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Identification and Prioritization of Black Spots in Hilly Road Segment Using Accident Severity Index Method

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Abstract

Introduction: Road traffic accidents (RTA) will become the third-largest contributor to the global burden of diseases after the ischemic heart diseases and depression. The place where the traffic accident percentages are higher is called as black spot location. The most common assumption for a black spot location is that, there should be any road environmental or geometric issues resulting in the repetition of accidents. **Methodology:** Our study was conducted in two districts of the Northern Region of India (Uttarakhand). The data were collected on various factors such as weather, accident type, severity levels, and road geometry such as number of curves, segment length, Annual Average Daily Traffic. **Results:** The present study was an attempt to find out the black spots and to measure the accident severity index (ASI) of the identified black spots in the areas of Dehradun and Haridwar. For each location the ASI was calculated and the Rankings were allotted to the black spots so as to find the severity of the black spots. **Conclusion:** The present study also suggests that the RTA should be taken under consideration as per the accident severity rather than the frequency of the accidents.

Keywords: Black spots, Hilly road segment, Road traffic accidents, Severity index.

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Introduction

Nowadays, there is rapid increase in the number of motor vehicles which is due to the population growth and advances in technology. Unlike developed countries, developing ones are facing financial difficulties in improving road safety.[1,2] Road safety improvement entails black spot treatment whose first step is the identification of black spots. "According to Ministry of Road Transport and Highways (MoRTH), Government of India, road accident black spot on National Highways is a road stretch of about 500 m in length in which either five road accidents (involving fatalities/grievous injuries) took place during last 3 calendar years or 10 fatalities took place during last 3 calendar years."[3] Injury and deaths due to RTA are a major public health problem in developing countries where more than 85% of all deaths and 90% of disability-adjusted life years were lost from road traffic injuries.[4] The basic elements in traffic accidents are road users, vehicles, road condition, road geometry, environmental factors, etc. There have been a number of recent examples in the literature[5-7] of panel data analyses using accident data. For example, the National Safety Council[8] devised a scheme for injury classification-no injury, possible injury, non-incapacitating injury, incapacitating injury, and fatal injury. The main cause of road accidents is road parameters such as road width, deficiency in super elevation, deficiency in site distance, and radius of horizontal curve. Road accidents cannot be totally prevented, but using suitable traffic engineering safety plan and management measures, the accident rate can be reduced. Even after an accident occurs, the common city roads have to face many problems such as traffic jams which cause loss of valuable time. Therefore, the accuracy in identifying black spots has a great effect on the effectiveness of the results of black spot analysis and treatment (Elvik, 2006).[9] This paper describes the identification of black spots in Dehradun and Haridwar City. The identification of black spots can help in better scheduling road safety policies. The previous studies and practices have also shown that the black spot identification method is an effective and reactive means of dealing with the occurrence of accidents.[10] According to a study, it was reported that the methods such as Accident Rate Method, Quality Control Method Accident Density Method, Number of Accidents Method, Combined Method and the method of severity Index were used for the identification of black spots.[11] Severity index method was used for finding the hotspots. In this method, a severity value was obtained for each crash location based on number of people died, number of people severely injured, and number of people who got minor injuries and so on. Thus, accident severity index (ASI) can be defined as a dimensionless value indicating the hazardousness of a spot in the road.

"Jorgensen[12] introduced a new method which employed two new factors: (1) Mean of expected accident counts calculated by the multivariable model, and (2) the observed accident number. The identification of black spots is based on the difference between the expected number and the observed number of accidents. As a result, the expected number of accident was employed as a new parameter in black spot identification".

Taylor and Thompson[13] suggested that a hazardous index is defined for each road section or spot as a weighted sum of a mix of accident frequency, rate, severity, volume-to-capacity ratio, sight distance, conflicts, erratic maneuvers, and driver expectancy. There is a general recognition here that there are clues to risk other than accident occurrence. As a result, hazardous/risk index was considered a new aspect in black spot identification.

