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ASSESSING THE BLACK SPOTS FOCUSED POLICIES FOR INDIAN NATIONAL HIGHWAYS

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Abstract

Road Traffic Injuries (RTIs) is one of the leading causes of death across the globe. As per the Indian government statistics, 150,785 persons were killed and 494,624 injured in road traffic crashes in the year 2016. In the recent past Government of India has formulated policies to reduce the road traffic crashes on Indian highways with prime focus on the National Highways (NHs). One of the dimensions of these policies is the identification and rectification of black spots on NHs and State Highways (SHs). Ministry of Road Transport and Highways (MoRTH) provides a definition and protocol for identifying black spots, and subsequently, states have identified black spots on their NHs. Top priority has been accorded to the correction of black spots on NHs. Consequently, short-term measures such as rumble strips, reflective stickers at junctions, fixing signboard/cautionary board, providing signages and various other speed restrictions are also being used. Whereas, the long-term measures such as the construction of the vehicular underpass, by-pass, flyover, and lane widening are being taken up. This study aims to present the current scenario of the policies pertaining to black spots in the country. This study assesses the effectiveness of the policies focused on the identification and rectification of black spots on the NHs. Further, it highlights the strengths and weaknesses of the policies based on the outcomes of the audit conducted to review the road safety status on Indian Highways. This study also recommends the measures to improve the safety at black spots locations.

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Keywords: Traffic Safety; Policies; LMICs; Highways; Black Spots

1. Introduction

Globally, Road Traffic Injuries (RTIs) are considered a major public health problem. They are one of the leading causes of deaths, disabilities and hospitalization as well as impose huge socio-economic costs to society. As per the Global Burden of Disease (GBD) 2016, road injuries are the 8th leading cause of death in India which has risen by 22.5% as compared to the year 2015 (IHME, 2017). It is among the top ten causes of death and disability combined, which is measured by Disability Adjusted Life Years (DALYS). In India, road injuries are among the top four leading causes of death and health loss among the persons of the age group 15-49 years. The alarming fact is that the persons of the age group of 18-45 years accounted for a share of 68.6% (103,409 persons) in the total road accident fatalities in the year 2016. As per the MoRTH, the total number of reported road accidents are 480,652 which have caused injuries to 494,624 persons and taken the lives of 150,785 people, in the country in

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the year 2016 (MoRTH, 2017b). In simpler terms, it is to affirm that every four-minute one person is dying on Indian roads. The crash pattern analysis has revealed that vulnerable road users (VRUs) have the highest share among the road users killed on the highways (Mohan et al. 2017).

India has the second largest road network in the world with 5.6 million km of roads length (MoRTH 2017b). The road network transports more than 60% of all goods in the country and 85% of India's total passenger traffic. The connectivity between villages, towns, and cities have improved due to the subtle increase in road transport across the nation. The transport infrastructure sector of India is expected to grow at a Compounded Annual Growth Rate (CAGR) of 5.9% through the year 2021, thereby becoming the fastest-expanding component of the country's infrastructure sector (MoRTH 2018). In recent years, the Government of India has formulated various policies targeting road safety issues. Additionally, the road safety task is on the top priority of the MoRTH to make road transport safer in the country. Also, India has pledged to reduce road accidents and fatalities by 50% by the year 2020 (World Health Organization 2015).

The NHs constitutes 1.8% of the total road network in the country and carry 40% of the traffic whereas accounted for 29.6% of total road accidents and 35% of the fatalities (Mohan et al. 2017). Traffic junctions are identified to be the major problematic areas and constitute about 37% of the total road accidents that took place during the year 2016 (MoRTH 2017a). Currently, the identification of black spots by states is based on two criteria, i.e. location with 5 accidents in the last 3 calendar years or location with 10 fatalities in the last 3 calendar years. It is expected that the proposed, as well as implemented treatment on these identified sites, will not be effective in long-term.

The objective of this paper is to assess the policies based on the black spots rectification and identification specific to India. The outcomes and findings of the audit conducted in four states of India would reveal the status of road safety on Indian highways. The recommendations are based on the review of the literature as well as on the outcome of the audit.

