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Risky Driving Behaviour Under Heterogeneous Traffic Condition On Indian Urban Expressway

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ABSTRACT

In developing countries like India, newly constructed National Highways charging fees for their use are also suffering from accident occurrence on them. One such stretch, NH-48, is also suffering from accidents over the years. Due to high access density, heterogeneous traffic, conflict points have increased on this highway and subsequently cause accidents. The comparison of results of a Personal Interview and in-field Videographic audit of drivers indicates that heavy vehicle driver is driving on the median lane and their higher share in traffic composition increases disturbance to other vehicles and forces other vehicles to change the lanes due to the difference in driving speeds. From the Videographic driver's audit study, it can be concluded that 32.7% of trucks, 54.3% multi-axle vehicles, are driving on the median lane, while only 36.6% car drivers are driving on the median lane. From the study, it can be concluded that 18.10% of the drivers are moving their vehicles with risk without following proper traffic rules and regulations while driving. Such a study might help the Traffic administration authority to capture such risky behavior of the drivers and take suitable measures to reduce such risky movements by drivers and consequently help in reducing accidents in the future.

Keywords
road accident; risky driving behavior; audit of drivers; traffic regulations

Introduction

Every year, 1.25 million people die in road accidents all over the world, wherein pedestrians, cyclists, and motorcyclists, who together make up 49% of all world road traffic deaths. Insufficient attention has been paid to the needs of making the world's roads safer will not be possible unless the needs of these road users are considered in all approaches to road safety [1].

National highways (NHs) in a developing country like India connect predominant cities and ports, with a total length of 132499 km as of 2019. Official information points out that NHs make contributions to a common of 30.2% of total crashes, 35.7% of deaths per year, even although NHs are solely 1.94 % of the whole highway network in India. In India, fatal road accident victims generally represent younger people in productive age groups. Young adults in the age range of 18 - 45 years accounted for 69.6 percent of victims in the year 2018. People in a working-age group of 18 – 60 years accounted for a share of 84.7 percentage in the whole road accident fatalities [2].

Multilane NHs frequently do not have service roads in suburban and rural areas and require frequent access through median openings and from minor roads resulting in frequent points of conflict. Moreover, unsuitable geometric architecture produces a dangerous situation by facilitating movement in the wrong direction; and a heterogeneous mix of heavy-duty vehicles, such as trucks and buses, light commercial vehicles, cars, and two-wheeler [2].

Very few research studies were carried out to determine the risky behavior of drivers on high-speed multi-lane highways. Also, a few researchers have been focusing on real driving data on high-speed multi-lane highways. This research is, therefore, carried out to test the attitude of the driver towards safety through questionnaires and field surveys through videography to assess the risky driving actions of the driver.

Even newly built national highways receiving tolls for their use also suffer from the occurrence of accidents on them. One such stretch of NH-48 is a 6-lane Indian National highway. It connects the national capital Delhi to the financial capital Mumbai, and other major cities along the way, including Gurgaon, Jaipur, Ajmer, Udaipur, Ahmedabad, Vadodara, and Surat. The selected Bharuch–Surat NH 8 Project passes through certain semi-urban and business centers, including Pipodra, Palod, and Ankleshwar. The length of the stretch is 65 km. The stretch is connecting two districts – first, Bharuch having 653 villages and 33.85% urban population while second, Surat having 713 villages with 79.74% urban population as per the 2011 Census of India. Due to so many villages coming across this National Highway, there are several median access points as well as access points on the sides of the National Highway merging with villages. (Reference District Census Handbook – Bharuch and Surat, Gujarat State, India) High access density, heterogeneous traffic constitutes conflict points and causes accidents.

All the different category vehicles travel at different speeds with different speed ranges under heterogeneous traffic conditions on the NHs. The proportion of trucks entering the median lane increases competition with other NH vehicles. Traffic volume surveys, spot speed surveys, access density surveys are performed on the stretch to get information about traffic composition, spot speeds of various types of vehicles, access density, which may affect the incidence of an accident.

A Personal Interview has been conducted to know the demographics of drivers, their attitude towards vehicle

condition and its maintenance, traffic regulations following, and review about roadway environment on the National Highway.
An attempt has been made to carry out drivers' audit using videographic recording done through the floating car method.

Literature Review

In addition to the death and injury rates, highway-related crashes result in considerable pain and misery, as well as several billions of dollars in medical costs and a loss in productivity. The enormity of the effect of road safety on human societies has resulted in massive spending on safetyrelated countermeasures, laws governing road use, and various regulations relating to the manufacture of road vehicles [3].
A relatively large number of studies on highway safety results have concentrated on the safety of two-lane roads, with fewer studies focusing on the safety of multi-lane highways, according to Mitra, Haque, and King (2017). The authors analyzed the access density studies and concluded that higher access points are causing more crashes. They also noticed that while medians were successful in reducing head-on collisions, a higher number of rear-end crashes on the road segment were associated with median openings [2].
Traffic on Indian roads is heterogeneous, and the research community has not yet extensively studied the safety impacts of this combination. Robert, Veeraragavan, and Murthy (2006) found the proportion of heavy-commercial vehicles was detrimental to road safety. Besides, parameters associated with most types of vehicles were found to be random in the overall vehicle composition of the traffic stream, offering no clear guidance on the safety effects of such vehicles on the mix, except for buses. As a result, it can be assumed that the safety effects in heterogeneous traffic from various compositions of vehicle types are still an underexplored area [2].
Most traffic accidents may be caused by one or a combination of many factors, including errors in decisions and acts of road users, the poor technical design of roads, inadequate traffic or regulatory controls, unsuitable road conditions, adverse environmental conditions, and vehicle defects. Human factors contribute to about 95 percent of all incidents, either alone or in combination with other factors. In comparison, road and environmental factors contribute to around 28 percent of all traffic accidents in combination with human factors [5], [6].
Drivers are living under complicated road traffic conditions, and the constant traffic congestion pressure will cause the drivers to be pessimistic and irritable. Thus, according to the statistical evidence, reckless driving activity is normal in everyday life. Much work has been done, but it is still uncertain how much reckless driving behavior leads directly to road traffic accidents. The drivers often work in a certain social and traffic climate; drivers' mental workload is shown to be a significant factor in risky driving behavior [7].
Fountas *et al.* (2019) showed that the impact of sociodemographic and behavioral factors on perceived and aggressive driving behavior that differ in magnitude and directional effects across driver groups. Also, the identification of the connection between the non-observed characteristics further demonstrates the complexities of the driving decision mechanism, especially where fundamental sources of aggressive driving are evident.
In addition to geometric parameters derived from field driving data, Charly and Mathew (2019) proposed the methodology for assessing road safety using driving performance measures. They developed a model of crash frequency using the parameters, thus identified and historical data of crashes along an expressway. They got a good correlation between driving performance, the geometry of the roads, and crashes.
In developing countries such as India, for heterogeneous traffic conditions and high-speed multi-lane highways, very limited studies have been conducted to assess driver behavior in the field through field Personal Interviews and stretch videography (naturalistic driver data) using the floating car technique. Therefore, such a study on one of the multi-lane high-speed highway stretch called NH-48 was felt appropriate.