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Selvasofia and Arulraj (2016) has done the hotspot identification within Coimbatore city. The analysis was conducted by establishing some control points. Analysis was done with the data from 2010 to 2014. Critical crash rate factor method was used to identify the hazardous locations. The more accidents were found near to the important landmarks. They listed the suggestive measures for each zones in the city after the analysis. The main reasons for the accidents were also identified in the study. Inadequate footpaths and problem regarding drainages were some of the main reasons identified through this study.[14]

Nguyen *et al*.[15] proposed a black spot safety management approach called safety-potential-based black spot management, which relies on an expected number of accidents as an additional parameter in identifying true black spots. That means in its

Table 1: Accident statistics on identified black spots of Dehradun

Name of the Identified black spots in Dehradun	*"No. of fatal accidents at the spot in the last 3 Year"*	*"No. of serious accidents at the spot in the last 3 year"*	*"No. of minor accidents at the spot in the last 3 year"*	*Name of the Identified black spots in Dehradun*	*"No. of fatal accidents at the spot in the last 3 Year"*	*"No. of serious accidents at the spot in the last 3 year"*	*"No. of minor accidents at the spot in the last 3 year"*
Shimla Bypass Chowk Patelnagar	1	9	20	Near Harrawala Police Chowki, Laxman Siddha Temple mod Doiwala	1	0	2
Chhidarwala Raiwala	1	9	20	Near R.T.O. office Haridwar bypass Road Rishikesh	1	0	1
Sai Mandir Rajpur	1	7	8	N.I.V.H. Jakhan Rajpur	1	0	1
Kale ki Dhaal Haridwar Road Rishikesh	1	5	12	I.T. Park Sahastrdhara Rajpur	1	0	1
Dharmawala Chowk Sahaspur	1	4	10	Near Shani Mandir Chakrata Road	1	0	1
Before Kulhaal power house mod	1	4	10	Charba Road Tri Junction Sahaspur	1	0	1
Old Chowki Bypass Road	2	3	5	Yamuna Pul mod Badwala	1	0	1
Satyanarayan Temple Raiwala	2	3	5	Ranghnwala Chungi Near I.M.A.	1	0	1
Telapur Chowk Nayagaon.	0	5	10	Khand Village Pulia Raiwala	1	0	1
Motichur Raiwala	3	1	4	St.Jude Chowk	0	1	1
Near Miyawala BridgeDoiwala	3	0	6	Ratanpur Chowk mod Nayagaon	0	1	1
Shiv Mandir Mussoorie Road Rajpur	2	1	6	Anahajare Chowk Patel Nagar	0	1	1
Saraswati Vihar Chowk Bypass Road	1	3	4	Saat Mod Dehradun Road Rishikesh	0	0	0
Ambadi mod Daakpathar Vikashnagr	0	3	6	Shimla bypass Pratitpur Sahaspur	0	0	0
Kali Mandir Dehradun Road Rishikesh	1	1	4	Near Kishan Nagar Chowk Chakrata Road Cantt	0	0	0
Langha Road Tri Junction Sahaspur	1	1	4	Chadni Chowk Nayagaon	0	0	0
Amitabh Textile Mill Chakrata Road	0	3	3	Near Wood Stark School	0	0	0
MothroWala Chowk Bypass Road	1	1	2	Before Maharani Suvakholi Mussoorie	0	0	0
Maggi Point Rajpur	1	0	2	Bright angle School line Jiwangarh	0	0	0
D.I.T. Mussoorie Road Rajpur	1	0	2	Near Lehman bridge mod both sides	0	0	0
Near Bhardwaj Clinic Haridwar Road Rishikesh	1	0	2	Pir Baba mod Dehari Chowk Premnagar	0	0	0
Near Kaflani Mussoorie.	1	0	2	Near Vanbeat Chowki. kunwawala	0	0	0
Bypass Road Hotel Solitaires Nehru Colony	1	0	2	Fatehpur Chowk Haridwar road Laltapad	0	0	0
Near Harbatpur Mazar Vikashnagar	1	0	2	Near PNB Bank Haridwar main road Laltapad	0	0	0
Opposite Law College	1	0	2				

identification of black spots, the safety- potential-based approach makes use of three parameters: Recorded number of accidents, expected number of accidents, and critical value.[15]

