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# ATTRIBUTES TO HIGH-RISK LOCATIONS FOR ROAD ACCIDENTS AT INTER-URBAN EXPRESSWAY

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## ABSTRACT

*Road accidents occurred everywhere along the expressway, especially at the inter-urban expressway, due to its high accessibility to wide-ranging highway networks. This study uses dataset from Shah Alam Expressway from 2013 to 2017 to determine the pattern of road accidents which includes the identification of high-risk locations at the expressway as well as the attributes to the accidents at those locations. In order to determine the high-risk location, the weightage point method and accident crash frequency method have been adopted. From the two methods applied, three popular identical sites have been identified as high-risk locations at both the westbound and eastbound. For the west bound, segments 19, 46 and 63 are considered as high risk whereas for the east bound, the high-risk locations are at segments 19, 46 and 60. Most of the accidents at the high-risk locations for west and east bounds caused no injury to road users and happened during daytime. Appropriate countermeasures should be done by local authorities in order to reduce accidents at the above-mentioned area. However, special countermeasures should be considered for segments 8, 28, 31 and 32 at the west bound whereby road accidents frequently happened during nighttime at these locations. On the other hand, a special scheme and countermeasure can be implemented for segment 46 at the eastbound where motorcyclists played a major involvement in road accidents at this location. Future research may consider applying some spatial statistics for detailed analysis to the accident dataset.*

**Keywords***: Attributes, Expressway, High-risk Location, Road Accident.*

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## 1. Introduction

Rapid growth in the economy has led to serious problems with road safety for most countries in the world. It has been a great challenge in sustainable development for the whole world when road accidents have become a leading killer and disaster. According to the World Health Organization (2018), more than 3000 people die every day due to road accidents. Road traffic accidents had been recognized as a major public health issue as it contributed to the increasing road death rate globally. For developing countries in the ASEAN region, road death rate grows consistently with their rapid development in economy. As reported in the Global Road Safety Report 2018, the top three countries for road death rate in ASEAN region were Thailand, Vietnam and Malaysia with the rates higher than the global road death rate of 18.2 deaths per 100,000 populations. Malaysia was reported to be the top five major principal causes of death due to road traffic accidents according to the Department of Statistics Malaysia (2019). Road traffic accidents in Malaysia have shown an upward trend since the past two decades and it seems to be gradually increasing each year. Expressways and highways showed a significant increase in the number of accident cases in Malaysia. For some expressways, the high-risk locations are not known to road users. Thus, it is of importance to identify these potential accident locations with their underlying attributes in order to develop awareness to road users and provide information for an action plan to be developed to prevent road accidents at the specific location on the expressway. Rapid development in technology has brought positive as well as negative impacts to the road transportation system. Such a negative impact is a road traffic accident. Three main contributors to road traffic accidents are human, vehicle and environment, where human error plays a vital role to it (Soehodho, 2017; Brătucu *et al.*, 2016; Wang *et al.*, 2022a; Wang *et al.*, 2022b).

A wide variety of methods have been used to investigate road traffic accident dataset. Sajed *et al.* (2019) introduced two methods based on a regression model and pattern recognition to identify high-risk locations based on time series models. Their results of time series models demonstrate that the frequency method of accidents tends toward places with high traffic volume. A study conducted by Oyenuga *et al.* (2016) used monthly accident data to identify the pattern of road accidents at an expressway in Nigeria where the study included estimation of trend, seasonal variation and random variation using moving average method. Results from the analysis show that the accident series exhibited trend and seasonal effect. The study has recommended an improvement in pattern analysis for road accidents where it should consider details at the accident location.

Many studies for road accidents used spatial analysis techniques. A study by Halim *et al.* (2017) focused on the E1 of North-South expressway using spatial techniques namely Nearest Neighborhood Hierarchical (NNH) Clustering and Spatial Temporal Clustering (STAC). The study found that the pattern of road accidents on the E1 resulted in a clustering pattern in which the accident was grouped at a specific location. Another study was done for E1 and E2 of North-South Expressway by Manap *et al.* (2019) focused on determining spatial pattern of road accident using Moran's I and accident hotspot using Getis-Ord Gi* which found that accidents occurred in clustering patterns where 64% of the accident hotspot occurred at interchange, ramp, lay by, slip road or rest area.

