FACTORS AFFECTING ROAD ACCIDENTS IN URBAN AREAS: A CASE STUDY OF NAKHON SI THAMMARAT MUNICIPALITY

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ABSTRACT

This paper describes a method for identity hazardous road location in Nakhon Si Thammarat municipality and the findings regarding the causes of the traffic accidents. The ranking of study locations were selected by using the criteria of number of critical accidents and severity index. The 3 study locations comprise Black Spot no.1 (*BS-1*): Robinson department store, Black spot no.2 (*BS-2*): Nakhon Si Thammarat Technical College and Black spot no.3 (*BS-3*): Thama-market intersection. Results of analysis using the Binary Logistic Regression model show that for *BS-1*, independent factors that are expected to influence the traffic accidents include gender, number of household motorcycles and driving with excessive speed. For *BS-2*, the independent variables that are expected to influence the incidence of traffic accidents include age, number of cars in a household and lack of traffic control devices. For *BS-3*, the independent variables are male and the age of the respondents. Recommendations are suggested to deal with the factors that influence the occurrence of the traffic accidents.

Keywords: Road accidents in urban area, Black spots, Binary logistic regression

1. INTRODUCTION

The continued growth of regional cities in Thailand are a result of the implementation of the development policies under the guidance of the National Economic and Social Development (NESD) Plans from No.4 to the current Plan No.11 which as address economic development plans, infrastructure development plans and rural cities development plans (NSED, 2012). The purposes of the national development plans are to decrease congestion due to the migration of people from rural areas to Bangkok and Vicinities and increase income in rural areas. According to the national development plans, each region has established a primary city which is a city of strategic importance at regional and national levels; as a consequence, travel demand in each region increase more than before implementation. However, inadequate public transportation services and insufficient road network still persist, even after the government has executed the infrastructure and public transportation system for supporting the daily travel demand. Therefore, most of people in rural areas decide to use their motorcycles and private cars for travelling over a short distance in the urban area

or to other provinces in the same region. The result of increasing use of motorcycles and private cars contribute to the rising of traffic accidents, air pollution, noise pollution and traffic jam. Related to these problems, they affect the quality of life of the people in community areas, especially in the absence of traffic regulations enforcement of involved state agencies.

The number of traffic accidents decreased gradually from 124,530 in 2004 to 68,583 in 2011. Most traffic accidents occurred on the minor roads especially in urban areas and accounted for about 85% of road accident deaths for the whole country. The proportion between road accident that occurred on the minor roads to those on the main highways was about 0.86 the corresponding ratio of deaths was about 0.85 and injuries about 0.84 (Chantruthai P., Kumtree, S., Mama, S., and Boonrueng, S., 2011). Because of the higher density of population and vehicles in urban areas, the number of road accidents that happened in the urban areas were thus higher when compared with rural areas. Additionally, traffic regulations have not been seriously enforced which contribute to the encroachment of public area; for instance, the setup of many temporary shops on footpath. These problems can cause black spots and directly affect the road users. Consequently, the study of hazardous road locations in urban area should be emphasized in order to identify black spots and accident causes which can lead to effective measures concerning traffic regulations.

2. OBJECTIVES

1. To find the causes of traffic accidents in urban areas
2. To identify the black spots on local roads in urban areas
3. To make specific and general recommendations on road traffic injuries management in study areas

3. SCOPE OF THE STUDY

Three locations in Nakhon Si Thammarat municipality were selected for the study using three highest ranking of severity index from the list of 20 high crash sites.

4. RESEARCH METHODOLOGY

1. Three-year road accident data were collected for use in the calculation of the critical crash number, followed by specified cut-off level. If the number of crashes at a site is higher than the cut-off level, it is considered as black spot as shown in equation 4.1. (MOT, 2004)

$$A_c = A_a + Z_{(\alpha=0.1)} \frac{SD}{\sqrt{n}} \qquad (4.1)$$

Where: A_c = Critical crash number
A_a = Average crash number
SD = Standard deviation of number of accidents
$Z_{(\alpha = 0.1)}$ = *Z-test* at the 0.1 level of significance
n = Number of accidents on the roads at any points ($n \geq 2$)

