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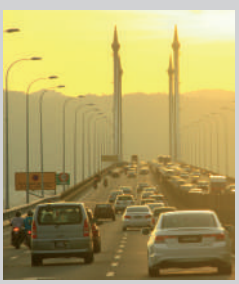

Research Report

Identification of Crash Determinants Involving Students at School Area in Selangor

Akmalia Shabadin
Rizati Hamidun
Azzuhana Roslan
Nur Zarifah Harun
Sharifah Allyana Syed Mohamed Rahim
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Abstract

Half of the world's road traffic deaths involving the vulnerable road users—pedestrians, motorcyclists and cyclists. In Malaysia, there are several strategies introduced to improve the road safety level of school children. However, crashes involving school children still worrisome. Recent trends of school children involved in crashes at school vicinity have become the nation's concern. Therefore, this study is aimed to investigate the contributing factors of pedestrian-vehicle conflict involving school children at school vicinity. This study focused on the utilization of the facilities provided at school, exposure measure and demographic characteristics of the schools. The facilities that being considered in this study are; zebra crossing, pedestrian bridge, drop off and pick-up zone and the presence of traffic warden. A total of 57 primary and secondary schools in Selangor were assessed for this study. The important variables have been analyzed using Negative Binomial Regression model to identify the significant attributes. Non-parametric analysis has been used to compare the differences in characteristics of the schools. The findings of the study concluded that road type and number of pedestrian are the underlying factors that would increase pedestrian-vehicle conflict at school vicinity.

1. Introduction

Half of the world's road traffic deaths occur among vulnerable road users where 22% of them are pedestrians and 23% are motorcyclists while cyclists contributed around 5% (WHO, 2015). Pedestrian is one of the vulnerable road users that always been neglected. In Malaysia, generally, the number of pedestrian death shows a decreasing trend since 2007 until 2016. However, when evaluated closely by annually, the fluctuating pattern can be seen. Statistics from Malaysian police recorded that pedestrian death has increased by 6% for 2016 (Royal Malaysia Police, 2016).

The leading cause of death among young people in the world are road traffic crash and it became the main cause of death among those aged between 15-29 years old (WHO, 2015). The young road users are at risk due to their small physical or growing characteristic that increase the risk. In addition, insufficient consideration of the young road users' specific needs when roads are being planned. Pedestrian safety especially school children constitute a world concern. Beterem (2008) reported that in Israel, 61.8% of children were injured in road traffic crashes where 29.2% of them were in motorized vehicles and 27.3% as the pedestrian. In Korea, the annual number of child death due to road crashes is decreasing but the rate is still approximately 50% higher than the fatality rate of other developed countries (Lee & Lee, 2014).

In Malaysia, 25% of road death in 2016 was those aged below 20 years old (Royal Malaysia Police, 2016). Focusing on young pedestrian aged below 15 years old, generally, the number of death involving them show the decreasing trend in ten years. The statistic was higher 15 years ago which lead to the introduction of Road Safety Education (RSE) programme in school. The programme has been implemented in stages since 2007. This initiative has been introduced to provide knowledge pertaining to road safety awareness to school children (Road Safety Plan 2014-2020). Providing safety environment for young citizen always been one of the government's priorities in Malaysia. Another programme that will be implemented is the implementation of speed control measure such traffic

calming would be installed to reduce vehicle speed at school and residential areas (Road Safety Plan 2014-2020).

Nevertheless, crashes resulting in death or serious injury involving school children still worrisome. Recent trends of school children involved in crashes at school vicinity have become the nation's concern. It has resulted in increasing the statistics of young pedestrian death in 2016. There are several studies have examined the factors that affect child-pedestrian involvement in road crashes. Some studies found that land use, urban environment and the neighbourhoods of children's residences affect children's risk of being involved in pedestrian road crashes (Wedagama et al., 2006; Petch & Henson, 2000).

Besides that, many studies have highlighted of the poor transportation facilities, such as pedestrian crossway, traffic sign, parking facilities, narrow road and the absence of shoulders; as well as the lack of traffic-law enforcement as factors that increased the children's risk of being injured in pedestrian road crashes (Elias et al., 2010; Elias & Shiftan, 2011; Al-Masaeid, 2009). Another study was done by Clifton and Kreamer-Fults (2007) on the environmental attributes associated with pedestrian–vehicular crashes near public schools found that the presence of driveways improves traffic flow and congestion in the school area, thus reducing the severity of crashes involving children of all ages.

In addition, exposures have also been found playing a significant role in child-pedestrian traffic safety. A study done in Israel has demonstrated that daily activity patterns and residential neighbourhood affect the probability of children being involved in pedestrian road crashes (Elias & Shiftan, 2014). The study concluded that children who walk more are also more likely to be injured in road crashes than are other children.

Traffic conflict has been used as a measure of the potential for traffic crashes (Davis et al., 1989). Though, the study regarding the pedestrian-vehicle conflict is still deficient especially traffic conflict at school vicinity. Most studies on pedestrian focused on the risk of the crashes. Thus, this study is aimed to investigate the contributing factors of pedestrian-vehicle conflict involving school children at school vicinity. This study focused

on the utilization of the facilities provided at school, exposure measure and demographic characteristics of the schools.