2. Defining Black spots

This section presents the literature review to understand the definitions adopted for black spots by some of the developed countries. In addition, a brief detail of the definition associated with black spots on Indian highways is also presented. The purpose of the review is to understand the methods used by developed countries to identify and rectify the black spots.

2.1 Review of Definitions of Black spot

Geurts et al. (2003) defined a black spot as a location on the road where the concentration of crashes has exceeded the specified value of the crashes in a certain duration of time. For example, a black spot is a location at which at least 4 injury crashes have been recorded during the last 5 years. Furthermore, the locations of high risk where crashes tend to concentrate over the time are known as hazardous locations, hot spot or black spot. However, there is no specific and unique definition of road accidents black spots around the world. The definitions vary from country to country based on their criteria for identification of black spot locations. Traditionally, the black spots are defined based on the number of accidents or the rate of accidents.
Elvik (2007) has categorized the definitions of black spots based on the following three criteria:

a. Numerical definitions based on accident number, accident rate, and accident rate and number;
b. Statistical definitions based on the critical value of accident number, and the critical value of accident rate, and;
c. Model-based definitions based on the Empirical Bayes method and Dispersion value

In another work by Geurts et al. (2005) proposed that the black spot can also be identified based on the level of risk and the likelihood of a crash occurring at each location. The level of risk at a certain location can be higher than normal level of risk in the neighbouring location. This level of risk and the likelihood of a crash occurring method was particularly used during the Australian black spot program from the year 1996 to 2002 (Bureau of transport economics 2001). It was evident from the literature that in European countries black spots were identified by the sliding window method which is statistically as well as empirically ineffective. In Germany, accident maps are used for the process of black spot identification which is somewhat similar to the sliding window method.

In one of the significant work by (Elvik 2008) which argues that the operational definition of black spots is not universal. It has been observed that the definition criteria also affects the identification method used for black spots ranking and treatment. Most of the countries have used sliding window method to identify black spot

locations on the road. However, there is no standard guideline to fix the length of the window. The duration of accidents record for the identification process is also varying from country to country. It is also evident that black spots identification is based on either past few years' numbers of accidents or the rate of accidents.

2.2. Definition of Black spots: Indian Highways Perspective

As per (MoRTH 2015), road accident black spot is a road stretch on NH of about 500m in length, in which either five road accidents took place during the last three years or the ten fatalities took place during the last three years. The road accident includes fatal as well as injury accidents. Further, the identified black spots on NHs are ranked based on average severity index (ASI).

3. Identification Methods of Black spots

3.1. Overview of Procedures used for Identification of Black spots

The purpose of the identification process is to select a few locations out of a large number of locations with the intention to improve safety. The rationale of the identification process should fulfil the criteria of being economically efficient, fairness to road users and professional responsibility (Hauer 1996). The author has suggested that the object of identification stage is to select locations which have a fair chance of being genuinely in need for remedial action and are also capable of being cost-effectively improved. Further, the black spot identification process is the first step of the road safety management program. This starts with the collection of crash data and identifying the locations which are changed into the black spots. Moreover, the identification process of black spots is not universally unique. Sørensen (2007) has reviewed several methods for identifying the black spot which are based on various crash based principals. Crash principal based identification methods are further divided into two sub-categories such as model based and non-model based. For the identification of black spots, the non-model based methods use crash number, crash frequency and crash rate, whereas the model-based methods use category analysis, traditional approach and modem approach. The best model-based methods are Empirical Bayes (EB) method, Poisson or Negative Binomial (NB) distribution method and category analysis method. Several researchers have used the EB method to estimate the expected number of crashes at any black spot location (Hauer 1992). However, the strength of these models and best results out of these models can only be gained if the quality of crash, traffic and road data is good. Moreover, the model-based methods can take into account systematic variation determined by general road design and traffic volume as well as the random variation (Geurts et al. 2003). On the other hand in the case of weak database non-model based methods of identification are better to use. The criteria and methods used in most of the countries for the identification of black spots are based on the non-model method of identification.