2. The collected road accident statistics data in step 1 had been used to specify black spots by using Severity Index (*SI*). Additionally, the higher value of the Severity Index indicated the higher level of severity at such locations (Taneerananon, P., 2006). The severity index can be calculated by using equation 4.2

$$SI = 4I + 3S + 1sl \tag{4.2}$$

Where; *SI* = Severity Index
I = Number of fatality with weighting of 4
S = Number of serious injury with weighting of 3
sl = Number of slight injury with weighting of 1

3. The data from step 1 and 2 were arranged in order of SI value; the three highest were selected as the most dangerous sites for further analysis as follows:

1) Survey number of vehicles that passed through the study sites during peak hours (7.00-9.00am and 3.00-6.00pm).
2) Survey the travel speed as well as the physical details of the sites for analysis of the relationship between related road accidents and these elements.
3) The selected sites from step 2 were identified by questionnaires. Additionally, the Yamane method, was used to obtain the required number of samples as shown in equation 4.3

$$n = \frac{N}{1 + Ne^2} \tag{4.3}$$

Where *n* = Number of sampling
N = Number of population
e = Error (use 5%)

The questionnaires were divided into two parts: 1) Socio-economic and traffic accidents data; and 2) causes of accident. The overall number of questionnaires of this study were 1,080 sets with the following breakdown for *BS-1*, *BS-2* and *BS- 3* at 350, 350 and 380, respectively.

4. The Binary Logistic Regression Model was used in the analysis of factors contributing to causes of road crashes in the study locations.

5. RESULTS AND RECOMMENDATIONS

5.1 Selected Areas Study

Nakhon Si Thammarat Municipality (NSTM) located in Nakhon Si Thammarat province (NST) in the southern of Thailand. It is subdivided into five sub districts (Tambon) which are Tha Wang, Khlang, Nai Mueng, Pho Dadet and some part of Na Khian and covers an area of 22.56 km^2 as shown in Fig.1

