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Black Spot Analysis on National Highway in Palembang

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Abstract
In the last five years, the number of accidents that have been occurred in Palembang, South Sumatra Province reached 7.016 incidents. This research aims to discover the characteristics of traffic accidents and accident-prone *(black spot)* locations. The characteristic of a traffic accidents will be analyzed by questionnaire, while the *black spot* analysis will be investigated based on the frequency (death, seriously injured), INDII Aus-Aid and AEK. The result of the components of accidents presented that the road users was the main factor of traffic accidents with around 83 %, 87% of incidents happened less than 3 (three) every month, and 47 % of the sacrifice of seriously injured, in which the highest gender victims was male (83%). The Black Spot analysis outcome at Soekarno Hatta Street located at STA 23 + 500, in which Soekarno Hatta Street experienced the most common traffic disaster with 110 of the circumstances were 31 casualty who passed away, 39 heavily wounded, and the material loss gained Rp. 10.439.901.000.
Keywords: INDII; AEK; Blackspot.

1. Introduction

The rapid growth and development of population has been affected by the growing number of people and goods mobility that causes the needs of transportation facilities escalation.((Fayaz *et al.*, 2018); (Apparao, Sssv and Raju, 2013).
The increase of the transportation facilities in South Sumatra Province has a moderate increase that can be seen from the rise of the number of vehicles in 2017 that showed 1.137.113 vehicles, whereas in 2018 the number was 1.225.824 and it reached 1.226.938 in 2019. (BPS Prov. Sumsel,2020). As the consequence of this traffic development, it has been provoked the traffic problems such as a road damage. If this matter not carried out with proper management, it will cause fatal impacts such as casualties and a large amount of property lost. In addition, the occurrence of long time travel, traffic congestion, the increasing number of traffic accidents along with traveller victims and road users. (Mohan and Landge, 2017).
The level of traffic accidents in Palembang, South Sumatra Province the last five years continuously climbed 7.016 incidents.
The problem will be discussed in this research, the traffic disaster in these roads will be liven up every year, so it will need identification of where the black spot location, the factor that has been caused it, the aspects of travel misadventure, the handling effort of black spot area. Because of that, it is necessary to conducted research to determine the characteristics of travel incidents and accident-prone point (black spot) location. The component of traffic accidents will be analyzed from the questionnaire result, while the black spot investigation based on the frequency method (death, seriously wounded), INDII-Aus Aid and The accident equivalent rate (AEK). An accident is an event that occurred on the highway and implicate vehicles with or without other road users that caused human casualties or property loss (UU RI No. 22, 2019; Agustin, 2019;Nair Baskara *et al.*, 2016).
The identification of traffic accident-prone place is a location of high travel misadventure and continuously happened in an area with the time of accidents relatively same and resulted from a particular cause. (Kashid *et al.*, 2019). Accident-prone areas have been categorised in 3 (three) different area, such as hazardous sites, hazardous routes, and hazardous area. Black spot has been involved in hazardous sites ((Bobade-sorate *et al.*, 2016); (Sandhyavitri *et al.*, 2017)) with the point of traffic accident-prone sections (0.3 – 1.0 kilometres). The consideration of traffic crack-up can be caused by some factors such as (1) the road users, both motorists and pedestrians, (2) Vehicles, (3) Road conditions, (4) environmental characteristics ((Huvarinen *et al.*, 2017); (Arung and Widyastuti, 2020); (Agustin, 2019); (Nair Baskara *et al.*, 2016); (Jain and Aggarwal, 2019); (Ghadi and Török, 2017); (Wiraguna, Mahmudah and Setiono, 2017); (Setiawati, Intari and Zailani, 2019)). The traffic accidents have been classified into 3 (three) types, namely minor traffic accidents that caused a damage to vehicles and goods, moderate traffic incidents that affected to insignificant injuries and affected to vehicles and goods harm, and heavy traffic matters that result in death and serious injuries. Traffic accidents have been classified into 14 (fourteen) category which based on-site, cause of incidents, misadventure frequency, casualty

conditions, time of the accidents, kind of vehicles, driver acceleration, gender of casualty, condition of casualty, the time of the accidents, the vehicle that involved in the accident, the gender of the accident victim, the age of the accident victim and the weather at the time of the accident. (Wiraguna, Mahmudah and Setiono, 2017)

2. Research Methods

2.1. Research Site

This research was conducted on The National Highway of Palembang with the selected road section were Soekarno Hatta Street which along 8.3 km, Gubernur H. Muhammad Ali Amin, SH Street throughout 3 km and Letjen Harun Sohar stret along 3.2 km. The determinations of road section will be investigated based on the level of traffic accidents that occurred on the roads in Palembang.