Study Area and Methodology

NH-48 is a four- to six-lane National highway in India. It connects the national capital Delhi to the financial capital Mumbai, and other major cities along the way, including Gurgaon, Jaipur, Ajmer, Udaipur, Ahmedabad, Vadodara, and Surat. The selected Bharuch–Surat NH-48 project passes through certain semi-urban and business centers, including Pipodra, Palod, and Ankleshwar.
The length of the stretch is 65 km. The stretch is connecting two districts – first, Bharuch having 653 villages and 33.85% urban population while second, Surat having 713 villages with 79.74% urban population as per the 2011 Census of India. Due to so many villages coming across this National Highway, there are several median access points as well as access points on the sides of the National Highway merging with villages. (Reference District Census Handbook – Bharuch and Surat, Gujarat State, India).
This stretch has 47.35 km six- Lane carriageway, 19 Bus Bays, 3 Railway Over Bridges, 14 major bridges, 33 minor bridges, 83 culverts, 27.5 km service Road, ten pedestrian underpasses, 6 Flyovers, 6 Major Intersections, and 1 Toll Fee Plaza.
Source:http://www.irb.co.in/home/projects-under-operationsmaintenance/bharuch-surat-national-highway-8-project/

All the different category vehicles travel at different speeds with different speed ranges under heterogeneous traffic conditions on the NHs. Truck shares occupying the median lane increase interferences on the NH with other vehicles. Traffic volume surveys, spot speed surveys via the Android app called "Speed Gun," access density surveys are performed on the stretch for getting detailed information on traffic composition, spot speeds of different types of vehicles, access density, which may affect the frequency of accidents.

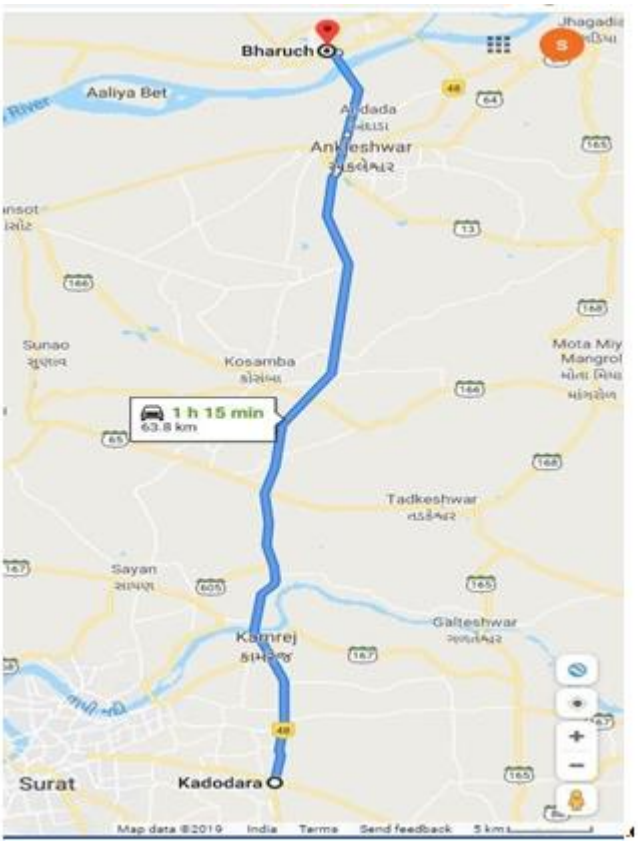

Figure 1: km 198/000 TO km 263/000, Bharuch to Surat section of NH-48.

A Personal Interview has been conducted to know 1. the demographics of drivers like age, qualifications, holding of valid driving license, wearing a helmet, 2. their attitude towards vehicle condition and its maintenance like age of the vehicle, age of the tire, the frequency for service of the vehicle, condition of the vehicle, 3. traffic regulations following responses such as lane preference, use of signals and sidelights, use of mirrors while overtaking, and 4. review about roadway environment like proper pavement maintenance, signals, safety crossing points, accident prevention infrastructure, road signs and markings on the National Highway. These Personal Interviews were carried out on the roadside on the toll road near restaurants, petrol pumps, bus lay bays, etc. The questionnaire was filled by trained persons (students) in the questionnaire for all different vehicle category drivers.

An attempt has been made to carry out drivers' audit using videographic recording done by the floating car method. The video recordings of the vehicles were then observed on (Personal Computers) PC for deciding the actual driver behavior in the field. All the risky movements by drivers' like median lane driving, wrong side driving, overtaking from the wrong side, overloading, haphazardly turning left/right movement, regarding driver movements, are noted by observing videography recordings frame by frame, noting for each vehicle coming across the frame and making the total for each risky movement under each vehicle category.

figure 3:

IV. DATA COLLECTION ANDANALYSIS

A. Accident Data

As the records of the Programme Implementation Unit (PIU), the accidents have been reducing continuously every year. This decreasing trend might be due to the improvement of black spots by the National Highway Authority of India (NHAI). The accident trend is represented graphically in figure 2:

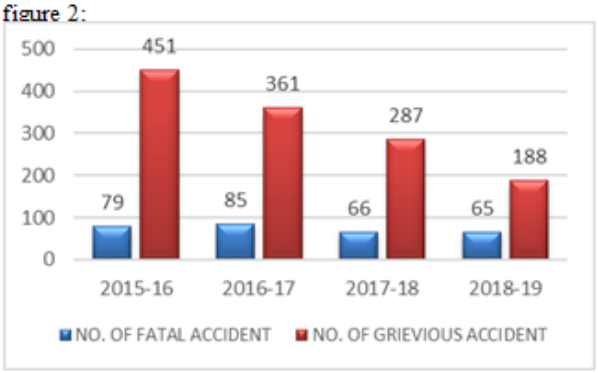

Figure 2 – Accident Trend of BharuchSurat stretch

B. Traffic composition

The traffic composition was compiled from the toll collection data supplied by the PIU -Surat and is as shown in