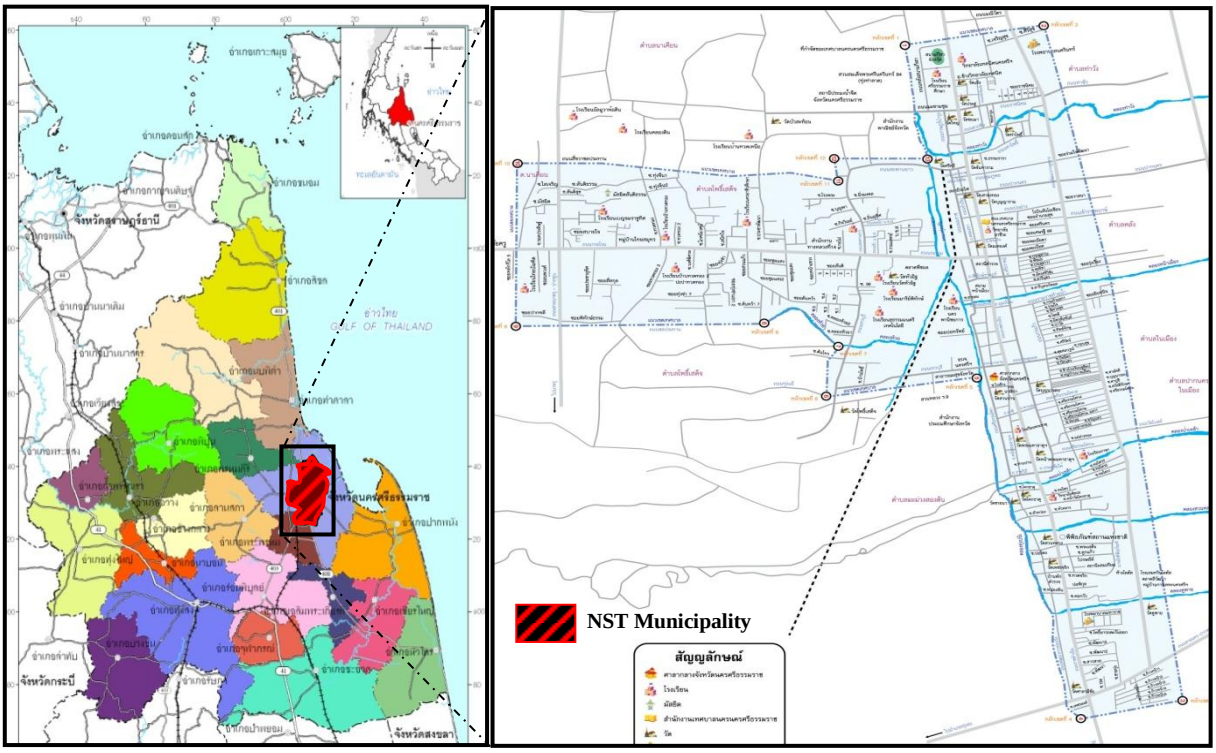

Figure 1: The Location of Nakhon Si Thammarat Province and NST Municipality

During 2009-2011, the road accidents statistical in NST showed that the number of fatalities and injuries were 39 and 752, respectively. When the number of fatalities per 100,000 populations in NSTM in 2009 were compared with those of the NST province and the whole country, the death rates of NST municipality were higher than both the NST province and whole country as shown in Table1.

Table 1: Comparison of Number of Fatalities/100,000 Populations among Municipality, NST and Whole Country in 2009

Sub-Districts in municipality	2009				Populations	No. of fatalities/100,000 populations		
	No. of accidents	Fatal	Serious injury	Slight injury		Sub-District in municipality	NST	Whole country
Nai Mueang	123	7	46	84	45,308	15.45		
Tha Wang	74	9	29	42	18,075	49.79		
Khlang	59	3	27	31	19,211	15.62		
Pho Sadet	96	7	45	53	24,430	28.65		
Na Khain	14	0	7	7	1,119	0.00		
Total	366	26	154	217	108,143	24.04	18.54	14.00

Source: Statistics Accidents Data from Tai Tek Tung Foundation and Pracha Ruam Jai Foundations.

Robinson department store (*BS-1*), Nakhon Si Thammarat Technical College (*BS-2*) and Thama market intersection (*BS-3*) were selected as the case study locations as they were ranked as highest for both average number of accidents and severity index during 2009-2011 among the other 20 sites with

high crash rate as shown in Fig.2. Consideration of potential black spots by using average critical crash number analysis showed that Khlang, Tha Wang, and Pho Sadet will be chosen as a black spots as their average frequency of accidents were three times higher. However, Nai Mueng, was also chosen as a black spot because of its average critical crash number was two times higher as shown in Table 2. When considered both the average critical crash number and Severity Index, the *BS-1, BS-2* and *BS-3* had the following values 6 and 13, 13 and 27, 15 and 24, respectively as shown in Table3