2.2. Data Collection

The data collection of this research includes the primary data which consists of road geometry, road conditions, roads equipment, and the questionnaire on the research site. Meanwhile, the secondary data that required to traffic accidents data collected from the police traffic unit in Palembang. The accident was a report that contains general incidents data, includes the casualty conditions, time of the accident, and the type of vehicle involved.

2.3. Analysis Method

In the case of accident-prone point (black spot) analysis, accidents data is taken every kilometre with utilizing the frequency method as part of the determination method of accident-prone point by looking at the number of an accident without considering the fatality rate. Whereas, The INDII- Aus Aid method classified the casualty based on the worst impact then weighted the death (10), serious injury (3), minor injury (1). Furthermore, the accident equivalent rate (AEK) method resolved an accident-prone point by giving points based on the victim fatality level, in which for the victim who died are given 12 points, a casualty with serious and minor injury are turned on 3 points respectively, and the material damage is directed to 1 point (Kimpraswil, 1996), with an equation : (Farida *et al.*, 2021); (Arung and Widyastuti, 2020); (Agustin, 2019);(Sartika Nisumantri, 2018); (Sugiyanto and Fadli, 2017).

2.4. Research Procedures

The stages of this research are shown at Figure 1.

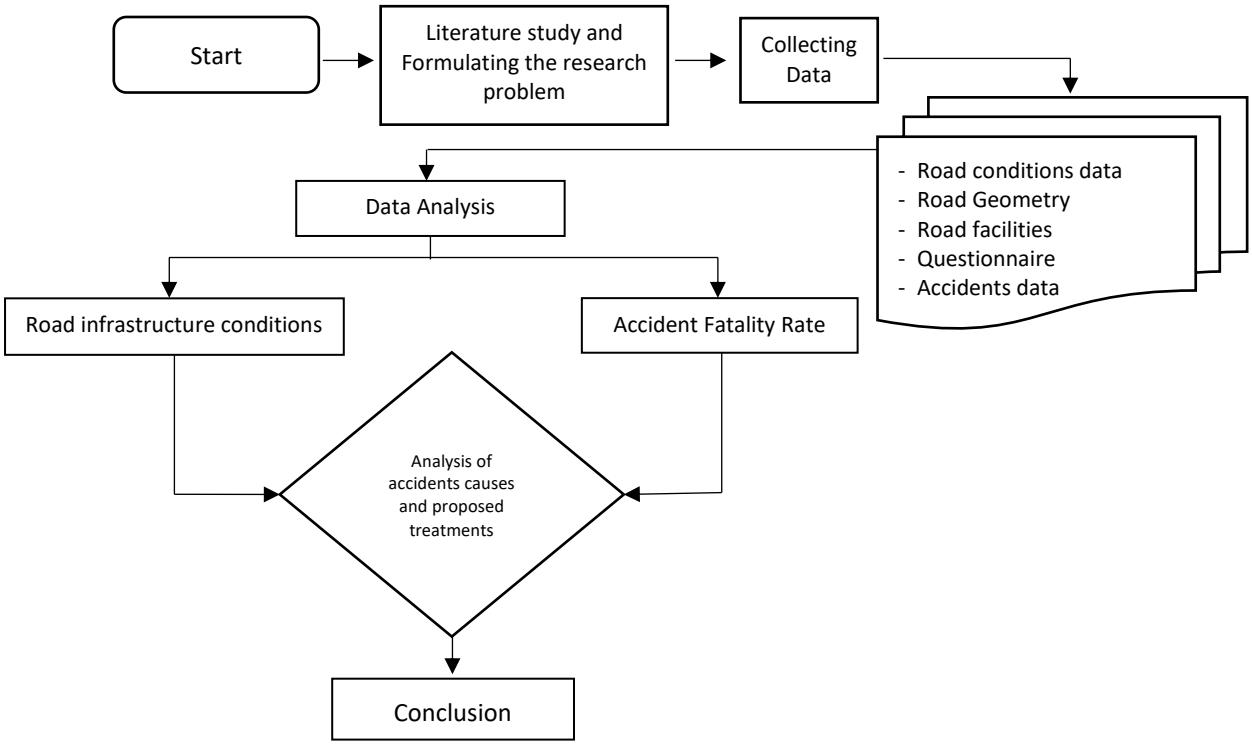


Figure 1. Research Procedures

3. Result and Discussion

3.1. The characteristics of traffic accidents in the selected road sections

3.1.1. The characteristics of traffic accidents on Soekarno Hatta Street