Countries from Europe, USA, Canada, and Australia have formulated their state-specific black spots management program. Australia has prepared state specific black spot management program for the identification and rectification of black spots, and subsequently established norms for the allocation of the budget (Meuleners et al. 2008). In addition, Meuleners L (2008) has found that Western Australia (WA) black spots program used non-model based definition and identification method. Further, author has summarised the identification methods used by various countries based on a model or non-model method. Summary parameters are the country name, identification principle, the method used, and minimum crash criteria. It was observed that most of the countries have used traditional methods, i.e. non-model based methods. The reason could be that the non-model based methods are easy to use. It is interesting to note that even the identification process criteria may vary at the local level of any region.

There are certain advantages as well as disadvantage associated with every method of identification of black spots. Non-model based method detects more sites with higher traffic volume, does not take into account systematic and random variations. This method likely to produce a high number of false positives and false negatives. The merit of the non-model based method is that they are easy to use and understand, hence can be useful to get grants and funds for rectification of black spots. Use of complex methods could discourage authorities from taking a step to improve road safety.

3.2. Identification of Black spots on Indian Highways

MoRTH (1996) elaborates the process to identify the black spots on NHs based on fatality data provided by traffic police of the states/ Union Territories'(UTs) for the calendar years. Each black spot is assigned a unique identification number which is an alphanumeric such as XX-YYY. Where XX is an alphabetical state/UT code. YYY is a numerical serial number of the black spot in the State or UT. The use of this identification number is to monitor the actions taken to rectify as well as for the feedback on accidents after rectification. As per the MoRTH (2017b), 700 black spots on NHs have been identified for rectification by the government. The identification of black spot on NHs by states is based on two criteria:

(a) The number of black spot with 5 or more accidents in 3 years.
(b) The number of black spot with 10 or more fatalities in 3 years.

Table 1. Black Spot Identification principles based on crashes, non-crashes and combinations of both.

Sl. No.	Name of State /UTs	No. of Black Spot Reported	No. of Black Spot with 5 or more accidents in 3 years	No. of Black Spot with 10 or more fatalities in 3 years	No. of Black Spot with one accident in all the 3 years
1	Andhra Pradesh	731	649	98	562
2	Assam	295	210	56	188
3	Bihar	61	61	11	50
4	Chhattisgarh	115	114	30	92
5	Haryana	79	76	29	77
6	Himachal Pradesh	90	87	3	66
7	Karnataka	961	755	149	710
8	Kerala	330	322	31	282
9	Madhya Pradesh	618	605	114	495
10	Maharashtra	53	44	22	38
11	Meghalaya	86	30	6	27
12	Punjab	10	9	6	8
13	Rajasthan	231	228	231	214
14	Tripura	17	17	0	12
15	Uttarakhand	125	81	37	61
16	West Bengal	743	743	152	609
17	Chandigarh*	18	18	2	16
18	Delhi#	73	73	25	38
	Total	**4636**	**4122**	**1002**	**3545**

Source: Ministry of Road Transport and Highways (MoRTH); *Indicates Union Territory (UT); # Delhi (National Capital Territory of Delhi or NCT)-New Delhi.

The bigger states, in terms of population as well as in area, like Uttar Pradesh (UP) and Tamil Nadu (TN) have not provided the data. As per the official statistics, these states are among the top 13 states contributing in the number of accidents as well as in the number of fatalities.

3.3. Best practices for Identification of Black spots

Elvik (2007) has opined on how to identify black spot locations as well as select their rectification measures. Author has presented the "state-of-the-art" approach based on statistics of road accident black spot management and safety analysis of road networks. The emphasis is on the systematic use of the EB method for road safety estimation which represents the current state-of-art with respect to both black spot management and network safety management. It has been suggested that EB is the best method until now to identify the black spots. However, Persaud and Lyon (2007) have cautioned the road safety experts and researchers on blind faith in the EB methodology.

