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Evaluation of School Children Crossing Facilities and Traffic Conflicts in The Vicinity of Schools in Selangor

Akmalia Shabadin
Malaysian Institute of Road Safety Research (MIROS), Lot 125-135, Jalan TKS 1, Taman Kajang Sentral 43000 Kajang Selangor

Hawa Mohamed Jamil, Alvin Poi Wai Hoong, Rizati Hamidun, Azzuhana Roslan, and Mohd Shafie Nemmang
Malaysian Institute of Road Safety Research (MIROS), Lot 125-135, Jalan TKS 1, Taman Kajang Sentral 43000 Kajang Selangor

Siti Zaharah Ishak
Universiti Teknologi MARA, 40450 Shah Alam, Selangor

ABSTRACT

Half of the world's road traffic deaths involve 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 are still worrisome. Recent trends of school children involved in crashes in school vicinity have become the nation's concern. Therefore, this study aims to investigate the contributing factors of pedestrian-vehicle conflict involving school children in vicinity of the school. This study focused on the utilization of the facilities provided at school, exposure measures, and demographic characteristics of the schools. The facilities that are being considered in this study are; a zebra crossing, pedestrian bridge, drop-off, and pick-up zone, and the presence of a traffic warden. A total of 57 schools in Selangor were assessed for this study. The important variables were analyzed using the Negative Binomial Regression model to identify the significant attributes. Non-parametric analysis was used to compare the differences in characteristics of the schools. The findings of the study conclude that the road type and pedestrian volume are the underlying factors that would increase pedestrian-vehicle conflict in the school vicinity.

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Corresponding Author Contact:

akmalia@miros.gov.my

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1. Introduction

Pedestrian is one of the vulnerable road users that have always been neglected. Based on the WHO report, 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). In Malaysia, generally, the number of pedestrian death shows a decreasing trend from 2007 to 2020 (Royal Malaysia Police, 2020). However, when evaluated closely annually, the fluctuating pattern can be seen as shown in Figure 1. Statistics from Malaysian police record that pedestrian death increase by 6% in 2016 (Royal Malaysia Police, 2020).

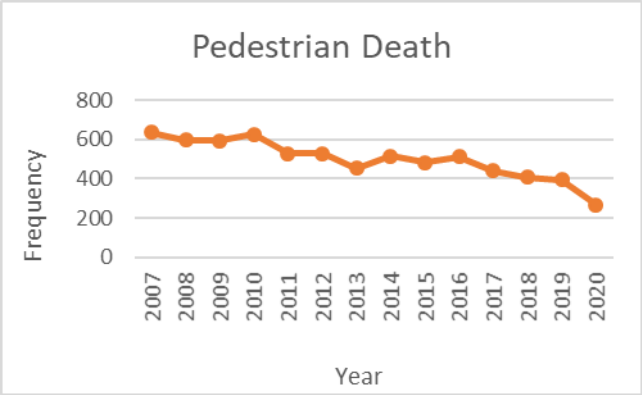

Figure 1 Pedestrian death from 2007-2020

The leading cause of deaths among young people in the world is road traffic crash and it becomes the main cause of death among those aged between 15-29 years old (WHO, 2015). 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 for school children constitutes a world concern. Beterem (2008) reported that in Israel, 61.8% of children are injured in road traffic crashes where 29.2% of them are in motorized vehicles and 27.3% 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 and Lee, 2014).

In Malaysia, 25% of road deaths in 2016 are those aged below 20 years old (Royal Malaysia Police, 2016). Focusing on young pedestrians aged below 15 years old, generally, the number of deaths involving them shows a decreasing trend in ten years. The statistic was higher than 15 years ago which led to the introduction of the Road Safety Education (RSE) program in 2007. This initiative was introduced to provide knowledge pertaining to road safety awareness to schoolchildren (Road Safety Plan 2014-2020). Providing a safe environment for young citizens has always been one of the governments priorities in Malaysia. Another program that will be implemented is speed control measures by installing traffic calming to reduce vehicle speed in school and residential areas (Road Safety Plan 2014-2020).

