentioned in Thai RSC, 2018), but based on the Global Status Report on Road Safety of WHO (2018), which showed that the number of deaths was not in decline but responsible for 33 deaths per 100,000 of the population. It indicated that so far Thailand has been unsuccessful in reducing the number of road traffic accidents. It is still a challenge for all relevant agencies to prevent road traffic accidents and to reduce the severity of accidents through public policies. Many studies have suggested that effective decision-making regarding road safety policy can only be made with adequate knowledge regarding its effectiveness. Therefore, an economic assessment of road safety policy can stimulate more efficient priorities for road traffic safety policy, and it can also provide alternative strategies for preventing or reducing losses from road traffic accidents as well (World Road Association, 2019; Gitelman and Hakkert, 2006; Baltussen, 2003).

From Figure 1, the office of Bureau of Non-Communicable Diseases (Strategy and Planning Division (2015) reported that Thailand's road traffic death toll in 2017 was 24 deaths per 100,000 inhabitants (with cancer as number one, followed by stroke, pneumonitis, heart attack, and road traffic accidents, respectively). Based on this statistics, road traffic accidents were becoming one of the top five leading causes of death among Thai people. The Thai government has realized that road traffic accidents are serious problems, not only due to the losses of human lives, but also massive damage to the economy, which is an obstacle to economic development.

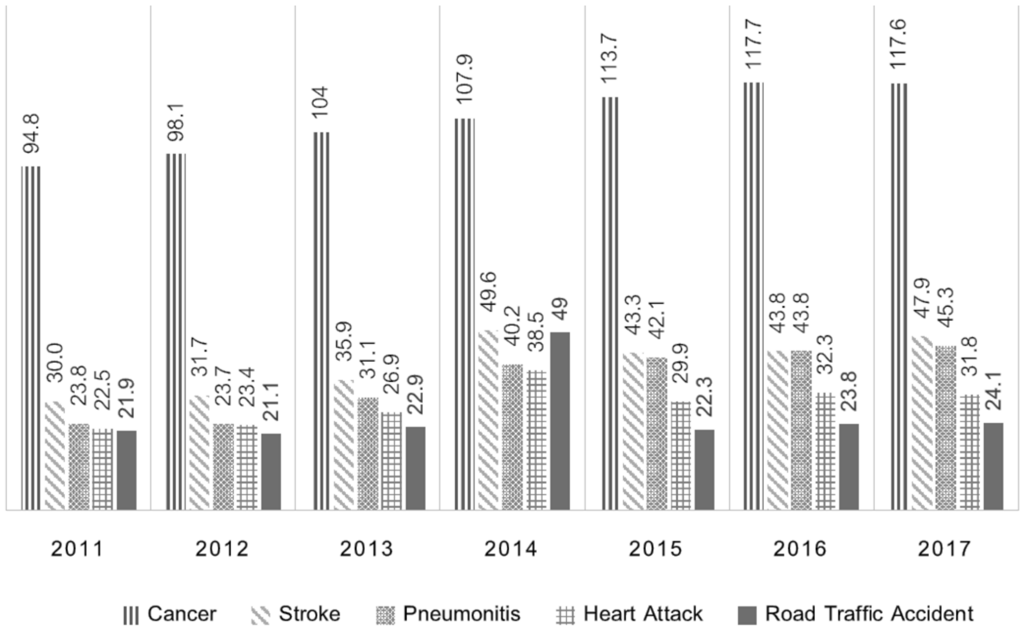

Figure 9 Mortality Rates by Leading Cause of Death per 100,000 Population, 2011-2017

Source: revised from Strategy and Planning Division (2015), Strategy and Planning Division (2018).

The government has been concerned about this issue and made an effort to solve the problem by continuing an increased budget for annual road traffic safety. In 2017, the road safety budget was almost doubled when compared with the road safety budget of 2011; 6,442 million Baht in 2011, to around 12,584 million Baht in 2017 (Budget Bureau, 2019). The government budgets were used for the construction of roadways, the maintenance of road and bridges, and the correction of sections of hazardous roads, prevention and reduction of road traffic accidents during festivals and normal periods, disaster prevention and mitigation, etc. Moreover, Thailand has implemented public policies following WHO recommendations, including a Speed Limit Law, a Helmet Use Law, a Seat Belt Use Law, and a Drunk Driving Law. Each policy has the following details (mentioned in WHO, 2016): ***1) Drunk-Driving Law***: no drivers shall drive the vehicle while drunk from alcohol or other intoxicants. Consistent with international standards, the legal limit for “Blood Alcohol Concentration: BAC” in Thailand is 0.05 g/dl, for both the general population and young/novice drivers. ***2) Helmet Use Law***: the driver and passenger must wear helmets while driving and traveling at all the time. ***3) Seat Belt Use Law***: the driver and passenger must wear seat belts while driving and traveling at all times; but the law only requires the front passenger to wear a seat belt, but not in the rear. ***4) Speed Limit Law***: a driver must drive not exceed the speed prescribed in the Ministerial Regulation[1] or traffic signs installed on the road.