As per Elvik (2007) the essential elements of an emerging state-of-the-art approach to safety analysis of road networks are as follows:

a. The identification of black spots should be in terms of the expected number of accidents.
b. Identification must be based on the reference to a clearly defined population of sites.
c. Sliding window method should not be used at all as it increases the variation in accident counts.
d. Multivariate accident prediction models should be used to estimate the expected number of accidents.
e. The EB method should be used to estimate the best estimate of the number of expected accidents for a site.
f. An optimal criterion should be selected to validate the sensitivity and specificity of the alternative critical values of the expected number of accidents to identify a site as a black spot location.
g. The frequent pattern of accidents at black spots should be validated. The risk factors hypothesis should be developed based on the accident analysis at black spots.
h. The accident analysis of black spot should recognize that the observed pattern is a matter of chance alone. To determine the stochastic nature of the number accidents of a certain type binomial tests should be done.
i. Analysis of black spots should be free from personal bias and based on the comparison to a safe location. The risk factors for the accidents should be determined with the help of analysis.
j. EB before-after study should be utilized to evaluate the effectiveness of black spot treatment program.

Hauer (1996) reviewed several studies conducted in line with the identification of black spots in the past and tried to build a historical sketch of used methods. The author had suggested a framework to identify as well as rank the black spots and coined the term "Sites with promise" (SWiPs) for black spots. Further authors argues that there are three motives behind the identification process, i.e. economic efficiency, professional and institutional responsibility and fairness. The author envisioned a further advancement in the improvement of identification procedures.

4. The government of India's Policies for Black Spots Management

As per the Planning Commission (2007), the government had constituted committees and rolled out policies to tackle the vagaries of road safety. Based on Sundar (2007), an expert committee was formed on 13th January 2005 based on the recommendations of the cabinet committee on infrastructure headed by the then prime minister of India. The committee was established to recommend a structure for the organization and also to advise on its role and functions for improving the status of road safety in the country. Based on the recommendations of Sundar (2007) report directions were given to various agencies for enhancing road safety. Figure 1 Illustrates the ASI for 2005 to 2016 and the targeted policies taken up by government of India (GoI).

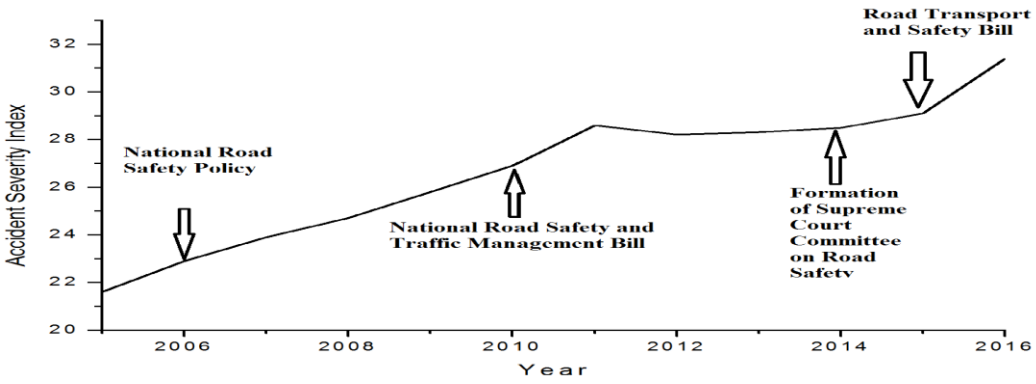

Fig. 1. Accident Severity and Road Safety Policies of GoI
Source of Data: MoRTH. (2017a): Road Accidents in India-2016

MoRTH (2010) recommends the formation of the National Road Safety Council (NRSC) as an advisory body, and which is an apex body under section 215 of Motor Vehicles Act, 1988 to take policy decisions in matters of road safety. Also, to oversee the strategies for implementation of the road safety policy statements the National

Road Safety and Traffic Management Board (NRSTMB) has been established. In addition to that "National Road Safety Policy"(NRSP) has also been formulated in the year 2010 based on the accepted multi-pronged strategy and safe-system approach for improving road safety (MoRTH 2010). Briefly, the various policy statements of the NRSP are as following:

a. Raise awareness about road safety issues.
b. Establish a road safety information database.
c. Ensure a safer road infrastructure.
d. Safer vehicles.
e. Safer drivers.
f. Safety of vulnerable road users.
g. Road traffic safety education and training.
h. Enforcement of safety laws.
i. Emergency medical services for road accidents.
j. Human resource development & research for road safety.
k. Strengthening enabling a legal, institutional and financial environment for the roads.

