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ANALYSIS OF TRAFFIC ACCIDENT PRONE AREAS (BLACK SPOTS) ON JAMIN GINTING NATIONAL ROAD

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Abstract

This study aims to identify traffic accident prone points (black spots) on the Letjen Jamin Ginting National Road section, North Sumatra Province, Indonesia. Traffic accident data in the period 2021 to 2024 was analyzed using a combination of several methods, namely the Equivalent Accident Number (EAN), Batas Kontrol Atas (BKA), Upper Control Limit (UCL), Cumulative Sum (CUSUM) method, and Bina Marga method. The analysis was carried out by considering the severity of the accident, the classification of the location based on the accident rate, and the comparison of the results between the black spot identification methods. In addition, road characteristics such as geometric shape, slope, and road surface conditions were also analyzed to see the correlation with the number of accidents. The results showed that black spots tend to be on straight and flat roads with good road surface conditions, but still have a high frequency of accidents, showing that road user behavior factors play a big role in the occurrence of accidents. The CUSUM method is able to identify the trend of increasing accidents more sensitively than other methods, while the Bina Marga method provides conservative results according to national standards. Based on the results of the identification, a number of mitigation measures are recommended, including the installation of additional road markings, improving street lighting, improving traffic signs, and monitoring vehicle speeds. The application of a GIS-based accident monitoring system is also recommended to facilitate mapping and black spot analysis in the future.

Keywords: ***Black Spot, EAN, BKA, UCL, CUSUM, Bina Marga, Jalan Jamin Ginting, Traffic Safety***

INTRODUCTION

Transportation is a very important part of human life, especially transportation by motor vehicle, both for the needs of human movement and freight transportation, in transportation safety is a serious thing and must be taken into account by service users. According to Law No. 22 of 2009 about Road Traffic and Transportation, transportation aims to realize traffic and road transportation safely, safely, quickly, smoothly, orderly and orderly, comfortable and efficient, and able to integrate other modes of transportation, reaching all corners of the mainland, to support equity, growth and stability as a driver, driver and support for national development.

Transportation plays a very important role in the development of a region. The movement of people and goods must be carried out with priority in the principle of safety, in accordance with the Law No. 22 of 2009. This makes the safety aspect a major concern. The number of traffic accidents that occur on a road section is one of the main indicators of the level of safety on the road. Losses due to accidents are not only a considerable number of victims, but also losses in the economic field (material losses) and social impacts.

According to Law No. 22 of 2009, *Black Spot* It is defined as a location on highways that are prone to accidents, while in urban areas the road section is limited to 20-30 meters, while for intercity roads it is around 500 meters. Location *Black Spot* It can be done by visually observing places where accidents often occur over a certain period of time. Once the location is known *Black Spot* exist, then the point can be repaired so that the potential for accidents can be minimized. (Setiawan et al., 2022).

There have been many accidents on the Jamin Ginting road section, such as an accident between a truck driver and a private car on Jalan Jamin Ginting, Rumah Sumbul Village, Sibolangit District, Deli Serdang, Friday (17/02/2023). As a result of the accident, the Medan-Berastagi route experienced congestion for hours (Bondan,

2023) Accidents on the highway, which mostly occur on national highways, impose a significant public health and economic burden.

LITERATURE REVIEW

1. Traffic Accidents

Based on article 1 Law No. 22 of 2009 About Road Traffic and Transportation, A traffic accident is an unexpected and unintentional road event involving a vehicle with or without other road users that results in human casualties and property loss.

2. Classification of Accidents

Traffic accidents are classified into: minor traffic accidents, moderate traffic accidents and severe traffic accidents.

3. Classification of Traffic Accident Victims

According to Government Regulations of the Republic of Indonesia No. 79 of 2013 Regarding infrastructure and road traffic, traffic accident victims are classified as follows: deceased victims, seriously injured victims and minor injured victims.

4. Factors Causing Traffic Accidents

The factors that cause traffic accidents are vehicle factors, road factors, human factors and environmental factors.

5. Accident-prone point analysis

Areas prone to traffic accidents are those that have a high number of traffic accidents, high risks and accidents on a road (Suwardjoko Proboadiningrat Warpani, 2011). The accident site ranking technique can be carried out by an accident rate and quality control statistics approach, or weighting based on the accident value (Pd T. 09- 2004-B, 2004).

6. Criteria for Handling Traffic Accident Locations

The determination of priority locations for handling is carried out based on:

a. Accident Frequency
b. Severity of Accident
c. Accident Rate
d. Statistical Expectation

7. Safety Enhancement Efforts

Modern traffic safety efforts use the **"Safe System Approach" framework**, which recognizes that:

- **Humans can be flawed and fragile**, so systems must be designed to minimize fatal consequences.
- Focus on **preventing fatalities and serious injuries**, not just reducing the number of accidents.