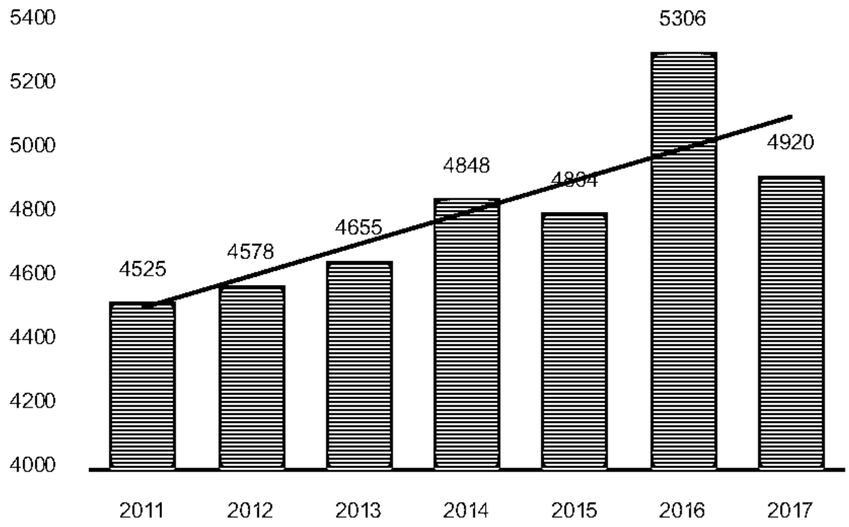

Figure 10 the number of deaths due to road traffic accident report from 2011 – 2017

Source: computed from Injury Surveillance Information System (ISIS, 2011, 2013, 2014, 2015, 2016, 2017).

However, Thailand road safety budget and significant traffic laws could not create a substantial change in the number of road traffic deaths as expected. Evidently, from the amounts of road traffic fatality data from the Injury Surveillance Information System reports, showed that between 2011 – 2017, the trend of road traffic deaths did not decline (as shown in Figure 10). Also, the road traffic deaths data based on ISIS report in 2017 revealed that there were 790 deaths caused by driving under the influence of alcohol, 431 deaths from not wearing a seat belt, 2,504 deaths from not wearing a helmet,

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[1] See WHO (2016) for detail.

and 1,195 deaths with no apparent cause (ISIS, 2017). These numbers were in contrast with the Global Status Report on Road Safety, which said that the estimation of Thailand road traffic fatalities was down from 37 deaths in 2015 to 33 deaths per 100,000 of population in 2018 (WHO, 2018).

The economic method as a road safety policy assessment might establish adequate knowledge of effectiveness of the policy, and could help to improve road safety policy as well (Elvik & Amundsen, 2000; Hoekstra & Wegman, 2011). The evaluation begins with collecting evidence such as the costs and the benefits (or consequences) of policies, then comparing them to selected policies which gives the highest expected value ((Centre for Epidemiology and Evidence, 2017). The two most common methods used for economic evaluation in public policy include Cost-Benefit Analysis (CBA) and Cost-Effectiveness Analysis (CEA). The characteristics of these two methods can be summarized as followed: the ***CBA*** aims to inform decision-makers about the economic feasibility of policy or project (OECD, 2016), attempts to measure all of the costs and consequences associated with a given policy in terms of money. The variation in the different policies can be compared by using CBA because all costs and benefits are measured in money values, then computed by a benefit/cost ratio (Gitelman & Hakkert, 2006; RESTRAIL, 2014; Wesemann, 2000). However, in road safety issues, benefits are usually measured by changes in the number of deaths. For the ***CEA***, it is an efficient way to identify the most cost-effective option based on the notion that certain targets, such as the reduction of road traffic deaths. It minimizes the actual value of costs in order to maximize the output (Davalos, French, Burdick, & Simmons, 2009; European Commission, 2015; Fryd et al., 2017; Muennig, 2008; Reardon, 2005). CEA is most useful, owing to well-provided measuring in terms of a "natural unit," e.g., the number of road traffic accident fatalities prevented (Elvik & Veisten, 2005). The focus of the policy is on real outcomes, and can be used as a natural unit because it is very different to place a cost on human life. In terms of the cost, CEA seeks to identify and place a monetary value on policy. Thereby, the efficiency of measures can be evaluated by a dividing unit of effectiveness that refers to a death or an injury resulting from road traffic accidents in terms of the budget spent on road safety policy (Elvik & Veisten, 2005; Fryd et al., 2017; Newcomer, Hatry, & Wholey, 2015; RESTRAIL, 2014).

It can be seen that the CBA is an analytical economic feasibility method. The main objective is to compare the costs associated with administration or investment by the benefits of implementation in a monetary unit, while the CEA aims at determining the least cost option of attaining a target without a monetary measurement of benefits. In the context of road safety policy-making the given goals are generally set so as to minimize road traffic risk and the danger to human life. That means the CEA comes in after the road safety impact of the policy has been determined.

