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Identification of Factors Causing Risky Driving Behavior on High-speed Multi-lane Highways in India Through Principal Component Analysis

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A B S T R A C T

In developing countries like India, Multilane high-speed National Highways (NHs) are victims of high accident rates. The Indian National Highway network comprises only 2% of the Indian road network, but transports 40% of traffic, resulting in traffic accidents on National Highways. As observed from past studies, drivers are the main responsible factors for accident causation due to their risky behavior. Hence, to determine significant factors causing the risky behavior of drivers on multi-lane high-speed highways, the personal interview survey through questionnaire was conducted for the road users of NH-47 comprising of the responses to the drivers' demographics, attitude towards vehicle condition and maintenance, traffic regulations/ enforcement following attitude characteristics, and roadway environment characteristics. Principal component analysis (PCA) was applied to the questionnaire variables, and significant category-wise variables for risky driving were identified. Fifteen important variables contributed to risky driving behavior from the questionnaire database by PCA. They are Roadway environment characteristics like improper signals, roadside accident prevention infrastructure, improper pavement, and no safe crossing points; Driver's age and experience; Using mirrors while overtaking, using lights and dipper during night-time, and using hand signals during daytime; Using helmets and seatbelts while driving and having a valid vehicle insurance policy; age of the vehicles, vehicle service frequency, and lane preference in their decreasing significance based on the questionnaire database. The authorities can take suitable measures to control the significant variables causing risky driving behavior on high speed multi-lane highways and reduce the accidents scenarios on the multilane highways.

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1. INTRODUCTION

In developing countries like India, Multilane National Highways (NHs) are victims of high accidents even after preventive measures. In India, driver error is the leading cause of accidents due to their risk-taking behavior [1]. For one such high-speed stretch, NH-47, the number of accidents has increased by 10.78% since the NH opened in 2014. Hence, to determine significant factors causing the dangerous behavior of drivers on such multi-lane highways, the personal interview survey was conducted for the road users of NH-47 comprising of the responses to the drivers' demographics, attitude towards vehicle condition and maintenance, traffic regulations/ enforcement following attitude characteristics, and roadway environment characteristics.

Questionnaire data are subjected to principal component analysis (PCA) to identify the significant factors that address the variability of risk-driven driving behavior.

In this paper, PCA has been conducted for the questionnaire survey responses, broadly categorized as 1. Driver's characteristics (10 variables) 2. Vehicle-related characteristics (8 variables) 3. Driver's regulation/enforcement following attitude characteristics (4 variables) and 4. Roadway environment review characteristics (5 variables).

Few studies have been undertaken to judge driver behavior by in-field questionnaire surveys and data

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analysis using PCA for heterogeneous traffic circumstances and high-speed multi-lane highways in developing nations like India. Compared to previous questionnaire-based research, this questionnaire includes extra questions such as the driver's attitude toward vehicle maintenance. In earlier road safety questionnaire-based research, such parameters were rarely considered. As a result, it was necessary to investigate NH-47, a multi-lane high-speed highway stretch. The researchers could identify several key characteristics contributing to unsafe driving behavior through PCA. Authorities can act appropriately to regulate these significant elements and limit the number of accidents and fatalities on multi-lane highways.

2. LITERATURE REVIEW

Road traffic deaths and injuries are important global public health issues, attracting increasing attention [2].

Because one part of sustainable transportation is safety, the elasticity of road accident variables concerning demographic, economic, and transportation supply factors across time were constructed and analyzed. A composite road safety sustainability index was proposed based on the established elasticities. According to the assessment of road accidents for Asia Pacific countries, road accidents have constituted a looming public safety concern for the area. The study found that the severity of the road accident problem differed significantly among countries [3].

The Road Safety Development Index (RSDI) was proposed [4], which includes eight road safety dimensions related to the human-vehicle-road-environment-regulation system: traffic risk, personal risk, road user behavior, socio-economic background, vehicle safety, road situation, road safety organization, and enforcement. Each dimension contained one or more quantitative indicators, the utility of which was judged based on the data available. To combine the Safety Performance Indicators (SPIs) that correspond to the eight domains indicated above into a composite index, three primary methodologies (objective and subjective) were used: the simple average, the application of theoretical weights, and the PCA (RSDI).

A log-linear model utilized categorical analysis techniques on drivers involved in traffic accidents or regulation infractions to determine the association between reckless driving behavior and influencing elements such as age, marital status, and educational level. The normal reckless driving qualities of drivers were uncovered using PCA in factor analysis [5]. The variations in reactivity between risky driving behavior and driver attributes were compared using odds multipliers from logit models.