1.1 Aim and Objectives of the Study

This study aims to investigate the contributing factors of pedestrian-vehicle conflict involving school children at school vicinity. To achieve this aim, three (3) objectives have been set to be achieved. The objectives of this study are as follows:

i. To identify factors of risk exposure
ii. To develop the risk exposure model of pedestrian-vehicle conflict involving students at school area
iii. To estimate traffic conflict occurrence at school in Selangor

1.2 Scope and Limitation of the Study

This study covers schools in Selangor only. The primary data collection was conducted at 60 schools. The schools were selected based on their area type, either urban or rural and road type (primary, secondary or local road).

2. Literature Review

Pedestrian is vulnerable because they share the road with other motorized vehicles. The probability of them having a severe injury is also higher. Many studies have been done to identify the contributing factors of pedestrian crashes. Among the factors that have been identified are road characteristics, environmental factors, motorized vehicle attributes and demographic characteristics. A study done in the USA found that age, the speed limit on the road, location of crashes and time of day were the most important variables that influence the non-motorist injury severity level (Eluru et al., 2008). The study concluded that the older the person is, the higher the risk of getting an injury and the risk of severity increase at night time. Besides that, the study also concluded that the higher the speed limit the higher the injury severity level and signalized intersection lowering the risk of severe injury (Eluru et al., 2008).

The same conclusion can be found from Sze and Wong (2007) study accept that they concluded that crashes happened at the signalized intersection resulting in more severe injury. They used a binary logistic model to investigate the pedestrian injury severity of traffic crashes in Hong Kong. Another variable such as age, time of crashes happens and speed limit shows a similar result with Eluru et al. (2008). Another study was done by Aziz et al. (2013) aimed to explore the determinants of pedestrian-vehicle crash severity in New York City concluded that road characteristics, traffic attributes and land use are found to be statistically significant in the estimated model. The analysis of the study was done separately by the district in which each district has a different model and conclusion.

Some other studies that investigates the determinants of pedestrian and bicyclist crash severity by party at fault in San Francisco concluded that for crashes involving pedestrian, age, driver soberness, vehicle type, speed limit, time of day, driver turning and highway status has highest associations with injury severity (Salon & McIntyre, 2018).

A study on the severity of pedestrian injuries in children found that children aged less than nine years sustained more severe injuries compared to children older than 9 years (Pitt et al., 1990). Children spend half of their time at schools. A study done by Clifton and Kreamer-Fults (2007) to examine the environmental attributes that associated with pedestrian-vehicle crashes near public schools found that the presence of a driveway or turning bay on the school entrance decreases both crashes occurrence and injury severity. Contrarily, the presence of recreational facilities on the school site has a positive relationship with the crashes occurrence and injury severity. The study also investigates the school area characteristics and has concluded that transit access, commercial access and population density are commonly related to the increase of exposure measure which leads to the increase of probability of crashes.

A study done on the involvement of pedestrian children in car crashes in Arab Saudi concluded that generally, socio-economic status, travel pattern and land use were the contributing factors of children involved in road crashes (Elias & Shiftan, 2014). The study highlighted that the most vulnerable children that will involve in car crashes are boys from a low socio-economic group who live in a high-density area and mixed land use near a major road and who tend to walk to and from school and has additional activities after school (Elias & Shiftan, 2014). Theoretically, the more that children walk, the more they are exposed to the risk. Travel pattern plays a significant role in which if the children have additional activities after school that involve walking, it can lead to the increased crash risk.

Another study used the negative binomial model to perceived the environmental attributes of having a high risk of producing crashes near elementary schools. The study found that a higher number of student crossings, a wider road width, the presence of crosswalks, student-friendly facilities at the intersection, and four-way intersections were significant and positively associated with perceived crash risk among school-aged children (Lee et al., 2016). The study suggested that the association of the perceived crash risk was weak with the traffic-calming measure, means that the measure was not effective in reducing the perceived crash risk. Though, traffic calming is undeniably one of the good countermeasure to control the speed at school area.

Besides that, traffic conflict has been used as the measure of the potential traffic crashes (Davis et al., 1989). The definition of traffic conflict can be grouped in two types, those based on evasive actions and those based on temporal or spatial proximity (Zheng et al., 2014). The evasive action-based conflict involves at least two road users in which the action of one user cause the other user to make an evasive manoeuvre to avoid a collision (Parker & Zegeer, 1989). Based on the literature, the conflict between pedestrian and vehicle conflict occurs if the oncoming vehicle has to brake abruptly, if the vehicle has to swerve to avoid colliding with the pedestrian, or if the pedestrian has to take sudden evasive action, such as jumping back to avoid a collision (Zheng et al., 2014).