In order to support policies reducing the number of road traffic fatalities, the CEA was selected. The CEA is very useful since it allows comparisons among options with the same indicators of effectiveness, in terms of natural units , e.g. the number of road traffic fatalities reduced (Elvik & Veisten, 2005; Fryd et al., 2017; Newcomer et al., 2015; RESTRAIL, 2014), compliant with the book “Making Choices in Health: WHO Guide to Use Cost-Effectiveness Analysis” (Adam & Murray, 2003) that suggested the exploration of the most cost-effective choice, based on policy targets.

This study aimed to evaluate an effectiveness of Thailand public policy on road safety. The CEA method was chosen and the efficiency of road safety measures can be evaluated as a Cost-Effectiveness Ratio (CER) by dividing the change in government budgets for road safety with the difference in the number of road traffic fatalities, then ranking each intervention from least to most effective. Furthermore, intervention with a lower CER is deemed preferable to one with a higher CER (Baltussen (2003). The expected results could give a suggestion for resource allocation for policy preventing or reducing life losses from a road traffic accidents and could stimulate more efficient priorities for road traffic safety policy.

Methods

This study analyzed the effectiveness of road safety policy in Thailand, including Drunk-Driving Law, Helmet Use Law, and Seat Belt Use Law, policies involved the causes of traffic death from the ISIS database by comparing costs and effectiveness between 2012 and 2017. The ISIS database is the only source that provided and completed both numbers and causes of road traffic deaths requires for analysis. The year 2012 was selected as it was the first year that it was implemented under the national agenda; "Prevention and Reduction of Road Accidents". 2017 was the most recent year that contained data on the unit of the effectiveness of the road safety policy.

This section presented methods for assessing policy effectiveness as well as the sources of the data used in the analysis. The research methods were sorted as follows: 1) model of traffic fatalities, and 2) cost-effectiveness analysis

1) Model of Traffic Fatalities

The study started with developed an econometric model believed to be beneficial to confirm the statistical significance of road safety policies and the reduction of traffic deaths. The pooled time series data of 608 observations crossed 76 provinces and was applied to evaluate the effectiveness of the road safety policies. The study used panel data from 2012 to 2017 for estimating the traffic fatalities model by using the Pooled ordinary least squares (OLS) regression technique. The pooled OLS regression methods may have limitations that do not consider the fluctuations in road safety policy management in different provinces. However, the road safety policy for preventing and reducing road traffic fatality is the same law enforced throughout the country, and it may not be affected by different external factors in each province.

The general form:

$$RTF^{2} = \beta_0 + \beta_1(Socio - Economic) + \beta_2(Geographic) + \beta_3(Demographic) + \beta_4(policy) + \varepsilon_t$$

[2] The analysis used herein are following the study done by Sarawasee et al. (2015).

Table 27 variables, definition road traffic fatalities model in 2012 – 2017.

Variable	Definition	Sources	Expected Sign
Dependent Variable			
RTF	Number of road traffic fatalities (person)	ISIS (2012, 2017)	
Independent Variables			
Socioeconomic Variables			
GPP	Gross provincial product per capita (Baht/person)	Office of the National Economic and Social Development Council (2018)	+
EDU	Average year of schooling, age 15 – 39 (year)	Office of the Education Council (2018)	-
Geographic Variable			
DEN	Population density (people per square kilometer)	National Statistical Office (2019)	+
Demographic Variables			
NMV	Number of motor vehicles (unit)	Department of Land Transport (2019 A)	+
NMC	Number of motorcycles (unit)	Department of Land Transport (2019 A)	+
Policy-related Variables			
DIB	Direct budget for road safety (Baht)	Budget Bureau (2019)	-
INB	Indirect budget for road safety (Baht)	Thai Health Promotion Foundation (2019) and Department of Land Transport (2019 B)	-
ACL	The proportion of those who do not drink alcohol before driving in each province (%)	Author's calculation	-
HML	Helmet use rate by province (%)	Thai Road Foundation (2019)	-
SBL	Seat belt use rate (%)	WHO (2013, 2015, and 2018)	-

2) Cost-effectiveness analysis

The study analyzed the effectiveness of road safety policy by policy characteristics and depending on the type of vehicles as follows: 1) Motorcycles & Bicycles, the policies involved were the Drunk-Driving Law and the Helmet Use Law; 2) Motor Vehicles, the policies involved were the Drunk-Driving Law and the Seat Belt Use Law. The study then evaluated road safety policies by using the CEA method.