Main Components:

1. Safe Roads (Jalan yang Aman)
2. Safe Vehicles (Kendaraan yang Aman)
3. Safe Speeds (Kecepatan Aman)
4. Safe Road Users (Pengguna Jalan yang Aman)
5. Post-Crash Response (Respons Setelah Kecelakaan)

The approach used is:

1. Management and engineering
2. Enforcing the law (*enfocement*)
3. Educating the public *on public relations,* education and community participation
4. Motivation (*encouragement*)
5. Serving emergencies (*emergency response*).

To calculate the number of accidents is to use the EAN method (*Equivalent Accident Number*) (Louis J. Pignataro, 1973), which is the weighting of the equivalent number of accidents referring to the cost of a traffic accident.

Table 1. Accident Equivalent Rate in Indonesia

Accident Rate	Accident Equivalent Numbers				
	Center for Research and Development	Ditjen Hubdat	Porli	ABIU-UPK	Sugiyanto (2017)

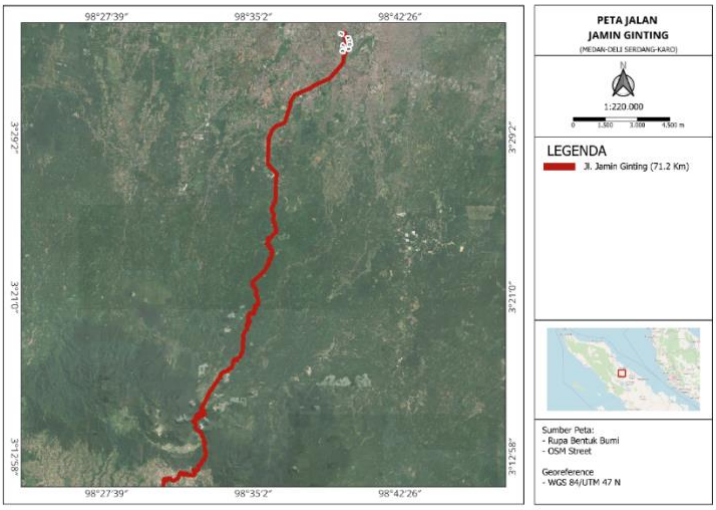
Passed Away (MD)	12	12	10	6	168
Severe Injuries (LB)	3	6	5	3	8
Minor Wound (LR)	3	3	1	0,8	2
Property Loss (K)	1	1	1	0,2	1

METHOD

Research Location

On the Letjen Jamin Ginting Road Section, North Sumatra Province. The pavement of the National Road section of Lt. Gen. Jamin Ginting with a total of 71.2 km. This study is to analyze the determination of traffic accident prone points on national roads Lt. Gen. Jamin Ginting. Map of the research location shown in Figure 3.1

Figure 1. Map of the research location



Analytical Approach

This study uses the EAN (*Equivalent Accident Number*) method, (BKA) Upper Control Limit, (UCL) *Upper Control Limit*, Bina Marga Method, and Cusum Method.

1. EAN BKA and UCL

To calculate the number of accidents is to use the EAN method (*Equivalent Accident Number*) (Louis J. Pignataro, 1973), which is the weighting of the equivalent number of accidents referring to the cost of a traffic accident.

$$EAN = 12\ MD + 6\ LB + 3\ LR + 1\ K$$

EAN is calculated by adding up the incidence of accidents on each kilometer of road length and then multiplying it by the weight value according to the severity. The standard weight values used were Death (MD) = 12, Serious injuries (LB) = 6, Minor injuries (LR) = 3, Vehicle damage (K) = 1 (Soemitro, 2005).

BKA (Upper Control Limit) formula

$$BKA = C + 3\sqrt{C}$$

The determination of accident-prone locations is carried out based on the number of accidents per kilometer of the road that has a weight value (EAN) that exceeds a certain limit value. This limit value can be calculated, among others, using the Upper Control Limit (BKA) and *Upper Control Limit* (UCL) methods.

$$UCL = \lambda + \psi \times \sqrt{[(\lambda / m) + ((0.829) / m) + (1 / 2 \times m)]}$$

Table 2. Probability Factor Values

Probability	0,005	0,0075	0,05	0,0075	0,1
ψ	2,576	1,96	1,645	1,44	1,282

2. Bina Marga Method

The determination of the location of black spots using this method is based on quantitative criteria, i.e. the number of accidents that exceed a certain threshold limit in a year or during a specific observation period (usually three years). The formula for identifying black spots with the Bina Marga method is:

$$N \geq A$$

3. Cussum Method

The CUSUM (Cumulative Sum Control Chart) method is a statistical approach used to detect small changes that occur continuously in sequential data. In the context of traffic safety, this method is used to identify accident-prone points (black spots) based on data on the number of accidents along certain roads or clusters.

$$Sn = \max(0, Sn_{-1} + (xn - \mu - k))$$

To mark black spots visually, a threshold is usually determined. If *the CUSUM* chart exceeds that threshold, then the location is categorized as a black spot.