On the other hand, the proximity-based traffic conflict can be defined as an observable situation in which at least two road users approach each other in space and same time to such an extent that there is a risk of collision if their movements remain unchanged (Amundsen, 1977). In simpler term, the closer the pedestrian and vehicle are to each other, either in time or in space, the closer they are to a collision. Pedestrian-vehicle conflict is difficult to formulate due to unpredictable behaviour of vehicle and pedestrian in which many factors influencing their behaviour and action.

There are some studies done on investigating the factors of traffic conflict occurrence. The studies highlighted that personal characteristics such age (Liu & Tung, 2014) and gender (Yagil, 2000), (Tom & Granie, 2011), traffic condition like traffic volume (Cheng, 2013), (Himanen & Kulmala, 1998) and vehicle speed (Cheng, 2013), (Himanen & Kulmala, 1998) and also environmental factors such traffic signal, road width, city size and lane definition, were the contributing factors to the probability of pedestrian-vehicle conflict.

3. Methodology

This chapter further explains the methodology of this study which includes study design, study location, study variables and data collection techniques. This study was carried out from March 2017 until December 2017. Figure 1 below shows the methodology framework that describes the overall approach of this study towards meeting the objectives.

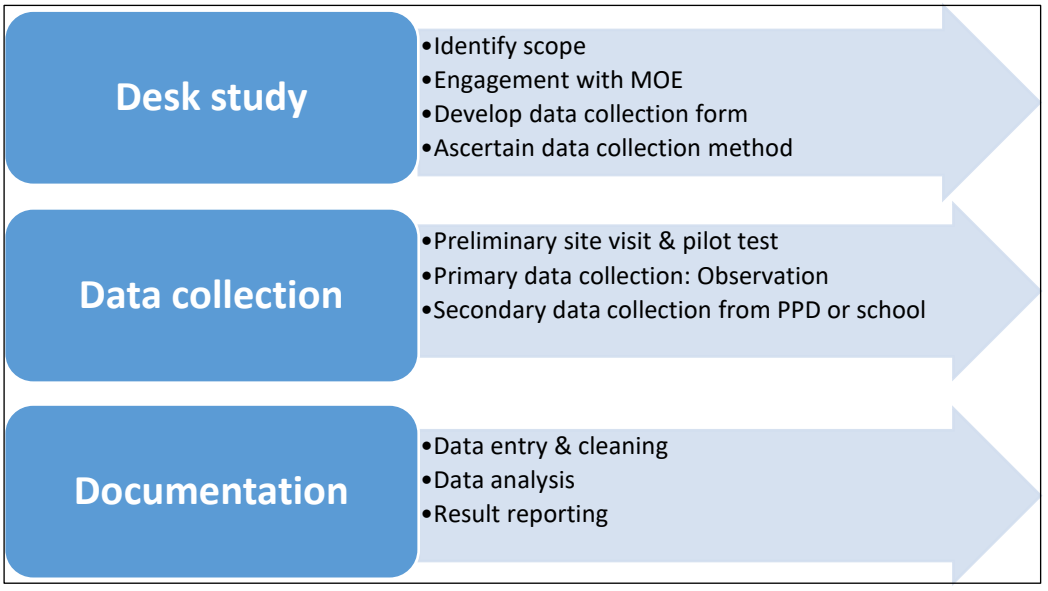


Figure 1 Methodology framework

3.1 Desk Study

Identifying the scope of the study was the first step in the desk study stage. At this stage, study location, sample selection and scope of the study were identified. Simultaneously,

engagement with the Ministry of Education (MOE) was made for collaboration and information sharing. Lastly, data collection method was confirmed and data collection form was developed.

3.1.1 Scope of the Study and Engagement with MOE

This study covers 57 schools in Selangor. The sample of the schools was selected based on the type of school; primary and secondary school, area type; urban or rural and also based on road type; primary, secondary or collector and local road. In addition, the schools were selected based on MOE's risky school criterion. MOE categorized the school based on this criterion:

i. Number of crash happened out of school vicinity
ii. The severity of the crashes,
iii. Type of road where the school is located
iv. Motorcycle usage among school
v. The presence of traffic warden at school

Table 1 shows the proportion of the sample based on the selection criterion. In total, sample of the study consisting of 30 primary schools and 27 secondary schools. The list of the selected schools can be referred to in the Appendix.

Table 1 Number of sample size for each category

Primary school			Secondary school		
	Urban	**Rural**		**Urban**	**Rural**
Primary	5	5	**Primary**	4	3
Secondary	6	5	**Secondary**	5	5
Local	8	1	**Local**	7	3

The list of schools in Selangor was obtained from the School Management Division, Ministry of Education (MOE). Before the data collection begins, as requirement from Educational Planning and Research Division, MOE, an application of conducting research form (BPPDP Form-1.2) needs to be filled up to get permission to conduct research at

schools, vocational college, matriculation college, Institute of Teacher Education, State Education Department or any division under MOE.

Figure 2 shows the sample distribution of the selected schools in Selangor. The blue marker indicates the primary schools while the red marker shows the selected secondary schools. As seen in Figure 2, the sample distribution was scattered throughout the Selangor state.

