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Analysis of Accident Data and Identification of Blackspots on National Highway 44 Between Kundli and Panipat, Haryana

Prayag Chaudhary[1], Gyanendra Singh[2]

[1]*M. Tech. Student, Deenbandhu Chhotu Ram University of Science and Technology, Murthal, Haryana (India)-131039*

[2]*Assistant Professor, Dept. of Civil Engineering, Deenbandhu Chhotu Ram University of Science and Technology, Murthal, Haryana (India)-131039*

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Abstract - *Roads are the most economical means of transport in India; but they are highly vulnerable to road accidents posing health and life risks to road users and causing damages to vehicles and other properties. In order to minimise the incidents of road accidents, it is important to identify accident blackspots on different roads and take corrective actions at these locations. At times, due to financial constraints it may not be possible to take countermeasures at all the identified blackspot locations simultaneously, hence in such situations it becomes essential to draw a priority list in order of ranking of the blackspot and accordingly take countermeasures in a phased manner. In this paper, a detailed analysis of road accident data has been carried out for the 60-km long section of the National Highway 44 between Kundli and Panipat in Haryana (India). The accident data accessed from Haryana Police website have been analysed for 3-year period spanning across 2019 - 2021, and then based on this data accident blackspots have been identified in both directions of the highway section i.e., from Delhi to Panipat and Panipat to Delhi. The identified blackspot locations have been ranked using four different existing criteria. The top ten identified blackspot locations have been further investigated and analysed in detail to find out the possible causes of accidents; and based on the findings of the study, countermeasures aiming to minimise road accidents on these identified locations have been suggested.*

Key Words: National Highway, Road Accident, Blackspot, Site Investigation, Ranking

1. INTRODUCTION

Roads are the backbones of the transport network across the word. In India, roads are the most economical mode of transport both for passengers and freight and carry about 85% of the country's passenger traffic and more than 60% of its freight. However, among all modes of transport, roads are most vulnerable to accidents putting the road users at the risk of accidental deaths and severe injuries and causing damages to the vehicles.

1.1 India's Road Network

India has the second largest road network in the world of about 63.72 km comprising National Highways (NH), Expressways, State Highways (SH), Major District Roads, Other District Road and Village Roads (Ministry of Road Transport and Highways, 2022) [1]. The National Highways connect the State capitals and State Highways connect important cities within the state. The length of India's road network under different categories has increased progressively from 3,99,942 kms in 1950-51 to 46,76,838 kms in 2010-11 and thereafter to 63,71,847 in 2021-22, as indicated in **Table-1.**

Table-1: India's roads length (in Km) under different categories

Category	1950-51	2010-11	2021-22
National Highways	19,811	70,934	1,40,995
State Highways	^	1,63,898	1,71,039
District Roads	1,73,723	9,98,895	6,33,383
Rural Roads	2,06,408	27,49,804	45,41,631
Urban Roads	0	4,11,679	5,41,636
Project Roads	0	2,81,628	3,43,163
Total	**3,99,942**	**46,76,838**	**63,71,847**

^ *Included in District Roads*

India's National Highways consists of only 2.21% of the total road network but, they carry about 40% of the country's traffic. The National Highways run through the length and breadth of the country and connect capitals of the States and UTs, major ports, rail junctions, industrial and tourist centres.

1.2 Road Accidents in India

Though roads are the most cost-effective mode of transport in India and play a vital role in the economy of the country, but they are more prone to accidents and fatalities, in comparison to the other modes, due to poor maintenance and low compliance of traffic regulations by the road users. A large number of road accidents and fatalities and injuries resulting therefrom is a growing public health concern in India, both for road users and the policy makers. A study by Singh (2017) [2] showed that the distribution of road accident deaths and injuries in India varies according to month and time, age and gender, and age group 30-59 years is most vulnerable population group, though males face more fatalities and injuries than their female counterparts, and that the frequency of road accidents is comparatively higher in extreme weather and during working hours.

As per the report on Road Accidents in India -2020 (Ministry of Road Transport and Highways, 2020) [3], a total of 1,31,714 people got killed and 3,48,279 got injured due to 3,66,138 road accidents in India during year 2020, which include 1,20,806 fatal accidents (33%), 96,302 grievous injury accidents (26%), 1,28,130 minor injury accidents (35%) and 20,900 non-injury accidents (6%) (Chart-1).

The report on Road Accidents in India-2020 further shows that the National Highways which comprise of only about 2% of the total road length of India were responsible for 32% of the total road accidents and about 36% of the accidental deaths in year 2020 and the State Highways which comprise of only about 3% of the total road network accounted for 25% each of the total accidents and the total accidental deaths in the year, which shows that the National Highways and the State Highways are the major killers of the road users in India and hence need focus of attention of the policy makers.

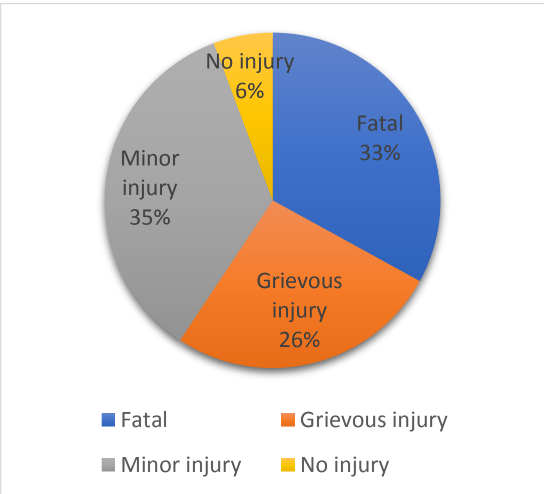

Chart-1: Category wise break-up of road accidents in India in year 2020

1.3 Road Accident Blackspots

Road accident is a random phenomenon; however, road accidents may not be randomly distributed across road networks. There are some locations or road stretches on any road network where road accidents occur more frequently compared to the other locations. Such locations are known as blackspots. A number of definitions of accident blackspots have been reported in literature. The United Kingdom defined the black spot as a location where four accidents occur in a year on 100-meter road. In Norway, the black spot refers to a 100-meter road which has traffic events involving more than four casualties in the past four years (Zhang et al. 2019) [4]. Hauer (1997) [5] defined black spots as the number of accidents (crashes) or accidents consequences by kind or severity, expected to occur during the specified period on an entity (an intersection, a road segment, a driver or a bus fleet, etc.). Garber and Hoel (2002) [6] defined high crash locations as the sites experiencing an abnormally high number of crashes relative to similar other sites.

In India, as per the Office Memorandum dated 28.10.2015 issued by the Ministry of Road Transport & Highways, Govt. of India, Road Accident Blackspot on National Highways is a stretch of National Highway of about 500 m in length in which either 5 road accidents (in all three years put together involving fatalities/ grievous injuries) took place during last 3 calendar years or 10 fatalities (in all three years put together) took place during last 3 calendar years.