RESULTS AND DISCUSSION

The following is a digram of the number of accidents per year, it can be seen that the number of accidents on the Jamin Ginting road section is increasing.

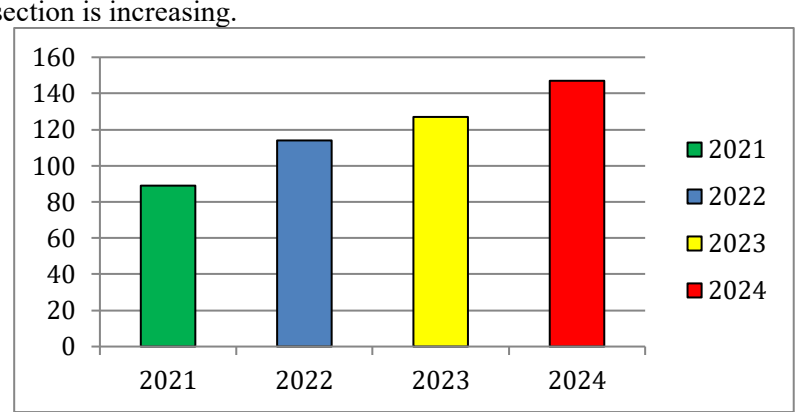


Figure 2. Diagram of the number of traffic accidents per year

A comparison of traffic accident data on the Jamin Ginting National Road section will be more clearly seen in the graph below:

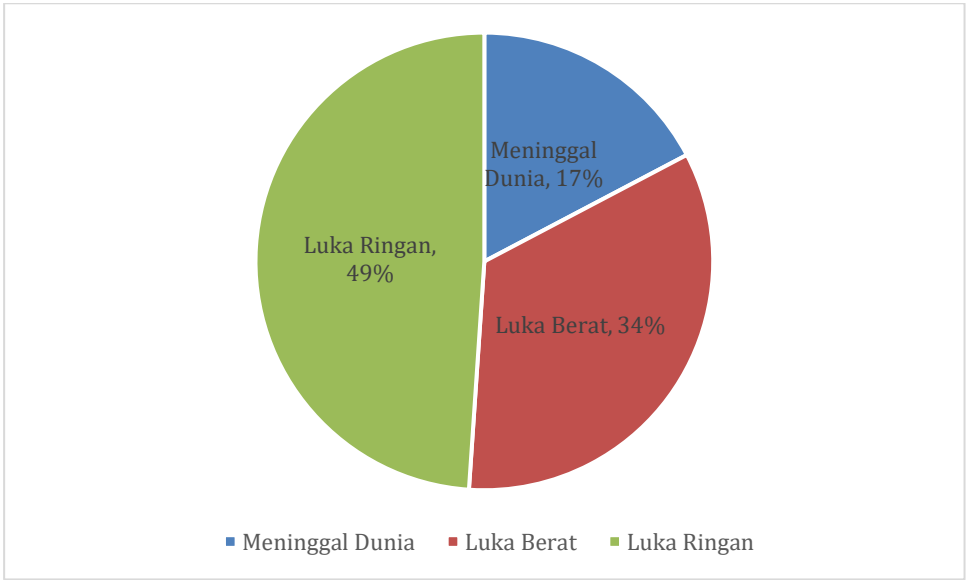


Figure 3. Traffic accident data diagram for 2021-2024

The following is a table of the results of the calculation of the EAN BKA and UCL values, the Bina Marga method and *the Cusum* method:

Table 3. Value of EAN BKA UCL, Bina Marga and *Cusum*

Cluster	EAN	BKA	UCL	Category	Düsseldorf	Category	*Cusum*	Information
1	12	44	35,54	No Blackspot	0,75	No Blackspot	-2,04	No Blackspot
2	48	44	40,85	Blackspot	3,25	Blackspot	5,92	No Blackspot
3	60	44	42,29	Blackspot	2,5	No Blackspot	10,88	No Blackspot