CEA is an effective measure to diagnose the best and most effective policy. The ICER is used to rank each road safety policy in terms of the results achieved. This measure is achieved by taking the costs of the road safety policy and dividing it by the unit of effectiveness of the policy. The costs were the government budget on preventing and reducing road traffic accidents, while the natural unit of effectiveness was the number of deaths that could be reduced by each policy. The ICER can draw as (Adam & Murray, 2003):

$$ICER = \frac{\Delta C}{\Delta E} = \frac{C_2 - C_1}{E_2 - E_1}$$

Where ΔC represents the change of budget, C_2 represents the budget for road safety policy in 2017, and C_1 is the budget for road safety policy in 2012. While ΔE is the change of number of deaths caused by road traffic accidents, E_2 stands for the number in 2017, and E_1 means the number of deaths in 2012

The ICER of each policy calculated from the above was taken into account with the cost-effective plane with four quadrants by plotting the graph according to the following concepts:

		Number of Deaths/Injuries	
		Decrease	Increase
Budget for Road Safety Policy	Increase	Quadrant 2 $\triangle C > 0, \triangle E < 0$	Quadrant 1 $\triangle C > 0, \triangle E > 0$
	Decrease	Quadrant 3 $\triangle C < 0, \triangle E < 0$	Quadrant 4 $\triangle C < 0, \triangle E > 0$

Figure 11 an analysis of cost-effective plane with four quadrants

Source: revised from Meerat (2016).

The meaning of each quadrant was explained as shown in Figure 12:

Quadrant 2: The road safety measure was effective, but still could not reduce the budget	**Quadrant 1:** Road safety policy was not effective at all; resulting in an increase in both the cost and in deaths
Quadrant 3: The expected goal. The policy was effective, the number of deaths and the budget decreased	**Quadrant 4:** The number of deaths increased, while the budget reduced. So, the policy was ineffective

Figure 12 the meaning of each quadrant by the concepts of ICER

The data used for evaluating the CEA of road safety policies in this study was as followings:

1) Costs of Road Safety Policy

This study is based on the complied budget for the prevention and reduction of road traffic accidents from government sectors and foundations from 2012 and 2017 only. The list of budgets for road safety policy were separated into two groups; direct budget and indirect budget for road safety policy following the studies of Sarawasee et al. (2015) and Kosalakorn (2001). The data collected for the road safety budget in 2012 to 2017 was from the Budget Bureau (2019), Thai Health Promotion Foundation (2019) and Road Safety Thailand (2019).

a) Direct Budgets (reported in the Budget Bureau (2019), were comprised of (1) the budget for the highway network safety from the Department of Highways, the Ministry of Transport, (2) the budget for the rural road network safety from the Department of Rural Roads, the Ministry of Transport, (3) the budget for the road safety prevention and reduction from the Department of Land Transport, the Ministry of Transport, (4) budget for road safety administration from the Office of Transport and Traffic Policy and Planning, the Ministry of Transport, (5) the budget for road accidents prevention and reduction during festivals and regular periods from the Department of Disaster Prevention and Mitigation, the Ministry of Interior, (6) the budget for training for disaster prevention and mitigation plan at the district/province level from the Department of Disaster Prevention and Mitigation, the Ministry of Interior, and (7) the budget for traffic and road safety administration, Royal Thai Police.

b) Indirect Budgets, consisting of (1) the budget for road safety and disaster administration plans, the Thai Health Promotion Foundation (Thai Health Promotion Foundation, 2019), and (2) the budget for road safety, the Road Safety Thailand Foundation (Road Safety Thailand Foundation, 2019).

Moreover, to compare the budgets for road safety policy between 2012 and 2017. The Consumer Price Indexes (CPI) from the Bank of Thailand (2019) were used to adjust the amount in 2012 to 2017 value.

2) Unit of Effectiveness of Road Safety Policy

The units of the effectiveness of road safety policy in this study were the annual number of deaths caused by driving under the influence of alcohol, not wearing a helmet, and not wearing a seat belt, in 2012 and 2017. These data were collected from the ISIS database (ISIS, 2012; ISIS (2017).

The conceptual framework of Thailand road safety policy by vehicle types summarized as Figure 13:

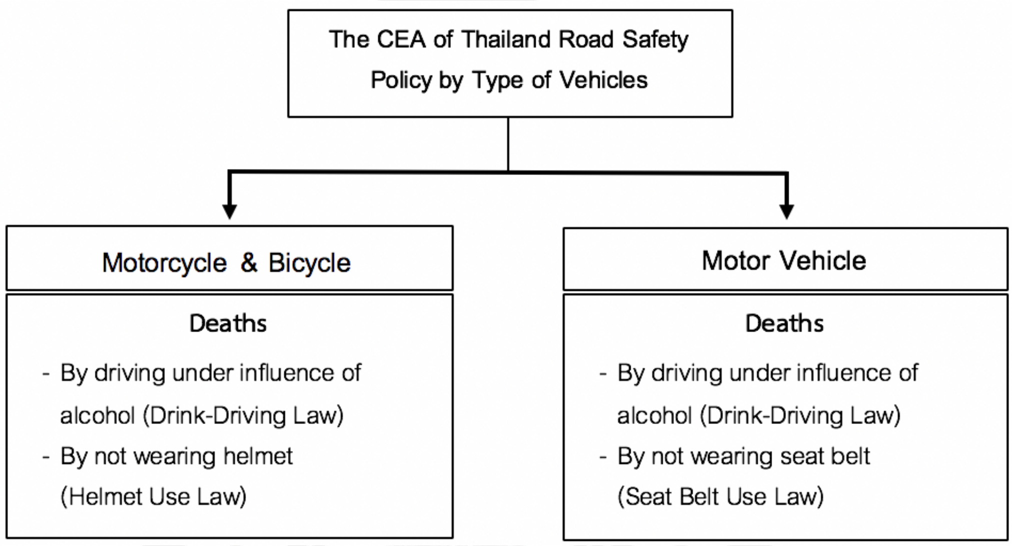

Figure 13 conceptual framework of the CEA of Thailand Road Safety Policy

Results

1) Regression results on road traffic fatalities model

Pooled time series analysis was used to evaluate the effectiveness of the road safety policies. The data description of the relevant statistics was defined as in Table 28.

Table 28 descriptive statistics of the model variables

Variable	Mean	S.D.	Min	Max
RTF	125.2	76.63	14.00	461.0.
GPP	1.184e+05	1.572e+05	8361	9.85e+05
EDU	10.61	0.1270	10.40	10.80
DEN	191.3	265.7	19.14	1976
NMV	1.137e+05	92988	4148	5.769e+05
NMC	2.163e+05	1.491e+05	6751	9.635e+05
DIB	1.057e+10	2.229e+09	5.643e+09	1.363e+10
INB	1.172e+09	2.180e+08	7.989e+08	1.520e+09
ACL	96.22	5.031	45.37	100.0
HML	0.3615	0.1059	0.1300	0.7100
SBL	54.12	0.3310	54.00	55.00

The Pooled OLS regression results on the model of road traffic fatalities after fixing various problems such as autoregressive, heteroskedasticity, and multicollinearity was presented in Table 29.

Table 29 pooled OLS model of the number of road traffic fatalities 2012 – 2017, using 608 observations

coefficient	std.	error	t-ratio	p-value
const	2280.62	464.733	4.907	1.19e-06***
GPP	0.00014004	1.16e-05	12.11	2.53e-30***
EDU	-7.59965	11.4534	- 0.6635	0.5072
DEN	0.0209843	0.00672297	3.121	0.0019***
NMV	0.00060777	1.82e-05	33.32	2.16e-138***
DIB	- 6.65812e-09	1.23e-09	- 5.429	8.26e-08***
INB	-1.32550e-08	8.54e-09	- 1.552	0.1211
ACL	- 0.313093	0.292312	- 1.071	0.2846
HML	- 38.0538	14.8135	- 2.569	0.0104**
SBL	- 37.5914	8.39366	- 4.479	9.00e-06***
Adjust-R^2	**0.797278**	**F 266.250**	**D.W.**	**1.915277**

From Table 29, the direction of relations of all independent variables is according to the hypothesis. For Thailand, when the GPP increases, the number of road traffic deaths increases with a mechanism that depends on increasing the number of road users. The same result in population density (DEN) and the number of motor vehicles (NMV) with statistically significant increases at the level of .01, while the rise in the average year of schooling (EDU) in the population in the age group 15 - 39 years results in a decrease in road traffic deaths. For the relationship between road safety policies and the number of deaths, it is found that increases in the direct budget (DIB) and seat belt use rate (SBL) result in reducing the number of road traffic deaths with statistical significance at the level of .01. An increase in helmet use rate (HML) will result in a decrease in the number of road traffic fatalities with statistical significance at the level of .05. For the remaining policy, which is an indirect budget (INB) and Drunk-driving law (the proportion of those who do not drink alcohol before driving: ACL), there is a statistically significant level lower than the 0.05 level. Still, when considering the direction of the relationship, it is found that there is an inverse relationship with the number of road traffic deaths. In other words, when the level of road safety policies increases, the number of deaths from accidents will decrease.

2) The Unit of Effectiveness of Road Safety Policy.

The annual number of road traffic deaths/injuries in 2012 and 2017, caused by driving under influence of alcohol, not fastening a seat belt, and not wearing a helmet were used as the unit of effectiveness of the road safety policy, as shown in Table 30 below.

Table 30 annual number of traffic deaths in 2017 and 2012 (unit: person)

Cause of Road Traffic Deaths/injuries	2012	2017
Motorcycle & Bicycle		
Driving under influence of alcohol	648	646
Not wearing helmet	2,110	2,504
Motor Vehicle		
Driving under influence of alcohol	119	114
Not wearing seat belt	528	431

Source: computed from ISIS (2012); ISIS (2017).

3) Budgets of Road Safety Policy. The annual budgets for road safety policy in 2012 and 2017 from the related organizations as mentioned previously were computed and adjusted to 2017 value by using the consumer price index (Bank of Thailand, 2019) as shown in Table 31.