2. LITERATURE REVIEW

Tamburri and Smith (1970) [7] introduced the concept of road 'Safety Index' for evaluating and rating road safety benefits. This was later incorporated into the practice of black spot identification based on the idea that sites with severe accidents may deserve prior attention. Deacon et al. (1975) [8] proposed a methodology for identifying hazardous locations using data for total number of accidents, number of fatal accidents, number of equivalent-property-damage-only (EPDO) accidents, total accident rate, fatal accident rate, and EPDO accident rate, which may be used singly or in combination to determine whether a location is hazardous based on a comparison of the observed accident pattern and the established critical limits.

The methodology proposed by Deacon et al. (1975) led to similar other accident frequency (AF) and accident rate (AR) based approaches for identification of accident-prone sites. In AF methods, accident prone sites are identified and ranked based on observed number of accidents on a road segment or intersection during a given observation period. The AF method however lacks the ability to differentiate between actual hot spots and the locations with increased accident frequency attributable to the randomness of traffic accidents. It also does not differentiate between two sites having same accident frequency but with different traffic volumes though it is readily apparent that a segment with higher traffic volume will be expected to have a higher accident count. Thus, the black spots identified using AF methods tend to overrepresent high traffic volume locations that may or may not be in need of immediate remedial action. The AR methods use accident count per unit traffic volume for hotspot identification; the sites with accident rate exceeding a critical value are identified as hotspots. Abbess et al. (1981) [9] introduced the Empirical Bayes' (EB) method for identification of accident black spots on a road segment or intersection, which addressed the issue of low precision in AF and AR methods, due to limited accident history. The EB method gives the expected number of accidents on a site based on observed and predicted accident frequency. The EB method gives more accurate results and has been widely used in various studies for accident black spot identification.

Hauer and Persaud (1984) [10] presented a mathematical procedure based on gamma probability distribution function for identifying hazardous locations (deviant sites) using past accident history (observed accident frequency), and applied it to highway ramps in Ontario and a population of California drivers. They examined the performance of the procedure in terms of proportions of correctly identified deviant sites (correct positives), falsely identified deviant sites (false positives) and truly deviant sites not identified (false negatives). Hingle and Witkowski (1988) [11] used Bayesian approach for identification of hazardous locations and the results of Bayesian analysis were compared with those of an analysis based on classical statistical methods. The Bayesian method assumes that the accident rate at any given site is a random variable and it accounts for this randomness in the identification process.

Hauer (1992) [12] reviewed the Empirical Bayes method for estimating 'unsafety' (meaning expected number of accidents by kind and severity) of a road stretch or entity and highlighted the constraints and shortcomings associated with the use of this method. The EB method requires information about not only the traits (traffic, geometry, age and gender) and historical accident record of the entity whose unsafety is to be determined but also the mean and variance of the unsafety in a 'reference population' of similar entities. Referring to the shortcomings of the EB method, he pointed out that the method requires a very large reference population and choice of reference population is to some extent arbitrary, and entities in the reference population cannot match the traits of the entity under evaluation. To alleviate these shortcomings, the author offered multivariate regression method for estimating the mean and variance of unsafety in refence populations. The use of multivariate methods makes the Empirical Bayes approach to unsafety estimation applicable to a wider range of circumstances and yield better estimates of unsafety.

Cheng and Washington (2005) [13] evaluated three black spot identification methods: simple ranking, confidence interval, and Empirical Bayes, using experimentally derived simulated data. The study found that the Empirical Bayes method significantly outperforms the simple ranking and the confidence interval techniques. The author also concluded that three years of crash history appears, in general, to provide an appropriate crash history duration.

Cheng and Washington (2008) [14] compared the performance of four commonly used hot spot identification methods namely accident frequency (AF), accident rate (AR), accident reduction potential (ARP) and empirical Bayes' (EB) using four new criteria – site consistency test, method consistency test, total rank differences test and poisson mean differences test. The study shows that, overall, the EB method is the most consistent and reliable method for identifying hot spots and the AR method performed consistently the worst.

Othman et al. (2009) [15] studied traffic safety investigation to find critical road parameters affecting accident rate. The study was based on accident and road maintenance data from Western Sweden, which showed that shoulders, curves and super-elevation were more strongly related to accident rate and that large radii right-turn curves were more dangerous than left-turn curves, in particular, during lane changing manoeuvres and motorway carriageways with no or limited shoulders had the highest crash rate when compared to other carriageway widths, while one lane carriageway sections on 2+1 roads were the safest. The study further showed that the crash rate increases significantly for super-elevations greater or lower than the interval 2.5 - 4% with greatest crash rate on super-elevations greater than 5% which are always on curves with high expected values of lateral acceleration. The study also showed that both wheel rut depth and road roughness have negative impacts on traffic safety.

Montella (2010) [16] presented a comparative analysis of seven commonly applied hotspot identification methods namely crash frequency (CF), equivalent property damage only (EDPO) crash frequency, crash rate (CR), proportion method (P), empirical Bayes estimate of total crash frequency (EB), empirical Bayes estimate of severe-crash frequency (EBs), and potential for improvement (PFI), using four quantitative evaluation criteria - site consistency test, method consistency test, total rank difference consistency test, and total score test. The study showed that the EB method performs better than the other hotspot identification methods. The test results highlighted that the EB model is the most consistent and reliable method for identifying priority investigation locations.

Bandyopadhayaya and Mitra (2011) [17] compared the performance of four hotspot identification methods – Crash Frequency (CF), Fatal Crash Frequency (FCF), Equivalent Property Damage Only (EPDO) and a newly proposed 'Index of frequency severity (I_{FS})' by applying Site consistency, Method consistency and Total difference tests, with the data from NH-6 in Howrah district of India. The Index of frequency severity (I_{FS}) which is a new metric, takes into consideration the frequency of total crashes and the ratio of fatal to total crashes for a site to evaluate the safety status of the site. The study found that though Crash frequency method seems to outperform other methods but when both frequency and severity are considered, the newly proposed metric 'Index of frequency severity (I_{FS})' proved to be better predictor of black spot locations.

Naidu et al. (2011) [18] based on the road accident data for 2008-2010, identified 5 black spot locations on Hanumanthwaka – Kommadi stretch of National Highway 5 in Visakhapatnam city. The study further analysed the accident data for these five locations presenting daily variation of accidents, timely variation of accidents, gender wise analysis, vehicle wise distribution, age limit variation of accidents, and monthly variation accidents. Finally, the study proposed remedial measures at each black spot location for the site improvement.

Agarwal et al. (2013) [19] presented a methodology for ranking of road safety hazardous locations using Analytical Hierarch Process (AHP). Unlike other existing methodologies that use accident data, this study presents a four-stage methodology for ranking of hazardous locations. In this methodology, road safety hazardous conditions are decomposed into safety hazardous condition at straight sections, curve sections and at intersections. Eight safety factors, two each pertaining to carriageway condition and roadside condition and four pertaining to road furniture condition, have been identified and assigned relative weightage using AHP. Further, each safety factor has been assigned a condition rating between 0 and 1, according to present condition of the safety factor. By combining relative weightage and condition ratings of the safety factors, Safety Hazardous Index has been developed separately for straight section, curve section and intersection. Finally, Safety Hazardous Index for the entire road section is determined by summation of safety hazardous indices for straight section, curve section and intersections.