4	12	44	35,54	No Blackspot	0,75	No Blackspot	8,84	No Blackspot
5	9	44	35,22	No Blackspot	0,5	No Blackspot	5,80	No Blackspot
6	51	44	41,22	Blackspot	2,25	No Blackspot	9,76	No Blackspot
7	147	44	50,18	Blackspot	5,5	Blackspot	26,72	Blackspot
8	27	44	37,90	No Blackspot	1,5	No Blackspot	27,68	No Blackspot
9	33	44	38,81	No Blackspot	2,25	No Blackspot	31,64	No Blackspot
10	30	44	38,36	No Blackspot	1,75	No Blackspot	33,59	No Blackspot
11	69	44	43,29	Blackspot	2,5	No Blackspot	38,55	No Blackspot
12	72	44	43,61	Blackspot	2,75	No Blackspot	44,51	No Blackspot
13	21	44	36,95	No Blackspot	1,5	No Blackspot	45,47	No Blackspot
14	6	44	35,27	No Blackspot	0,25	No Blackspot	41,43	No Blackspot
15	24	44	37,43	No Blackspot	1,5	No Blackspot	42,39	No Blackspot
16	54	44	41,59	Blackspot	2,75	No Blackspot	48,35	No Blackspot
17	117	44	47,81	Blackspot	6,25	Blackspot	68,31	Blackspot
18	21	44	36,95	No Blackspot	1,25	No Blackspot	68,27	No Blackspot
19	36	44	39,24	No Blackspot	1,25	No Blackspot	68,23	No Blackspot
20	39	44	39,66	No Blackspot	1,25	No Blackspot	68,19	No Blackspot
21	51	44	41,22	Blackspot	2,75	No Blackspot	74,15	No Blackspot
22	33	44	38,81	No Blackspot	1,5	No Blackspot	75,11	No Blackspot
23	69	44	43,29	Blackspot	3,75	Blackspot	85,07	No Blackspot
24	36	44	39,24	No Blackspot	1,5	No Blackspot	86,03	No Blackspot
25	63	44	42,63	Blackspot	4	Blackspot	96,99	Blackspot
26	78	44	44,23	Blackspot	2,5	No Blackspot	101,95	No Blackspot
27	3	44	36,67	No Blackspot	0,25	No Blackspot	97,91	No Blackspot
30	66	44	42,97	Blackspot	3	Blackspot	104,86	No Blackspot
31	21	44	36,95	No Blackspot	0,75	No Blackspot	102,82	No Blackspot
32	54	44	41,59	Blackspot	3	Blackspot	109,78	No Blackspot
33	36	44	39,24	No Blackspot	2,25	No Blackspot	113,74	No Blackspot
34	6	44	35,27	No Blackspot	0,5	No Blackspot	110,70	No Blackspot
35	36	44	39,24	No Blackspot	1,75	No Blackspot	112,66	No Blackspot
36	18	44	36,46	No Blackspot	1,25	No Blackspot	112,62	No Blackspot
37	66	44	42,97	Blackspot	2,25	No Blackspot	116,58	No Blackspot
38	42	44	40,07	Blackspot	1,5	No Blackspot	117,54	No Blackspot
39	9	44	35,22	No Blackspot	0,5	No Blackspot	114,50	No Blackspot
40	18	44	36,46	No Blackspot	1	No Blackspot	113,46	No Blackspot
41	18	44	36,46	No Blackspot	1	No Blackspot	112,42	No Blackspot
42	33	44	38,81	No Blackspot	1	No Blackspot	111,38	No Blackspot
43	42	44	40,07	Blackspot	1	No Blackspot	110,34	No Blackspot
44	45	44	40,46	Blackspot	1,75	No Blackspot	112,30	No Blackspot
45	42	44	40,07	Blackspot	1,25	No Blackspot	112,26	No Blackspot
46	15	44	35,98	No Blackspot	1	No Blackspot	111,22	No Blackspot
47	24	44	37,43	No Blackspot	1,25	No Blackspot	111,18	No Blackspot
48	6	44	35,27	No Blackspot	0,25	No Blackspot	107,14	No Blackspot