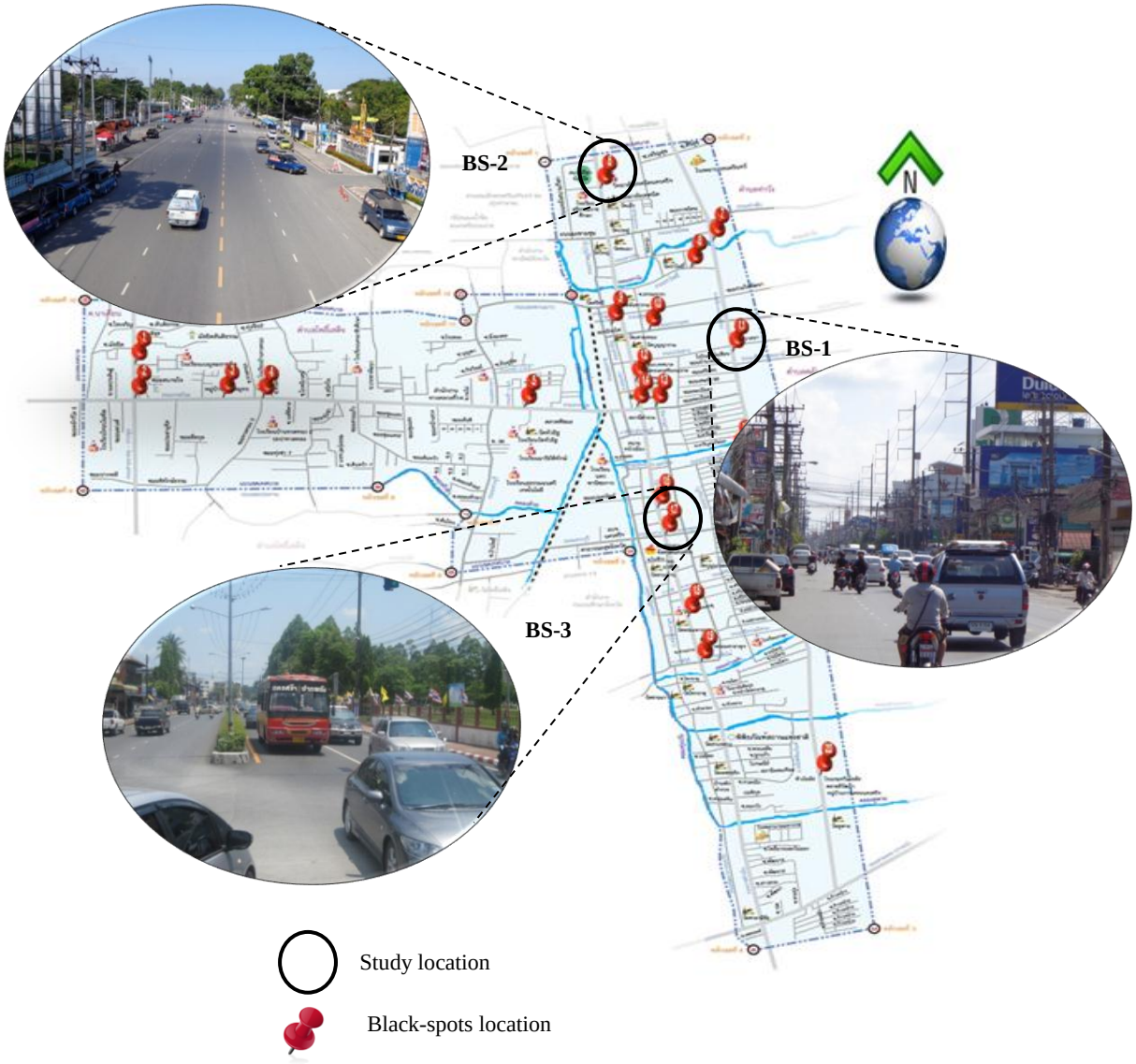

Figure 2: Three Case- Study Locations and the 20 High-Crash Locations

Table 2: Average Critical Crash Number in NST Municipality during 2009-2011

Areas	A_a	Z	$S.D.$	n	$\sqrt{n}$	A_c
Khlang	1.93	1.65	1.723	19	4.358899	3
Tha Wang	2.47	1.65	2.001	32	5.656854	3
Pho Sadet	2.24	1.65	2.002	41	6.403124	3
Nai Mueang	1.71	1.65	1.433	46	6.78233	2

Source: Calculation by Authors

Table 3: Three Highest Ranks of Average Frequency of Accidents and Severity Index of the Total 20 High-Crash Sites in NST Municipality during 2009-2011

Locations	Average frequency of accident/year (>A_c)	*SI*
BS-1	6	13
BS-2	13	27
BS-3	15	24

Source: Calculation by Authors

According to the Fig.2, the figure shows physical characteristics of three case study locations which can be summarized as follows.

BS -1 located on the four lanes of Pattakan Kookwang road and is surrounded between Ratchapruek village and Robinson department store on both sides. The road has a lane width 3.50 m and without raised median island. Moreover, there are also footpaths on both sides .The width of footpaths in front of Robinson department store and Ratchapruek Village is 2.30 and 2.70 m. respectively.

BS-2 located on Ratchadamnoen road and this section is a straight line with six lanes and the width per lane is approximately 2.765 m. Additionally, there are footpaths on both sides of the road whose width varies from 2.75 m. to 4.00 m. On both sides of this road section, there exists a primary & secondary school, a technical college and stadium. Most of the technical students and people who go to exercise travel to the college and stadium by own motorcycles and most of the motorcyclists age between 17 -21 years old (data from survey).

BS-3 located at the intersection between Ratchadamnoen road and Pratoolod road. This section of Ratchadamnoen road is a straight line with four lanes and the lane width is approximately 3.46 m. Also, there are footpaths on both sides of the road which has a raised median island. The width of road of Thama Market and city hall is 2.45 and 2.15 m., respectively and the width of the median is 0.60 m.