A study conducted by Bobade *et al*. revealed that by ranking the parameters based on their severity and calculating the severity index, the accident-prone locations can be identified. The maximum weightage and top rank were assigned to the parameters which caused maximum number of accidents.[16] Tamburri and smith (1970) introduced the notion of the safety index which is actually combined criterion of accident number and accident severity.[17]

McGuigan.[18,19] suggests that for each road section and intersection one calculate the difference between the actual number of accidents and the expected number of accidents for such a class of road or intersection is given by the same traffic. This suggestion furthered the accuracy of black spot identification using accident rate rather than accident frequency.

Several studies reported that there are various approaches that are aimed at identifying hotspots. One of the well-known approaches is using statistical crash models. This approach focuses on relating crashes as a function of potential variables such as road characteristics, traffic level, and weather factors using historical records.[20-24]

Methodology

The aim of this study is to identify black spots on the basis of accident frequency, severity, and recurrence with responsible risk factors at different severity levels for Hilly road segment.

Road accident data for a 3 year period from 2016 to 2018 were collected through respective police station limits of Dehradun and Haridwar city. Identification of black spot was carried through Accident Severity method and ranking was provided for the hazardous accident prone locations using ASI. Based on the data collected, the ASI value was calculated. The black spots were prioritized according to the severity of the location and road safety analysis was done in the identified black spots. "The concept of this method is that the number of fatal or injury accidents at a location is given a greater weight than property damage-only accidents."

ASI is a dimensionless value indicating the hazardous of a location. The following equation has been used:

$$ASI = Nf \times Wf + Ns \times Ws + Nm \times Wm$$

Where,

Nf = No. of fatal accidents at the spot in the past 3 years
Wf = Weight assigned to fatal accident = 6
Ns = No. of serious accidents at the spot in the past 3 years
Ws = Weight assigned to serious accident = 3
Nm = No. of minor accidents at the spot in the past 3 years
Wm = Weight assigned to minor accident = 1.

Severity of Accidents

Severity of accidents can be expressed in terms ASI which measures the seriousness of an accident. It is defined as the number of person killed per 100 accidents (MoRTH, 2012).

Study Area and Data Collection

Study area

In Uttarakhand, 132 black spots are identified by Transport Research Wing, Government of Uttarakhand. According to MoRTH, Government of India, road accident black spot on National Highways is a road stretch of about 500 m in length in which either five road accidents (involving fatalities/grievous injuries) took place during past 3 calendar years or 10 fatalities took place during

Table 2: Accident statistics on identified black spots of Haridwar

Name of the Identified black spots in Haridwar	*"No. of fatal accidents at the spot in the last 3 Year"*	*"No. of serious accidents at the spot in the last 3 year"*	*No. of minor accidents at the spot in the last 3 year*	*Name of the Identified black spots in Dehradun*	*"No. of fatal accidents at the spot in the last 3 Year"*	*"No. of serious accidents at the spot in the last 3 year"*	*"No. of minor accidents at the spot in the last 3 year"*
Narsan Jhabreda tirah to whole Gurukul	7	20	54	Daulatpur	3	5	8
Sugar Mill to Libbarhri	7	18	25	Double Fatak over bridge Mohanpura	3	3	12
Jahanwi del	7	9	32	Shantikunj Gate	2	5	7
Rashiyabad	7	8	30	Militry Chowk	3	3	6
Rampur Chungi	9	8	17	Puhana	1	5	12
Padartha	8	6	28	Devband thirah to Kasba Market	1	5	12
Peelinadi	5	6	22	Dudhadhari	2	4	6
Gandikhata	5	8	13	Singhdwar	2	4	6
Harilok tri Junction	6	6	12	Baderi Sulfur Road	2	2	8
ABB Chowk	5	5	20	Shani dev Temple	3	1	4
Bongla Bypass	4	9	13	Chidiyapur	2	2	4
Ranipur Jhaal	5	7	12	Malakpur Chungi	1	1	2
SankaraCharya Chowk	4	6	20	Gurukul	0	0	0
Chandi Chowk	3	5	16	Mandawar	0	0	0
Shikariwala pir to Deepshikha	4	5	9	Tricha pul	0	0	0
Karoundi	4	5	9	Birla Factory to shani dev mandir	0	0	0