Table 31 the annual costs for road safety policy in 2017 and 2012 (unit: Baht)

List of Budgets for Road Safety Policy	2012	2017
Direct Budgets	10,022,890,100	11,372,732,300
1) budget for the highway network safety*	3,705,566,500	4,264,083,200
2) budget for the rural road network safety*	1,548,136,900	2,343,954,000
3) budget for the road safety prevention and reduction*	546,778,500	247,125,300
4) budget for road safety administration*	4,379,000	-
5) budget for road accidents prevention and reduction during festivals and regular periods*	85,012,600	74,052,000
6) budget for training for disaster prevention and mitigation plan at the district/province level*	21,641,000	35,853,700
7) budget for traffic and road safety administration*	3,937,395,300	4,291,692,100
8) providing health services for Thai people	173,980,300	115,972,000
Indirect Budgets	1,170,214,798	1,211,515,436
1) budget for road safety and disaster administration plans**	196,000,000	260,000,000
2) budget for road safety Thailand foundation***	974,214,798	951,515,436
Total	11,193,104,898	12,584,247,736
Present Value (based 2017)	13,677,501,763	12,584,247,736

Source: collected from Budget Bureau (2019)*, Thai Health Promotion Foundation (2019)** and Road Safety Thailand (2019)***.

4) An effectiveness of the policy.

The CEA is an efficient method to analyze the cost-effective option based on the depletion of road traffic fatalities provide. The CEA method is using the changes in budget divided by changes in the number of fatalities of road traffic policies based on vehicle types, (1) motorcycles and bicycles, and (2) motor vehicles. Then using ICER interpreted the results with a cost-effective plane with four quadrants, as previously shown in figure 12. The results were as follows.

4.1) the effectiveness of policy involved motorcycle and bicycle, including the Drunk-Driving Law and the Helmet Use Law.

4.1.1) the CEA of Drunk-Driving Law for reducing road traffic deaths from motorcycle and bicycle accidents (CEA_{MCDDL}).

$$CEA_{MCDDL} = \frac{12{,}468{,}275{,}736 - 13{,}464{,}905{,}179}{646 - 648}$$

$$= \frac{-996{,}629{,}443}{-2}$$

$$= 498{,}314{,}721.50$$

4.1.2) The CEA of Helmet Use Law for reducing road traffic deaths from motorcycle and bicycle accidents (CEA_{MCHML}).

$$CEA_{MCHML} = \frac{12{,}468{,}275{,}736 - 13{,}464{,}905{,}179}{2{,}504 - 2{,}110}$$

$$= \frac{-996{,}629{,}443}{394}$$

$$= -2{,}529{,}516.35$$

The CEA results of the Drunk-Driving and Helmet Use Law to reduce road traffic deaths from motorcycle and bicycle accidents were shown in Figure 14 below:

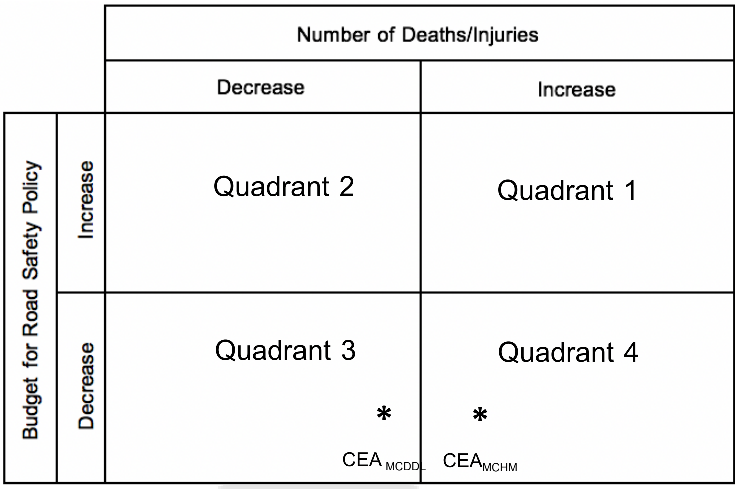

Figure 14 an analysis of cost-effectiveness plane with four quadrants from motorcycle and bicycle accidents

The CEA of the Drunk-Driving Law to reduce deaths (CEA_{MCDDL}) from motorcycle and bicycle accidents was in the third quadrant. This means, the policy was effective and efficient because the number of road traffic deaths was reduced; moreover, costs for road safety policy decreased as well. With regard to the Helmet Use Law, the results of CEA_{MCHML} indicated that it was in the fourth quadrant, which means that the number of road traffic deaths and injuries were not reduced while the cost was lower. This policy was not able to achieve its goals.

4.2) the effectiveness of policy involving motor vehicles, including the Drunk-Driving Law and the Seat Belt Use Law.