5.2 Results of the Study

The survey data of the number of vehicles in peak hours (7.00-9.00 am. & 3.00-6.00 pm.) and travel speed were collected at the 3 locations. The collected data and the surveyed questionnaires enable an analysis of the relationship between road accidents and other elements. The questionnaires were divided into two parts 1) Socio-economic and traffic accident data 2) causes of accident. The overall numbers of questionnaires in this study were 1,080 sets which were sub-divided for *BS-1*, *BS-2* and *BS- 3* at 350, 350 and 380 respectively and this is summarized in Tables 4, 5 and 6.

Table 4: Statistical Data of Total Traffic Accidents of Study Locations for 2009-2011

Descriptions	Study Locations		
	BS-1	*BS-2*	*BS-3*
Total number of accidents	19	38	45
Total no. of fatalities	1	3	1
Total no. of serious injury	8	13	10

Total no. of slight injury	11	30	39

Source: Statistics of Accident Data from Tai Teck Tung Foundation and Pracha Ruam Jai Foundation

Table 5: Traffic Volume Surveys of Study Locations

Study locations	Peak hours	Traffic volume in two directions (vehicles)			
		*Car (%)	**M/C (%)	Total (%)	Grand Total
BS-1	07.00:09.00	4,277 (47.3)	4,767 (52.7)	9,044 (100.0)	15,039
	15.00:17.00	3,391 (56.6)	2,604 (43.4)	5,995 (100.0)	
BS-2	07.00:09.00	2,349 (49.7)	2,376 (50.3)	4,725 (100.0)	8,341
	15.00:17.00	1,593 (44.1)	2,023 (55.9)	3,616 (100.0)	
BS-3	07.00:09.00	3,320 (66.5)	1,670 (33.5)	4,990 (100.0)	10,245
	15.00:17.00	3,324 (63.3)	1,931(36.7)	5,255 (100.0)	

Remark: *Car include private car, pick up and truck, **M/C = Motorcycle
Source: Survey by authors

Table 6: Travel Speed Surveys of Study Locations

Study locations	Travel speed at 85th percentiles (km/h)	
	Motorcycle	Car
BS-1	50	41
BS-2	55	43
BS-3	37	45

Remark: Speed limit in urban area is 80 km/h.
Source: Survey by authors

Table 4 to Table 6 showed that *BS-3* had the highest crash frequency, followed by *BS-2* and *BS-1*, respectively. Yet, *BS-2* had higher crash severity than *BS-1* and *BS-3* since it was next to the technical college. Most of students used motorcycles for travelling to the college. In contrast, *BS-3* had the highest number of injuries, followed by *BS-2* and *BS-1*. Consideration of the travel speed and traffic volume in each area showed that *BS-1*and *BS-2* had more number of motorcycles than other type of vehicles. The total number of vehicles at the *BS-2* was less than the other two sites even though the physical layout of *BS-2* was larger comprising six lane highway; this is because such area is an education zone and most students travelled by using motorcycles and rode with high speed. Considering *BS-3*, this area is a city zone which is close to market and city hall that results in a lot of vehicles during office time. Furthermore, the proportion of private cars was higher than motorcycles because people who wanted to contact with the government agencies in city hall came from outside urban areas; this contributed to traffic jam problems. Also, the travel speed was limited by the traffic congestion and many intersections on Ratchadamnoen road.

5.3 Results of Model Simulations

The result of model simulations for forecasting the variables that influence the road crashes at each location by using Binary Logistic Regression from SPSS version 20 are as shown in equations 1 and 2.

$$P_{iq} = \frac{e^{V_{iq}}}{\sum_{j=1}^{k} e^{V_{jq}}} \quad (1)$$

Where; P_{iq} = Probability of the i^{th} alternative for the q^{th} individual
U_{iq} = the utility of the i^{th} alternative for the q^{th} individual
= $Viq + \varepsilon_{iq}$
V_{iq} = Representative utility
= $\alpha + \beta_1 X_1 + \beta_2 X_2 + ...\beta_i X_i$
ε_{iq} = Error Component of Utility
α = Y intercept
β_{iq} = Utility parameter of independent variables
X_{iq} = Independent variables of the i^{th} alternative for the q^{th} individual

Binary logistic regression equation model is to take a natural log in odds ratio equation that result in a logit equation according to the equation 2. (Ben-Akiva, M.E., and Lermam, S., 1985)

$$\ln\left[\frac{P_{iq}}{1-P_{iq}}\right] = V_{iq} = \alpha + \beta_{niq} X_{niq} \quad (2)$$

There are two variables in this research as follows.