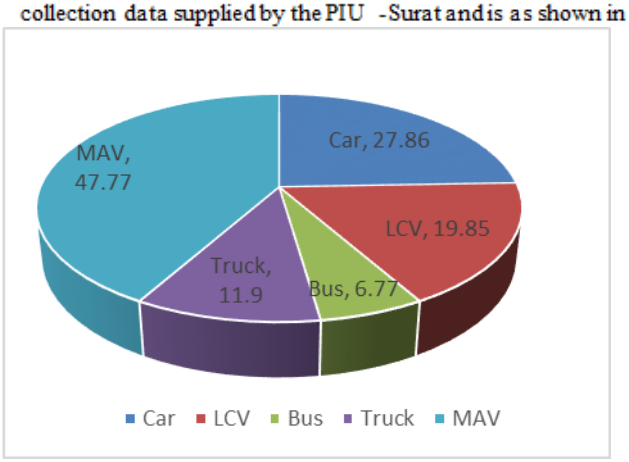

Figure 3 – Traffic composition by toll fees collection data

The above graph indicates that a major portion of the vehicle is consisting of Multi-axle vehicles having 47.77%, followed by 4w having 27.86%, LCVs 19.85%, and trucks 11.9% and bus 6.77% in the traffic composition. So, the major traffic composition (i.e., 66.44%) is of heavy commercial vehicles.

C. Average Annual Daily Traffic (AADT) on the toll road

The annual traffic data for the last five years were obtained from the Program Implementation Unit – Bharuch-Surat expressway and the same is reproduced in the following figure 4.

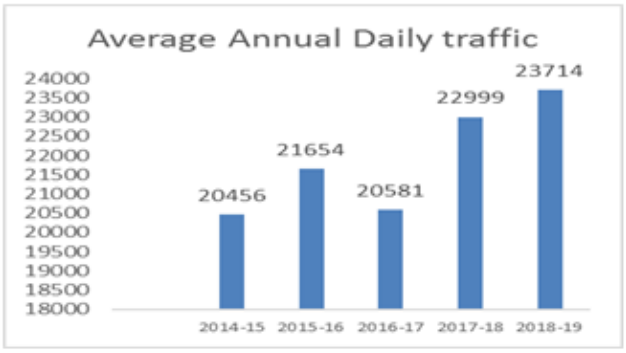

Figure 4 - Trend of AADT data over the years

Source: Office of the PIU Surat (Expressway) NHAI, December 2019

AADT is continuously increasing over the years.

D. Access Densit survey

During the field surveying on the stretch, all access points on the median, left-hand side, Right-hand side of the carriageway were observed, and their locations were also noted down. However, it is a toll road, it has 33 median access points, 24 left side access points, and 20 access points on the right-side carriageway, so overall, the stretch is having an access density of 1.28/km. Such access points may result in accidents on the stretch.

E. Spot speed survey

As "Overspeeding" is considered as the major cause of accidents observed in most of the accident cases in India on National Highways, hence spot speed surveys were conducted along with different locations on the toll road. Speed gun" android application was used to measure the spot speed of vehicles on the National Highway. The summary of the spot speeds (kmph) for various vehicles is shown in table 1:

TABLE 1 Descriptive Statistics of Spot Speed (Kmph) Observations for Various Vehicle Categories

Vehicle category-->	Two wheeler	Four wheeler	LCV	Truck	MAV	Bus
Sample size	337	433	292	450	372	69
Mean	53.86	82.64	42.47	48.81	61.00	49.28
Std. Deviation	9.22	10.22	9.08	12.85	11.48	9.54
Variance	85.06	104.38	82.43	165.03	131.80	91.08
Range	37.60	46.00	38.00	58.80	40.00	41.40
Minimum	34.50	63.20	22.40	21.60	39.50	24.00
Maximum	72.10	109.20	60.40	80.40	79.50	65.40
15th Percentile	43.50	73.60	32.40	39.00	47.50	41.60
50th Percentile	55.30	82.50	41.50	49.80	59.70	49.40
85th Percentile	64.10	93.29	52.10	56.60	74.50	59.80

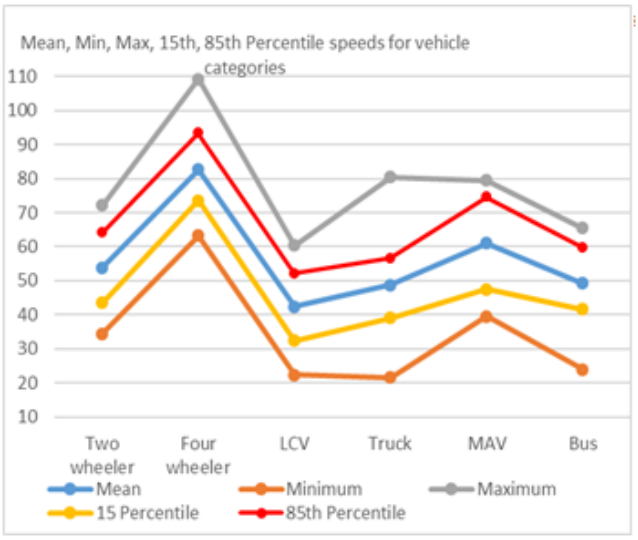

Figure 5: Important statistics of Spot speeds of various vehicles on the stretch

Figure 5 indicates different vehicle categories plying on the National Highway have different speed range, with 4w having the maximum range and truck having the minimum. 85th percentile speed for 4w is maximum in all vehicle categories while the minimum for the LCV category. This heterogeneity in vehicle category and speed characteristics may also influence conflicting movements in the stream, and subsequently, cause accidents.