The SUNflower technique was used to develop an integrated and comprehensive set of indicators that collaborated with a composite index (the so-called SUNflower Index) to condense the vast amount of data on road safety [6, 7]. The authors classified the indicators into three categories: road safety performance indicators (outcome indicators), implementation performance indicators (process indicators), and policy performance indicators (the quality of national road safety plans). The three categories of indicators were also placed in a policy context in an attempt to add some background variables: a country's structure and culture. Using PCA and Common Factor Analysis (CFA), the fundamental indicators were combined into a composite index, weighting based on statistical models.

The relationship between road safety management and road safety performance was explored [8]. The 'SUNflower' pyramid is a five-level structure that describes road safety management systems: For that reason, (i) structure and culture, (ii) programs and measurements, (iii) 'intermediate' outcomes - safety performance indicators (SPIs), (iv) final outcomes - fatalities and injuries, and (v) social costs were selected. As for road safety performance indicators, they looked at mortality and fatality rates, the percentage reduction in fatalities over time, a composite indicator of road safety outcomes, and a composite indicator of 'intermediate' outcomes (SPIs). According to the findings, road safety management can be represented by three composite indicators: "vision and strategy," "budget, assessment, and reporting," and "measurement of road user attitudes and behaviors." When a statistical association between road safety management and 'intermediate' outcomes was found to affect 'final' outcomes, the SUNflower method to the sequential effect of each layer was confirmed.

Using the driver behaviour questionnaire [9], the authors attempted to identify the factors that influence driving behavior, develop a factor model, identify the role of age, gender, annual kilometers driven, and social status, and investigate the relationship between self-reported driver behavior and self-reported accident involvement and offenses among Czech drivers (DBQ). They used Varimax rotation to run the 50-item DBQ through PCA. They discovered that a three-factor approach to data evaluation is the most effective. The three-factor model could be responsible for 31.75 percent of the total variation.

The relationship between risk perceptions of drivers and potential predictive characteristics was looked into the incidence of texting and driving in Jordan [10]. Data were collected anonymously at several locations using a self-report questionnaire, with 423 drivers participated. The authors employed statistical analysis to demonstrate the relationship between risk levels and the drivers' demographics and exposure factors. Despite being aware of the risks and legal requirements, 93.1 percent of drivers, mostly young male college students, engaged in this dangerous behavior. According to the research, cell phone was used while driving was associated with gender, employment status, age, education level, driving experience, and daily driving distance.

Factor analysis was conducted to identify the major components influencing road traffic crashes with high fatalities [11]. Twenty variables were collected: personnel, vehicles, roads, and the environment. Validity was checked on the significance of their correlations. The most important factors in accidents were fault behavior, driving experience, vehicle purpose, vehicle safety condition, driver, road surface condition, roadside protection facilities, road lighting, and road terrain.

Drivers face difficult road traffic circumstances [12]. Drivers may become aggressive and impatient due to the constant pressure of traffic congestion. As a result, dangerous driving conduct was commonplace in everyday life. They concluded that the mental burden of drivers was a key determinant in unsafe driving behavior.

An attitudinal questionnaire was developed [13] based on Ajzen's Theory of Planned Behavior (TPB) [14]. The findings validated the explanatory utility of the market segmentation approach in comprehensively relating the relationship between attitudes, behaviors, and the socio-demographic characteristics of drivers. The authors concluded that the technique effectively distinguishes between safe and risky drivers and may thus be utilized as the foundation for road safety initiatives.

The impact of socio-demographic and behavioral variables on perceived and aggressive driving behavior varies in size and direction depending on the driver group [15]. The discovery of a relationship between unobserved qualities revealed the complexities of the driving choice mechanism, especially when fundamental drivers of aggressive driving were present.

A study of young student drivers' and riders' views on road safety issues investigated driving practices in hypothetical settings, risk perception, and concerns [16]. The authors discovered that motorcyclists were likelier to break traffic laws than car drivers. The more common risk-taking behaviors among motorcycle riders appear to be a trait of riding a motorcycle rather than a feature of being a motorcycle rider. The study projected that, unlike cars, the structural features of motorcycles allow for dangerous driving behavior. Motorcycles that are smaller and lighter take up less road space. They are more agile and quicker than cars; therefore, they are more direct and responsive.

The relationship between bus driver safety culture and unsafe behavior was investigated [17]. Two questionnaires were used to analyze risky behavior and safety culture among 336 public transportation bus drivers in Tehran, Iran: The Driver Safety Culture Questionnaire (DSCQ) and the Public Transport Driver Behavior Questionnaire (PTDBQ). In addition, a questionnaire was devised to examine socio-demographic factors and the frequency of accidents. The DSCQ and PTDBQ had acceptable psychometric properties. The data shows a negative relationship between accidents, safety culture, and drivers' harmful activities. Accidents and unsafe behaviors were also found to have a positive association. On the other hand, Unsafe behavior significantly mediated the link between safety culture and accidents.