Apparao et al. (2013) [20] analysed the road accident data of 5 years, from 2007 to 2011, on 63 km road stretch of National Highway-58 between Meerut and Muzaffarnagar and presented a methodology to identify accident black spots using GIS and the Critical Crash Rate Factor method. The study shows that during the period of the study (2007 to 2011) the total accidents on the stretch had increased by five-fold. The study further showed that the maximum number of accidents occurred during the weekends, probably due to the large number of tourists visiting Hardwar and Rishikesh; and the months of August and December reporting highest number of accidents, probably due to rainy season in August and fog in December.

Mohammed (2013) [21] studied the relationship between road geometric design elements and accident rates based on the results of the past studies carried out in different countries. The study came out with the following conclusions: (i) probability of accidents on a two-lane road is highest at curves, intersections and bridges, (ii) average accident rate for highway curves is about three times the average accident rates for highway tangents, (iii) highway curves are more accident-prone when combined with gradients and surfaces with low coefficient of friction, (iv) accident rates in mountainous terrain can be 30% higher than in flat terrain, (v) accidents increase with gradient and down-gradients have considerably higher crash rates than up-gradients, and (vi) there is significant increase in accident rates for sight distances less than 100 m.

Sorate et al. (2015) [22] carried out a study of identifying accidental black spots on National Highwa-48 (formerly NH-4) spanning 14.5 kms from New Katraj Tunnel to Chandni Chowk, Pune, Maharashtra. The methodology adopted in this study for identification of blackspots is correlating the existing accident data with physical survey. The data collected during physical survey at different chainage points was analysed by using the method of ranking and severity index. The chainage points/stretch where severity index was more than the severity index benchmark were identified as possible blackspots. Further, the existing accident data collected from NHAI was analysed by using method of ranking and severity index, accident density method, and weighted severity index method. The chainage stretches returning severity index and accident density above the reference values were marked as blackspots. The results obtained from the physical survey were correlated with the analysis of the accident data and accordingly the black spots were identified for suitable remedial actions.

Vivek and Saini (2015) [23] in their study, prioritised 5 accident prone locations in 29 km long road section on National Highway-3 in Una district, Himachal Pradesh, using Weighted Severity Index (WSI) method. In the WSI method followed, scores are assigned to an accident-prone location based on the number and severity of accidents. WSI score is a weighted sum of number of accidental deaths, grievous injuries and minor injuries; with weights of 5, 3 and 1 assigned to them, respectively.

Ambros et al. (2016) [24] compared three approaches for identification of hazardous road locations; (1) Traditional approach based on recorded accident frequency leading to identification of blackspots; (2) Empirical Bayes method and (3) Preliminary road safety inspection, identifying the risk factors which may contribute to occurrence of accident and increase accident severity and generating a risk index based on evaluation of the identified risk factors. For the purpose of this study, rural road network, approx. 100 km, in South Moravia, Czech Republic, was used. The study found that accident frequency approach is not a suitable ranking method, especially in a low volume road network with scattered accident occurrence. On the other hand, risk index approach based on road safety inspection is a valid alternative, with ranking performance comparable with empirical Bayes method.

Sandhu et al. (2016) [25] used Kernel Density Estimation and GIS in identification of black spots on 225 km long stretch of National Highway (NH-8) between Gurgaon-Jaipur. The selected Gurgaon-Jaipur Highway stretch and the accident data were loaded into ArcGIS software program. Each data point represented a single vehicle accident or multiple accidents (if more than one accident occurred at the same location). To know the high or low clustering, weighted count of accidents in terms of severity index was used. The severity index used in the study is weighted sum of fatal injury accidents, serious injury accidents, minor injury accidents and property damage accidents only, with fatal, serious, minor and 'property damage only' accidents assigned weightage of 6, 3, 1.2 and 0.8 respectively. The kernel density estimation was conducted with accident severity index data of accident locations. The locations of blackspots were identified on the basis of their Kernel density and the ranks assigned to the blackspots were decided on the basis of their Kernel density severity indices. The study identified seven blackspots on the 225 km long stretch.

Dhanoa et al. (2017) [26] presented the results of road traffic fatal crash data of two small size cities – Patiala and Rajpura in Punjab and proposed a methodology for blackspot identification with minimal available police data. The study used Empirical Bayes technique for blackspot identification, which is recommended for best estimations for truly unsafe sites with minimal false identifications. A total of 188 and 61 fatal road accidents were recorded in Patiala and Rajpura respectively in 3 years from 2013 to 2015. The study showed that highest proportion of fatalities is of the motorised two-wheelers occurring primarily due to collision with cars and trucks, followed by the fatalities of pedestrians with the highest proportion being struck by car. The study further showed that in both the cities the highest percentage of fatal accidents are of the 'vehicles hit from back' (34% in Patiala and 29% in Rajpura) followed by 'hit pedestrian' (21% and 27% respectively) collision type. The study showed that there were 6 blackspots in Rajpura city, 35 in urban Patiala and 12 in rural Patiala, and the blackspots mainly lied on National Highways, State Highways and Major District Roads passing through the cities.

Keymanesh et al. (2017) [27] presented a method to identify and prioritise accident prone locations not on the basis of past accident data but on the environmental, traffic and geometric conditions of the road. The technique was applied to identify black spot locations on 'Iraanshahr- Sharbaaz-Chabahar' road in Baluchistan, Iran. The road was divided into eight uniform and homogeneous sections in terms of physical and road performance properties. Nine factors expected to contribute to road accidents were identified: inappropriate horizontal curves, inappropriate vertical curves, lack of traffic signs, lack of adequate lighting at night, inappropriate sight distance, lack of road shoulder, lack of guard rails and passage of animals across the road, traffic of smugglers vehicles, and lack of interchanges at residential areas. The data related to these nine factors for the potentially hazardous locations on all eight sections were collected and based on the expert inputs and using Analytical Hierarchy Process, the locations were prioritised.

Mohan and Landge (2017) [28] conducted a study to identify blackspot location on about 13 km long stretch on Amaravati – Nagpur Road (on National Highway-6) using crash data collected from the local police station for 3 years 2014-2016. Weighted Severity Index (WSI) method, which calculates WSI score for a location of road section based on number of persons killed (K), grievous injuries (GI) and minor injuries (MI) and relative weights 41 to K, 4 to I and 1 to MI ($WSI = 41 \times K + 4 \times GI + 1 \times MI$), was used to identify blackspots. In the study, five locations that returned a WSI score of more than 40 were identified as blackspots. Each identified blackspot location was analysed in detail and possible improvements were suggested.