The traffic accidents features in Soekarno Hatta road sections is known that in this street have been occurred an accident (100%) with a four-fifth (80%) of road users as the main the cause of the incidents, the frequency of occurrence ≥ 3 (three) events every month (83%), less than two-fifth (38%) have serious injuries, 43 % occurred in sunny day, more than a half (54%) caused by car as the vehicles that often involved in accidents, 87% of high-speed driving, man as the highest casualty (77%), the age of wounded ≥ 17 years old (90%), and 80% of the accident happened during the sunny weather.

3.1.2. The characteristics of traffic accidents on Gub.H. M. Ali Amin, SH Street

The traffic accidents components in Gub. H. M. Ali Amin, SH is discovered that on these road sections ever happened the incidents (100%) with the street wounded as a major reason of the causes of accidents (83%), 87% of < 3 of the accident frequency that held every month, accounted serious wounded (47%), occurred in the morning (44%), motorcycle as the kind of a vehicle that usually bounded in traffic incidents (60%), high-speed when driving (83%), male as a foremost casualty (83%), the age of casualty ≥ 17 years old (87%) and the accidents occurred in the clear weather.

3.1.3. The characteristics of traffic accidents on Gub.H. M. Ali Amin, SH Street

The characteristics at Letjen Harun Sohar Street is recognized that on these roads (100%) with the road users as a top element of the traffic accidents (83%), frequency of the accidents <3 events every month (67%), causes serious injuries (47%), occurred in daytime (36%), motorcycles as the type of vehicles that often get involved in accidents (57%), high acceleration on driving (63%), man as the prominent casualty (80%), the age of casualty ≥17 years old (93%) and the accidents occurred when the weather was clear (87%).

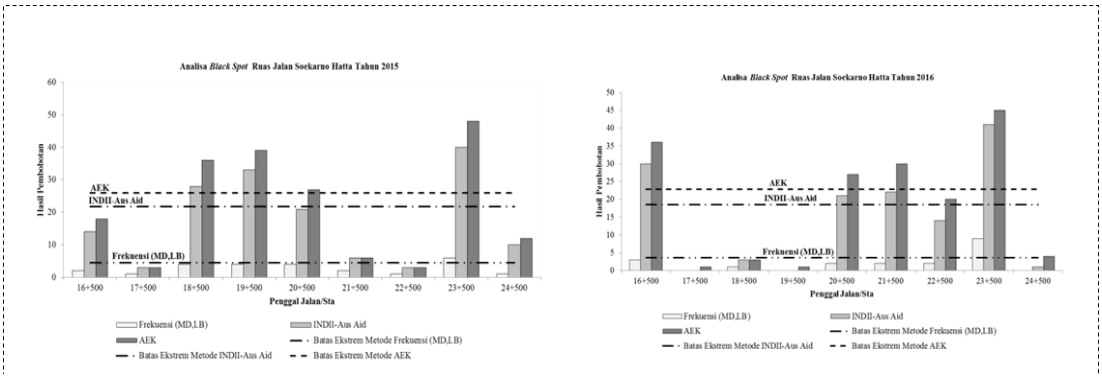
3.2. Black Spot Analysis

The location of black spot analysis in the investigation road is obtained from the accident data from the police unit in Palembang and online newspapers can be viewed at the table and figure below.