49	33	44	38,81	No Blackspot	1,25	No Blackspot	107,09	No Blackspot
50	18	44	36,46	No Blackspot	0,5	No Blackspot	104,05	No Blackspot
51	15	44	35,98	No Blackspot	0,5	No Blackspot	101,01	No Blackspot
52	54	44	41,59	Blackspot	3,5	Blackspot	109,97	No Blackspot
53	72	44	43,61	Blackspot	3,5	Blackspot	118,93	No Blackspot
54	15	44	35,98	No Blackspot	1	No Blackspot	117,89	No Blackspot
55	18	44	36,46	No Blackspot	0,5	No Blackspot	114,85	No Blackspot
56	72	44	43,61	Blackspot	2,75	No Blackspot	120,81	No Blackspot
57	84	44	44,83	Blackspot	3,75	Blackspot	130,77	No Blackspot
58	24	44	37,43	No Blackspot	1,25	No Blackspot	130,73	No Blackspot
59	15	44	35,98	No Blackspot	0,75	No Blackspot	128,69	No Blackspot
60	27	44	37,90	No Blackspot	1,25	No Blackspot	128,65	No Blackspot
62	6	44	35,27	No Blackspot	0,25	No Blackspot	124,61	No Blackspot
63	12	44	35,54	No Blackspot	0,25	No Blackspot	120,57	No Blackspot
64	9	44	35,22	No Blackspot	0,5	No Blackspot	117,53	No Blackspot
65	39	44	39,66	No Blackspot	1,5	No Blackspot	118,49	No Blackspot
67	6	44	35,27	No Blackspot	0,25	No Blackspot	114,45	No Blackspot
68	54	44	41,59	Blackspot	2	No Blackspot	117,41	No Blackspot
70	18	44	36,46	No Blackspot	1	No Blackspot	116,36	No Blackspot
71	36	44	39,24	No Blackspot	1,5	No Blackspot	117,32	No Blackspot
72	33	44	38,81	No Blackspot	1,25	No Blackspot	117,28	No Blackspot
73	39	44	39,66	No Blackspot	1,25	No Blackspot	117,24	No Blackspot
74	18	44	36,46	No Blackspot	0,5	No Blackspot	114,20	No Blackspot
75	9	44	35,22	No Blackspot	0,5	No Blackspot	111,16	No Blackspot
76	21	44	36,95	No Blackspot	1	No Blackspot	110,12	No Blackspot
77	30	44	38,36	No Blackspot	1,5	No Blackspot	111,08	No Blackspot
78	3	44	36,67	No Blackspot	0,25	No Blackspot	107,04	No Blackspot
80	51	44	41,22	Blackspot	2,5	No Blackspot	112,00	No Blackspot
81	42	44	40,07	Blackspot	2	No Blackspot	114,96	No Blackspot
82	36	44	39,24	No Blackspot	1,25	No Blackspot	114,92	No Blackspot
83	6	44	35,27	No Blackspot	0,5	No Blackspot	111,88	No Blackspot
84	18	44	36,46	No Blackspot	0,75	No Blackspot	109,84	No Blackspot
85	9	44	35,22	No Blackspot	0,5	No Blackspot	106,80	No Blackspot
86	3	44	36,67	No Blackspot	0,25	No Blackspot	102,76	No Blackspot
87	12	44	35,54	No Blackspot	0,25	No Blackspot	98,72	No Blackspot
89	18	44	36,46	No Blackspot	0,75	No Blackspot	96,68	No Blackspot
91	6	44	35,27	No Blackspot	0,25	No Blackspot	92,64	No Blackspot
92	12	44	35,54	No Blackspot	0,25	No Blackspot	88,59	No Blackspot
95	6	44	35,27	No Blackspot	0,5	No Blackspot	85,55	No Blackspot
96	54	44	41,59	Blackspot	1,75	No Blackspot	87,51	No Blackspot
97	42	44	40,07	Blackspot	1,5	No Blackspot	88,47	No Blackspot
103	36	44	39,24	No Blackspot	1,5	No Blackspot	89,43	No Blackspot
104	9	44	35,22	No Blackspot	0,5	No Blackspot	86,39	No Blackspot