Appropriate countermeasures can be taken by local authorities in order to reduce road accidents at the expressway if only the attributes to road accidents at the specific locations are known (Sattar *et al.*, 2023; Liu *et al.*, 2022). Thus, this study aims to determine the attributes related to the road accident at Shah Alam Expressway for both west and east bounds. This study can be used as a baseline for implementing appropriate countermeasures at the accident location. A plan of action to create awareness to road users regarding the potential accident area at the expressway can be developed in order to prevent road traffic accidents at the specific sites.

This paper begins with the introduction of the study area, followed by the description of data collection, methodology, result and discussions. The conclusion and recommendations for future research will be presented in the last section of this paper.

This study focuses on Shah Alam Expressway which is also known as KESAS or E5. The six-lane, straight and long expressway with posted speed limit of 90 km/h, spans a total length of about 34.5 kilometres, has 15 interchanges and 3 toll plazas along east and west bounds. The Shah Alam Expressway is the third expressway after New Klang Valley Expressway (NKVE) and Federal Highway which connect the east and west bounds of Klang Valley. It is also part of the Kuala Lumpur Middle Ring Road 2 Scheme from Sunway Interchange to Sri Petaling Interchange. This controlled access expressway has been a popular travelling mode due to its high accessibility to a wide range of highway networks that links numerous industrial and residential areas including Cheras, Kuala Lumpur, Petaling Jaya, Subang Jaya, Shah Alam and Klang. As shown in Figure 1, the expressway runs between Pandamaran in Klang, Selangor to Sri Petaling in Kuala Lumpur.

The road traffic accident dataset comprises the reported accident date, time and location, weather condition, vehicle involved, causal factor, collision type, and severity type. The data were gathered from KESAS Sdn. Bhd. between January 1, 2013, to December 31, 2017. For these five consecutive years, 2,823 accident data have been prepared. The distribution of data that presents the percent of attributes involved in the dataset will be presented in the later section. In this study, the attributes refer to the parameters provided in the dataset. Seven parameters have been considered which include accident route, time, severity, weather condition, vehicle type, collision type and causal factors.


Figure 1. Shah Alam Expressway

## 2. Methodology

This study involved three steps as shown in Figure 2. The first step taken was segmenting the study area, followed by identifying high-risk locations at the expressway, and determining the attributes for the high-risk location.

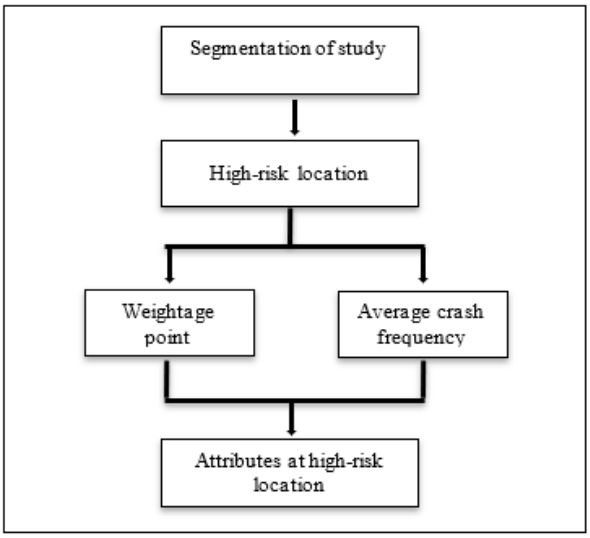


Figure 2. Study flow.

The accident dataset for Shah Alam Expressway consists of accident location in the form of kilometer marker. Each accident in the dataset is recorded in a unit of 100 metres. In this study, the 34.5-kilometre expressway is divided into segments. 400-metre segmentation has been used with respect to the Interim Guide of the Public Work Department that considers scratches of 300 metres to 500 metres for road treatment around the accident location. 69 segments have been prepared for the expressway from Pandamaran to Sri Petaling. Table 1 represents the segments that had been prepared.