Reddy et al. (2017) [29] analysed the road accidents data for Nandiyal Mandal in Karnool district of Andhra

Pradesh, which witnessed 567 accidents at 143 locations during past seven years from 2010 to 2016. Based on the accident data, weighted severity index (WSI) was calculated for different locations and the ten locations returning highest WSI were identified as blackspot locations. In calculation of WSI, the number of persons killed was assigned a relative weightage of 41, number of grievous injuries assigned a weightage of 4 and the number of minor injuries a weightage of 1. The statistical analysis carried out in the study using chi-square test shows independence of accidents with the attributes like month, season, day, hours in a day, and age group; however, accident severity and type of vehicle were found to be inter-related.

Saran (2017) [30] carried out an evaluation of accident blackspots on the roads in Kozhikode district, Kerala. He collected 3-year road accident data for the study area from the police department and Kerala Crime Records Bureau and utilized it to prioritise accident prone locations using Weighted Severity Index (WSI) method, thereby identifying ten blackspots, five each in rural area and urban area. Further, primary data pertaining to road inventory survey, traffic volume count, speed and delay study and spot speed survey alongwith coordinate recording using GPS were collected at the identified accident-prone stretches for GIS based analysis. During road inventory survey, ten blackspots identified based on WSI method were further evaluated with respect to the eleven parameters which tend to influence the occurrence of accidents on roads; number of lanes in each direction, width of road, type of road, surface type, surface condition, drainage facility, vehicle type, number of vehicles, shoulders, edge obstruction, and median. For prioritisation of the identified blackspots, each of these eleven parameters was assigned a weight in such a manner that the parameter values which tend to increase the probability of accidents have lower weights, with the maximum weight assigned to any parameter being 10. The final weight assigned to a black spot was arrived at by adding all the individual weights to eleven parameters and normalising the value by dividing it 110 and multiplying by 100.

Ghadi and Torok (2018) [31] evaluated four commonly applied blackspot identification methods – Empirical Bayes' (EB) method, excess EB, accident frequency (AF) and accident rate (AR), against four different segmentation methods namely spatial clustering, constant length, constant traffic volume, and the standard Highway Safety Manual segmentation method. The study used two evaluations to compare the performances of the methods. In the first approach, the evaluation was done based on the accuracy of the safety performance functions developed from the datasets generated by the four segmentation methods. In the second evaluation, four consistency tests (site consistency test, method consistency test, total rank difference test and total score test) were used to compare the joint performances between the blackspot identification methods and the segmentation methods. The study showed that the EB method was the most consistent method for identifying priority investigation sites followed by the AF method. The performance of EFB and AR methods was found to be weakest in most segmentation cases.

Maskooni and Haghighi (2018) [32] compared seven commonly applied black spot identification methods namely accident frequency (AF), accident rate (AR), P-value method, equivalent property damage only (EPDO), societal risk-based, combined criteria, and empirical Bayes', against six robust and informative quantitative evaluation criteria; the site consistency test, method consistency test, total rank differences test, total score test, sensitivity test and specificity test. The study was applied to 63 km road section Jiroft-Kerman, in Iran. The study showed that the Empirical Bayes' method performed better than the other blackspot identification methods, and was the most reliable and consistent method for identifying priority investigation locations. The societal risk-based method was found to be the worst performing in all of the tests.

Kashid et al. (2019) [33] conducted a study to identify accidental blackspots on 12 km stretch of National Highway 48 between Bhujbal Chowk (Wakad Bridge) to Chandani Chowk in Pune Region. The blackspots were identified by using the existing road accident data as well as by visual survey of the road stretch. The accident data was analysed by the method of Ranking and Severity Index, Accident Density method, and Weighted Severity method and the chainage points returning severity index, accident density and weighted severity index above the benchmark values were identified as the blackspots. Additionally, visual survey was carried out for the different chainage points on the road section, collecting data at each point for 10 identified parameters characterising road condition such as improper shoulder, visibility at junction, drainage facility, absence of signboards & road marking etc., and based on the data collected, severity index was collected for all the chainage points. The locations with severity index above the benchmark value were considered as the blackspots.

Chauhan et al. (2020) [34] conducted to study to identify black spot locations on 13 km long section of National Highway 5 between Panthaghati to Dhalli in Shimla District. They collected 5-year accident data (2015 – 2019) from two police stations - Dhalli police station and Chhota Shimla East police station, having jurisdiction over the road section under the study. The accident data analysed for time of accident, type of collision, type of accident according to severity, type of vehicles involved in the accident, and month of accident. The study found that maximum number of accidents (23%) occurred during 6:00 PM to 9:00 PM and 38% accidents involved side on collisions followed by 30% head on collisions. Cars/jeeps accounted for highest share (37%) of the accidents among all types of vehicles, and overspeed (accounting 50% of accidents) and drink and drive (37%) were the main causes for the accidents. Five blackspot locations were identified using Weighted Severity Index (WSI) which was calculated for different locations based on number of accidental deaths, serious injuries and minor injuries assigning them relative weights of 5, 3 and 1 respectively.

A study by Iqbal et al. (2020) [35] presented a road accident analysis and a methodology for identification of blackspots on the Lahore- Islamabad Highway M-2, having a length of 353 km. The road accident data were collected from National Highway and Highway Police Pakistan for the period 2009 to 2017. The Accident Point Weightage (APW) method was used to identify and rank the blackspots. APW is weighted sum of number of fatal accidents, number of major injury accidents, number of minor injury accidents and number of property damage only accidents. The study showed that the trend of the road accidents was characterised by a high rate of fatal accidents of over 35%, with human errors being major contributing factors in the road accidents - accounting for 66.8% of the accidents, and vehicle errors (25.6%) and environmental factors (7.6%) acted as secondary and tertiary contributing factors. The study found that the main causes of accidents were the dozing on wheels (27.9%), careless driving (24.6%), tyre burst (11.7%) and brakes failure (7.4%). Kallar Kahar (Salt Range) that returned highest APW was identified as a black spot due to vehicle brakes failure.

Meer et al. (2020) [36] carried out accident analysis and identification of black spots on erstwhile NH1 (now a part of NH-44) from Singhpora Pattan to Pantha Chowk Srinagar, a 34 km long stretch. Severity Index was used to identify black spot locations and then based on five factors affecting occurrence of road accidents namely relative severity index, approximate numbers of vehicles per day, width of road, frequent vehicle type and type of drainage facility provided, and relative weighs assigned to these factors, 9 identified locations were ranked in order of proneness to accidents.

IRC (2020) [37] presents a method for prioritization of accident blackspots for treatment, when due to financial constraints, all identified blackspots cannot be taken up for rectification immediately. The method calculates Severity Index for a blackspot location based on the number of fatal road accidents, serious injury accidents, minor injury accidents and property damage only accidents. The method suggests 10 points for a fatal crash, 5 points for a serious injury crash, 2 points for a minor injury crash and 1 point for a no injury or damage only crash. A blackspot location with higher severity index shall be prioritised higher for treatment over other accident locations.