A self-report questionnaire was used to collect demographic information, psychological features, and driving practices from 245 cab drivers [18], while the DBQ was calibrated for the Iranian driver population and investigate their abnormal driving behavior and sample of 524 Iranian drivers [19].

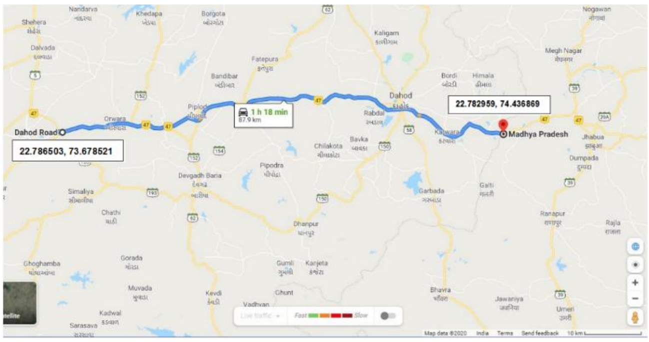
In developing nations like India, few studies have been undertaken to judge driver behavior by in-field questionnaire surveys for heterogeneous traffic circumstances on high-speed multi-lane highways. Hence, a questionnaire was conducted to judge risky driving factors, which included categorized responses to driver characteristics, attitude towards vehicle status and maintenance, traffic rules/regulation compliance and road environment in NHs. In addition, for the questionnaire data, PCA was not used on exclusive multi-lane highways. This questionnaire also includes additional questions such as the driver's attitude toward vehicle upkeep and the regulations attitude being followed by road users. In earlier road safety questionnaire-based research, such parameters were rarely considered. As a result, it was required to conduct research for users of NH-47, a multi-lane high-speed highway segment.

3. METHODS AND DATA

3. 1. Study Area Characteristics The NH-47, one of the country's most important roads, connects Ahmedabad with Indore. It is an important link connecting the major cities of Indore and Ahmedabad with the fertile lands of Gujarat, Rajasthan, and Madhya Pradesh. This is a national road NH-47 from Ahmedabad to Indore. The Godhra bypass is the first of the selected section. On this national highway, the end is the border of Gujarat-MP, as shown in Figure 1. The route covers two regions: the first, PanchMahals, with 1210 villages and 14 percent of the urban population. Second, according to the 2011 Indian Census, Dohad has 696 villages with an urban population of 9%. Due to many communities crossing this national highway, many central access points and adjacent NH access points intersect with residential areas.

3. 2. Accident Data Table 1 shows the annual trend of accidents on the stretch for 2012-2020, compiled from the First Inspection Reports (FIRs) of police

(a) Location of the stretch on the Indian map



(b) The stretch location on Google map

(c) A photograph of the stretch

Figure 1. The selected stretch of NH-47

TABLE 1. Year-wise Accidents for the stretch

Year	Classification of accident					
	Fatal	Grievous Injury	Minor Injury	Non-Injury	Total	Increase in total accidents %
2012	11	22	25	0	58	--
2013	18	6	27	0	51	--
2014	9	32	11	2	54	5.88
2015	26	27	10	5	68	25.93
2016	16	34	11	0	61	-10.29
2017	31	29	12	1	73	19.67
2018	35	32	13	1	81	10.96
2019	39	35	15	2	91	12.35
2020	45	40	14	2	101	10.99
Total	230	257	138	13	638	
Avg. Increase						10.78

3. 3. Access Density On the stretch, access points and their chainage were also noted. However, it is a toll road with 31 middle access points, 41 left side access points, and 53 right side carriageway access points on the stretch; the stretch has an overall access density of 1.36/km, increasing conflicting sites on the stretch.

3. 4. Monthly Annual Daily Traffic (ADT) Data ADT data has continuously increased over the years since the opening of the toll road in 2014.

3. 5. Questionnaire Survey For around two weeks, these surveys were conducted on the side of the toll road near restaurants, gas stations, and bus lay-bys on weekdays from 9 a.m. to 1 p.m. and 3 p.m. to 7 p.m. The questionnaires were filled out on paper by trained persons who interviewed all major vehicle categories' drivers. 43 two-wheeler (2w) drivers, 67 four-wheeler (4w) drivers, 84 bus drivers, and 64 truck drivers were questioned for the questionnaire study.

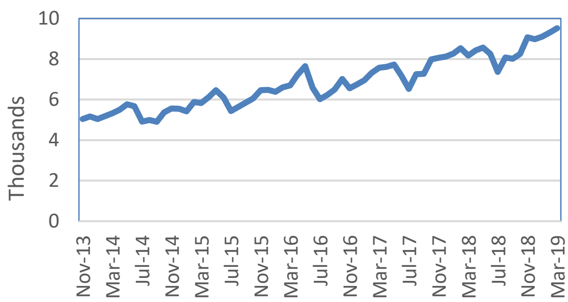


Figure 2. The trend of ADT data over the years
Source: Office of the Manager, Godhra Expressway Limited, Godhra

The responses of all the respondents noted in questionnaire forms were then converted into a tabular form in excel. Each question response was converted on a likert scale from 1-to 7, based on the questionnaire variable data. After this final data set was obtained in excel, PCA was applied through IBM SPSS version 25.