Table 1. Segmentation of location.

| **Segment** | **Location (KM)** | **Segment** | **Location (KM)** | **Segment** | **Location (KM)** |
|---|---|---|---|---|---|
| 1 | 18.0 – 18.4 | 24 | 29.5 – 29.9 | 47 | 41.0 – 41.4 |
| 2 | 18.5 – 18.9 | 25 | 30.0 – 30.4 | 48 | 41.5 – 41.9 |
| 3 | 19.0 – 19.4 | 26 | 30.5 – 30.9 | 49 | 42.0 – 42.4 |
| 4 | 19.5 – 19.9 | 27 | 31.0 – 31.4 | 50 | 42.5 – 42.9 |
| 5 | 20.0 – 20.4 | 28 | 31.5 – 31.9 | 51 | 43.0 – 43.4 |
| 6 | 20.5 – 20.9 | 29 | 32.0 – 32.4 | 52 | 43.5 – 43.9 |
| 7 | 21.0 – 21.4 | 30 | 32.5 – 32.9 | 53 | 44.0 – 44.4 |
| 8 | 21.5 – 21.9 | 31 | 33.0 – 33.4 | 54 | 44.5 – 44.9 |
| 9 | 22.0 – 22.4 | 32 | 33.5 – 33.9 | 55 | 45.0 – 45.4 |
| 10 | 22.5 – 22.9 | 33 | 34.0 – 34.4 | 56 | 45.5 – 45.9 |
| 11 | 23.0 – 23.4 | 34 | 34.5 – 34.9 | 57 | 46.0 – 46.4 |
| 12 | 23.5 – 23.9 | 35 | 35.0 – 35.4 | 58 | 46.5 – 46.9 |
| 13 | 24.0 – 24.4 | 36 | 35.5 – 35.9 | 59 | 47.0 – 47.4 |
| 14 | 24.5 – 24.9 | 37 | 36.0 – 36.4 | 60 | 47.5 – 47.9 |
| 15 | 25.0 – 25.4 | 38 | 36.5 – 36.9 | 61 | 48.0 – 48.4 |
| 16 | 25.5 – 25.9 | 39 | 37.0 – 37.4 | 62 | 48.5 – 48.9 |
| 17 | 26.0 – 26.4 | 40 | 37.5 – 37.9 | 63 | 49.0 – 49.4 |
| 18 | 26.5 – 26.9 | 41 | 38.0 – 38.4 | 64 | 49.5 – 49.9 |
| 19 | 27.0 – 27.4 | 42 | 38.5 – 38.9 | 65 | 50.0 – 50.4 |
| 20 | 27.5 – 27.9 | 43 | 39.0 – 39.4 | 66 | 50.5 – 50.9 |
| 21 | 28.0 – 28.4 | 44 | 39.5 – 39.9 | 67 | 51.0 – 51.4 |
| 22 | 28.5 – 28.9 | 45 | 40.0 – 40.4 | 68 | 51.5 – 51.9 |
| 23 | 29.0 – 29.4 | 46 | 40.5 – 40.9 | 69 | 52.0 – 52.4 |

This study seeks to observe the pattern of road accidents for each year from 2013 to 2017. This includes the identification of high-risk locations, namely segments at the expressway as well as the attributes to the accidents at those locations. Two methods, weightage point and average crash frequency, have been adopted in order to determine the high-risk location, as described below. The results are then ranked from highest to lowest value.

The weightage point considers the severity of road accidents at a location. This method uses weightage to compute the score of weightage point (WP) in which weightage 6 is used for fatal ($x_1$), 4 for severe injury ($x_2$), 2 for light injury ($x_3$) and 1 for no injury ($x_4$) as represented in (1) as follows.

$$WP = 6x_1 + 4x_2 + 2x_3 + x_4 \tag{1}$$

The second method is an average crash frequency in which this method counts the number of road accidents that occurred at a given location over a specified time period, typically three to five years. For this study, a one-year period will be used as the pattern observation will be done by year. The average crash frequency (*ACF*) is calculated by using equation (2) as follows.

$$ACF = \frac{Number\ of\ accidents}{Period\left(in\ years\right)} \tag{2}$$

Attributes to road accidents at Shah Alam Expressway refers to the variables or factors that related to the accident occurrence. This is done by analysing the information pertaining to the accident dataset using Microsoft Excel spreadsheet. Each high-risk location will be presented with a set of attributes to it.