past 3 calendar years. The black spots were identified in Dehradun and Haridwar comprising of 81 black spots. Out of which there were 49 black spots which were identified in Dehradun followed by 32 black spots in Haridwar.

Data collection

The road accident details were collected of the past 3 years (2016–2018) from city police records and the following details were obtained:

Table 1 shows the accident statistics of the identified black spots in Dehradun. The majority of the minor accidents (20 accidents) followed by the number of serious accidents (9 accidents) were observed in the black spot Shimla Bypass Chowk Patelnagar and in Chhidarwala Raiwala whereas the majority of the fatal accidents (3 Accidents) were found in the identified black spots – Motichur Raiwala and Near Miyawala Bridge Doiwala.

Table 2 shows the accident statistics of the identified black spots in the areas of Haridwar. The majority of the minor accidents (54 accidents) followed by the number of serious accidents (20 accidents) were observed in the black spot Narsan Jhabredatirah to whole Gurukul whereas the majority of the fatal accidents (9 Accidents) were found in the identified black spots - Rampur Chungi.

Results and Discussion

For each location of the identified black spots, the equation of ASI of the black spots in the areas of Dehradun was calculated as shown in [Table 3 and Figure 1] and after obtaining those severity values the rankings were allotted to the identified black spots. Rank 1 was allotted to the black spots- Shimla Bypass Chowk Patelnagar and Chhidarwala Raiwala as the ASI of these black spots was the highest (ASI = 53) whereas there were 12 black spots in the region of Dehradun with the ASI equals to zero (which were ranked as 17). No Accidents were observed in these 12 black spots.

The identified black spots - Shimla Bypass Chowk Patelnagar, Chhidarwala Raiwala, Sai Mandir Rajpur, Kale ki Dhaal Haridwar Road Rishikesh, Dharmawala Chowk Sahaspur, Before Kulhaal power house mod, Old Chowki Bypass Road, and Satyanarayan

Table 3: Accident severity index (ASI) and the ranking of the black spots (Dehradun)

Name of the Identified black spots in Dehradun	*Accident Severity Index*	*Ranking*	*Name of the Identified black spots in Dehradun*	*Accident Severity Index*	*Ranking*
Shimla Bypass Chowk Patelnagar	53	1	Near Harrawala Police Chowki, Laxman Siddha Temple mod Doiwala	8	14
Chhidarwala Raiwala	53		Near R.T.O. office Haridwar bypass Road Rishikesh	7	15
Sai Mandir Rajpur	35	2	N.I.V.H. Jakhan Rajpur	7	
Kale ki Dhaal Haridwar Road Rishikesh	33	3	I.T. Park Sahastrdhara Rajpur	7	
Dharmawala Chowk Sahaspur	28	4	Near Shani Mandir Chakrata Road	7	
Before Kulhaal power house mod	28		Charba Road Tri Junction Sahaspur	7	
Old Chowki Bypass Road	26	5	Yamuna Pul mod Badwala	7	
Satyanarayan Temple Raiwala	26		Ranghnwala Chungi Near I.M.A.	7	
Telapur Chowk Nayagaon.	25	6	Khand Village Pulia Raiwala	7	
Motichur Raiwala	25		St.Jude Chowk	4	16
Near Miyawala BridgeDoiwala	24	7	Ratanpur Chowk mod Nayagaon	4	
Shiv Mandir Mussoorie Road Rajpur	21	8	Anahajare Chowk Patel Nagar	4	
Saraswati Vihar Chowk Bypass Road	19	9	Saat Mod Dehradun Road Rishikesh	0	17
Ambadi mod Daakpathar Vikashnagr	15	10	Shimla bypass Pratitpur Sahaspur	0	
Kali Mandir Dehradun Road Rishikesh	13	11	Near Kishan Nagar Chowk Chakrata Road Cantt	0	
Langha Road Tri Junction Sahaspur	13		Chadni Chowk Nayagaon	0	
Amitabh Textile Mill Chakrata Road	12	12	Near Wood Stark School	0	
MothroWala Chowk Bypass Road	11	13	Before Maharani Suvakholi Mussoorie	0	
Maggi Point Rajpur	8	14	Bright angle School line Jiwangarh	0	
D.I.T. Mussoorie Road Rajpur	8		Near Lehman bridge mod both sides	0	
Near Bhardwaj Clinic Haridwar Road Rishikesh	8		Pir Baba mod Dehari Chowk Premnagar	0	
Near Kaflani Mussoorie.	8		Near Vanbeat Chowki. kunwawala	0	
Bypass Road Hotel Solitaires Nehru Colony	8		Fatehpur Chowk Haridwar road Laltapad	0	
Near Harbatpur Mazar Vikashnagar	8		Near PNB Bank Haridwar main road Laltapad	0	
Opposite Law College	8				