3.2.1. The black spot analysis at Soekarno Hatta Street

Table 1. Black Spot Analysis at Soekarno Hatta Street from 2015 to 2019

Station	Years																													
	2015							2016							2017						2018							2019				
	MD	LB	LR	K	Frequency	INDII Aus-Aid	AEK	MD	LB	LR	K	Frequency	INDII Aus-Aid	AEK	MD	LB	LR	K	Frequency	INDII Aus-Aid	AEK	MD	LB	LR	K	Frequency	INDII Aus-Aid	AEK	MD	LB	LR	K	Frequency	INDII Aus-Aid	AEK
16+500	1	1	1	0	2	14	18	3	0	0	0	3	30	36	0	2	2	0	2	8	12	0	0	0	0	0	0	0	1	2	1	1	3	17	22
17+500	0	1	0	0	1	3	3	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	10	12
18+500	2	2	2	0	4	18	36	0	1	0	0	1	3	3	2	0	0	0	2	20	24	0	0	1	0	0	1	3	0	0	3	0	0	3	9
19+500	3	1	1	0	4	33	39	0	0	0	1	0	0	1	1	0	1	0	1	11	15	0	3	1	0	3	10	12	0	0	0	0	0	0	0
20+500	1	3	2	0	4	21	27	2	0	1	0	2	21	27	0	0	0	0	0	0	0	1	1	1	1	2	14	19	1	0	3	0	1	13	19
21+500	0	2	0	0	2	6	6	2	0	2	0	2	22	30	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	1	0	0	1	3	3
22+500	0	1	0	0	1	3	3	1	1	1	0	2	14	20	0	1	3	1	1	6	13	0	2	1	1	2	7	10	0	0	0	0	0	0	0
23+500	3	3	1	0	6	40	48	2	7	0	0	9	41	45	0	1	1	0	1	4	6	2	0	0	0	2	20	24	1	2	2	1	3	18	25
24+500	1	0	0	0	1	10	12	0	0	1	1	0	1	1	1	1	1	0	2	14	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean					2.78	17.56	21.3					2.11	14.67	19					1	7	9.78					1	5.78	7.67					1	7.11	10
Deviation Standard					1.67	4.19	4.62					1.45	3.83	4.3					1	2.65	3.13					1	2.4	2.77					1	2.67	3.16
Extreme Limits					4.45	21.75	25.92					3.56	18.5	23.3					2	9.65	12.91					2	8.18	10.44					2	9.78	13.16



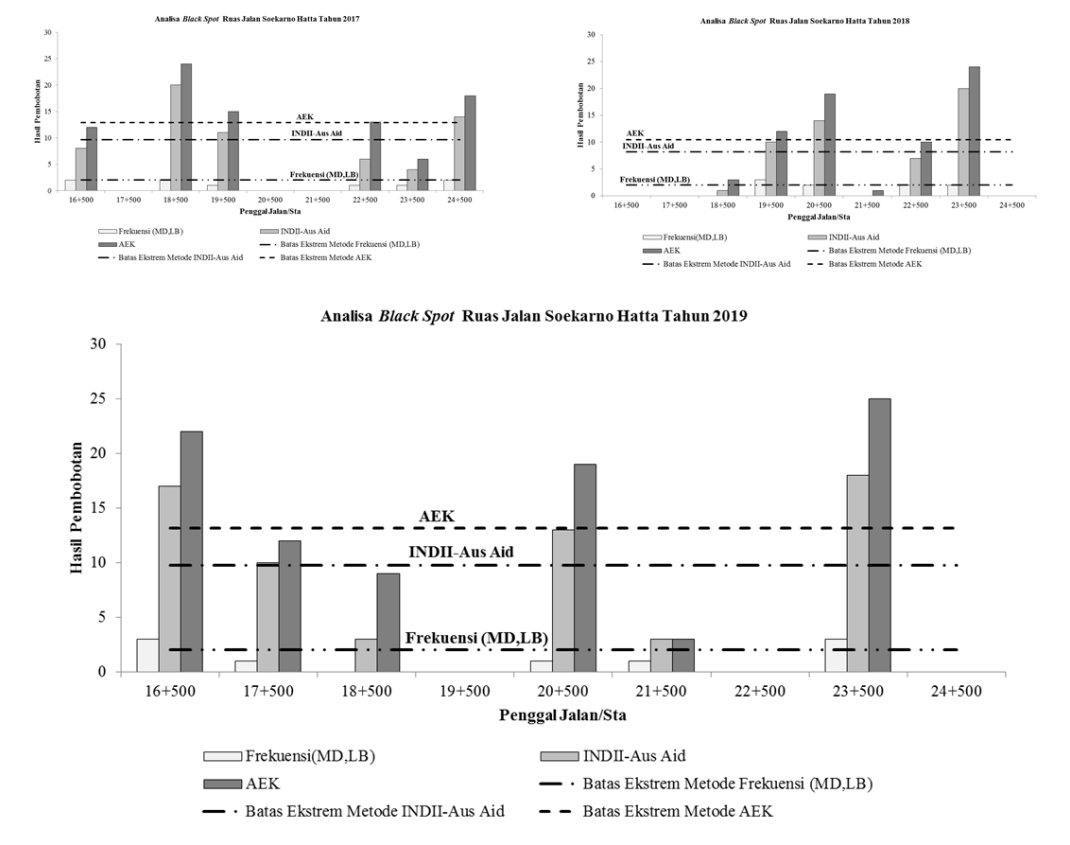


Figure 2. Black Spot Analysis at Soekarno Hatta Street from 2015 to 2019

According to Table 1 and Figure 2, it is presented that INDII Aus-Aid and the accident equivalent rate (AEK) methods explained an the downward trend for extreme limits over the first 4 (four years), while in 2019 the limits showed a noticeable rise to 9.78 and 13.16 respectively. While the frequency method decreased steadily for the first 2 (two) years, as opposed to the last 3 (three) years that highlighted stable limits at 2 (two).