105	42	44	40,07	Blackspot	2,25	No Blackspot	90,35	No Blackspot
106	51	44	41,22	Blackspot	1,75	No Blackspot	92,31	No Blackspot
107	12	44	35,54	No Blackspot	0,5	No Blackspot	89,27	No Blackspot
112	30	44	38,36	No Blackspot	1,75	No Blackspot	91,23	No Blackspot
113	18	44	36,46	No Blackspot	0,5	No Blackspot	88,19	No Blackspot
116	6	44	35,27	No Blackspot	0,25	No Blackspot	84,15	No Blackspot
117	15	44	35,98	No Blackspot	0,5	No Blackspot	81,11	No Blackspot
118	36	44	39,24	No Blackspot	1,75	No Blackspot	83,07	No Blackspot
119	27	44	37,90	No Blackspot	1	No Blackspot	82,03	No Blackspot
121	6	44	35,27	No Blackspot	0,25	No Blackspot	77,99	No Blackspot
122	36	44	39,24	No Blackspot	1,25	No Blackspot	77,95	No Blackspot
123	48	44	40,85	Blackspot	2	No Blackspot	80,91	No Blackspot
124	18	44	36,46	No Blackspot	0,75	No Blackspot	78,86	No Blackspot
125	21	44	36,95	No Blackspot	0,75	No Blackspot	76,82	No Blackspot
126	24	44	37,43	No Blackspot	1,25	No Blackspot	76,78	No Blackspot
127	27	44	37,90	No Blackspot	0,75	No Blackspot	74,74	No Blackspot
129	33	44	38,81	No Blackspot	1	No Blackspot	73,70	No Blackspot
130	9	44	35,22	No Blackspot	0,5	No Blackspot	70,66	No Blackspot
132	45	44	40,46	Blackspot	2,75	No Blackspot	76,62	No Blackspot
133	3	44	36,67	No Blackspot	0,25	No Blackspot	72,58	No Blackspot
138	12	44	35,54	No Blackspot	0,25	No Blackspot	68,54	No Blackspot
139	9	44	35,22	No Blackspot	0,5	No Blackspot	65,50	No Blackspot
141	42	44	40,07	Blackspot	1,25	No Blackspot	65,46	No Blackspot
142	12	44	35,54	No Blackspot	0,75	No Blackspot	63,42	No Blackspot
143	27	44	37,90	No Blackspot	1,25	No Blackspot	63,38	No Blackspot
144	15	44	35,98	No Blackspot	1	No Blackspot	62,34	No Blackspot
145	30	44	38,36	No Blackspot	1,25	No Blackspot	62,30	No Blackspot
146	12	44	35,54	No Blackspot	1	No Blackspot	61,26	No Blackspot
147	12	44	35,54	No Blackspot	0,75	No Blackspot	59,22	No Blackspot
152	9	44	35,22	No Blackspot	0,5	No Blackspot	56,18	No Blackspot
156	51	44	41,22	Blackspot	2,25	No Blackspot	60,14	No Blackspot
157	12	44	35,54	No Blackspot	0,25	No Blackspot	56,09	No Blackspot
158	12	44	35,54	No Blackspot	0,5	No Blackspot	53,05	No Blackspot
161	3	44	36,67	No Blackspot	0,25	No Blackspot	49,01	No Blackspot
163	12	44	35,54	No Blackspot	0,25	No Blackspot	44,97	No Blackspot
164	0	44	28,07	No Blackspot	0	No Blackspot	39,93	No Blackspot
165	15	44	35,98	No Blackspot	0,5	No Blackspot	36,89	No Blackspot
166	45	44	40,46	Blackspot	2	No Blackspot	39,85	No Blackspot
167	6	44	35,27	No Blackspot	0,25	No Blackspot	35,81	No Blackspot
168	9	44	35,22	No Blackspot	0,5	No Blackspot	32,77	No Blackspot
169	12	44	35,54	No Blackspot	0,25	No Blackspot	28,73	No Blackspot
171	30	44	38,36	No Blackspot	1,5	No Blackspot	29,69	No Blackspot
172	21	44	36,95	No Blackspot	0,75	No Blackspot	27,65	No Blackspot

173	9	44	35,22	No Blackspot	0,5	No Blackspot	24,61	No Blackspot
174	27	44	37,90	No Blackspot	1,5	No Blackspot	25,57	No Blackspot
175	6	44	35,27	No Blackspot	0,25	No Blackspot	21,53	No Blackspot
176	15	44	35,98	No Blackspot	0,75	No Blackspot	19,49	No Blackspot
178	9	44	35,22	No Blackspot	0,5	No Blackspot	16,45	No Blackspot
179	78	44	44,23	Blackspot	2,5	No Blackspot	21,41	No Blackspot
181	24	44	37,43	No Blackspot	0,75	No Blackspot	19,36	No Blackspot
182	15	44	35,98	No Blackspot	1	No Blackspot	18,32	No Blackspot
184	0	44	28,07	No Blackspot	0	No Blackspot	13,28	No Blackspot
185	0	44	28,07	No Blackspot	0	No Blackspot	8,24	No Blackspot
186	15	44	35,98	No Blackspot	0,75	No Blackspot	6,20	No Blackspot
187	18	44	36,46	No Blackspot	1,5	No Blackspot	7,16	No Blackspot
191	3	44	36,67	No Blackspot	0,25	No Blackspot	3,12	No Blackspot
197	33	44	38,81	No Blackspot	1	No Blackspot	2,08	No Blackspot
198	12	44	35,54	No Blackspot	1	No Blackspot	1,04	No Blackspot
199	18	44	36,46	No Blackspot	1	No Blackspot	0,00	No Blackspot

Description of Each Method

- UCL BKA EAN Method: Using the upper control limit (UCL) based on the normal accident equivalent (EAN) figure. If the number of accidents exceeds the UCL, then the point is declared a blackspot.
- Bina Marga Method: Designate a point as a blackspot if there is an average of ≥ 3 accidents in one year.
- CUSUM method: Uses cumulative deviation accumulation techniques to detect shifts in accident patterns.