Table 4: Accident severity index (ASI) and the ranking of the black spots (Haridwar)

Name of the Identified black spots in Haridwar	*Accident Severity Index*	*Ranking*	*Name of the Identified black spots in Dehradun*	*Accident Severity Index*	*Ranking*
Narsan Jhabreda tirah to whole Gurukul	156	1	Daulatpur	41	16
Sugar Mill to Libbarhri	121	2	Double Fatak over bridge Mohanpura	39	17
Jahanwi del	101	3	Shantikunj Gate	34	18
Rashiyabad	96	4	Militry Chowk	33	19
Rampur Chungi	95	5	Puhana	33	
Padartha	94	6	Devband thirah to Kasba Market	33	
Peelinadi	70	7	Dudhadhari	30	20
Gandikhata	67	8	Singhdwar	30	
Harilok tri Junction	66	9	Baderi Sulfur Road	26	21
ABB Chowk	65	10	Shani dev Temple	25	22
Bongla Bypass	64	11	Chidiyapur	22	23
Ranipur Jhaal	63	12	Malakpur Chungi	11	24
SankaraCharya Chowk	62	13	Gurukul	0	25
Chandi Chowk	49	14	Mandawar	0	
Shikariwala pir to Deepshikha	48	15	Tricha pul	0	
Karoundi	48		Birla Factory to shani dev mandir	0	

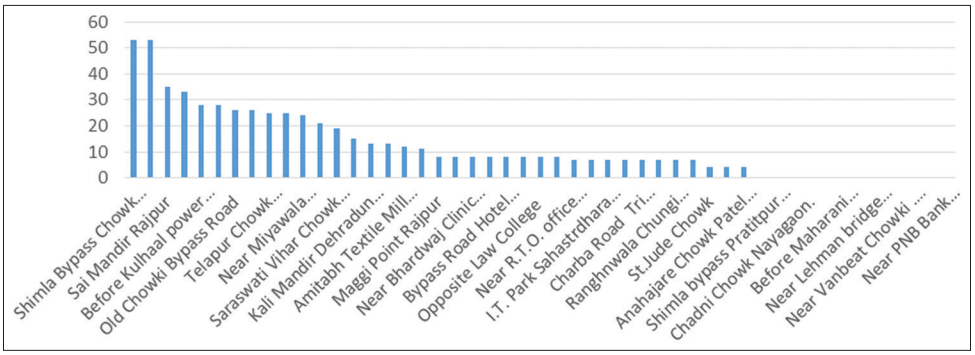

Figure 1: Accident severity index (Dehradun)