1. Independent Variable (*X*) is the variable that influences the dependent variable. It consists of the variable that related with the basic information of respondents and the factors on information that can cause traffic accidents such as cause of accidents, types of media (campaign for prevent traffic accident) and attitude of road users on law enforcement.
2. Dependent Variable (*Y*) is the variable that varies with the independent variable. The two dependent variables can be defined as follows.

Y = Had you ever been in a road crash in this area?
= 1 if the answer is "Yes"
= 0 if the answer is "No"

5.3.1 Model Results of *BS-1*

The results of parameter estimation that influence the traffic accidents comprise gender (male), motorcycle ownership and excessive speed by using the coefficient and statistics of the Logit model as can be seen in Table 7.

Table 7: Parameter Estimation Results of the Logit Model for *BS-1*

Variable	*β*	*S.E.*	*Wald*	*df.*	*Sig.*	*Exp(β)*
Gender (male)	3.009	0.781	14.838	1.000	0.000	20.259
Motorcycle ownership	1.137	0.392	8.436	1.000	0.004	3.118
Excessive speed	1.897	0.709	7.163	1.000	0.007	6.665
Constant	-89.065	72311.183	0.000	1.000	0.999	
Number of observations			*349*			
Loglikelihood			*112.473*			
Cox & Snell R^2			*0.280*			
Nagelkerke R^2			*0.586*			
Percentage correct			*94.6*			

Remak: *Hosmer & Lemeshow;* $\chi^2 = 11.675$, *df = 8, Sig. 0.166*

Table 7 shows the results of parameter estimation that influence the traffic accidents. Considering both *Cox & Snell* R^2 and *Nagelkerke* R^2, these variables account for 28% and 58.6%, respectively. *Nagelkerke* R^2 indicates a moderately strong relationship of 58.6% between observed and expected values. Furthermore, the percentage of accuracy of the Logit model is 94.6%. *Hosmer & Lemeshow* showed that this model is fit since χ^2*= 11.675, df = 8 and p-value* (0.166) > 0.05 (accepted null hypothesis). The coefficient of the model is a positive value which confirms the fact that 1) gender (male) tends to get into more traffic accidents than female, 20 times 2) if the number of motorcycles have been increased by one, the motorcyclists will have 3.118 times more accidents and 3) For respondents who consider excessive speed is the cause of the accident, the likelihood of getting into a crash significantly increase 7 times.

5.3.2 Model Results of *BS-2*

The results of independent variable analysis that is expected to influence traffic accidents include age, number of car ownership, lack of traffic control device as well as the coefficient and statistics of the Logit model presented in Table.8.

Table 8: Parameter Estimation Results of the Logit Model for *BS-2*

Variable	*β*	*S.E.*	*Wald*	*df.*	*Sig.*	*Exp(β)*
Age	0.112	0.041	7.363	1.000	0.007	1.119
Car ownership	0.609	0.287	4.512	1.000	0.034	1.839
Lack of traffic control devices	-0.818	0.399	4.193	1.000	0.041	0.441
Constant	38.466	56838.685	0.000	1.000	0.999	
Number of observations			*347*			
Loglikelihood			*242.054*			
Cox & Snell R^2			*0.234*			
Nagelkerke R^2			*0.379*			
Percentage correct			*85.6*			

Remark: *Hosmer & Lemeshow;* χ^2 *= 8.588, df = 8, Sig. 0.378*

The results of *BS-2* analysis found that *Cox & Snell* R^2 and *Nagelkerke* R^2 are 23.4% and 37.9%, respectively. *Nagelkerke* R^2 indicates a moderately strong relationship of 37.9% between observed and expected values. Also, the percentage of accuracy of the Logit model is 85.6%. *Hosmer & Lemeshow* showed that this model is fit since χ^2*= 8.588, df = 8 and p-value* (0.378) > 0.05 (accepted null hypothesis). The independent variable's coefficient of the model can confirm the fact that 1) if age is increased by one, the chance for road users to get into an accident will increase significantly to 1.119 times. 2) The chance of being in a car accident increases to 1.839 times, when the number of car ownership increases by one. Considering the attitude on law enforcement, if traffic control devices are adequate for enforcement, the model showed that the chance of getting accident has been decreased by 55.9 percent when compared with the answer "agree" more than "disagree".