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

In addition, many studies highlight the poor transportation facilities, such as pedestrian crossways, traffic signs, parking facilities, narrow roads, and the absence of shoulders; as well as the lack of traffic-law enforcement as factors that increased the childrens risk of being injured in pedestrian road crashes (Elias et al., 2010; Elias and Shiftan, 2011; Al-Masaeid, 2009). Another study done by Clifton and Kreamer-Fults (2007) on the environmental attributes associated with pedestrian–vehicular crashes near public schools find 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, a study was done to estimate the impacts of built environments on child pedestrian crashes at the street segment level in Austin, TX USA conclude that no sidewalks, crosswalk density, longer block lengths, and commercial land uses around schools may affect child pedestrian safety (Hwang, Joh, and Woo, 2017). On top of that, crossing behaviors also play a significant contribution to the increase in the risk of a crash. Children who cross the road alone usually do not look before crossing and running to cross the road (Hamidun, Liew & Roslan, 2022; Zhang et al., 2013). Another study on children crossing behavior was done in China and it is observed that the children show unsafe behavior such as sneaking behind a vehicle, entering and crossing a lane with a moving vehicle approaching (Schwebel et al., 2018).

Traffic conflict has been used as a measure of the potential for traffic crashes (Davis et.al, 1989). Nevertheless, the study regarding the pedestrian-vehicle conflict is still deficient, especially regarding traffic conflict in the school vicinity. Most studies on pedestrians focused on the risk of crashes. Thus, this study aims to investigate the contributing factors of pedestrian-vehicle conflict involving school children in the school vicinity. This study focuses on the utilization of the facilities provided at school, exposure measures, and demographic characteristics of the schools.

2. Methodology

57 schools in Selangor, Malaysia have been selected as a sample of the study. The selected schools include primary and secondary schools with the involvement of students aged from seven to 17 years old. The schools were selected based on the area type; either urban or rural area and based on their road type (highway, primary and secondary road).

Naturalistic observation has been chosen as the data collection method for this study. There are two types of observations used; on-site observation and video observation. Figure 2 shows an example of the research assistant position during an on-site observation. Variables collected during the on-site observation were the number of pedestrian facilities utilization, number of students crossing, availability of the pedestrian facility, and demographic of the selected school. These variables were collected after school hours. During on-site data collection, a video was installed for an hour to record the schools' situation.

Figure 2 The research assistant position during observation

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

The discrete response variable of this study has counted data as the possible outcome. The simplest Generalized Linear Model for count data is 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 a response variable, Denote Y= number of pedestrian-vehicle conflicts in the school area and its $E(Y) = Var(Y) \neq \mu$. Its variance was larger than its 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.

The Negative Binomial distribution was formed from the Poisson means to follow a gamma distribution with parameters 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.

3. Results and Discussion

This section will discuss the result of the study. The number of pedestrian-vehicle conflicts and the type of pedestrian facilities provided at school will be discussed. The Negative Binomial model was regressed to identify the contributing factors. The model parameters estimate that was included in the model are shown in Table 1.

Table 1 Explanatory Variables

Variable	Values
School characteristics	
School type	Primary, secondary
Area type	Urban, rural
Road type	Highway, primary, secondary
Availability of zebra crossing	Yes, No
Availability of pedestrian bridge	Yes, No
Presence of a traffic warden	Yes, No
Availability of drop-off & pick-up (D&P) zone	Yes, No
Exposure Measure	
Vehicle Volume	Vehicle volume count
Pedestrian Volume	Pedestrian volume count
Pedestrian facilities utilization	Utilization of zebra crossing or pedestrian bridge count
Number of student crossing	Student crossing count number
Proportion of mode of transport used to school	Proportion of students use their parent's car and motorcycle, student's motorcycle, bicycle, school van/bus or walk to school

3.1 Facilities provided at school

A child's ability to safely cross a road is limited due to their inability to judge the safe crossing gap. Thus to provide a safe environment for the school children especially for crossing the road, several facilities must be provided such as a zebra crossing, pedestrian bridge, drop-off, pick-up zone, etc. The pedestrian facilities that are being considered in this study are; zebra crossing and pedestrian bridge. Usually, zebra crossing is located near the school gate and the facilities are painted with yellow and white colour. Other facilities that should be included are the presence of the drop-off and pick-up (D&P) zone and traffic warden. The D&P zone is the specific area provided to drop off or pick up the students while a traffic warden is provided to control the traffic especially while students cross the road.