F. Driver Personal Interview Analysis

The questions were chosen carefully based on the existing literature on drivers' self-reported behavior. The questionnaire was divided into four sections, namely: 1. Driver demographic characteristics, 2. Vehicle-maintenance related information (driver's attitude towards maintaining the vehicle), 3. Drivers' attitude towards following traffic regulations and 4. Driver's review of roadway conditions on the stretch. These Personal Interviews were carried out on the roadside on the toll road near restaurants, petrol pumps, bus lay bays, etc. In the Personal Interview, responses of 52 two-wheelers (2w) drivers, 80 four-wheelers (4w) drivers, 43 Light commercial vehicles (LCV) drivers, 51 bus drivers, and 74 truck drivers were collected. Table 2 shows the percentage of responses related to driver's demographics, vehicle-related information, traffic regulation, and review about the roadway environment.

Table 2: Demographic Information of Drivers

Sr.	Variable	Categories	2w driver	4w driver	LCV driver	Bus driver	Truck driver
1	Gender	Male	100.0	100.0	100.0	100.0	100.0
		Female	0	0	0	0	0
2	Age	12-18	3.8	1.3	0	0	0

	(Years)	19-28	55.8	30.0	30.2	5.9	14.9
		29-38	25.0	35.0	53.5	29.4	44.6
		39-48	11.5	26.3	11.6	37.3	29.7
		49-58	3.8	7.5	4.7	25.5	10.8
		>= 59	0	0	0	2.0	0
3	Educational Qualifications	SSC	17.3	10.0	55.8	64.7	55.4
		HSC	25.0	21.3	34.9	31.4	39.2
		Undergraduate	26.9	13.8	7.0	3.9	2.7
		Graduate	26.9	35.0	2.3		2.7
		Postgraduate	3.8	18.8	0	0	0 0
		Doctorate	0	1.3	0	0	0
4	Valid driving license	Yes	88.5	95.0	83.7	96.1	93.2
		No	5.8	1.3	9.3	3.9	4.1
		Not sure	5.8	3.8	7.0	0	2.7
5	Distance (km) driven since morning	0-100	46.2	11.2	18.6	11.8	2.7
		101-200	28.8	23.8	20.9	3.9	12.2
		201-300	21.2	40.0	46.5	51.0	40.5
		301-400	1.9	22.5	7.0	19.6	24.3
		401+	1.9	2.5	7.0	13.7	20.3
6	Distance (km) yet to be driven	0-100	38.5	21.2	30.2	15.7	14.9
		101-200	38.5	22.5	41.9	21.6	18.9
		201-300	11.5	25.0	14.0	13.7	16.2
		301-400	9.6	18.8	4.7	11.8	12.2
		401+	1.9	12.5	9.3	37.3	37.8
7	Driving experience (years)	0-5	40.4	8.8	20.9	3.9	6.8
		6-10	28.8	37.5	34.9	29.4	31.1
		11-15	25.0	40.0	39.5	51.0	32.4
		16-20	5.8	13.8	4.7	7.8	25.7
		21+	0	0	0	7.8	4.1
8	Break distance in km	≤50	1.9	1.3	0	3.9	1.4
		51-100	26.9	17.5	11.6	15.7	6.8
		101-150	42.3	27.5	51.2	37.3	28.4
		151-200	25.0	46.3	32.6	31.4	51.4
		201+	3.8	7.5	4.7	11.8	12.2
9	Continuous driving hours	0-2	7.7	3.8	4.7	0	1.4
		3-5	53.8	47.5	51.2	35.3	36.5
		6-8	26.9	33.8	34.9	25.5	36.5
		9-11	9.6	15.0	7.0	23.5	13.5
		12+	1.9		2.3	15.7	12.2
						17.6	
10	Drunken condition	Yes	13.5	5.0	11.6		9.5
		No	63.5	57.5	72.1	41.2	56.8
		Not sure	23.1	37.5	16.3	41.2	33.8
11	No. of times met with an accident	≤2	36.5	15.0	23.3	15.7	14.9
		3-6	32.7	35.0	44.2	31.4	27.0
		7-10	25.0	40.0	20.9	23.5	29.7
		11+	5.8	10.0	11.6	29.4	28.4

The results of the demographics of drivers obtained through the Personal Interview are as follows:

Regarding gender, all the respondents on the highway were male. Truck and bus drivers are predominantly in the 29-48 age group, the majority of LCV drivers in the 29-38 age group, while 4w drivers in the 19-48 age group and 2w drivers predominantly in the 19-28 age group. LCV, truck, and bus drivers are least educated, having SSC, HSC qualification only, while 4w drivers possess the highest qualifications of Doctorate, Postgraduate, and 2w drivers having undergraduate and graduate degrees. 96.1% bus drivers, 95.0% 4w drivers, 93.2% truck drivers, 88.5% 2w drivers, and 83.7% LCV drivers having a valid driving license. 51.0% bus drivers, 46.5% LCV drivers, 40.5% truck drivers, and 40.0% 4w drivers had driven 201-300km since morning. 37.8% truck drivers and 37.3% bus drivers had responded to drive more than 400km, while 41.9% LCV drivers and 22.5% 4w drivers had responded to drive 101-200km further. 51.0% bus drivers, 40.0% 4w drivers, 39.5% LCV drivers, and 32.4% truck drivers were having experience in the range of 11-15 years, while 40.4% 2w drivers had driving experience up to 5 years.

51.20% LCV drivers, 42.3% 2w drivers, 37.3% bus drivers, 28.4% truck drivers, 27.5% 4w drivers take breaks at a 101150km distance, while 51.4% truck drivers, 46.3% 4w drivers, 32.6% LCV drivers, 31.4% bus drivers, 25% 2w drivers, take breaks at a 151-200km distance. 53.8% 2w drivers, 51.20% LCV drivers, 47.5% 4w drivers, 36.5% truck drivers, 35.3% bus drivers take breaks at 3-5-hour interval. 17.6% bus drivers, 13.5% 2w drivers, 11.6% LCV drivers, 9.5% truck drivers, 5.0% 4w drivers were driving the vehicle in a drunken condition. 32.7% 2w drivers, 44.20% LCV drivers, 35.0% 4w drivers, 27.0% truck drivers, 31.4% bus drivers had met with an accident in the range of 3-6 times in their driving 4weer, while 25.0% 2w drivers, 40.0% 4w drivers, 29.7% truck drivers had met with an accident in the range of 7-10 times in their driving career.