Table 2 illustrates the various policy initiatives taken by the government to enhance road safety. Indisputably, one of the targets of these policies is to identify and treat black spots on NHs.

Table 2 Timeline of the Government of India's initiative to improve road safety

Year	Policy Initiatives
1990	Setting up of National Road Safety Council (NRSC)
2000	Planning Commission set up Working Group on road accident injury prevention
2006	The inclusion of Road Safety Policy in 11th Five year plan
2007	Establishment of National Road Safety Agency
2010	Promulgation of The National Road Safety and Traffic Management Bill
2010	Approval of National Road Safety policy by Union Cabinet
2011	Constitution of the task force on road safety by MoRTH
2011	Formation of 5 working groups on road safety
2014	Constitution of the committee to monitor the implementation of road safety laws and directives

Due to the deterioration of road safety, it is recommended to incorporate road safety right from the beginning of the planning stage of road infrastructure projects. The government of India has also decided to improve the road accidents database upon understanding its importance in prioritizing research and for selecting countermeasures. Based on the Ministry of Urban Development, MOUD (2014), a committee had been constituted to prepare accident database framework and to prepare an accident recording format. It included experts from Indian Institute of Technology Delhi, Indian Institute of Technology Kharagpur, senior officers from Police and Transport Departments of States, Ministry of Health & Family Welfare, WHO and officers of the MoRTH to review and recommend the road accident formats to be filled by the state/UT police departments. The accident recording format has to be used by the ministry to prepare its annual publication of 'Road Accidents in India' report. The committee has recommended a uniform recording format to be adopted by the police in all states/UTs, and a set of the corresponding annual road accident data reporting format in which state/UT would furnish data to the ministry.

5. Outcomes of the Road Safety Audit of four states of India

As per the notification of Government of India (2017), the Supreme Court Committee on Road Safety (SCCRS) was formed to assess the road safety status of the nation's roads. The committee had set up guidelines and directives to the states to improve the road safety, especially on National and State highways. Consequently, the consultant was selected based on the request for proposal (RFP) bidding process to verify the status of the road safety implementation by states based on the guidelines and directions provided by the committee.

The information provided herein is based on the outcomes of project study titled "consulting services to audit the implementation by the states of the directions issued by the supreme court committee on road safety" which is monitored by supreme court committee on road safety for the states of India. The audit was done in the five dimensions for the fourty one audit points. The five dimensions are institutional arrangements, enforcement, engineering, education and emergency care. One of the objectives was to reduce road accidents and fatalities in India through improving engineering aspects of road geometrics. Hence, the scope of identification of black spots and recommendation to effective countermeasures is under engineering dimension. The audit team used the specified sampling strategy adopted for conducting the black spots location's audit. Table 3 briefly explains the audit methodology used for the audit.

Table 3. Audit Methodology and sampling strategy for field investigation of black spots.

State(s)	Actual Sampling	Sample Selection Criteria	Rural or Urban
Gujarat and Punjab	8 locations of Gujarat and 9 locations of Punjab	Based on Black Spot details communicated to SCC by State PWD/R&B* and NHAI#	Rural Stretch
Maharashtra	6 locations	Selected Based on Black Spot details communicated to SCC by State PWD/R&B and NHAI	Rural Stretches

*Public Works Department-Roads and Bridge (PWD/R&B) # National Highways Authority of India (NHAI)

The protocol followed for black spots identification, rectification and monitoring by the state authority has been verified by the audit team and illustrated in the Table 4. Besides, the audit team verified the arrangements made by the state for identification of black spots and their rectification, and also assessed the efficacy of the rectification measures on the NHs, SHs and on major district roads (MDR). The status of proposed and implemented short term and long term remedial measure's has also been verified by the audit team.