Table 2 shows the number of facilities provided by the type of schools. Out of 57 schools, around 44% of them have zebra crossing where 64% of the schools are primary schools. Only 11 schools have pedestrian bridges provided at their schools. Normally, a pedestrian bridge will be provided if the schools are

located at the high-volume road while traffic warden usually is provided at primary school. It is found that 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 Facilities provided by the type of schools

Facilities	Type of school	Available	Not available
Zebra Crossing	Primary	16	14
	Secondary	9	18
Pedestrian Bridge	Primary	5	25
	Secondary	6	21
Traffic Warden	Primary	14	16
	Secondary	2	25
Drop-off & Pick-up Zone	Primary	9	21
	Secondary	10	17

3.2 Exposure Measure Description

Exposure measure is often used to describe differences in the road safety situation. It is often used as a denominator in the index calculation to calculate the risk. The common measures are distance travel, population, traffic volume, etc. This study also collects the exposure perimeter for each school. Table 3 shows the description of the exposure measure by type of school. The parameter used to describe the number of student crossing, vehicle, and pedestrian volume is the mean whereas the percentage is used to describe the pedestrian facilities utilization and the proportion of mode of transport used to school.

On average, it was found that the volume of vehicles in primary school was 1329 vehicles while the average of vehicles that passes by the secondary school were 1205. On the other hand, the mean number of pedestrians after the school hour in secondary school was higher compared to primary school. Specifically, on average, there were 159 people during the midday after school hours at secondary school while only 106 pedestrians at the primary school. In addition, the number of students crossing was also higher in secondary school compared to primary school. This may be due to primary students are usually picked up by their parents while secondary students would go home on their own by bus or on foot.

Besides that, the percentage of pedestrian facilities utilization is also shown in Table 3. 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 was lower compared to the zebra crossing. Of 2072 students observed, 41.7% of primary students used pedestrian bridges while only 30.3% of secondary students utilize the facilities provided. The fewer usage of the pedestrian bridge may be due to the students' behaviour such as being too lazy to climb the stairs or they think it will waste their time.

Table 3 The description of the exposure measure by school type

School Characteristics	Type	School Type	
		Primary	Secondary
		Mean	
Vehicle volume		1329	1205
Pedestrian volume		106	159
Number of students crossing		109	212
		Percentage	
Pedestrian facilities utilization	Zebra Crossing	54.7%	41.1%
	Pedestrian Bridge	41.7%	30.3%

3.3 Pedestrian-Vehicle Conflict

The occurrence of pedestrian-vehicle conflict was tabulated by the school characteristics and 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 the p-value of 0.05. To understand further the traffic conflict occurrence, the odds ratio value of the significant variables was calculated.

Based on the table below, the odds ratio value for a pedestrian bridge after taking the reciprocal of the odds ratio is 5. This means the risk of conflict occurring is 5 times greater for schools without pedestrian bridges than schools that are equipped with the facility. Generally, schools with pedestrian bridge are located on a high-volume road in which the facility is needed for crossing the road. Furthermore, Ismail et. al (2018) indicates that a pedestrian bridge can be considered the safest and most efficient crossing facility.

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 showed that schools without a D&P zone are 3.3 times more likely to have pedestrian-vehicle conflict as compared to schools that have a D&P zone. The presence of the D&P zone eases the traffic flow during pick-up and drop-off time which during that time the probability of conflict occurring higher. A study done by Clifton and Kreamer-Fults (2007) ascertained that the presence of driveways and recreation facilities is statistically significant with the pedestrian crashes. Another study done in Toronto, Canada also found that designated drop-offs can be a protective measure against several risky pedestrian crossing and driving behaviours at uncontrolled locations mid-block as well as between parked cars (Rothman et al., 2017).

Table 4 The occurrence of pedestrian-vehicle conflict by school characteristics

Characteristics		Conflict		ratio)
		Yes	No	
School Type	Primary	18	12	0.077
	Secondary	22	5	(2.9)
Area Type	Rural	16	6	0.738
	Urban	24	11	(0.8)
Road Type	Highway	10	7	
	Primary	16	5	0.467 (-)
	Secondary	14	5	
Zebra Crossing	Yes	17	8	0.751
	No	23	9	(0.8)
Pedestrian Bridge	Yes	4	7	0.006*
	No	36	10	(0.2)
Traffic Warden	Yes	9	7	0.151
	No	31	10	(0.4)
Drop-off & Pick-up Zone	Yes	10	9	0.041*
	No	30	8	(0.3)

*significant at α=0.05

3.4 The Contributing Factors Of Pedestrian-Vehicle Conflict

Negative binomial regression (NBR) was used to identify the underlying factors of the occurrence of the pedestrian-vehicle conflict in the 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 conflicts 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, the number of pedestrian and road types was significant at α=0.10, and 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, the total number of students, the proportion of mode of transport used to school were not significant.