Table 3: Driver's Responses To Vehicle-Related information

Sr.	Variable	Categories	2w driver	4w driver	LCV driver	Bus driver	Truck driver
1	Age of vehicle (Years)	0-4	5.8	5.0	2.3	2.0	5.4
		5-9	30.8	30.0	30.2	27.5	20.3
		10-14	26.9	20.0	32.6	23.5	41.9
		15-19	30.8	36.3	34.9	37.3	21.6
		20-24	3.8	7.5	0	7.8	4.1
		25+	1.9	1.3	0	2.0	6.8
2	Age of tires (months)	0-6	5.8	7.5	7.0	3.9	6.8
		7-12	30.8	28.8	23.3	27.5	25.7
		13-24	40.4	30.0	30.2	29.4	17.6
		25-36	19.2	27.5	34.9	21.6	37.8
		37+	3.8	6.3	4.7	17.6	12.2
3	Availability of valid insurance policy of the vehicle	Yes	57.7	75.0	65.1	64.7	64.9
		No	7.7	1.3	7.0	7.8	4.1
		Not sure	34.6	23.8	27.9	27.5	31.1
4	Frequency of service (Months)	0-3	3.8	3.8	7.0	2.0	2.7
		4-6	40.4	25.0	23.3	15.7	20.3
		7-9	46.2	45.0	65.1	39.2	45.9
		10-12	7.7	20.0	4.7	35.3	24.3

		13+	1.9	6.3	0	7.8	6.8
5	Working of sidelights, headlight, brake lights, and dipper	Yes	67.3	72.5	65.1	70.6	60.8
		No	1.9	3.8	4.7	2.0	8.1
		Not sure	30.8	23.8	30.2	27.5	31.1
6	Dents (ghoba-damages) on the vehicle	Yes	23.1	43.8	48.8	52.9	36.5
		No	76.9	56.3	51.2	47.1	63.5
7	All Mirrors availability	Yes	98.1	98.8	100.0	100.0	100.0
		No	1.9	1.3	0	0	0
8	Vehicle Speed (kmph) on the toll road	≤40	0	1.3	11.6	2.0	12.2
		41-60	51.9	20.0	37.2	17.6	33.8
		61-80	46.2	65.0	48.8	68.6	48.6
		81-100	1.9	12.5	0	11.8	4.1
		>100	0	1.3	2.3		01.4
9	Travel time ra minutes	25-30	0	0	0	2.0	1.4
		31-35	1.9	0	0	3.9	1.4
		36-40	0	3.8	2.3	0	1.4
		41-45	3.8	7.5	4.7	5.9	4.1
		46-50	3.8	8.8	14.0	9.8	4.1
		51+	90.4	80.0	79.1	78.4	87.8

The results of the driver's vehicle-related information obtained through the Personal Interview are as follows: 30.8% 2w drivers, 34.9% LCV drivers, 36.3% 4w drivers, 21.6% truck drivers, 37.30% bus drivers were having 15-19 years old vehicles, while 41.9% truck drivers, 32.6% LCV drivers were having 10-14 years old vehicles. 40.4% 2w drivers, 30.0% 4w drivers, 30.2% LCV drivers, 17.6% truck drivers, 29.40% bus drivers were having 13-24 months old tires in their vehicles, while 37.8% truck drivers, 34.9% LCV drivers, and 27.5% 4w drivers were having 25-36 months old tires in their vehicles. 7.7% 2w drivers, 1.3% 4w drivers, 7.8% bus drivers, 7% LCV drivers, 4.1% truck drivers were not having valid insurance policy of the vehicles. 46.2% 2w drivers, 45% 4w drivers, 39.2% bus drivers, 65.1% LCV drivers, 45.9% truck drivers were getting their vehicle service at an interval of 6-9 months. 1.9% 2w drivers, 3.8% 4w drivers, 2% bus drivers, 4.7% LCV drivers, 8.1% truck drivers were not having sidelights, headlight, brake lights, and dipper working properly in the vehicle. 23.1% 2w drivers, 43.8% 4w drivers, 52.9% bus drivers, 48.8% LCV drivers, 36.5% truck drivers were having dents (ghoba-damages) on their vehicles. Only 1.9% 2w drivers,1.3% 4w drivers were not having all mirrors on their vehicles. 51.9% 2w drivers, 20% 4w drivers, 17.6% bus drivers, 37.2% LCV drivers, 33.8% truck drivers drive their vehicle at 41-60 kmph speed range on the highway, while 46.2% 2w drivers, 65% 4w drivers, 68.6% bus drivers, 48.8% LCV drivers, 48.6% truck drivers drive their vehicle at 61-80kmph speed range on the highway. 90.4% 2w drivers, 80% 4w drivers, 78.4% bus drivers, 79.1% LCV drivers,
87.8% truck drivers had usual travel time 51+ minutes between the Surat and Bharuch section of the toll road.

TABLE 4: Driver's Responses to Regulation, Enforcement & Management Devices

Sr.	Variable	Categories	2w driver	4w driver	LCV driver	Bus driver	Truck driver
1	Lane preference	Edge lane	88.5	36.3	55.8	19.6	58.1
		Middle	0	0	0	0	0
		Median lane	11.5	63.8	44.2	80.4	41.9
2	Use of hand signals (by the driver) while driving in the daytime	Never	0	1.3	0	3.9	1.4
		Rarely	5.8	2.5	9.3	7.8	8.1
		Sometimes	46.2	20.0	32.6	17.6	13.5
		Most of the times	17.3	32.5	11.6	31.4	31.1
		Always	30.8	43.8	46.5	39.2	45.9
3	Use sidelights, headlight, and dipper while driving during nighttime	Never	0	0	0	2.0	1.4
		Rarely	11.5	6.3	2.3	5.9	4.1
		Sometimes	9.6	18.8	16.3	11.8	14.9
		Most of the times	28.8	26.3	32.6	15.7	41.9
		Always	50.0	48.8	48.8	64.7	37.8
4	Use of Mirrors while overtaking maneuvers	Never	0	0	0	0	1.4
		Rarely	7.7	7.5	7.0	13.7	4.1
		Sometimes	13.5	15.0	4.7	9.8	21.6
		Most of the times	40.4	27.5	39.5	35.3	37.8
		Always	38.5	50.0	48.8	41.2	35.1
5	Wrong si overtaking maneuvers	Never	11.5	5.0	7.0	11.8	4.1
		Rarely	32.7	26.3	27.9	29.4	28.4
		Sometimes	46.2	56.3	58.1	51.0	55.4
		Most of the times	5.8	10.0	2.3	3.9	6.8
		Always	3.8	2.5	4.7	3.9	5.4
6	Wrong side driving to reduce the length of the trip	Never	5.8	2.5	9.3	7.8	10.8
		Rarely	28.8	28.8	46.5	35.3	36.5
		Sometimes	44.2	43.8	30.2	39.2	32.4
		Most of the times	9.6	16.3	11.6	11.8	16.2
		Always	11.5	8.8	2.3	5.9	4.1
7	% of times driving in median lane on the toll road	0-20	34.6	5.0	14.0	3.9	17.6
		21-40	46.2	16.3	32.6	15.7	31.1
		41-60	11.5	27.5	27.9	21.6	21.6
		61-80	3.8	41.3	20.9	54.9	27.0
		81-100	3.8	10.0	4.7	3.9	2.7