On the other hand, it reveals that during the past 5 (five) years, the highest extreme limits in Soekarno Hatta Street by using the frequency and the accident equivalent rate (AEK) methods were in 2015 with 4.45 and 25.92 respectively. Moreover, the large limits by utilizing INDII Aus Aid was 21.75 at STA 16+500.

Overall, the black spot location on Soekarno Hatta street was at STA 23+500 as these points have dominated the occurrence of accidents during the last 5 (five) years with the intensity of recurring events.

3.2.2. The black spot analysis at Gub.H. Ali Amin, SH Street

Table 2. Black Spot Analysis at Gub.H.Ali Amin,SH Street between 2015 and 2019

Station	Years																														
	2015							2016							2017							2018							2019					
	MD	LB	LR	K	Frequency	INDII Aus-Aid	AEK	MD	LB	LR	K	Frequency	INDII Aus-Aid	AEK	MD	LB	LR	K	Frequency	INDII Aus-Aid	AEK	MD	LB	LR	K	Frequency	INDII Aus-Aid	AEK	MD	LB	LR	K	Frequency	INDII Aus-Aid	AEK
1+000	0	1	0	0	1	3	3	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	3	3
2+000	0	2	0	1	1	6	7	0	2	1	0	2	7	9	1	3	0	0	4	19	21	1	0	0	0	1	10	12	0	1	2	0	1	5	9
3+000	0	0	0	0	0	0	0	0	1	1	0	1	4	6	0	0	0	0	0	0	0	0	1	1	0	1	4	6	0	0	1	0	0	1	3
4+000	1	1	1	0	2	14	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	2	13	15	2	1	1	0	3	24	30
Mean					1	5.75	7					0.75	2.65	4					1	4.75	5.25					1	6.75	8.25					1.25	8.25	11.3
Deviation Standard					1	2.4	2.65					0.87	1.66	2					1	2.18	2.29					1	2.6	2.87					1.12	2.87	3.35
Extreme Limits					2	8.15	9.65					1.62	4.41	6					2	6.93	7.54					2	9.35	11.12					2.37	11.12	14.6