3. METHODOLOGY FOR THE STUDY

In the present study, the accident blackspots on 60 km stretch of NH-44 have been identified based on the blackspot definition of the Ministry of Road Transport and Highways (MoRTH), Govt. of India, i.e., the locations or road sections of about 500 m experiencing 5 or more accidents or 10 or more fatalities during the 3-year period between 2019 and 2021 have been identified as blackspot locations. The past accident data has been accessed from the Haryana Police website and then analysed in terms of date, time and month of occurrence of accidents, location of accidents, number of fatal accidents, persons killed and injured (with grievous & minor injuries), vehicles/ road users involved in accidents, and type of collisions. The locations of the accidents and distances between different locations have been determined / approximated with the help of Google maps. The two roads of NH-44 i.e., Delhi-Panipat Road and Panipat-Delhi Road, have been considered two separate roads and black spot locations have been identified on the two roads separately.

The schematic representation of the methodology adopted for study is indicated in Chart-2.

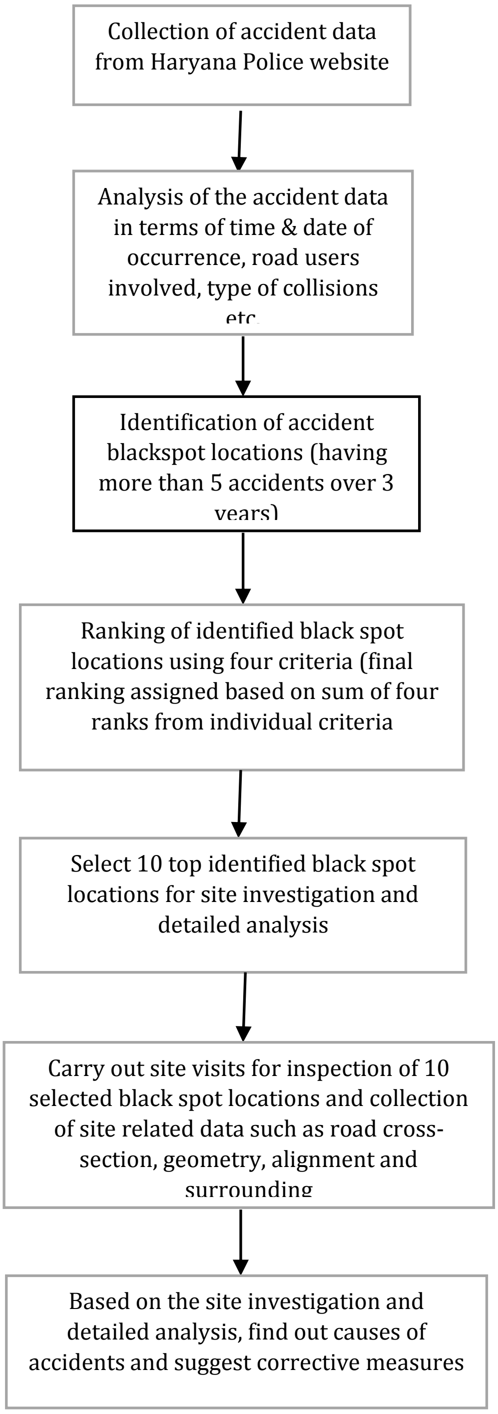

Chart-2: Schematic representation of the methodology adopted

4. THE STUDY AREA

The proposed study covers about 60 km stretch of National Highway-44 (formerly NH-1) between Kundli and Panipat falling under jurisdiction of 6 police stations namely, Kundli, Rai, Murthal, HSIDC Barhi, Gannaur, and Samalkha, of Sonipat and Panipat Districts of Haryana. NH-44 is a major National Highway in India, passing through the Union Territory of Jammu and Kashmir, and 11 States namely Punjab, Haryana, Delhi, Uttar Pradesh, Rajasthan, Madhya Pradesh, Maharashtra, Telangana, Andhara Pradesh, Karnataka, and Tamil Nadu, connecting several important cities of these states. This Highway starting from Srinagar and terminating at Kanyakumari is the longest in the country, running over 3,806 km of road length. NH-44 connecting Delhi to the states of Haryana, Punjab, Himachal Pradesh, Jammu & Kashmir and the Union Territory of Chandigarh, carries lots of traffic - both passenger and commercial vehicles. Due to its proximity to Delhi, the national capital, the stretch of NH-44 under the study, has a number of commercial and industrial establishments, including road side dhabas, on its both the sides, and therefore has a significant volume of local traffic as well.

Delhi (Mubarak Chowk) to Panipat 70 km section of NH-44 is being upgraded to a barrier-free tolled expressway with 8 main lane and 4 (2+2) service lanes. Besides widening of the road to 12-lane, a number of flyovers are also being constructed on this stretch. This stretch of NH-44 is a tolled road and a toll is already being charged. The work of widening and ugradation of NH-44 was started in 2015 and after remaining stalled for a long period, most of the work between Rai and Panipat got completed by the end of June 2022 but the work in the Kundli area was still in progress at the time of the study. The widening of the highway and construction of flyovers near the towns and villages have significantly changed the road conditions that may have earlier contributed to road accidents during the study period.

5. ACCIDENT DATA ANALYSIS

The accident data collected from the Haryana Police website shows that a total of 501 accidents occurred on NH-44 between Kundli and Panipat during the 3-year period from 2019 to 2021; 180 number of accidents in 2019, 162 in 2020 and 159 in 2021. The analysis of these 501 accidents in terms of fatalities and injuries caused, road users involved in the accidents, time and months of occurrence, and type of collisions is presented below.

5.1 Fatalities and Injuries due to Road Accidents

The Table-2 presents the data pertaining to the fatalities and injuries caused due to road accidents on NH-44 during the period 2019-2021. It is seen from Table 4 that among 501 total accidents occurred on NH-44 during the period, more 60% accidents were fatal which killed 326 persons and about 35% accidents were injury accidents that caused severe injuries to 272 persons and minor injuries to 74 persons. In the remaining 4% accidents, only property damage was caused.

Table-2: Fatalities and injuries caused due to road accidents on NH-44 during 2019-2021

	Number
Number of road accidents	501
Number of fatal accidents	307
Number of persons killed	326
Number of injury accidents	173
Number of persons injured	
a) Grievous injuries	272
b) Minor injuries	74
Number of 'Property Damage Only' accidents	21

Table-3 classifies the accident deaths on NH-44 during the study period according to the type of victim road user category. The data shows that pedestrian accounted for highest number of the accident deaths (41%) followed by two-wheeler riders which accounted for about 32% deaths.

Table-3: Accident deaths on NH-44 classified according to type of victim road user category

Road user category (victim)	**Number of persons killed**
Trucks / Lorries	20
Buses	4
Tractors	6
Cars, Vans, Taxis, LMVs	32
Tempos, Auto-Rikshaws (Three-wheelers)	11
Two-wheelers	103
Cycles, Cycle-Rikshaws & others	16
Pedestrians	134
Total	**326**

5.2 Type of Road Users Associated with the Accidents

The road accident data for 2019-2021 for the NH-44 section under the study have been analysed in terms of different categories of road users involved in the accidents and presented in Table-4. Usually, a road accident involves two road users but some accidents can involve just one or more than two road users. In this study, road users were classified in 9 categories namely, Trucks & Lorries, Buses, Tractors, Cars/ Vans/ Taxis/ LMVs, Three-wheelers (Tempos/Autos), Two-wheelers (Bike/Scooty), Cycles/Cycle-Rikshaws, Vehicle drivers / helpers and Pedestrians. Further, the road user against whom FIR has been registered is considered as a road user at fault, and the other road user who has suffered due to accident is the victim road user.