## 3. Results and Discussion

### 3.1 Data Distribution

Road accidents at Shah Alam expressway occurred along west and east bounds as well as intersections. As shown in Figure 3, the accident occurrence at west bound showed slightly higher than at east bound with 49.0% and 43.4% respectively, while accident occurrence at intersections with only 7.6%. Majority (61.9%) of road accidents at Shah Alam expressway did not involve any injury, 28.9% led to light injury, 3.5% with severe injury while 5.7% of the total accidents led to fatality. Most accidents (57.1%) occurred during daytime compared to night time (35.1%), while only 7.8% of the total accidents occurred during dawn or dusk. It is revealed also that rainy day did not influence to road accident where most accidents (94.5%) occurred during good weather condition. Almost half of total accident (48.9%) involved cars, followed by motorcycle of 24.1% and other vehicles which include four-wheeled drive (4WD), multi-purpose vehicles (MPV) and class 1 lorries of 14.4%. Most accidents at Shah Alam expressway involved lost control (51.9%), followed by rear-end collision (29.3%), other types of collision such as collision with highway assets (10.7%) and sideswipe (6.5%). As far as we concern, the major contributing factor to most road traffic accidents is human error. This study also found that 90.0% of the accidents occurred because of humans, while vehicle and environment contributed only 8.0% and 2.0% respectively.

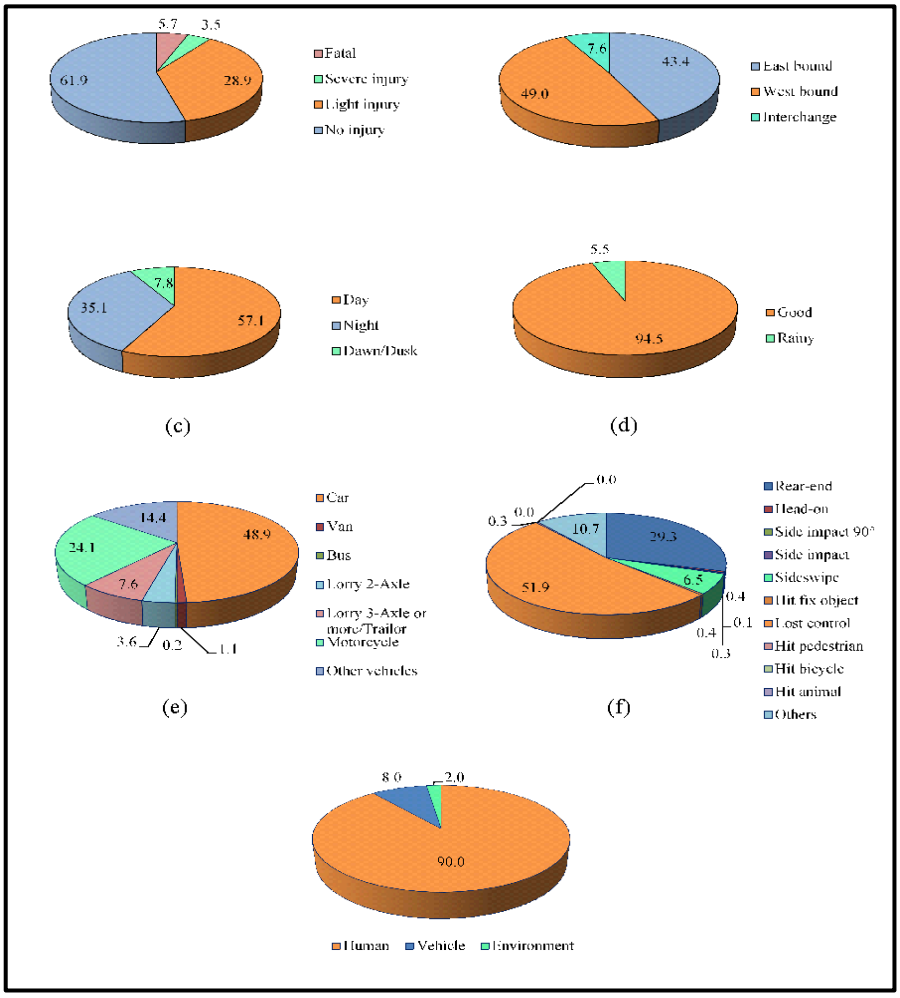


Figure 3. Accident distribution of (a) severity, (b) route, (c) time, (d) weather condition, (e) vehicle type, (f) collision type and (g) causal factor.

### 3.2 High-risk location

The high-risk locations at the expressway have been identified using weightage point and average crash frequency methods. Comparison was made by year in order to observe whether there is an identical accident location at the expressway for the five consecutive years. Table 2 and Table 3 represent the score of high-risk locations identified using both methods as mentioned above for westbound and eastbound respectively. Results revealed that some accident locations at the expressway can be considered as high-risk locations in which some identical spots were observed every year from 2013 to 2017. The scores from weightage point and average crash frequency methods also indicated the same accident locations at the expressway.