Table 4. Table of Number of Blackspot Points per Method

Method	Number of Blackspot Points	Cluster
EAN BKA UCL	36	2, 3, 6, 7, 11, 12, 16, 17, 21, 23, 25, 26, 30, 32, 37, 38, 43, 44, 45, 52, 53, 56, 57, 68, 80, 81, 96, 97, 105, 106, 123, 132, 141, 156, 166, 179
Bina Marga	10	2, 7, 17, 23, 25, 30, 32, 52, 53, 57.
CUSUM	3	7, 17, 25

The EAN BKA UCL method produces the highest number of blackspot points compared to other methods. This is because this method is very sensitive to the increase in the number of accidents compared to the normal average. The Bina Marga method is relatively conservative because it only considers the minimum number of events in one year. The CUSUM method detects trend changes more subtly, so it can be more adaptive to long-term accident patterns.

Each method has its own advantages and disadvantages. The choice of the best method depends on the purpose of the analysis: whether it wants early detection (*CUSUM),* regulatory standards (Bina Marga), or high sensitivity to the increase in accidents (EAN BKA UCL). In practice, a combination of several methods can provide more comprehensive and effective blackspot identification results.

The graph of geometric shapes, road surface conditions and road slopes in each accident for 4 years, namely 2021 to 2024, are as follows:

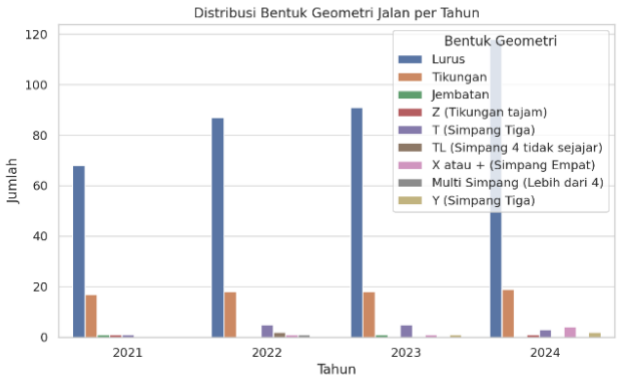


Figure 4. Road Geometry Shape Diagram

Figure 5. Road lightness diagram

Figure 6. Road Surface Condition Diagram

Comparison Chart

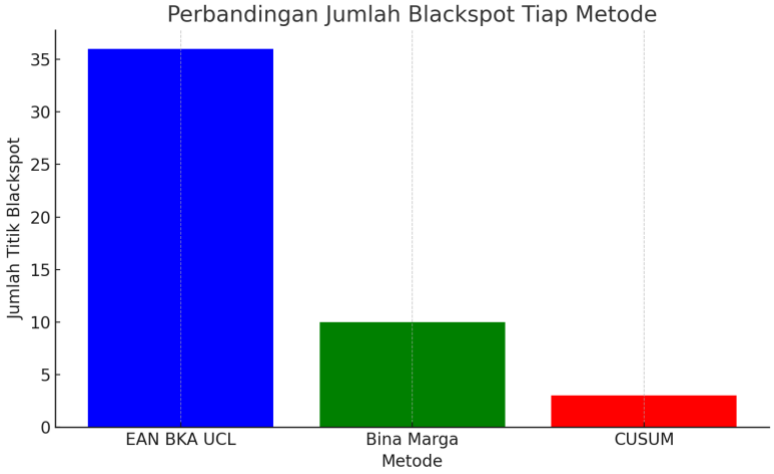


Figure 7. Comparison Chart of the Number of Blackspots for Each Method

The graph of the form of the accident factor diagram on the Jamin Ginting road section for the last 4 years, namely 2021 to 2024, is as follows:

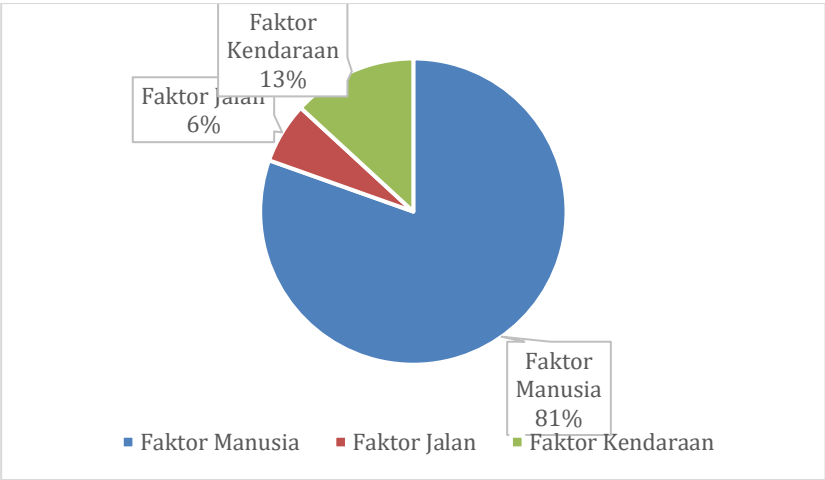


Figure 8. Accident Factor Diagram (2021-2024)