Table 4. Black spots protocol for the Identification, Rectification and Monitoring

Item	State	Criteria for Identification	Compliance Level
Arrangements made by the States for detection of Black spots	Gujarat	• A clearly defined process exists as per MoRTH. • After analysis of data collected from the police station by the executive engineer of division, if the causes of accidents are due to lack of road geometry, then those stretches shall be identified as accident Black Spots.	Fully Complied
	Punjab	A clearly defined process exists as per MoRTH.	• Fully Complied • The State PWD is following ASI formulated by World Bank for identification and rectification of Black Spots
	Maharashtra	• NHAI: Based on Police data received from State Government, TRW-(MoRTH) finalizes black spots. • PWD used MoRTH's definition to identify the black spot.	• Process initiated • The state does not have clearly defined process for detection of Black spots. • MoRTH Identified black spots based on data from 2011 to 2014 are being rectified. • No regular mechanism in place for the identification of black spots
	Haryana	• A clearly defined process exists as per MoRTH. •The Black spots are identified, and the list was handed over to PWD (B&R) for rectification.	Fully complied
Assess the efficacy of the rectification measures both on SH and NH	Gujarat	• Visited 7 black spots location and verified with rectification measures being submitted to the committee. • The status of rectification measures was similar to status submitted to SCCRS.	Fully Complied
	Punjab	• No Black spots exist on NHs as confirmed by NHAI Regional Office, Chandigarh. • 200 black spots identified by Punjab Roads and Bridges Development Board (PRBDB) on 1700 Km of SHs (World Bank-financed Punjab State Road Sector Project).	• Fully Complied • NH Roads: As there are no black spots reported, auditors could not visit any site for verification • State PWD (B&R)-PRBDB: • 142 out of 200 black spots were rectified • 10 black spots were verified by the team
	Maharashtra	Monitoring is being done by NHAI for 3 years post rectification	• Fully complied • 6 black spot locations were verified on the site and observed that only 30% of the locations were rectified
	Haryana	• Visited 11 black spots location and verified with rectification measures being submitted the committee. • Efficacy in terms of measures adopted is 70:30 ratio (efficient: Inefficient).	Partially complied
Protocol Status	Gujarat	The protocol was drawn up and being implemented.	Fully Complied

	Punjab	Protocol for NHs decided by the transport department.	• Partially Complied. • NH Roads Protocol not clear • State Roads: Provided as part of the "Plan of Action to Improve Road Safety in the State"
	Maharashtra	No protocol was in place during the audit.	• No action was taken until now • No Protocol for identification and rectification of Black spots has been prepared and notified as per the directions of SCCRS
	Haryana	The protocol was drawn up and being implemented.	Fully complied

The subsequent tables summarizes the outcomes of the audit conducted by the audit team in states of Gujarat, Maharashtra and Punjab. The audit was conducted at eight, nine and six identified black spot locations of the Gujarat, Punjab and Maharashtra state respectively. Table 5 summarizes the status of safety and rectification measures adopted on the identified black spots in the state of Gujarat. The rectification measures taken at the black spots are such as the construction of pedestrian underpass, installation of delineators, bollards, junction improvement and other traffic control devices.

Table 5. Audit Summary at the identified black spots of the Gujarat State.

Road Name	Observations by the audit team	Compliance level
NH-48 near Padri	• No Delineators • Bollards – Not present • Pedestrian facilities are Substandard with no signboard • No "Keep Left" sign provided.	Partially Rectified
NH27 (Near Rajkot)	• Viaduct flyover, • Pedestrian Underpass is under Construction • Traffic management for under construction not followed	Under Rectification
NH48	• Road signs, pavement markings, delineators provided under short-term measures. • No medium term and long term measures are taken.	Rectified
Kheda, Ahmedabad	• Flyover is constructed and speed breakers and markings provided on the minor road	Rectified
SH158 Vadodara	• Speed breakers provided No signage's provided Junction widened	Rectified
NH64 near Vadodara/ Borsada Intersection	• No measures are taken	Not rectified

In the Maharashtra state, the audit was conducted at six previously identified black spots locations. The rectification measures adopted at the black spots are such as the installation of road studs, markings, vehicular underpass and installation of informatory and cautionary signages. The summary of the observations of the audit is presented in Table 6.

Table 6. Audit Summary at the identified black spots of the Maharashtra State.