Table 2. High-risk location for west bound.

| **Year** | **2013** | | **2014** | | **2015** | | **2016** | | **2017** | |
|---|---|---|---|---|---|---|---|---|---|---|
| Method | Segment | Score | Segment | Score | Segment | Score | Segment | Score | Segment | Score |
| WP | 63 | 37 | 63 | 30 | 46 | 32 | 63 | 44 | 63 | 35 |
| | 19 | 15 | 46 | 20 | 63 | 28 | 31 | 20 | 46 | 20 |
| | 45 | 15 | 6 | 16 | 26 | 21 | 8 | 16 | 32 | 19 |
| ACF | 63 | 21 | 63 | 24 | 63 | 26 | 63 | 32 | 63 | 26 |
| | 19 | 11 | 46 | 14 | 46 | 18 | 31 | 12 | 46 | 13 |
| | 45 | 11 | 19 | 7 | 26 | 10 | 28 | 9 | 19 | 11 |

Table 3. High-risk location for east bound.

| **Year** | **2013** | | **2014** | | **2015** | | **2016** | | **2017** | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |
| Method | Segment | Score | Segment | Score | Segment | Score | Segment | Score | Segment | Score |
| WP | 46 | 40 | 60 | 23 | 47 | 28 | 46 | 35 | 46 | 26 |
| | 19 | 28 | 19 | 21 | 46 | 22 | 47 | 21 | 19 | 19 |
| | 60 | 27 | 46 | 18 | 37 | 13 | 52 | 21 | 5 | 15 |
| ACF | 46 | 23 | 19 | 16 | 46 | 15 | 46 | 22 | 46 | 14 |
| | 19 | 22 | 60 | 14 | 47 | 13 | 60 | 18 | 19 | 12 |
| | 60 | 19 | 46 | 9 | 37 | 8 | 19 | 12 | 60 | 11 |

For west bound, segments 63, 19 and 46 are considered as high-risk accident locations since these two segments recorded the highest score from both methods for almost every year, whereas for east bound, segments 46, 19 and 60 recorded the highest score among all segments. Locations with relatively high scores are selected as high-risk locations as they become possible sites for detailed investigation. However, some other locations at west and east bounds as listed in Table 2 and Table 3 respectively, will be considered also as high-risk locations by their ranking scores obtained from methods applied.

### 3.3 Attributes to the high-risk locations

Further analysis was done on the high-risk locations in order to determine the attributes of road accidents at these locations. This information is crucial for appropriate schemes and countermeasures to be implemented at the specific locations (Al-Omari *et al*, 2020; Shuib & Ibrahim, 2021; Hassan & Masrom, 2022). Most of the accidents at the high-risk locations of Shah Alam Expressway occurred during good weather conditions and the major contributing factor for road accidents at these locations was human error while other factors varied. Four attributes that varied are vehicle type, collision type, accident severity and time of the accidents occurred represented as in Figure 4.

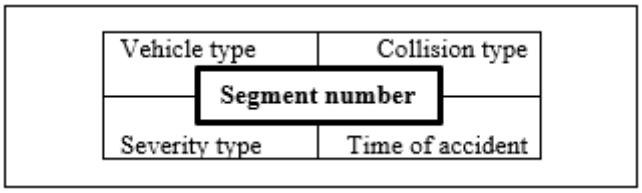


Figure 4. Attributes for each location.

Figure 5 and Figure 6 represent the attributes for road accidents at each high-risk location identified in the previous section. We could see the same spots of road accidents from 2013 to 2017 which are considered as popular high-risk locations as quite a number of accidents occurred at these sites. As shown in Figure 5 for west bound, segments 19, 46 and 63 are popular spots for accidents to occur since almost every year road accidents happen here. In terms of attributes, there is no identical pattern that contributed to road accidents at these locations. Most accidents at the high-risk locations for west bound caused no injury to road users and happened during daytime. However, at some other locations such as at segments 8, 28, 31 and 32, road accidents frequently happened during nighttime.