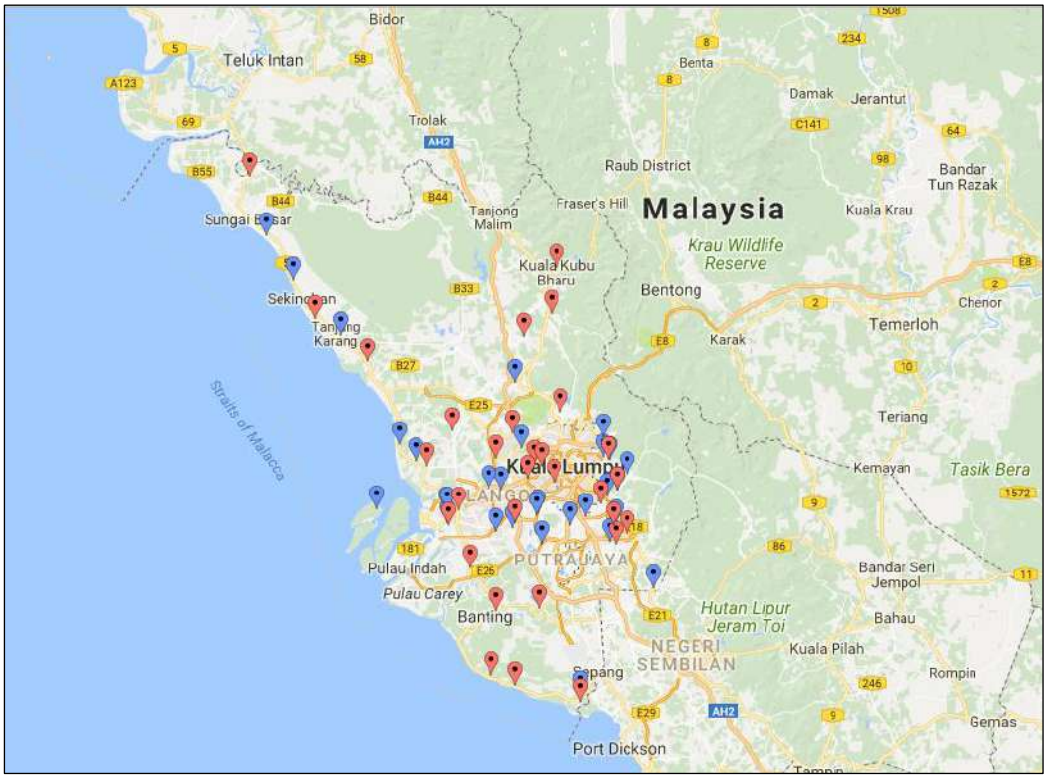
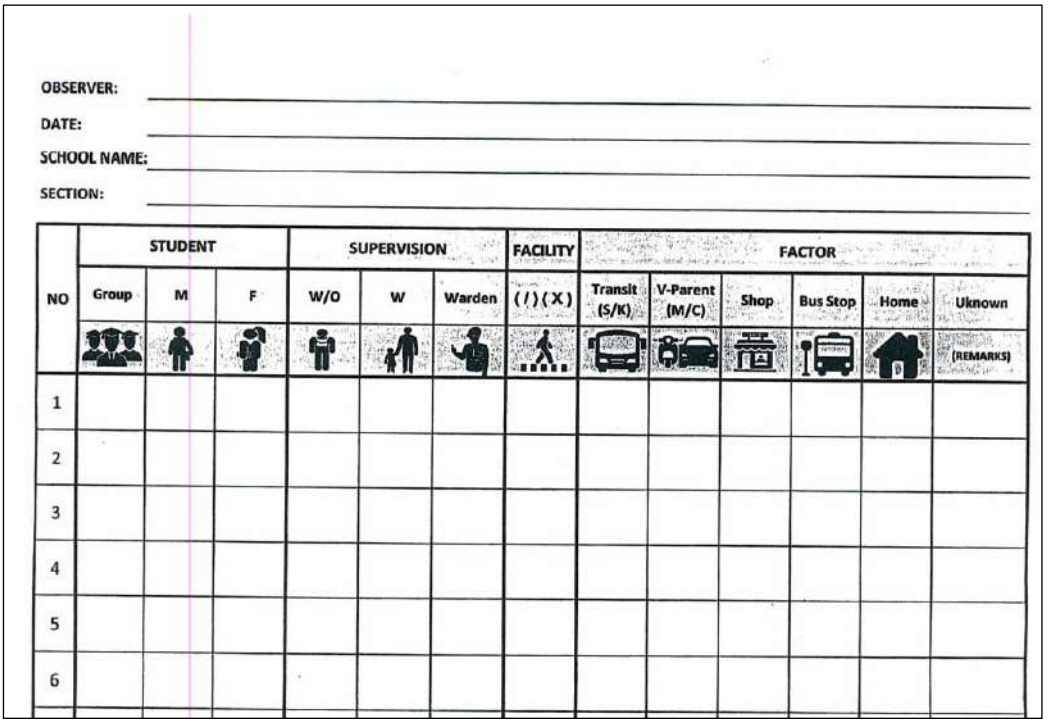


Figure 2 Distribution of the selected schools in Selangor

3.1.2 Type of Data Collected and Data Collection Form

There are two (2) types of data that were collected for this study; primary and secondary data. Primary data was collected through observation while secondary data was

obtained from schools. Observation has chosen as data collection method for primary data. The method will further discuss in Section 3.2. Data collection form was developed at this stage. Important variable such utilisation of pedestrian facilities, number of student crossing and the school location were recorded as shown in Figure 3. Other variables that were collected in the form are for other studies.