Table-4: Type of road users involved in the road accidents occurred in the study area during 2019-2021

Road user	**Number accidents in which the road user is a culprit**	**Number accidents in which the road user is a victim**
Trucks / Lorries	163	24
Buses	17	02
Tractors	17	06
Cars, Vans, Taxis, LMVs	169	67
Tempos, Auto-Rikshaws (Three-wheelers)	11	12
Two-wheelers	26	175
Cycles, Cycle-Rikshaws & others	00	14
Pedestrians# / Vehicle drivers/helpers	-	198
Unknown vehicles	98	-
None / Property Damage	-	4
Total	**501**	**502***

#Also includes passengers, shopkeepers, villagers, road side hawkers, and policemen also who suffered due to road accidents

**One accident involves two victim road users*

Table-4 shows that among the road users at fault, cars/vans/taxis/LMVs were responsible for highest number of road accidents accounting for more than 33% of the total road accidents (169 out of 501)), closely followed by Trucks / Lorries which accounted for 32.5% of the total accidents. Among the victim road users, pedestrians/vehicle drivers/helpers were victims in highest number of accidents (198 out of 502 i.e., about 39% of the total accidents), followed by two wheelers which were victims in 175 accidents - about 35% of the total accidents.

5.3 Accidents Classified according to Month of Occurrence

Chart-3 depicts the month wise number of road accidents occurred on NH-44 during the period 2019-2021. It is seen that the months of September, July and October reported the highest number of accidents of 53, 52 and 50 respectively, and the months of May, February and April reported the lowest. The higher number of accidents on NH-44 in July, September and October can be attributed to monsoon season in July and September and festivities season in the month of October.

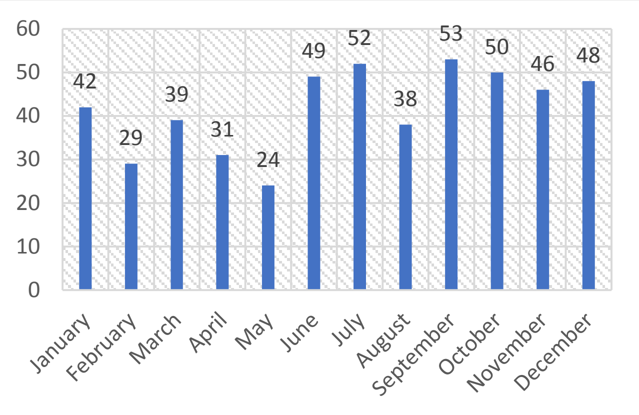

Chart-3: Month-wise break up of road accidents on NH-44 for 2019-2021

5.4 Accidents Classified according to Time of Occurrence

The accidents occurred on NH-44 during 2019-2021 have analysed according to time of occurrence and presented in Table-5. The data shows show that the highest number of road accidents took place during the time 08: PM to 12:00 AM and the least during 12:00 PM to 04:00 PM. The higher number of the accidents on NH-44 during 08:00 PM to 12:00 AM can be attributed to drunken driving, fast speed and low visibility.

Table-5: Accidents on NH-44 classified according to time of occurrence

Time slot	Number of accidents
12:00 A.M. to 04:00 A.M.	37
04:00 A.M. to 08:00 A.M.	60
08:00 A.M. to 12:00 P.M.	64
12:00 P.M. to 04:00 P.M.	2
04:00 P.M. to 08:00 P.M.	105
08:00 P.M. to 12:00 A.M.	119
Day time	34
Night time	9
Not indicated in FIR	1
Total	**501**

5.5 Accidents classified according to type of collisions

The analysis of the accident data according to type of collisions (Table-6) shows that rear-end collisions account for the highest number of accidents (31.14%) followed by 'Pedestrians hit while crossing road' which accounted for more than 20% accidents. The only reason that can be attributed for higher number of accidents involving rear end collisions is rash driving by some drivers including sudden application of brakes by the leading vehicles. It is also seen that road crossing by pedestrians is one of the major factors contributing to large number of road accidents and accident deaths on NH-44 and the same needs to be taken into consideration while taking countermeasures to minimize accidents on this stretch.

Table-6: Road Accidents Classified according to Type of Collision

Type of collision	Number of collisions (%age share)
1. Head on collision	41 (8.18%)
2. Rear end collision a) Due to rash driving of the following vehicle b) Due to suddenly applying brakes / taking turn / changing lane or making reverse movement by leading vehicle	156 (31.14% *139* *17*
3. Side swipe (while overtaking or passing by from opposite direction)	29 (5.79%)
4. Collision at right angle (at cross roads, T-junctions or U-turns)	21 (4.19%)
5. Stationary vehicles hit on the side lane of the road	32 (6.39%)
6. Pedestrian hit while crossing road	102 (20.36%)
7. Pedestrians/ passengers/ vehicle drivers etc. hit while walking / resting on the side of road	64 (12.77%)

8. Vehicle hit animal or object on road (police barricades / road median / kerbs)	3 (0.6%)
9. Vehicle hit object / properties off the road (buildings/electric poles etc.)	3 (0.6%)
10. Vehicle overturned	3 (0.6%)
11. Others	7 (1.40%)
12. Not known (not indicated in FIR)	40 (7.98%)
Total	**501**

6. IDENTIFICATION OF ACCIDENT BLACKSPOTS

Accident blackspots are high-risk road segments that have registered excessive number of accidents in comparison to the other locations, in a specified time period. In this study, the locations showing 5 or more accidents during the 3-year period i.e., 2019-2021 have been treated as accident blackspots. Accordingly, 22 blackspots have been identified on NH-44 between Kundli and Panipat, of which 11 locations lie on Delhi-Panipat Road, 9 locations on Panipat-Delhi Road, and 2 are located on crossings receiving traffic from all four directions. The accident data of these 22 locations are given in Table-7.