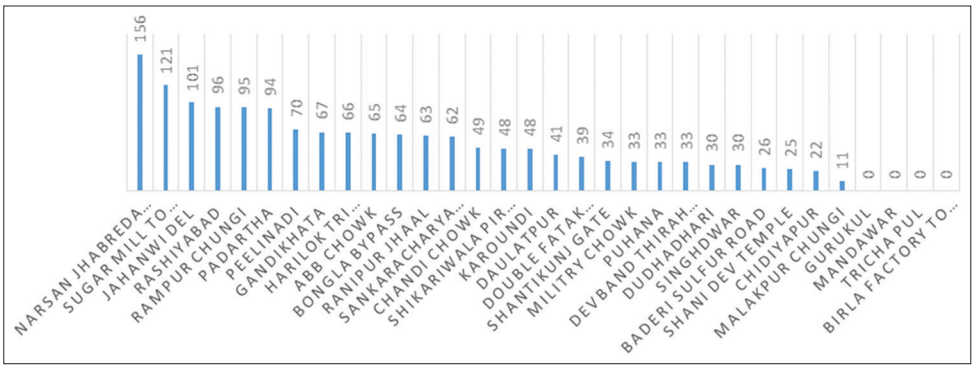

Figure 2: Accident severity index (Haridwar)

Temple Raiwalawere ranked from 1 to 5 as per the ASI and were categorized as the highest hazardous rate of accident zones in Dehradun region. Almost 50 % of the accidents were taken place in these black spots which clearly indicates that the maintenance of these black spots will definitely lead to the decrease in the frequency of accidents. Furthermore, the black spots with zero ASI should not be considered as black spots.

Similarly, the ASI of the black spots in Haridwar's locations is displayed in [Table 4 and Figure 2]. For each location the equation of ASI was calculated and after obtaining those severity values the rankings were allotted to the identified black spots. Rank 1 was allotted to the black spot- Narsan Jhabredatirah to whole Gurukul as the ASI of this black spot was the highest (ASI = 156) whereas there were 4 black spots in the region of Haridwar with the ASI equals to zero (which were ranked as 25). No accidents were observed in these 4 black spots.

The identified black spots – Narsan Jhabredatirah to whole Gurukul, Sugar Mill to Libbarhri, Jahanwi del, Rashiyabad, and

Rampur Chungi were ranked from 1 to 5 as per the ASI and were categorized as the highest hazardous rate of accident zones in Haridwar region.

Conclusion

The present study was an attempt to find out the black spots and to measure the ASI of the identified black spots in the areas of Dehradun and Haridwar. For each location the ASI was calculated and the Rankings were allotted to the black spots so as to find the severity of the black spots. The identified black spots – Narsan Jhabredatirah to whole Gurukul in Haridwar (ASI = 156), Shimla Bypass Chowk Patelnagar in Dehradun (ASI= 53), and Chhidarwala Raiwala in Dehradun (ASI = 53) were found to be with the highest ASI. The majority of the accidents were recorded in these black spots. There were several black spots with the ASI equals to Zero (Saat Mod Dehradun Road Rishikesh, Shimla bypass Pratitpur Sahaspur, Near Kishan Nagar Chowk Chakrata Road Cantt., Chadni Chowk Nayagaon, Near Wood Stark School, Before Maharani Suvakholi Mussoorie, Bright angle School line Jiwangarh, Near Lehman bridge mod both sides, Pir Baba mod Dehari Chowk Premnagar, Near Vanbeat Chowki. Kunwawala, Fatehpur Chowk Haridwar road Laltapad, Near PNB Bank Haridwar main road Laltapad, Gurukul, Mandawar, Trichapul, and Birla Factory to shanidevmandir).

The present study suggests that as per accident records, either there is an urgent need to adopt proper traffic management procedures to check the growth of accidents especially in the areas with the identified black spots with ASI = 0 or these should not be considered as the identified black spots. The present study also suggests that the road traffic accidents should be taken under consideration as per the Accident Severity rather than the frequency of the accidents. The list of the black spots must be updated after every 3 years.

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