OBSERVER: _____

DATE: _____

SCHOOL NAME: _____

SECTION: _____

NO	STUDENT			SUPERVISION			FACILITY	FACTOR					
	Group	M	F	W/O	W	Warden	(/)(X)	Transit (S/K)	V-Parent (M/C)	Shop	Bus Stop	Home	Uknown
													(REMARKS)
1													
2													
3													
4													
5													
6													

Figure 3 On-site observation form

The secondary data that has been obtained from schools were number of students, proportion of transportation used for student commute to/from school and number of crashes that happened near school area. Figure 4 and 5 show the form that teachers need to fill up. The form was given to the predefined teacher during school hours. The forms will be collected two (2) weeks after the distributions.

Bilangan Pelajar dan Jenis Pengangkutan yang digunakan ke Sekolah

Pengangkutan	Tahun/Tingkatan						Jumlah
	1	2	3	4	5	6	
Kereta							
Motorsikal							
Motorsikal (Tunggang sendiri)							
Basikal							
Van/Bas Sekolah							
Pengangkutan Awam							
Berjalan Kaki							
Jumlah							

Figure 4 Mode of transport student used to school form

Maklumat Kemalangan yang Melibatkan Pelajar

Sekolah: _____

Tahun 2014

Jenis Jalan	Lelaki							Perempuan						
	Tahun/Tingkatan							Tahun/Tingkatan						
	1	2	3	4	5	6	Jumlah	1	2	3	4	5	6	Jumlah
Jalan Utama														
Jalan kecil/kampung														
Luar Waktu Sekolah														

Tahun 2015

Jenis Jalan	Lelaki							Perempuan						
	Tahun/Tingkatan							Tahun/Tingkatan						
	1	2	3	4	5	6	Jumlah	1	2	3	4	5	6	Jumlah
Jalan Utama														
Jalan kecil/kampung														
Luar Waktu Sekolah														

Tahun 2016

Jenis Jalan	Lelaki							Perempuan						
	Tahun/Tingkatan							Tahun/Tingkatan						
	1	2	3	4	5	6	Jumlah	1	2	3	4	5	6	Jumlah
Jalan Utama														
Jalan kecil/kampung														
Luar Waktu Sekolah														

Figure 5 Crash information form

3.2 Data Collection

A pilot test has been done on 7th April 2017 at Sekolah Kebangsaan Taman Universiti, Serdang to test the method chosen and the suitability of the form. The form was improved to ease the data collection process later. The second pilot test was done at Sekolah Menengah Kebangsaan Sultan Abdul Aziz Shah, Kajang on 13th April 2017. The second pilot test confirmed the method and data collectors position.

Before the data collection started, the authorization from the school was acquired and also the secondary data form was given to the predefined teacher. As mention in section 3.1.2, observation has been chosen as data collection method for this study. There is two (2) type of observations that have been used; on-site observation and through video observation. Variables collected during on-site observation was number of pedestrian facilities utilization, number of student's crossing, availability of the pedestrian facility and demographics of the selected school. These variables were collected after school hours' end. Eight data collectors were needed for each time data were collected. During on-site data collection, a video was installed for an hour to record the school's situation. An example of on-site observation can be seen in Figure 6.

Figure 6 An example of research assistant position during observation

Through video recording, few important variables were extracted. Number of pedestrian-vehicle conflicts, pedestrian and vehicle volume were recorded. The pedestrian-vehicle conflict occurs when a driver has to take some action such as breaking, slow down, weaving or honking in order to avoid collision with child pedestrian.

3.3 Data Entry and Data Analysis

All the data (primary and secondary data) were keyed-in in Microsoft Excel and IBM SPSS Statistics 20 software for analysis. Initially, the dependent variable was number of crash happen at school vicinity. However, data analysis cannot be performed due to unbalanced data. Thus, conflict data was used as the dependent variables. This study is aimed to investigate the contributing factors of pedestrian-vehicle conflict involving school children at school vicinity. To achieve the aim, data analysis using regression model was needed. The discrete response variable of this study has counts data as a possible outcome.

The simplest Generalized Linear Model for count data is the Poisson Regression Model. It has a single parameter $\mu > 0$, which is both its mean and variance $E(Y) = Var(Y) = \mu$. This study has response variable, Denote Y= number of pedestrian-vehicle conflict at school area and its $E(Y) = Var(Y) \neq \mu$. Its variance was larger than it's mean which this phenomenon is called overdispersion.