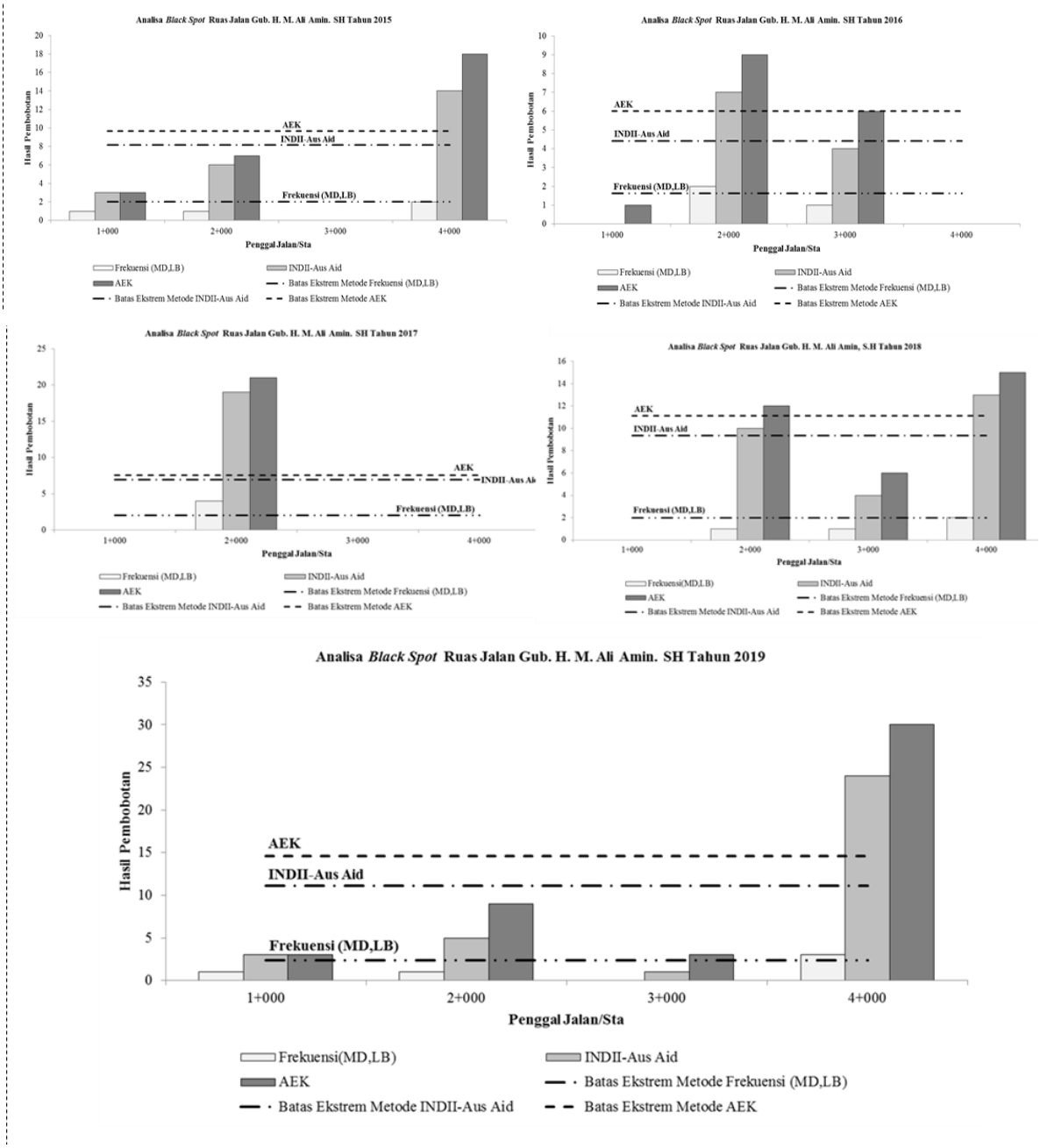


Figure 3. Black Spot Analysis at Gub.H.Ali Amin,SH Street between 2015 and 2019

Based on the table 2 and figure 3, all method (frequency, INDII Aus-Aid and the accident equivalent rate (AEK)) described a fluctuation limits. Between 2015 and 2016, the limits of INDII Aus-Aid and the accident equivalent rate (AEK) showed a descending tendency, in which 8.15 and 9.65 plummeted to 4.41 and 6 severally, while in 2017 the limits outlined a remarkable increase to just under and just above 7 (seven). Likewise, the limits have tremendous growth in the last 2 (two years) that the limits reached 11.12 and 14.16 in 2019. In contrast with the frequency method that explained a marginal palpitation, whereabouts 2 in 2015 decreased marginally to 1.62, then the limits jumped to 2 and stable until 2019 before rising significantly to 2.37 in the last year.

Furthermore, from the given table and graph above, it is reasonable to surmise that the highest limits of black spot at Gub.H. Ali Amin, SH street was in 2019 with the value of limits were 2.37 for the frequency method, 11.12 for the INDII Aus-Aid and 14.6 for the accident equivalent rate (AEK).

In brief, the location of black spot in Gub. H. Ali Amin, SH street was at STA 4+000 that in this station have a prolonged intensity of incidents during the last 5 (five) years.

3.2.3. The black spot analysis at Letjen Harun Sohar Street

Table 3. Black Spot Analysis at Letjen Harun Sohar Street from 2015 to 2019

Station	Years																													
	2015							2016							2017							2018							2019						
	MD	LB	LR	K	Frequency	INDII Aus-Aid	AEK	MD	LB	LR	K	Frequency	INDII Aus-Aid	AEK	MD	LB	LR	K	Frequency	INDII Aus-Aid	AEK	MD	LB	LR	K	Frequency	INDII Aus-Aid	AEK	MD	LB	LR	K	Frequency	INDII Aus-Aid	AEK
9+600	1	2	0	0	3	16	18	0	1	2	0	1	5	9	1	1	2	0	2	15	21	0	0	1	0	0	1	3	1	2	1	0	3	17	21
10+600	1	2	0	1	3	16	18	0	1	2	0	1	5	9	0	1	0	0	1	3	3	0	1	1	0	1	4	6	0	0	0	0	0	0	0
11+600	0	4	0	0	4	12	12	0	1	0	0	1	3	3	0	1	0	1	1	3	4	0	0	1	0	0	1	3	0	0	0	0	0	0	0
12+600	3	4	1	2	7	43	53	1	3	4	0	4	23	33	2	3	3	2	5	32	44	3	1	3	0	4	36	48	1	0	0	2	1	10	14
Mean					4.25	21.75	25.25					1.75	9	13.5					2.25	13.25	18					1.25	10.5	15					1	6.75	8.75
Deviation Standard					2.06	4.66	5.02					1.32	3	3.67					1.5	3.64	4.24					1.12	3.24	3.87					1	2.6	2.96
Extreme Limits					6.31	26.41	30.27					3.07	12	17.2					3.75	16.89	22.24					2.37	13.74	18.87					2	9.35	11.71