The results of the driver's responses to regulation, enforcement, and management devices obtained through the Personal Interview are as follows:

The majority of all drivers prefer the median lane for driving; however, the edge lane must be preferred by comparatively slow-moving Trucks, buses, and 2w. 11.5% 2w drivers, 63.8% 4w drivers, 80.4% bus drivers, 44.2% LCV drivers, 41.9% truck drivers prefer median lane for driving on the highway. 30.8% 2w drivers, 43.8% 4w drivers, 39.2% bus drivers, 46.5% LCV drivers, 45.9% of truck drivers always use hand signals (Driver) while driving the vehicle in the day time. 50.0% 2w drivers, 48.8% 4w drivers, 64.7% bus drivers,

48.8% LCV drivers, 37.8% of truck drivers always use sidelights, headlight, and dipper while driving during NIGHT time. 38.5% 2w drivers, 50.0% 4w drivers, 41.2% bus drivers, 48.8% LCV drivers, 35.1% of truck drivers always use mirrors while overtaking maneuvers on highways. 11.5% 2w drivers, 5.0% 4w drivers, 11.8% bus drivers, 7.0% LCV drivers, 4.1% truck drivers never drive on the wrong side to reduce the length of the trip on the highway. 3.8% 2w drivers, 41.3% 4w drivers, 54.9% bus drivers, 20.9% LCV drivers, 27.0% truck drivers drive for 61-80% of the time on the median lane on the highway.

Table 5: Driver's Responses To The Roadway Environment

Sr.	Variable	Categories	2w driver	4w driver	LCV driver	Bus driver	Truck driver
1	Feeling that pavement is not properly maintained	Never	9.6	16.3	20.9	21.6	20.3
		Rarely	26.9	40.0	41.9	27.5	29.7
		Sometimes	44.2	32.5	30.2	43.1	35.1
		Most of the times	17.3	11.3	2.3	7.8	14.9
		Always	1.9	0	4.7	0	0
2	Feeling that signals are not properly located and maintained at intersections	Never	17.3	16.3	16.3	15.7	18.9
		Rarely	30.8	32.5	39.5	29.4	33.8
		Sometimes	40.4	37.5	37.2	45.1	36.5
		Most of the times	7.7	11.3	7.0	7.8	10.8
		Always	3.8	2.5	0	2.0	0
3	Feeling that the no safe crossing points are provided on highways	Never	25.0	18.8	14.0	21.6	17.6
		Rarely	23.1	22.5	37.2	37.3	37.8
		Sometimes	40.4	43.8	46.5	33.3	41.9
		Most of the times	7.7	15.0	2.3	7.8	2.7
		Always	3.8	0	0	0	0
4	Feeling that the roadside accident prevention infrastructure is not proper	Never	34.6	23.8	25.6	27.5	23.0
		Rarely	25.0	33.8	34.9	29.4	32.4
		Sometimes	21.2	28.8	18.6	31.4	25.7
		Most of the times	17.3	13.8	20.9	11.8	17.6
		Always	1.9	0	0	0	1.4
5	Feeling the road signs & markings are not proper	Never	38.5	26.3	23.3	25.5	29.7
		Rarely	34.6	32.5	37.2	41.2	43.2
		Sometimes	19.2	28.8	34.9	27.5	24.3
		Most of the times	7.7	11.3	4.7	5.9	2.7
		Always	0	1.3	0	0	
6	Use of mob phones while driving	Never	21.2	21.3	14.0	21.6	25.7
		Rarely	28.8	32.5	30.2	37.3	21.6
		Sometimes	46.2	41.3	48.8	35.3	47.3
		Most of the times	3.8	3.8	7.0	3.9	5.4
		Always	0	1.3	0	2.0	0
7	Feeling disturbance due to other vehicles	Never	17.3	15.0	16.3	21.6	17.6
		Rarely	32.7	26.3	27.9	25.5	39.2
		Sometimes	38.5	41.3	46.5	43.1	40.5
		Most of the times	9.6	16.3	9.3	7.8	1.4
		Always	1.9	1.3	0	2.0	1.4
8	Suffering from Road rage while driving	Never	26.9	26.3	25.6	23.5	21.6
		Rarely	30.8	26.3	23.3	31.4	17.6
		Sometimes	25.0	27.5	32.6	37.3	43.2
		Most of the times	15.4	17.5	14.0	5.9	16.2
		Always	1.9	2.5	4.7	2.0	1.4
9	Driving behav type	Never safe	0	2.5	0	2.0	0
		Rarely safe	1.9	0	4.7	3.9	5.4
		Sometimes safe	13.5	12.5	4.7	7.8	16.2
		Most of the times safe	57.7	42.5	46.5	45.1	52.7
		Always safe	26.9	42.5	44.2	41.2	25.7

The results of Driver's Review about road conditions obtained through the Personal Interview are as follows:

9.6% 2w drivers, 16.3% 4w drivers, 21.6% bus drivers, 20.9% LCV drivers, 20.3% of truck drivers never felt that pavement is not properly maintained on highways. 17.3% 2w drivers,