Based on the data recapitulation, it can be concluded that the main factor causing traffic accidents is the human factor, which accounts for about 81% of the total incidents, while vehicle and road factors account for 13% and 6%, respectively. According to the World Health Organization (World Health Organization, 2018) More than 90% of traffic accidents in the world are caused by human error, including speeding, negligence, and violations of traffic rules. According to the World Health Organization (World Health Organization, 2018) More than 90% of traffic accidents in the world are caused by human error, including speeding, negligence, and violations of traffic rules.

Mapping Results

After going through a series of stages of data collection and processing, the results of mapping accident-prone points (*blackspots) will be* presented. This mapping aims to reveal the patterns and characteristics of accidents in the research area.

The following is a map of accident points on the Jamin Ginting road section.

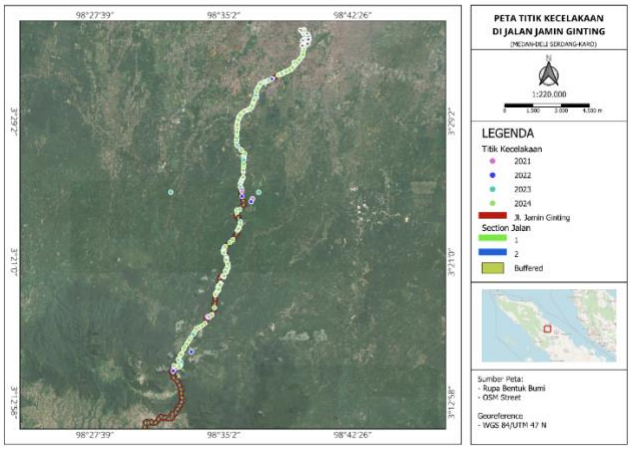


Figure 9 Map of Accident Points

Figure 10 Map Blackspot EAN BKA UCL

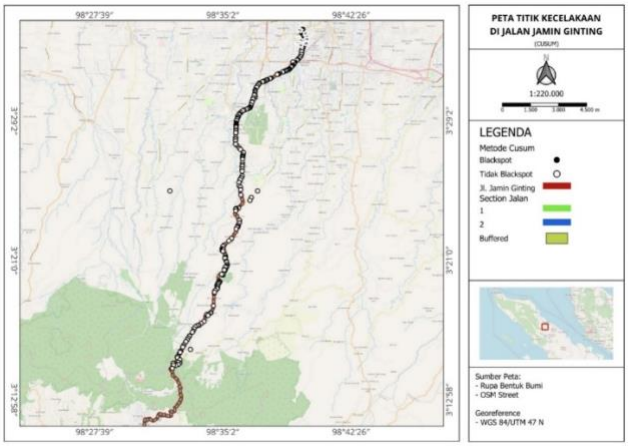


Figure 11. Map Blackspot *Cusum*

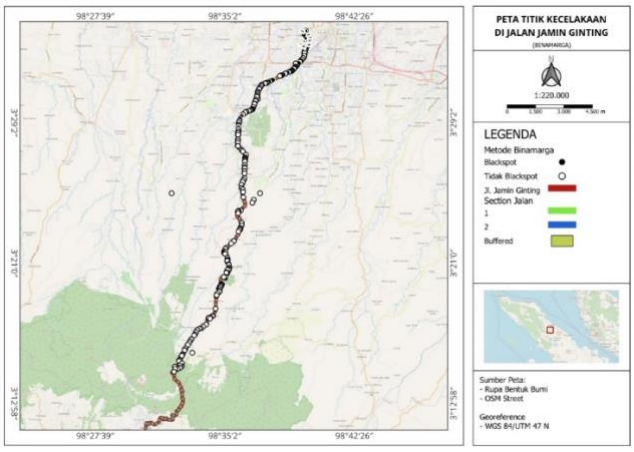


Figure 12. Map Blackspot Bina Marga

CONCLUSION

Based on the results of the survey and discussion on the research conducted on the national road section of Lieutenant Jamin Ginting. The EAN BKA UCL method is very sensitive to change, but it can produce many false positives. The Bina Marga method is easy to apply and national standard, but less sensitive to small fluctuation patterns. As for the *Cusum* Method, it can detect trend changes more subtly, suitable for long-term analysis, but more computationally complex. The factors causing the accident were Human *Error* 81%, road factor 6% and prison factor 13%.

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