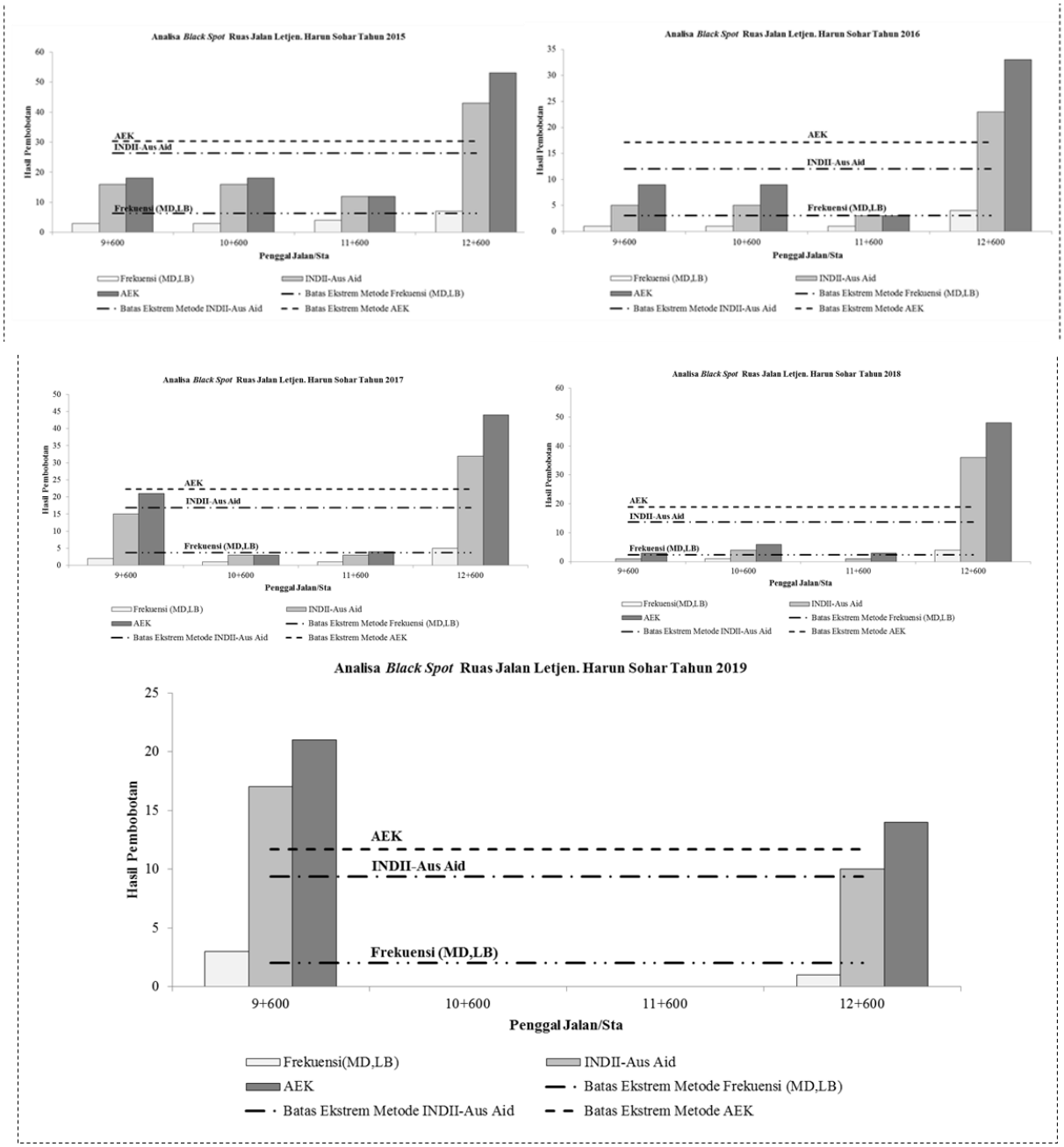


Figure 4. Black Spot Analysis at Letjen Harun Sohar Street from 2015 to 2019

As shown in table 3 and figure 4, The INDII Aus-Aid and the accident equivalent rate (AEK) presented an almost similar trend over the 5 (five) years of period, in which the extreme limits in the earliest the year that more than 25 has dropped to 12 and 17.12, while in the next two years the limits explained waves that terminated at 13.74 and 18.87. Then, in last year, the limits decreased dramatically to 9.35 and 11.71 respectively. Likewise, the frequency

method described an oscillation, where the limits halved from 6.31 to 3.07 from 2015 to 2016, yet the limits unexpectedly increase to 3.75 in 2017 and has fallen to around 2 in the last 2 (two) years.

Moreover, the highest limits of black spot at Letjen Harun Sohar street was in 2015 with the value of limits were 6.31, 26.41, and 30.27 for each frequency method, the INDII Aus-Aid method, and the accident equivalent rate (AEK).

To summaries, the black spot location in Letjen Harun Sohar street was at STA 12+000 that in this station have a highest frequency of accident during the past 5 (five) years.

3.3. The factor that causes the traffic accidents

Based on the analysis, it is known that the black spot location at Soekarno Hatta Street at STA 23+500. The undisciplined road users have triggered the traffic accidents, in which it is dominated with the driver of car and motorcycle that driven their vehicles with high speed and it also propped with the unrestraint motorcyclist. Besides that, there is not found a sidewalk that fitted the road users access is very limited, then the road wearers have utilized the roadside as the sidewalks alternative that simplifies the conflict that may happen between the road users and vehicles. Moreover, some of the road signs have been relieved that establish the road conditions being a factor that led the driver to lose their control of the vehicles, especially at night. Stand on the signs, some marks hindered by leaves or the branch tree and the vehicles that parking on the sidewalks.