16.3% 4w drivers, 15.7% bus drivers, 16.3% LCV drivers, 18.9% truck drivers never felt that the signals are not properly located and maintained at intersections on the highway. 25.0% 2w drivers, 18.8% 4w drivers, 21.6% bus drivers, 14.0% LCV drivers, 17.6% truck drivers never felt that that the no safe crossing points are provided on highways. 34.6% of 2w drivers, 23.8% of 4w drivers, 27.5% of bus drivers, 25.6% of LCV drivers, 23.0% of truck drivers never felt that the roadside accident prevention infrastructure is not proper on the highway. 38.5% of 2w drivers, 26.3% of 4w drivers, 25.5% of bus drivers, 23.3% of LCV drivers, 29.7% of truck drivers never felt that the road markings are not proper on the highway. 21.2% of 2w drivers, 21.3% of 4w drivers, 21.6% of bus drivers, 14.0% of LCV drivers, 25.7% of truck drivers never use mobile phones while driving on the highway. 17.3% 2w drivers, 15.0% 4w drivers, 21.6% bus drivers, 16.3% LCV drivers, 17.6% of truck drivers never feel disturbance due to other vehicles on the highway. 26.9% 2w drivers, 26.3% 4w drivers, 23.5% of bus drivers, 25.6% of LCV drivers, 21.6% of truck drivers never suffer from Road rage while driving on the highway. 26.9% 2w drivers, 42.5% of 4w drivers, 41.2% bus drivers, 44.2% of LCV drivers, 25.7% of truck drivers consider themselves as always safe regarding their driving behavior.

G. Audit of drivers through videography

As vehicle driver is the main cause responsible for accident causation, it was felt necessary to carry out an audit of drivers' turning movements, lane discipline behavior, etc. on

the field by the floating car method. Hardly any research paper is available for in-field drivers' audit. Many researchers have analyzed Driver Behaviour questionnaires, but it is not justifiable to rely on these results due to biasedness in the design of questionnaire drafting and the biasedness in the responses from drivers. Hardly any researcher has conducted an in-field audit for drivers' movements to judge the actual field driver behavior. So, a new approach/ methodology for conducting drivers' audit has been suggested for determining risky driver movements along with the flow of traffic. In this approach, videography recording of the flow of traffic was done in a floating car at different times of the day on the stretch.

The video recordings were studied in detail and frame by frame; the behavior of each vehicle passing through the frame was noted.

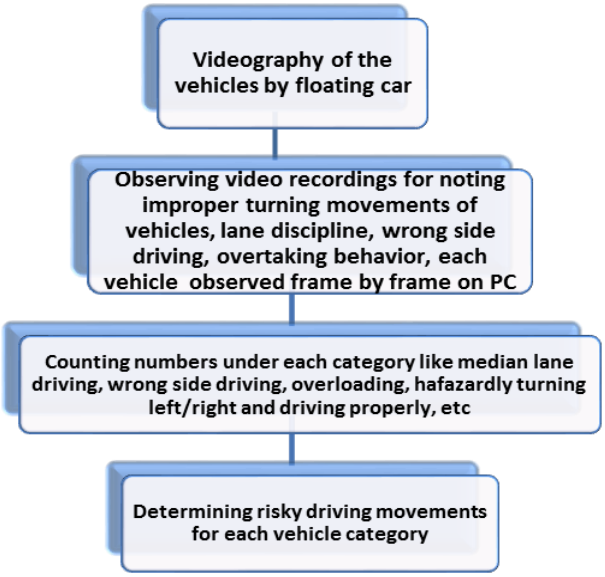

Figure 6: Methodology for Videographic audit of drivers' risky driving behavior

a. Trucks moving on the median lane, fast-moving cars overtaking the trucks from the wrong side

b. Overloaded truck moving in the middle lane

Figure 7: Typical Risky driving behavior movements captured in the frame

Some typical improper vehicle movements taken by the drivers are shown in figure 7.

The video recordings were studied in detail and frame by frame, the behavior of each vehicle passing through the frame was noted, and several risky driving movements were noted down for predominant vehicle category drivers, namely 2w, 4w, LCV, MAV, Bus, and truck and summarized in a tabular manner and summarized in Table 6.

Table 6: Results of Risky Driving Movements Observed In Videography

Sample No. →	1	2	3	4	5	6	7	8	9	10	Average
Overall vehicle Total, Numbers (In the sample)	71	83	66	55	76	79	81	76	64	60	71.00
Share of Truck in vehicle composition, %	16.9	28.9	18.2	3.6	13.2	12.7	8.6	10.5	4.7	10.0	12.7
Share of MAV in vehicle composition, %	8.5	9.6	18.2	16.4	17.1	21.5	19.8	11.8	20.3	18.3	16.1
Share of Bus in vehicle composition, %	1.4	4.8	6.1	7.3	1.3	1.3	1.2	3.9	3.1	3.3	3.4
Share of 2w in vehicle composition, %	33.8	28.9	12.1	21.8	19.7	13.9	19.8	27.6	37.5	25.0	24.0
Share of 4w in vehicle composition, %	28.2	21.7	37.9	49.1	42.1	48.1	48.1	28.9	26.6	33.3	36.4
Share of LCV in vehicle composition, %	11.3	6.0	7.6	1.8	6.6	2.5	2.5	17.1	7.8	10.0	7.3
Median lane driving (Truck), %	40.0	21.7	0.0	87.5	0.0	30.0	14.3	50.0	33.3	50.0	32.7
Median lane driving (MAV), %	88.9	42.9	66.7	87.5	16.7	52.9	50.0	44.4	38.5	54.5	54.3
Median lane driving (Bus), %	75.0	75.0	75.0	75.0	100.0	100.0	100.0	66.7	0.0	50.0	71.7
Median lane driving (2w), %	21.7	4.2	22.2	16.7	0.0	0.0	0.0	4.8	20.8	6.7	9.7
Median lane driving (4w), %	35.5	23.3	28.0	52.0	18.8	43.2	48.7	47.6	39.1	30.0	36.6

% Trucks running properly	75.0	87.5	75.0	50.0	70.0	90.0	57.1	100.0	33.3	100.0	73.8
% MAV running properly	83.3	87.5	83.3	88.9	84.6	88.2	75.0	88.9	76.9	90.9	84.8
% 2w running properly	87.5	79.2	62.5	58.3	33.3	54.5	68.8	81.0	83.3	46.7	65.5
% 4w running properly	80.0	77.8	88.0	92.6	90.6	97.4	92.3	90.9	88.2	80.0	87.8
The weighted average for all vehicles running safely for sample, %	78.9	84.3	81.8	83.6	75.0	88.6	81.5	84.2	82.8	78.3	81.9

The following points are deduced from the results of the infield audit of drivers:

32.70% truck drivers and **54.3%** MAV drivers are driving the truck on median lanes, which creates interference to other fast-moving vehicles such as 4w on the National Highway; instead, they must drive on the edge lane. **36.6%** of 4w drivers are driving on median lanes. As the National Highway passes through the number of villages and industries, so village people, particularly using 2w (share was found as 24% in traffic composition), and in that **9.7%** of 2w drivers are driving on the median lane that indicates good traffic regulation behavior by 2w drivers. Overall, on average, 81.9% of vehicles were running safely in the existing videography samples.