In the presence of Poisson overdispersion for count data, an alternative distribution called the Negative Binomial Distribution may avail a better model (Agresti, 2007). The Negative Binomial distribution was formed from the Poisson means to follow a gamma distribution with parameter μ and β. Let $Y \sim$ Negative Binomial (μ,β) then the $E(Y) = \mu$ and $Var(Y) = \mu + D\mu 2$ where D is nonnegative dispersion parameter.

4. Results and Discussions

This section discusses the results and findings of the study. This section is divided into three (3) subsections; the first section described on the explanatory variables while the second section illustrated on the pedestrian-vehicle traffic conflict. The last section described on the contributing factors.

4.1 Description of Explanatory Variables

The model parameters estimate that was included in the model are shown in Table 2 and 3. The variables were group into two categories; school characteristic and exposure measure. The school characteristics that have been examined were area type, road type, the availability of zebra crossing and pedestrian bridge and also the presence of traffic warden and drop-off and pick-up zone as shown in Table 2. Based on the table below, 30% of schools, located at the primary road (federal road) which usually has higher volume while the other 70% of the school located at secondary and local roads. The secondary road is covering main and collector road while local road consists of a residential and local street.

The pedestrian facilities that being considered in this study are; zebra crossing and pedestrian bridge. Usually, zebra crossing will be located near the school gate and the facilities were painted with yellow and white colour. Other facilities that were included are the presence of drop off and pick-up zone and traffic warden. The drop-off and pick-up zone is the specific area provided to drop-off or pick-up the students while traffic warden is provided to control the traffic especially while student cross the road.

Out of 57 schools, around 44% of them has zebra crossing where 64% of the schools are primary schools. Only 11 schools have pedestrian bridge provided at their schools. Normally, the pedestrian bridge will be provided if the schools were located at high

volume road. Traffic warden usually was provided at primary school. 47% of total primary schools have traffic warden at their schools and only 33% out of 57 schools have drop-off and pick-up zone at the school.

Table 2 School characteristic

		Primary	Secondary
Area type	Urban	19	16
	Rural	11	11
Road type	Primary	10	7
	Secondary	11	10
	Local	9	10
Zebra crossing	Available	16	9
	Not available	14	18
Pedestrian bridge	Available	5	6
	Not available	25	21
Traffic warden	Available	14	2
	Not available	16	25
Drop-off & pick-up zone	Available	9	10
	Not available	21	17

Table 3 shows the measure of road exposure. Variables that group under this category were vehicle and pedestrian volume, number of student cross the road, percentage of pedestrian facilities utilisation, and proportion of transport mode the student use commuting to/from schools. On average, primary schools have more vehicles volume compared to secondary schools. The theory is may be due to the fact that usually for primary students, parents will send or pick-up their child using their own vehicles such as car or motorcycle. On the other hand, the average pedestrian volume was higher in secondary schools. The same trend can be seen for number of student crossing the road. On average, 212 secondary students crossed the road while half of the figure is average number of primary student cross the road.

Utilization of pedestrian facilities was observed to investigate its usefulness. More than half of the primary students utilized the zebra crossing while only 41.1% of the secondary student used the facilities. The usage of the pedestrian bridge is lower compared to the

zebra crossing. From 2072 students observed, 41.7% of primary students used pedestrian bridge while only 30.3% of secondary students utilize the facilities provided. The fewer usage of the pedestrian bridge may due to the student behaviour such as too lazy to climb the stairs or they think it will waste their time.

Table 3 shows the percentage of mode transport students used to school. More than half of the primary students were sent by their parents either by car or motorcycle. These modes were preferred mostly because it's the transport the parents used to commute to work. The same trend can be seen for secondary students where around 27% were sent by parent's car and 17% by parent's motorcycle, however, the percentage is less compared to the primary student. The quite sum of the percentage goes to student motorcycle where about 12% of the secondary students ride the motorcycle to school. Another thing that can be highlighted is the differences in the percentage of students walk to school between primary and secondary student. Only 4% of primary student walk to school while 15% of secondary students walk to school. This differences may due to safety issues which secondary students are grown up enough to take care of themselves.

Table 3 Exposure measure

		Primary	Secondary
Vehicle volume	Mean	1353	1205
	Median	832	705
Pedestrian volume	Mean	106	159
	Median	85	132
No. of student crossing	Mean	111	212
	Median	90	211
Ped. facilities utilisation	Zebra crossing	54.7%	41.1%
	Pedestrian bridge	41.7%	30.3%
Mode of transport	Parent's car	46.08%	26.69%
	Parent's motorcycle	20.17%	16.80%
	Student's motorcycle	0.04%	11.83%
	Bicycle	1.50%	4.23%
	School bus/van	28.29%	25.01%
	Walking	3.92%	15.44%

4.2 Pedestrian-vehicle Conflict

The occurrence of pedestrian-vehicle conflict was tabulated by the availability of the facilities at school. As shown in Table 4, the occurrence of conflict was significantly different by the availability of pedestrian bridge and drop-off & pick-up (D&P) zone. The Chi-square significant value was smaller than p-value 0.05. To understand further on the traffic conflict occurrence, the odds ratio value of the significant variables was calculated.