4.2.1) the CEA of Drunk-Driving Law to reduce road traffic deaths in motor vehicle accidents (CEA_{MVDDL}).

$$CEA_{MVDDL} = \frac{12{,}468{,}275{,}736 - 13{,}464{,}905{,}179}{114 - 119}$$

$$= \frac{-996{,}629{,}443}{-5}$$

$$= 199{,}325{,}888.60$$

4.2.2) The CEA of Seat Belt Use Law for reducing road traffic deaths from motor vehicle accidents (CEA_{MVSBL}).

$$CEA_{MVSBL} = \frac{12{,}468{,}275{,}736 - 13{,}464{,}905{,}179}{431 - 528}$$

$$= \frac{-996{,}629{,}443}{-97}$$

$$= 10{,}274{,}530.40$$

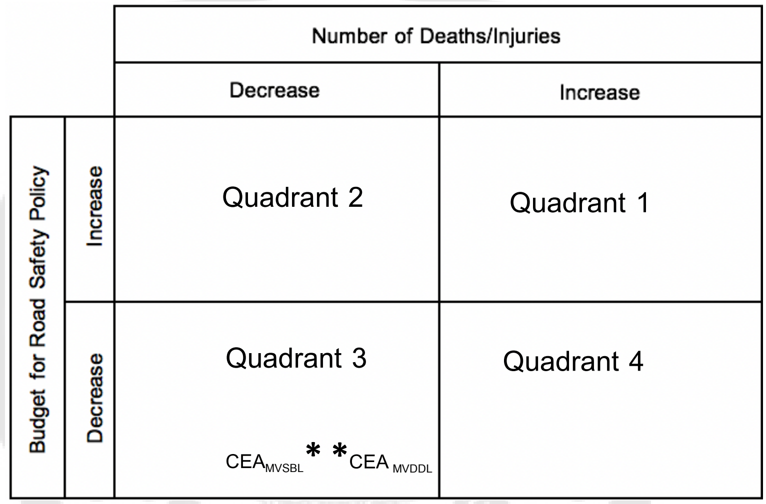

Figure 15 an analysis of cost-effectiveness plane with four quadrants from motor vehicle accidents

The CEA of the Drunk-Driving Law and the Seat Belt Use Law were in the third quadrant (as shown in Figure 15). This means that the policies were effective and efficient, because not only was the number of motor vehicle deaths and injuries reduced, the budgets for road safety policy also decreased.

Discussions

From the results showed that the Helmet Use Law in Thailand is ineffective and inefficient policy, according to the WHO (2018) report, the helmet-wearing rate in Thailand was about 51% for riders and 20% for passengers while the enforcement level was at level 6 (The level of law enforcement refers to the perception of the public regarding the severity of enforcement of the law. The score is measuring score from 1 – 10 with 1 being not enforced at all, and 10 being effective enforcement). When comparing helmet laws with Vietnam, countries in the same region, and middle-income countries, it is found that helmet laws in Vietnam are effective and successful policies to reduce motorcycle deaths (the helmet-wearing rate in Thailand was about 81% for drivers and 60% for passengers while the enforcement level was at level 8 mentioned in WHO, 2018). A significant accomplishment of the helmet use law in Vietnam is strict and consistent enforcement, which requires every driver and passenger to wear a helmet on every road at all times. Moreover, there is also an increased fines rate (30% of average monthly income) that applies to offenders (Passmore, Nguyen, Nguyen, & Olivé, 2010). As you can see, higher law enforcement is a key success factor that could help to reduce the number of motorcycle deaths in Thailand.

Conclusions

The ISIS data pointed out that the annual number of road traffic deaths/injuries in Thailand between 2012 and 2017 followed the same pattern. The causes of deaths were the result of not wearing a helmet at the highest rate, followed by fatalities from driving under the influence of alcohol and not wearing seat belts, respectively. For the budgets of road safety policy in Thailand, the highest portion of the main budgets went to the traffic and road safety administration budget of Royal Thai Police, followed by highway network safety budget and rural road network safety. The budget for road safety prevention and reduction in nominal term in 2017 was increased, compared with the road safety budgets of 2012. However, the amount of the budgets in 2017 was considered to be lower than the amount in 2012 due to the present value adjustment.

The involved road safety policy, including the Drunk-Driving Law, the Helmet Use Law, and the Seat Belt Use Law, were analyzed using the CEA method and characterized into two groups based on types of vehicle; motorcycles and bicycles, and motor vehicles. The results were interpreted by using cost-effectiveness plane with four quadrants It revealed that in terms of the road traffic policies related to motorcycles and bicycles, the CEA of the Drunk-Driving Law was in the third quadrant, which demonstrated on effective policy in reducing road traffic deaths and injuries. However, the CEA of the Helmet Use Law was in the fourth quadrant, which means the Helmet Use Law was not successful in reducing the number of motorcycle and bicycle deaths. For the policies relating to motor vehicles, the Drunk-Driving Law and the Seat Belt Use Law, the CEA of both policies were in the third quadrant, which means they were effective in reducing road traffic deaths while being able to utilize less of their budget.

The largest number of deaths from road traffic accidents, were those involving motorcycles. This was consistent with a recent from the Injury Surveillance System, Bureau of Epidemiology, Department of Disease Control, Ministry of Public Health (WHO, 2018). Moreover, from the above results it can be inferred that the Helmet Use Law has not been successful. Note that the Drunk-Driving Law reduced the number of road traffic deaths, but only slightly.