Results

The final dataset obtained from this study consisted of several types of variables regarding driver characteristics, parameters extracted from the questionnaire as well as parameters extracted from the in-field audit videography for driving movements.

From the accident records obtained through the PIU-Surat, due to the improvement of the blackspots, there is a decreasing trend observed in the number of fatal and grievous injury accidents, which indicate the positive effect of blackspot improvements by NHAI.

The access density found out for the stretch as 1.28/km, which increase conflicting movements at access points by the turning vehicles and subsequently cause accidents.

In India, driving under drunken condition is prohibited. However, around 5-18% of drivers were driving in the drunken condition at the time of the Personal Interview.

From the Personal Interview, it can be concluded that the majority of truck drivers are least educated with a qualification up to HSC (high school) only. In response to valid driving license, 4.10% of truck drivers, 9.3% LCV drivers did not have a valid driving license at the time of the Personal Interview; however, they are not eligible to drive the vehicle on the roads.

Truck and Bus drivers were having majority old vehicles (more than ten years old) and having more than two years old tires in their vehicle, which indicates the poor condition of trucks and buses running on highways. Major commercial vehicle drivers reported dents on their vehicles. 51.9% 2w drivers, 20% 4w drivers, 17.6% bus drivers, 37.2% LCV drivers, 33.8% truck drivers drive their vehicle at 41-60 kmph speed range on the highway, while 46.2% 2w drivers, 65% 4w drivers, 68.6% bus drivers, 48.8% LCV drivers, 48.6% truck drivers drive their vehicle at 61-80kmph speed range on the highway. While the result of the spot speed survey indicates 85th percentile speed values as 93.29 kmph for 4w, 64.1 kmph for 2w, 52.1 kmph for LCV, 56.6kmph for truck, 59.8 kmph for Bus, 74.5 kmph for MAV.

The majority of all commercial drivers reported a preference of median lane for driving; however, but edge lane must be preferred by comparatively slow-moving trucks, MAV, and LCV. The majority of all drivers were using hand signals in the daytime while using sidelights, headlight, and dipper while driving during night time. Most of the drivers were using mirrors while overtaking maneuvers, and very few drivers reported for wrong side driving and overtaking behavior, which indicates good practice by the urban expressway drivers for road safety.

Very few drivers responded negatively for the availability of proper pavement maintenance, proper signal location and maintenance, proper roadside accident prevention infrastructure, and proper road signs and markings. Very few drivers used mobile phones while driving and felt disturbance due to other vehicles while driving on the stretch. 26.9% 2w drivers, 42.5% 4w drivers, 41.2% bus drivers, 44.2% LCV drivers, 25.7% truck drivers consider themselves as always safe regarding their driving behavior, while 65.5% 2w drivers, 87.8% 4w drivers, 87.15% LCV drivers, 73.8% truck drivers were driving properly on the stretch when observed through videographic audit.

Conclusions

Under heterogeneous traffic conditions on NHs, all different vehicles move at different speeds with different speed ranges, which can be deduced from the spot speed survey. Variations in speeds of different vehicles also cause frequent overtaking maneuvers and lane changes and which may subsequently lead to accidents.

Access points increase possible conflicting movements on the stretch.

The administration needs to take strict action against the drivers without valid licenses, who are driving the vehicles and endangering their lives as well as other road users. Heavy commercial vehicle drive on the median lane, which create hindrance to other fast-moving lighter vehicles like cars and cause interference to other vehicles while maneuvers.

From the Videographic driver's audit study, it can be concluded that 18.1% of the drivers are moving their vehicles with risk and don't follow proper traffic rules and regulations while driving. 32.70% truck drivers and 54.3% MAV drivers are driving on median lanes, which create interference to other fast-moving vehicles such as 4w on the National Highway; instead, they must drive on edge lane. 36.6% of 4w drivers are driving on median lanes.

This study was conducted for a 6-lane (3-lanes in both directions) divided multi-lane high-speed urban highway. Such a study can also be applied to other NH stretches in developing countries like India to decide the number of risky driving movements by drivers and their attitude

towards road safety in maintaining their vehicle, attitude towards traffic rules and regulations on highways, attitude towards road infrastructure.

Such a study might help the Traffic administration/ traffic police to capture such risky behavior of the drivers and take suitable measures to reduce such risky movements by risky drivers and consequently help in reducing accidents. However, the drivers continue their risky behavior at the rest of the places during their ride, endangering their as well other road users' lives. Particularly in developing countries like India, the least risky driver behavior is observed near the installations of CCTVs and traffic police points (police enforcement points) near intersections to avoid penalties. Such a study methodology of videography audit will prove to be useful to the authorities. It may serve as one of the measures to reduce the accidents on Multi-lane highways. While issuing a driving license, only driving skill and judgment is determined in India, while there is no regulation regarding the driver's attitude towards road safety while driving. Such an audit of drivers will help in judging about improvement in the driving behavior after certain enforcement/punishments by the traffic regulation authority.

Recently, the Ministry of Road Transport and Highways, Government of India, has passed the Motor Vehicle (Amendment) Bill 2019 on July 15, 2019, to amend the Motor Vehicles Act, 1988, to enhance road safety in the country. The Act provides for the grant of licenses and permits related to motor vehicles, standards for motor vehicles, and penalties for violation of these provisions, and such enforcement measures may prove to be useful in reducing the accidents in the years to come.

From the study, the major uncontrollable factor which affects the occurrence of the accident is the indiscipline of driver behavior in lane changing, lane following, overtaking maneuvers, wrong side driving, improper parking on roads, etc. Even if the best roads are designed by the administration and from time to time, road safety audits are also being conducted for the improvement of the roads. Still, if the drivers don't behave systematically on the roads, all the efforts of the administration go in vain. If a systematic policy framework is framed for conducting such driver's audits, there are likely chances of reduction of accidents, and a decreasing trend in accidents will be seen in the years to come. The present study will help the researchers and policymakers to make systematic drivers audit to save the resource and control the accidents and saves human life by just making scientific and engineering studies.

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