5.3.3 Model Results of *BS-3*

The results of parameter estimation that influence the traffic accidents consisting of gender and age were obtained by using the coefficients and statistics of the Logit model as can be seen from Table 9.

Table 9: Parameter Estimation Results of the Logit Model for *BS-3*

Variable	*β*	*S.E.*	*Wald*	*df.*	*Sig.*	*Exp(β)*
Gender (male)	1.473	.560	6.917	1.000	.009	4.363
Age	-.116	.045	6.621	1.000	.010	.891
Constant	83.875	59728.014	.000	1.000	.999	

Number of observations	*380*
Loglikelihood	*154.794*
Cox & Snell R^2	*0.197*
Nagelkerke R^2	*0.423*
Percentage correct	*91.3*

Remark: *Hosmer & Lemeshow;* $\chi^2 = 5.272$, *df = 8, Sig. 0.728*

The results of *BS-3* analysis give *Cox & Snell* R^2 and *Nagelkerke* R^2 as 19.7% and 42.3%, respectively. *Nagelkerke* R^2 indicates a moderately strong relationship of 42.3% between observed and expected values. Also, the percentage of accuracy of the Logit model is 91.3%. *Hosmer & Lemeshow* showed that this model is fit since $\chi^2 = 5.272$, *df = 8 and p-value* (0.728) > 0.05 (accepted null hypothesis). Moreover, the percentage of accuracy of the Logit model is 91.3%. The independent variable's coefficient of the model confirm the fact that males are likely to get into more accident than females by 4.363 times when age has been increased by one. Also, the chance of road users getting into a crash has been decreased by 10.9%.

5.3.4 Traffic Management in Nakhon Si Thammarat Municipality

NST municipality has implemented traffic management for reducing traffic accidents in cooperation with traffic police since 12 July 2013. Traffic management plans have been implemented on both projects 1) The City of Safety project: installation CCTV at 50 points around the NST municipality and 2) The Wanted project: announcement to search for the motorcyclist and pillion passenger who wear safety helmets who will receive a reward from the governor (www.nakhoncity.org). (see in Fig. 3 & Fig.4)

Figure 3: The City of safety Project

Figure 4: The Wanted Project

6. CONCLUSIONS AND RECOMMENDATIONS

The three study locations selected from the ranking of crash frequency and severity were: Robinson department store (*BS-1*), Nakhon Si Thammarat Technical College (*BS-2*) and Thama market intersection (*BS-3*). Three year records of past road accident statistics were analyzed in order to find the critical crash number, and the specified cut-off level. Afterward, Severity Index were computed and used to identify black spots by using such data.

The result of model simulations for forecasting the variables that influence the occurrence of road accidents at each site obtained by using Binary Logistic Regression shows that *BS-1*, independent variables that are expected to influence the traffic accidents include gender (male), number of households that own motorcycles, and excessive driving speed. For *BS-2*, independent variables that are expected to influence the traffic accidents include age, number of cars in a household and lack of traffic control devices. For *BS-3*, the independent variables that are expected to influence the road accidents include gender (male) and age.

NST municipality has implemented traffic management to reduce traffic accidents in cooperation with the traffic police. Two projects which started on July 2013 comprise installation of CCTV which was implemented by NST municipality and the reward for motorcyclists who wear safety helmet.

The recommendation for solving traffic accident problems for the three selected case study locations are as follows: *BS-1*; municipality, polices and entrepreneur department store should be collectively responsible for organizing the traffic at entrance area and inside the department store. For *BS-2*, Nakhon Si Thammarat municipality should carefully recheck the road sign, for example, speed limit sign and install raised median island. For *BS-3*, the municipality should readjust traffic signal phase at the city hall intersection site.

For general recommendation, municipality officers and police officers should be strict on motorcyclists who use excessive speed by setting up more checkpoints. Also, more warning sighs should be provided, especially in black spot areas and the text for advertisement should focus on motorcyclist and pillion passenger. Moreover, the motorcyclists, age between 17-21 years old must wear safety helmets, especially for male riders. Lastly, the municipality should remove temporary shops on the footpath and sign boards that could obstruct the entrance to the alleys or intersections.

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