On the other hand, the black spot location in Gub. Muh. Ali Amin, SH is at STA 4+000, it is described that there is no signal as a guide for the driver to be more careful when they passed the accident-prone location of traffic accidents and it also not found sidewalks so that the access of road users is so narrow. It also sustained with no signs boundaries of speed that affected the fastness of driving when passing that location. Whereas, the black spot location at Letjen Harun Sohar Street is founded at STA 12+ 600 which undiscovered by speed limit signs that caused the occurrence of traffic accidents with the highest casualty fatality rate that happened when the driver is driven their vehicles with high speed that also supported by the presence of the median barrier. The marks disharmony to the road functions is indicated that the road infrastructure is not a self-explaining road, it means that the road is not able to explain the safety of road users rightly, so that the road wearers are less careful when they passed that accident prone location.

4. Conclusions

From the research, it can be concluded that the black spot location at Soekarno Hatta Street is located at STA 23+500, the factor that causes the traffic accidents are road users (80%), the accident frequency ≥ 3 traffic incidents in 1 (one) month (83%), causing a serious injury (37%), occurred on a sunny day (43%), car as the vehicle that often involved in traffic accidents (54%), high-speed while driving (87%), man as the highest casualty (77%), age of casualty ≥ 17 years old (90%), and the traffic accidents that happened when the weather is clear (80%). Furthermore, the black spot area at Gub.H. Ali Amin, SH street is found on STA 4+000 with the components that affected the traffic, the incident is a road wearers (83%), the events frequency < 3 accidents in 1 (one) month (87%), prompted weighty injuries (47%), developed in the morning (44%), motorcycle as the vehicle that usually engaged on the circumstances (60%), drive-in high speeder (93%), male as the prominent victims (83%), the age of the victims ≥ 17 years old (87%), and the accidents that come about the sunny weather (77%). Moreover, the place of black spot on Letjen Harun Sohar Street is at STA 12+600, the causing factor of traffic accident is road users (83%), the frequency of events < 3 incidents in 1 (one) month (67%), create the serious damage (47%), happened during the afternoon (36%), motorcycle as a vehicle that often get involved in an accident (57%), high speed on driving (63%), man as the most-common casualty (80%), age of victims ≥ 17 years old (83%), and the accident happened during cheery weather (87%).

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Conflict of Interests

The Authors declare no conflict of interest.

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