Based on the table below, the odds ratio value for pedestrian bridge is 5 which it means that the risk of conflict to occur are 5 times greater for schools that do not have pedestrian bridge than schools that have the facility. Generally, the school that been provided with the pedestrian bridge are located at high volume road in which the facility is needed for student to cross the road. In line with that, the presence of drop-off and pick-up zone reduces the risk of conflict occurrence. The odds ratio of the D&P zone shows that schools without D&P zone are 3.5 times more likely to have pedestrian-vehicle conflict as compared to school that have D&P zone. The presence of D&P zone eases the traffic flow during pick-up and drop-off time in which during that time the probability of conflict to occur is higher.

Table 4 The occurrence of pedestrian-vehicle conflict by the availability of the facilities

Facilities	Facilities availability	Conflict	No conflict	Odds ratio
Total	-	40	17	-
Zebra crossing	No	24	9	-
	Yes	17	8	
Pedestrian bridge*	No	36	10	**5.0**
	Yes	5	7	
Traffic warden	No	32	10	-
	Yes	9	7	
Drop-off & pick-up zone*	No	31	8	**3.5**
	Yes	**10**	**9**	

*Significant at α=0.05

4.3 The Contributing Factors

Negative Binomial Regression (NBR) was used to identify the underlying factors of the occurrence of the pedestrian-vehicle conflict at school vicinity. The assumption of the NBR needs to be checked before going further with the analysis. The NBR was used for over-dispersed count data where the variance is larger than the mean. The mean number of pedestrian-vehicle conflict is E(μ)= 2 while the variance is Var(μ)=7.5. Indeed, the variance value is larger than the mean, thus can proceed with the model. The p-value of the Omnibus test for the full fitted model is equal to 0.013 and it is larger than α=0.10; hence we can conclude that the overall model is statistically significant by having all the independent variables.

Using the Wald Chi-Square analysis, the significant variables are shown in table 5. Based on the table, number of pedestrian and road type were significant at α=0.10. Let μ denote the expected number of pedestrian-conflict and let Xs denote the explanatory variables. The Negative Binomial Model is

$$\text{Log } \hat{\mu} = -0.479 + 0.004X_1 + 0.645X_{2(1)} + 1.206X_{2(2)}$$

The interpretation of the model is explained by the odds ratio value for each of the significant variables.

Table 5 The significant variables

Parameter	Variables	β	Exp(β)	Wald chi-square
X_1	Pedestrian volume	0.004	1.004	0.076
$X_{2(1)}$	Road type-primary	0.645	1.906	0.063
$X_{2(2)}$	Road type-secondary/collector	1.206	3.341	
X_0	Intercept	-0.479	0.620	0.676

All the other variables; school type, area type, vehicle volume, availability of zebra crossing and pedestrian bridge, the presence of traffic warden and drop-off and pick-up zone, proportion of pedestrian facilities utilization, number of student crossing, total

number of students, proportion of mode of transport used to school were not significant as shown in Table 6.

Table 6 The insignificant variables

Parameter	Variables	Categories	β	Wald chi-square
$X_{3(1)}$	School type	Primary	0.673	0.627
$X_{4(1)}$	Area type	Urban	-0.352	0.355
X_5	Vehicle volume	-	-0.000034	0.795
$X_{6(1)}$	Zebra crossing	Not available	0.023	0.951
$X_{7(1)}$	Ped. bridge	Not available	0.703	0.156
$X_{8(1)}$	Traffic warden	Not presence	0.486	0.248
$X_{9(1)}$	D&P zone	Not presence	-0.103	0.808
X_{10}	Utilisation	-	-6.113	0.282
X_{11}	Student no.	-	0.000	0.654
X_{12}	Parent's car	-	-1.644	0.100
X_{13}	Parent's mc	-	1.341	0.257
X_{14}	Student's mc	-	-0.195	0.938
X_{15}	Bicycle	-	6.563	0.243
X_{16}	School van/bus	-	-0.379	0.719
X_{17}	Walk	-	2.806	0.173

Odds ratio value for significant variables were calculated by exponentiating the β value as shown in the fourth column of Table 4. The Exp(β) give the multiplicative effect on the fitted value for each one-unit increase in Xs. The Exp(β) value for pedestrian volume is 1.004 and it can be explained simply as an addition of one pedestrian has a 0.4% increase in the estimated mean number of pedestrian-vehicle conflict.

Between the primary road and local road, the study can say that the odds of the pedestrian-vehicle conflict to occur increase by 91% if the school is in front of primary road. The Exp(β) value for secondary road is 3.34, which indicates that the pedestrian-vehicle conflict is 3.3 times more likely will occur at secondary road compared to a local road.

5. Conclusion and Recommendations

The high number of conflict at school area is risky for students which can lead to crashes, hence thorough investigation needs to be done. This study is aimed to investigate the contributing factors of pedestrian-vehicle conflict involving school children at school vicinity. There is a very little study on pedestrian-vehicle conflict especially, at school area. In the knowing of the factors contributing to the conflict, the preventive measure can be taken before the crash happen.