Table-7: Accident Details of 22 Identified Blackspot Locations for 2019-2021

Black Spot Location (1)	No. of total accidents (2)	No. of fatal accidents (3)	No. of grievous accidents (4)	No. of minor accidents (5)	No. of PDO accidents (6)
1	9	7 (7)	1 (1)	1 (1)	0
2	8	5 (5)	3 (6)	0 (1)	0
3	8	3 (3)	5 (11)	0 (1)	0
4	6	3 (4)	2 (5)	0 (0)	1
5	8	5 (7)	3 (8)	0 (3)	0
6	7	6 (6)	0 (2)	0 (2)	1
7	5	3 (4)	1 (5)	1 (2)	0
8	9	4 (4)	4 (7)	0 (4)	1
9	5	1 (1)	3 (4)	1 (1)	0
10	6	3 (3)	3 (3)	0 (3)	0
11	5	3 (3)	1 (2)	1 (2)	0
12	6	2 (5)	4 (5)	0 (0)	0
13	6	1 (1)	5 (6)	0 (1)	0
14	6	5 (5)	1 (5)	0 (0)	0
15	6	3 (3)	2 (3)	0 (0)	1
16	10	8 (8)	2 (10)	0 (0)	0
17	8	6 (7)	2 (5)	0 (1)	0
18	7	5 (6)	1 (2)	0 (0)	1
19	6	3 (3)	3 (6)	0 (3)	0
20	5	5 (5)	0 (0)	0 (0)	0
21	5	4 (4)	1 (1)	0 (3)	0
22	5	4 (4)	0 (0)	0 (0)	1

1. Pyau Maniyari (Delhi-Panipat Road), 2. Rasoi Village (Panipat-Delhi Road), 3. Jati Mor (Panipat-Delhi Road), 4. Nathupur Cut, 5. Bahalgarh Flyover (Delhi-Panipat Road), 6. Bahalgarh Flyover (Panipat-Delhi Road), 7. 20th Mile Chowk, 8. Near Kumaspur Chowk (Delhi-Panipat Road), 9. Murthal Flyover (Panipat-Delhi Road), 10. Sukhdev Dhaba (Delhi-Panipat Road), 11. Tau Devi Lal Park (Delhi-Panipat Road), 12. Pahalwan Dhaba-Gulshan Dhaba (Delhi-Panipat Road), 13. Barhi Industrial Area Phase-I (Delhi-Panipat Road), 14. Gannaur Flyover (Panipat-Delhi Road), 15. Larsouli Village (Panipat-Delhi Road), 16. Near Patti Kalyana Village (Panipat-Delhi Road), 17. Reliance Petrol Pump - Patti Kalyana Village (Delhi-Panipat Road), 18. Near Jhattipur Village (Panipat-Delhi Road), 19. Near Jhattipur Village (Delhi-Panipat Road), 20. Near Karhans Village (Panipat-Delhi Road), 21. Machhroli Village (Panipat-Delhi Road), 22. Machhroli Village (Delhi-Panipat Road)

Note: Figures in round brackets in column nos. 3, 4 and 5 indicate number of persons killed, persons grievously injured and persons minorly injured respectively at a location from all the accidents at that location.

PDO: Property Damage Only

6.1 Ranking of Blackspot Locations

Accident blackspot locations require corrective measures to minimize the occurrence frequency of road accidents, ensuring the safety of road users. However, in many cases, due to limited resources, remedial actions cannot be taken at all the locations simultaneously. Therefore, it becomes essential to prepare a priority list of the blackspot locations, with the most hazardous location accorded the highest rank and the least hazardous location the lowest rank. In this study, the identified blackspot locations have been ranked using the following four criteria, which are most widely used in India and other countries, and then based on the rankings from these four criteria, the final ranks have been assigned:

(i) Criteria-1: *Relative Accident Severity Index (ASI) Method proposed by NHAI:*

In this criterion, ASI is calculated for each blackspot location and the locations returning the higher ASI are ranked higher.

ASI = $\frac{WSI}{A_N}$, where WSI is weighted severity index, and A_N is the number of accidents at the location.

WSI = 7 × No. of fatal accidents + 3 × No. of grievous injury accidents + 1× No. of minor injury accidents.

However, in the present study, the blackspot locations have been ranked based on the WSI and not based on the ASI mentioned above; because when ranking is done based on ASI, the locations with higher number of accidents but having same value of WSI, tend to return lower ranks which does not seem to be justified.

(ii) **Criteria-2:** *Using Accident Point Weightage (APW) Method*

APW = 6×A + 3×B + 0.8×C + 0.2×D

Where: A=Number of fatal accidents, B=Number of major injury accidents, C=Number of minor injury accidents, D= Number of property damage only accidents

(iii) Criteria-3: *Using Equivalent Property Damage Only (EPDO) Method*

In this method, ranking is based on the number of equivalent property damage only accidents, calculated as shown below:

EDPO = 9.5 × No. of fatal and severe injury accidents + 3.5 × No. of moderate and minor injury accidents + 1× No. of property damage only accidents.

(iv) Criteria-4: Using Weighted Severity Index (WSI) based on number of persons killed and injured in road accidents.

WSI = 41×K + 4×GI + 1×MI

Where, K= Number of persons killed, GI= Number of persons grievously injured and MI= Number of persons with minor injuries

To determine final ranks of the identified blackspot locations, first the locations are ranked according the four criteria, thus generating four ranks to each location; and then sum of all the four ranks is computed and the location with the lowest value of sum of the four ranks is assigned highest rank (1). Accordingly, the final ranks to different locations are arrived. Table-8 presents the individual ranks of 22 identified blackspot locations as per criteria 1 to 4 as well as the finals ranks. Table-9 presents the ten top-ranked blackspot locations.

Table 8: Ranking of the Identified Blackspot Locations based on Criteria-1 to 4

Black Spot Location	WSI score & rank as per Criteria-1	APW score & rank as per Criteria-2	EPDO score & rank as per Criteria-3	WSI score & rank as per Criteria-4	Sum of all four ranks and final rank*
1	53 (2)	45.8 (2)	79.5 (2)	292 (4)	10 (2)
2	44 (4)	39 (4)	76 (5)	230 (7)	20 (5)
3	36 (10)	33 (9)	76 (7)	168 (15)	41 (10)
4	27 (16)	24.2 (15)	48.5 (15)	184 (13)	59 (16)
5	44 (4)	39 (4)	76 (5)	322 (2)	15 (4)
6	42 (6)	36.2 (7)	58 (8)	256 (5)	26 (6)
7	25 (20)	21.8 (19)	41.5 (19)	186 (12)	69 (18)
8	40 (7)	36.2 (6)	77 (3)	196 (11)	27 (7)
9	17 (22)	15.8 (22)	41.5 (21)	58 (22)	87 (22)
10	30 (13)	27 (12)	57 (11)	138 (18)	54 (13)
11	25 (19)	21.8 (19)	41.5 (19)	133 (21)	78 (21)
12	26 (18)	24 (18)	57 (13)	225 (8)	57 (14)
13	22 (21)	21 (21)	57 (14)	66 (21)	77 (20)
14	38 (9)	33 (10)	57 (10)	225 (8)	37 (9)
15	27 (16)	24.2 (15)	48.5 (15)	135 (19)	65 (17)
16	62 (1)	54 (1)	95 (1)	368 (1)	4 (1)
17	48 (3)	42 (3)	76 (4)	308 (3)	13 (3)
18	38 (8)	33.2 (8)	58 (9)	254 (6)	31 (8)
19	30 (13)	27 (12)	57 (11)	150 (17)	53 (12)
20	35 (11)	30 (11)	47.5 (17)	205 (10)	49 (11)
21	31 (12)	27 (14)	47.5 (18)	121 (14)	58 (15)
22	28 (15)	24.2 (17)	39 (22)	164 (16)	70 (19)