It can be seen that the budget for prevention and reduction of accidents in Thailand is not classified according to the types and causes of road accidents. Therefore, promoting specific policies and budgets for each road safety policy is necessary. Moreover, increasing the rate of wearing helmets for both riders and passengers through higher law enforcement, the quality of helmets, and the education of the general public, especially young riders about the importance of helmet use will lead to reduced road traffic fatality rates. The study also found that there were many road traffic deaths for which a cause was unable to be determined were due in large part, to the fact that the data concerning road traffic fatalities caused by speeding were not available at the time of writing. There was a problem in the analysis of the data and finding a solution. Therefore, using technology to collect data may help to improve the integrity of the data and lead to correct and sustainable road safety policies.

CHAPTER 5
CONCLUSION

Road traffic accident is a big problem and great interest to economists, policymakers, as well as relevant government and private agencies in order to address a pressing public health concern. This dissertation was conducted in order to evaluate socio-economic damage, to update and raise a better knowledge about the harm of traffic accidents. Moreover, to assess the effectiveness of road safety policies such as Helmet Use Law, Seat Belt Use Law, and Drunk-Driving Law. This study was done in three essays; the first essay addresses the measure of productivity loss due to road traffic accidents in Thailand. The second one is to estimate the socio-economic cost of road traffic accident per case. The last essay addresses the cost-effectiveness of road safety policy for preventing and reducing road traffic accidents in Thailand. The data were mainly collected from Road Accident Victims Protection company limited (reported on the website of Thai Road Safety Collaboration: Thai RSC), the Injury Surveillance Information System of Division of Non-Communicable Diseases, Ministry of Public Health, and Budget Bureau, Office of the Prime Minister, Thailand.

The results from the three essays showed that due to the massive loss from road traffic accidents to the economics of the country. Thai government has tried to reduce and prevent road accidents, operating through policies and campaigns to overcome and to avoid road traffic accidents under the national agenda. However, the road traffic accident statistics in 2012 and 2017 from ISIS showed that the number of deaths and injuries caused by riding motorcycles and bicycles without wearing a helmet increased (See Table 23 of Chapter 4). While the number of deaths and injuries caused by driving under the influence of alcohol and not wearing seat belts decreased, as a consequence, the use of helmet laws is not yet an effective policy as it should be. The details of each essay were the following: (1) the productivity loss due to road traffic accidents; the assessment process was carried out by using the human capital approach. The value of productivity loss due to road traffic accidents included the following; 45 billion

Baht of productivity loss from road traffic fatalities, 7 billion Baht from disabilities,67.5 billion Baht from serious injuries, and more than 1.5 billion Baht for slight injuries. The total amount of damage was approximately 121 billion Baht. (2) The socio-economic damages were indicated into three families of costs: direct economic costs (medical expenses, property damage costs, administrative costs), indirect economic cost (productivity losses), and intangible cost (painful, sorrow, etc.). The evaluation of socio-economic damage was used to update previous national economic damage costs and also created the road accident costs calculator. (3) For the study of the effectiveness of road safety policy in Thailand, the study separated the policies relating to the vehicle types into two groups, motorcycle and bicycle, and motor vehicle. For the road traffic policies related to motorcycle and bicycle, the Drunk-Driving Law was effective in reducing road traffic deaths and injuries while being able to reduce the budget. However, the Helmet Use Law was not successful in reducing the number of motorcycle and bicycle deaths. The policies relating to motor vehicles, Drunk-Driving Law, and Seat Belt Use Law were efficient and effective; not only the number of road traffic deaths and injuries reduced, but also the budget of the policies abled to decrease.

The contribution of this study was gathering and computing economic damage information. The studies found that socio-economic damage effects to the future income of road traffic victims, and this could help policymakers raising public awareness about road traffic accidents. Moreover, the assessment of the effectiveness of the road safety policy related vehicle types can assist policymakers in reallocating resources for reducing or preventing road traffic accidents in such a better alternative. The studies found that motorcycle and bicycle use is the leading cause of traffic deaths and injuries, especially, not wearing a helmet while riding. Therefore, the government and related agencies should reallocate the budget and gear for helmet use more.

Interestingly, the socio-economic damage caused by road traffic death, disability, and injuries that occur the most during the age of 15 - 24 years old. This age group is a significant labor force that leads to a massive productivity loss of the country's economy. Therefore, for future studies, strategies for communicating with teens and young adults about road accident damage to build their awareness and behavioral change are essential. Besides, studies new approaches to stimulate the proportion of helmet wearing for riders and passengers, including the promotion of quality helmets use to reduce the severity of accidents, are urgent. As you can see, the road traffic accident data is gathered from many sources, general information that does not identify the characteristics such as their occupations, incomes, etc. of road traffic victims. And the cause of the accident is not comprehensive in all cases.

For this reason, data analysis at the micro and macro levels to study the behavior of road traffic victims or to determine appropriate policies for solving problems is still limited. Therefore, restrictions on data usage should be addressed. Moreover, the budget for road safety should be separated into each policy or intervention; it useful to evaluate the efficiency and effectiveness and could give a better solution.

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