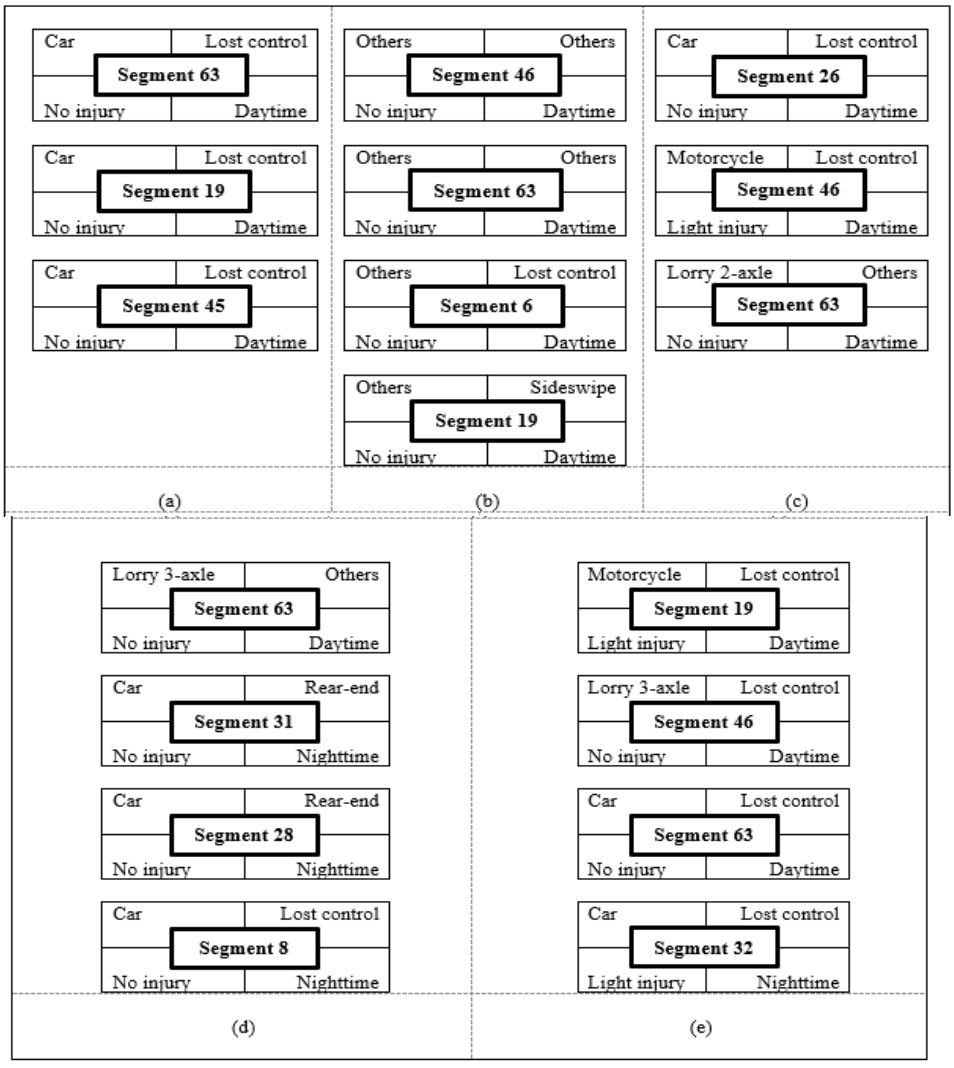


Figure 5. Attributes to high-risk location at west bound for (a) 2013, (b) 2014, (c) 2015, (d) 2016 and (e) 2017.

Figure 6 shows the attributes to high-risk locations for east bound. Three popular sites have been identified to be high risk for accidents to occur, namely segments 19, 46 and 60 based on the high scores obtained from both methods. Most accidents at high-risk locations for eastbound happened during daytime and involve no injury. Road accident at those locations did not portray any specific pattern at each specific site. However, a special countermeasure can be considered at segment 46 whereby this segment revealed that accidents involving motorcycles and lost control collision-type were the highest at this location.