Note: The figures in bracket are ranks as per different criteria

Table-9: Top Ten Blackspot Locations in the Order of Ranking

Sl. No.	Black Spot Location	Rank
1	Patti Kalyana Village (Panipat-Delhi Road)	1
2	Pyau Maniyari (Delhi-Panipat Road)	2
3	Reliance Petrol Pump - Patti Kalyana Village (Delhi-Panipat Road)	3
4	Bahalgarh Flyover (Delhi-Panipat Road) Road)	4
5	Rasoi Village (Panipat-Delhi Road)	5
6	Bahalgarh Flyover (Panipat-Delhi Road)	6
7	Kumashpur Chowk (Delhi-Panipat Road)	7
8	Jhattipur Village (Panipat-Delhi Road)	8
9	Gannaur Flyover (Panipat-Delhi Road)	9
10	Jati Mor (Panipat-Delhi Road)	10

6.2 Blackspot Analysis and Investigation

The top ten identified blackspots were investigated and analysed in detail to find out the likely causes of accidents and accordingly suggest countermeasures at each of them. First the accident details of each blackspot, such as date and time of occurrence, location, number of persons killed and injured, vehicles involved, and description of accident / collision were thoroughly studied and analysed to find out whether the accidents at a blackspot occurred at any particular time or in a particular manner. After having detailed information about the accidents, the identified blackspot locations were visited for site investigation and the following data / information were collected for each location:

(i) Description of Road Conditions
The information includes road category, number of lanes, lane width, traffic volume, shoulder width, type of pavement and surface condition, drainage facility, type of median etc.

(ii) Site Factor Diagram
A hand made sketch of the location giving all details pertaining to physical structures around the black spot (road names, market, school, bust stops, shops, dhabas/ restaurants, parking, industrial / commercial establishments, road hums etc.).

(iii) Photographs: Photographs of the black spot location on the road and its surroundings were taken.

(iv) Physical and Operational Checklist
The checklist assesses the availability of those factors that may enhance or reduce the possibility of road accidents, such as speed limit sign, road markings, sharp bend, steep gradient, pedestrian crossing etc.

The accident data such as time and month of occurrence of accident, vehicles involved and type of accident / collision, and the data collected during site investigation have been used to find out likely causes of accidents and required remedial actions at each blackspot location. However, due to on-going work of widening and upgradation of NH-44 from Mubarak Chowk Delhi to Panipat (including construction of flyovers), a large part of which is already completed between Rai and Panipat and also opened to traffic, a lot of changes in site conditions have occurred at the identified black spot locations, hence the blackspot locations identified in this study may not be blackspots any longer.

The accident analysis and site investigation at the identified black spot locations reveals a number of causes of the accidents but the most common being (i) excessive speed of highway traffic (ii) sudden lane change and slowing down by the local traffic to diverge from the main highway, (iii) low visibility at the highway intersections during night, (iv) no designated places for road crossing by pedestrians, and (v) side lane parking of vehicles.

As is clear from the study, most of the accidents on NH-44 occurred near habitations primarily due to mixing up of slow-moving local traffic with the fast-moving highway traffic, the only way to avoid accidents at these locations is to construct grade separators (flyovers) to keep the local traffic and the main traffic segregated or allowing smooth interaction between them. The construction of flyovers and underpasses at many of these locations is already completed and at some locations it is still going on. The other common measures that need to be taken at the above black spot locations include put up speed limit signs, restrict access to the highway road, make crossover resistant medians and improve visibility at the accident-prone locations during night.

7. CONCLUSIONS

A detailed analysis of the 3-year accident data for the period 2019-2021, for 61 km stretch of NH-44 between Kundli and Panipat has been presented, and based on the analysis of the accident data, 22 blackspot locations have been identified. The following major conclusions can be drawn from the study:

i) A total of 501 road accidents took place on NH-44 section between Kundli and Panipat during the 3-year period between 2019 and 2021, of which over 60% accidents (324 out of 501) were fatal. In these accidents, 326 persons were killed and 346 were injured.

ii) Among 326 persons killed in the accidents, 134 were pedestrians and 103 were two-wheeler riders; which shows that these two categories of users put together accounted for about 73% of the fatalities.

iii) The study shows that about 24% of the total accidents took place during 08:00 PM to 12:00 AM followed by 21% accidents during 04:00 PM to 08:00 PM. Highest number of road accidents occurred during the months of July, September and October which can be attributed to monsoon season from July to September and increased movements in October due to festivities season, and the lowest during the month of February, April and May which is primarily due to nationwide lockdown in April 2020 and May 2021 due to COVID-19.

iv) The study shows that Cars/Vans/Taxis were the leading road users at fault and responsible for 34% of the total accidents closely followed by Truck/Lorries (33%), and two-wheelers and pedestrians were the leading victim road users being victims in 35% and 33% accidents respectively.

v) Rear-end collisions accounted for highest number of accidents (over 31%) followed by Pedestrians hit while crossing road in 20% accidents. Head-on collisions accounted only for 8% accidents. This shows that allowing pedestrians to walk access NH-44 roads is a major factor contributing to road accidents and fatalities on NH-44.

vi) Among 22 identified blackspot locations on the NH-44 section, 10 locations lie on Panipat-Delhi Road, 9 on Delhi-Panipat Road and 3 on intersections / T-junctions. The top ten ranked locations are Patti Kalyana village (Panipat-Delhi Road), Pyau Maniyari, Kundli (Delhi-Panipat Road), Patti Kalyana village (Delhi-Panipat Rod), Bahalgarh Flyover (Delhi-Panipat Road), Rasoi village (Panipat-Delhi Road), Bahalgarh Flyover (Panipat-Delhi Road), Kumashpur Chowk, Jhattipur village (Panipat-Delhi Road), Gannaur Flyover (Panipat-Delhi Road) and Jati Mor, Kundli.

vii) The site investigations and analysis of accident data at ten top blackspot locations show that the possible major causes of the accidents are easy access of local traffic / pedestrians to NH-44 leading to mixing up of slow moving local traffic with the fast-moving highway traffic, no proper road-crossover facility for the pedestrians, no speed limit signs near villages /residential areas along the highway, lack of adequate lighting on NH-44 during night / dark hours, and reckless and drunken driving during late evenings and nights.

viii) The suggested countermeasures at the identified ten top ranked blackspot locations include construction of flyovers at the congested locations (especially near villages or towns along the highway) to separate the local traffic / pedestrians from the highway traffic and provide crossover facility from one side of the highway to the other side, putting up speed limit signs, restrict access to the highway road, make crossover resistant medians and keep the locations lighted or illuminated during night.

ix) It was however, seen during the site investigation at the black spot locations that after the completion of widening of NH-44 to 12-lane in its larger part and construction of flyovers at several locations, some remedial actions have already been taken at many blackspot locations, except at three locations in Kundli area where the work of the road widening and construction of flyovers is still in progress. However, the other suggested measures such as restricting excessive speed, restricting access to the highway roads, making crossover resistant medians and keeping the locations lighted or illuminated during night are yet to be taken at all the identified black spot locations.

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