Let μ denote the expected number of pedestrian-conflict and let Xs denote the explanatory variables.

The Negative Binomial Model is:

$$\text{Log } \hat{\mu} = -0.479 + 0.004X1 + 0.645X2(1) + 1.206X2(2)$$

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-Highway	0.645	1.906	0.063
$X_{2(2)}$	Road Type-Primary	1.206	3.341	
X_0	Intercept	-0.479	0.620	0.676

The odds ratio value for significant variables was calculated by exponentiating the β value as shown in the fourth column of Table 4. The Exp(β) gives the multiplicative effect on the fitted value for each one-unit increase in Xs. The Exp(β) value for the 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 conflicts. Between highway roads and secondary roads, it can be said that the odds of the pedestrian-vehicle conflict occurring increased by 91% if the school is in front of the highway road. The Exp(β) value for the primary road is 3.34, which indicates that the pedestrian-vehicle conflict is 3.3 times more likely will occur on the primary road compared to the secondary road.

The same conclusion was also recorded in a study on the impacts of school sitting and surrounding environments on traffic safety. The study concluded that local road reduces pedestrian crashes whereas vehicle and pedestrian crashes will increase on the highways and commercial area (Yu and Zhu, 2015). A study that used the negative binomial model to perceive the environmental attributes of having a high risk of producing crashes near elementary schools also has the same conclusion. 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 and Lee, 2014).

A study done by Elias & Shiftan (2014) 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. Besides that, a study conducted in Brescia, Italy by Bina et. al (2021) indicates that a lower probability of observed near-miss was associated with the presence of a 30km/h speed limit zone.

In 2007, a study in Orange County, Florida examined the crashes involving school-aged children (aged 4 to 18) and concluded that middle and high school children were correlated with the high frequency of crashes, particularly on high-speed multi-lane roads (Abdel-Aty et. al., 2007). A study done to examine the environmental attributes associated with pedestrian-vehicle crashes near public schools concluded that school area characteristics such as transit access, commercial access, and population density are commonly related to the increase of exposure measures which leads to the increase in the probability of crashes (Clifton and Kreamer-Fults, 2007).

Some other studies that investigated the influence of the micro street environment on pedestrian accidents in Seoul, Korea

found that vehicle traffic volume, pedestrian flow, commercial streets, and pedestrian crossings were closely related to pedestrian-vehicle collisions (Seo and Lee, 2014). Many studies have been done to identify the contributing factors to pedestrian-vehicle crashes. Among the factors that have been identified are road characteristics, environmental factors, motorized vehicle attributes, and demographic characteristics.

4. Conclusion

The high number of conflicts in school areas serves as a risk factor for students which can lead to crashes, hence a thorough investigation needs to be done. This study is aimed to investigate the contributing factors of pedestrian-vehicle conflict involving school children in the school vicinity. This study summarizes that the presence of a pedestrian bridge and a drop-off & pick-up (D&P) zone made a considerable difference in the occurrence of conflict. This study also concludes that the contributing factors are the number of pedestrian volumes in the school area and the type of road on which the school is located.

The increasing number of pedestrians obviously will increase the probability of the conflict occurring. Besides that, road type also plays a significant contributor to the occurrence of conflict. Different type of road has different number of volume which leads to a riskier situation. Suitable facilities such as a pedestrian bridge should be provided to facilitate students to cross with the help of a traffic warden to control the traffic. However, the traffic warden should be trained and equipped with safety tools. Besides that, installing traffic calming can reduce the risk caused by speeding, and providing a sidewalk is a good traffic control to improve students' safety.

There is very little study on pedestrian-vehicle conflict especially, in the school area. Knowing the factors contributing to the conflict, a preventive measure can be taken before the crash happen. Generally, many factors can contribute to the pedestrian-vehicle conflict or crashes particularly in the school vicinity. Human behaviour is one of the eminent factors to road safety mainly, for school children where the level of road safety awareness is less compared to an adult. This study focused on road engineering and environmental aspects, which based on other studies, there are a lot more variables that significantly contribute to the crashes such as personal characteristics.

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