This study concludes that the presence of pedestrian bridge and drop-off and pick-up zone are significantly reducing the risk of pedestrian-vehicle conflict to occur. This study also concludes that the two (2) significant contributing factors are number of pedestrian volume at the school area and type of road that the school is located. The increasing number of pedestrian obviously will increase the probability of the conflict to occur. Besides that, road type also plays a significant contributor to the occurrence of conflict. Different type of road has a different number of volume which leads to the riskier situation.

Suitable facilities such pedestrian bridge should be provided to facilitate students to cross with the help of traffic warden to control the traffic. However, the traffic warden should be trained and equipped with safety tools. Even though the presence of traffic warden is not significant for this study, it is undeniable that traffic warden is one (1) of the good traffic controllers particularly for primary students. Besides that, installing traffic calming can reduce the risk caused by speeding and providing sidewalk is a good traffic control to improve students' safety while walking. Improving pedestrian facility is always an important agenda for the nation to support the road safety decade of action's aim to promote non-motorized form of transport.

Generally, there are many factors that can contribute to the pedestrian-vehicle conflict or crashes particularly at school vicinity. Human behaviour is one of the eminent factors

to road safety mainly, for school children where their safety level of awareness is less compared to an adult. This study focused on road engineering and environment aspect, which based on other studies, there a lot more variables that significantly contribute to the crashes such as personal characteristics and the crossing behaviour.

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Appendix

Primary school
Sekolah Kebangsaan Sinaran Budi
Sekolah Kebangsaan Abdul Samat
Sekolah Kebangsaan Telok Gadong
Sekolah Kebangsaan Sungai Haji Dorani
Sekolah Kebangsaan Sungai Leman
Sekolah Kebangsaan Tanjong Karang
Sekolah Kebangsaan Tambak Jawa
Sekolah Jenis Kebangsaan (Cina) Ying Wah
Sekolah Kebangsaan Taman Kosas
Sekolah Kebangsaan Ampang
Sekolah Kebangsaan Hulu Kelang
Sekolah Kebangsaan Bukit Rimau
Sekolah Kebangsaan Seksyen Enam
Sekolah Kebangsaan Seksyen 13
Sekolah Kebangsaan Putra Heights 2
Sekolah Kebangsaan Pulau Meranti
Sekolah Kebangsaan Pusat Bandar Puchong 2
Sekolah Jenis Kebangsaan (Tamil) Castlefield
Sekolah Kebangsaan Seksyen 9 Kota Damansara
Sekolah Kebangsaan Sungai Pelek
Sekolah Kebangsaan Seksyen 7
Sekolah Kebangsaan Batu Sembilan
Sekolah Kebangsaan Taman Sungai Besi Indah
Sekolah Kebangsaan Taman Universiti
Sekolah Kebangsaan Tun Abd Aziz Majid
Sekolah Kebangsaan Dusun Nanding
Sekolah Kebangsaan Saujana Impian
Sekolah Kebangsaan Taman Melawati 2

Sekolah Kebangsaan Sungai Binjai
Sekolah Kebangsaan Jalan Semenyih 1

Secondary school
Sekolah Menengah Kebangsaan Bukit Sentosa 2
Sekolah Menengah Kebangsaan Syed Mashor
Sekolah Menengah Kebangsaan Dato' Haji Kamaruddin
Sekolah Menengah Kebangsaan Convent
Sekolah Menengah Kebangsaan Pendamaran Jaya
Sekolah Menengah Kebangsaan Puncak Alam
Sekolah Menengah Kebangsaan Bandar Baru Sungai Buloh
Sekolah Menengah Kebangsaan Sungai Burong
Sekolah Menengah Kebangsaan Pengkalan Permatang
Sekolah Menengah Kebangsaan Tengku Idris Shah
Sekolah Menengah Kebangsaan Taman Kosas
Sekolah Menengah Kebangsaan Selayang Bharu
Sekolah Menengah Kebangsaan Alam Megah
Sekolah Menengah Kebangsaan Damansara Utama
Sekolah Menengah Kebangsaan Bandar Utama Damansara (2)
Sekolah Menengah Kebangsaan Kelana Jaya
Sekolah Menengah Kebangsaan La Salle, Petaling Jaya
Sekolah Menengah Kebangsaan Batu Laut
Sekolah Menengah Kebangsaan Tanjung Sepat
Sekolah Menengah Kebangsaan Pantai Sepang Putra
Sekolah Menengah Kebangsaan Telok Panglima Garang
Sekolah Menengah Kebangsaan Bukit Changgang
Sekolah Menengah Kebangsaan Bandar Tun Hussein Onn 2
Sekolah Menengah Kebangsaan Dusun Nanding
Sekolah Menengah Kebangsaan Jalan Reko
Sekolah Menengah Kebangsaan Sultan Abdul Aziz Shah
Sekolah Menengah Kebangsaan Setia Alam

Research Report

Identification of Crash Determinants Involving Students at School Area in Selangor

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