Road Name	Observations by the audit team	Compliance level
Khadavali Junction on NH 3 Chainage: 528.200 KM (Latitude: 19.371646, Longitude: 73.194778)	• Solar Blinkers are available but not functional • Road reflective **studs not provided;** • Signage is provided but some of them are **not as per IRC standards** • VUP not Provided • Bar Markings exist but not visible and not as per IRC • Road signs are not provided on the minor road • Due to excess vegetation s**igns are not visible** • Pavement markings are provided • Speed breaker is provided on the minor road	No rectification
Vadodara T Junction on NH 6 Chainage: 527.160 (Latitude: 21.136393, Longitude: 9.320205)	• Vehicle Underpass has been constructed • Signage on the major road and the minor road has been provided • Markings are provided but not visible	Rectified

Ghoti Sinner Road Junction on NH 3 Chainage: 453.800 KM (Latitude:19.72461, Longitude: 73.63054)	• Solar Blinkers are provided on median but one blinker is damaged • Road reflective studs are provided • Pavement markings are provided but not visible in some parts • Rumble strips are provided but not fully visible • Signage is provided, however some of them are not as per IRC 67: 2012 standards • Due to excess vegetation on the median, signs are not visible properly • Vehicle Underpass/ Flyover not provided • No measures are given on minor road and also no signage, no marking and no speed breaker • Very poor pedestrian facility and zebra crossing marking are provided but not visible. • Bollards are provided on the median	Rectified but require Maintenance.
Gurewadi NH 60 Chainage:179.800 KM (Latitude:19.81902, Longitude: 74.02716)	• Signage's provided • Rumble strips provided • Zebra crossing provided • Flashing Beacons provided • Bollards and Crash barriers provided • Cautionary and Regulatory signs, speed breakers are provided on minor roads	Rectified
New Kasara Ghat on NH 3 Chainage: 470/500 KM (Latitude:19.68219, Longitude:73.51501)	• Signage's provided • Road markings are provided • Road reflective studs are provided • Some of the road reflective studs are damaged / old • Rumble strips provided but not properly visible • Insufficient length of Guard Rail	Partially Rectified
Palaspe at NH 17 & NH 4B junction Chainage: 250 m ((Latitude:18.96805, Longitude:73.13181)	• Flyover construction- ongoing, work is under progress • No proper barricading provided on both the sides of the construction area • Inadequate number of signage • Diversion boards with sub-standard reflectivity • Flashing Beacons not provided • Short-term measures are not provided • Lack of major road signs for construction sites • No speed breakers • Pavement marking not provided • Delineators not provided	Rectified Construction zone safety was not adhered as per IRC-SP 55

The rectification measures adopted at the black spots are such as the use of reflective pavement marker, installation of rumble strips, pedestrian crossing, and installation of the crash barrier. Table 7 presents the status of the nine identified and audited black spots of the Punjab state.

Table 7. Audit Summary at the identified black spots of Punjab state.

Road Name	Observations	Compliance Level
Near Khojewal on Ludhiana-Kapurthala Road	• All Required signage's are installed • Road Marking are provided • Rumble Strips provided • Pedestrian Crossing is provided • Reflective Pavement Marker is provided	Rectified
Chuharpur on MDR 48	• All Required signages are installed • Rumble strips are provided. • Unavailability of pedestrian crossings • Pavement markings are not visible • No Reflective Pavement Markers	Partially Rectified