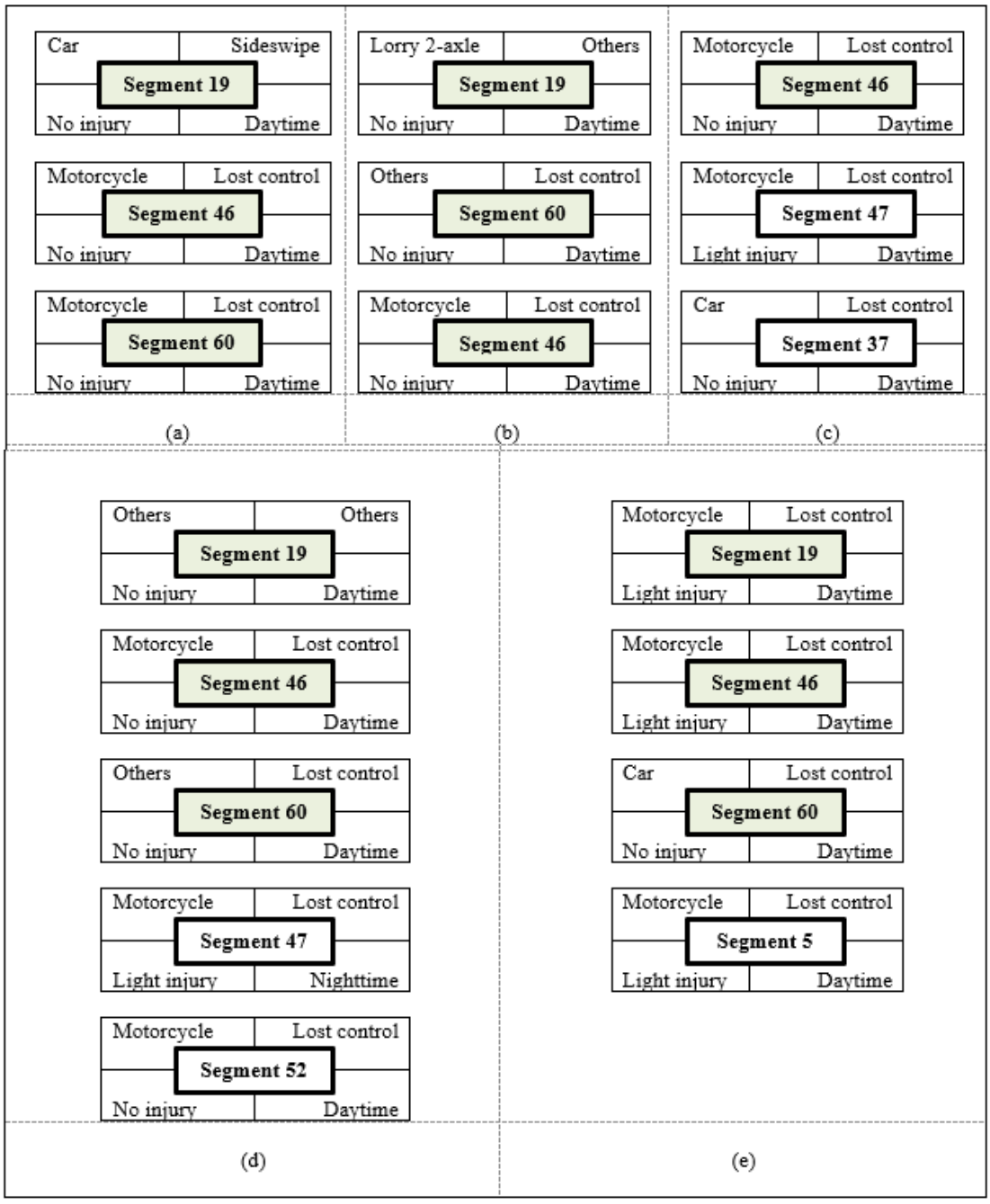


Figure 6. Attributes to high-risk location at east bound for (a) 2013, (b) 2014, (c) 2015, (d) 2016 and (e) 2017.

## 4. Conclusion

Road accidents occurred everywhere along the expressway. From this study, three popular sites have been identified as high-risk locations at both the westbound and eastbound. For the west bound, segments 19, 46 and 63 are considered as high risk whereas for the east bound, the high-risk locations are at segments 19, 46 and 60. Most of the accidents at the high-risk locations for west and east bounds caused no injury to road users and happened during daytime. Appropriate countermeasures should be done by local authorities in order to reduce accidents at the above-mentioned area. However, special countermeasures should be considered for segments 8, 28, 31 and 32 at the west bound whereby road accidents frequently happened during night time at these locations. On the other hand, a special scheme and countermeasure can be implemented for segment 46 at the eastbound where motorcyclists played a major involvement in road accidents at this location. Future research may consider applying some spatial statistics for detailed analysis to the accident dataset.

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## Author Contribution

Author 1 conducted statistical analysis, the literature review and oversaw the article writing. Author 4 wrote the research methodology and performed fieldwork. Authors 2 and 3 are supervisors who monitored and oversaw the whole study.

## Conflict of Interest

The authors should declare if any conflicts of interest exist. If no conflict exists, the authors should state: The authors have no conflicts of interest to declare.

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