Chabal Kalan on Tarn Taran Road	• All Required signage's installed • Road Marking are provided • Reflective Pavement Marker is provided • A flashing beacon is provided • Bollards are provided	Rectified
Baba Sidhwana Gurudwara on Chabal-Tarn Taran Road	• All Required signage's • Road Marking are provided • Crash Barrier Provided • Pedestrian Crossing Provided • Reflective Pavement Marker is provided • A flashing beacon is provided • Bus bay not provided	Rectified, except bus bay is not provided
Kot Dharam Chand Kalan on Chabal-Tarn Taran Road	• All Required signage's • Road Marking are provided • Pedestrian Crossing Provided • Reflective Pavement Marker is provided • Speed Breaker Not provided • Bus bay not provide • A flashing beacon is provided • Rumble Strips Provided	Rectified, except bus bay
Near Bridge at Village Dado on Chabal-Attari Road	• All Required signage's • Road Marking are provided • Pedestrian Crossing Provided • Reflective Pavement Marker is provided • The crash barrier Provided • Rumble Strips Provided • A flashing beacon is provided	Rectified
T-point of Village Jandali Khurd on SH-11	• All Required signage's • Road Marking are provided • Pedestrian Crossing Provided • Speed Breakers provided • Reflective Pavement Marker is provided • A flashing beacon is provided	Rectified
Near Dhulma Khurd on SH-11	• All Required signage's • Road Marking are provided • Directional Arrows are provided • Pedestrian Crossing Provided • Speed Breaker not provided • Bus bay is not provided	Rectified, except bus bay
Near Canal Bridge on Patiala – Sirhind Road	• All Required signage's • Road Marking are provided • Pedestrian Crossing Provided • The crash barrier provided • Rumble strips provided • A flashing beacon is provided	Rectified

The purpose of the audit was to inspect the status of safety according to 4E's of safety, and also to verify the institutional arrangement in the state after the directive issued to states by Supreme Court of India. It was observed that the countermeasures adopted at the audited black spots are based on prevalent practices and has also been adopted due to lack of availability of scientifically backed countermeasures. Hence, their impact on safety is relatively unknown. Attempts were made to recommend countermeasures to the state authority based on the current status of road safety. Speed calming measures are proposed at black spot locations as speed is one of the major risk factor responsible for the occurrence of a crash. The effective recommendations are such as physical measures on the road such as texture change, rumble strips, speed humps and raised pedestrian's crossings. Due consideration must be given to reduce the speed if highways are passing through populated areas such as village and town. Since junctions are among the problematic areas on the highway, care must be taken to treat the junction with carefully designed traffic calming and speed reduction measures.

6. Conclusion and Recommendations

India is facing an increasing burden of road traffic injuries and fatalities due to the rapid growth of motorization. According to GBD 2016, RTI is the 8th leading cause of death in India in the year 2016. To address the issue of road safety, evidence-based black spot management program should be the mandate. As we know, the crash is a rare and random event; this makes the identification and rectification of black spots locations even more tedious. Furthermore, the crash is a multi-causal event, hence multi-pronged and well-coordinated actions are needed to address the issue. The definitions of black spots has to be country-specific, and even sometimes locality specific. The identification process adopted also vary based on geographical boundaries, also with the advancement in technology as well as in research. It was observed that agencies have started following the scientific procedures for identifying and rectifying the black spot locations.

In recent decades, due to the deteriorating condition of road safety in the country and continuous effort by the international lead agencies authorities have formulated policies to improve road safety. Consequently, the government of India has formed the SCCRS to assess the road safety status of the nation's roads, particularly on NHs. Hence, the audit was undertaken to assess the safety scenario on NHs, SHs and MDRs.

Based on understanding from the outcomes of the conducted audit and various policies, the recommendations are as follows:

a. Uniform accident recording format across the nation is required.
b. Development of accident database system and institutionalize the database system in the agencies like police department of all states, health units of government and hospitals.
c. To revise the road infrastructure design codes, manual and standards to incorporate safety aspect along with the engineering aspect and also to incorporate the best international practices.
d. To formulate the road safety policies with measured and tangible outcomes.
e. To evaluate the policies in order to minimize the cost and maximize the effectiveness.
f. To formulate the policies which should incorporate all the E's of road safety.
g. As the crash is a multi-causal event, there should exist the coordination of all the stakeholders, ministries and department at all levels.
h. Road safety audit should be made an integral part of the project planning, report preparation, appraisal, designing, implementation, operation and maintenance.
i. Appropriate traffic calming techniques should be adopted for highways passing through populated areas such as villages.
j. The safety policies should be aligned to safeguard the interest of VRUs.
k. Road safety research should be supported by government agencies to solve the safety problem efficiently.
l. The road safety agencies should be established exclusively with sufficient executive power and equipped with experts from all the aspects of road safety.

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