4. PRINCIPAL COMPONENT ANALYSIS (PCA)

Large datasets are becoming more frequent, yet they can be difficult to comprehend [20]. The basic goal of the PCA is to minimize a data set's dimensionality. Many connected variables try to preserve as much diversity as possible in the data collection. The uncorrelated principal components ordered are transformed into a new set of variables to achieve this dimension reduction. The first few keep most of the variation in the original variables while reducing information loss. The concept is straightforward: lower the dimensionality of a dataset while keeping as much 'variability' (i.e., statistical information) as possible. For a positive-semidefinite symmetric matrix, computing the primary components reduces the eigenvalue-eigenvector issue [21].

PCA can be based on either the covariance matrix or the correlation matrix.

Steps in SPSS for conducting PCA:

1. Importing data of questionnaire survey from Excel into SPSS.
2. Analyse > Dimension Reduction > Factor...> Selecting variables> Descriptives - Univariate descriptives - Initial solution - KMO and Bartlett's Test-. Checking whether it is coming more than 0.5, then only proceed for PCA.
3. Extraction > Method -Principal component > Analyse -Correlation matrix; Extract - Based on Eigen value>1>Display - Unrotated factor solution, Scree plot> Maximum iterations for convergence – 25
4. Rotation> Method> Display- Rotated solution
5. Score> Display- factor score coefficient matrix greater than 0.4. Lesser values will be ignored.
6. Options> Missing values> Coefficient Display format- Sorted by size- Suppressing small co-efficient (Absolute value below 0.4).
7. Repeat the steps from 1 to 6 until there are no components matrix values in Negative or no two variables repeated in any Principal component.

In the study methodology for extracting the final essential variables from the questionnaire, the data was first entered in Excel format and converted into a Likert scale from 1-to 7. PCA for the whole questionnaire was done after verifying obtained KMO 0.634>0.5 and extracted Eigenvalues more significant than 1. The steps in SPSS for PCA are repeated until no component's matrix values in negative or no two variables are repeated in any principal component.

4. 1. Data Analysis

There were 27 questions in the questionnaire for which the response was obtained. There were ten questions about the driver's characteristics, eight about vehicle characteristics, four about regulation/enforcement characteristics, and five about roadway environment characteristics. Table 2 shows the questionnaire variable names and section categories of the variables.

TABLE 1. Questionnaire variables' names and categories

Sr.	Variable name	Question	Category
1	Age	Age	Driver personal
2	Gender	Gender	
3	Quali	Educational Qualification	
4	Driving_exp	How much is the driver's driving experience on the highway?	
5	Val_DL	Whether the driver holds a valid driving license?	
6	Helmet_SB	Whether the driver wears the helmet/seat belt?	
7	Drunken_condn	Whether the driver in a drunken condition?	
8	Break_km_range	While driving for longer journeys, how many km do you take breaks if you are tired?	
9	Break_hrs_range	How many hours will you drive continuously for long journeys >80km?	
10	Accident_freq_range	How often have you met with an accident in your driving career until now?	
11	Veh_cat	Vehicle category	Vehicle
12	Age_vehicle	What is the age of the vehicle?	
13	Age_wheels_range	What is the age of the wheels of your vehicle?	
14	All_Mirror_ availability	Whether all Mirrors available on the vehicle?	
15	All_light_availability	Are sidelights, headlights, brake lights, and dipper working correctly? If not mentioned, what is not working?	
16	Veh_service_freq	At what frequency (km or Period of 3 months, six months, or Yearly) do you get your vehicle serviced?	
17	Valid_veh_insur_ policy	Whether you hold a valid insurance policy for the vehicle?	
18	Dents_ availability	Whether any dents (ghoba-damages) on the vehicle? If yes, then how many and their location?	

19	Using_ handsignals_ daytime	How often do you use hand signals (Driver)while driving the vehicle in DAY time?	Regulation/ enforcement
20	Using_lights_dipper_ nightime	How often do you use sidelights, headlights, and dipper while driving the vehicle during night-time?	
21	Using_mirrors_ overtaking	How often do you use Mirrors while overtaking maneuvers?	
22	Lane_preference	Which lane do you prefer for driving?	
23	Feeling_improper_ pavement	How often do you feel that pavement is not maintained correctly?	Roadway environment
24	Feeling_improper_ signals	How often do you feel the signals are not properly located and maintained at intersections?	
25	Feeling_ nosafetypoints	How often do you feel no safe crossing points are provided on highways?	
26	Feeling_roadsideinfra	How often do you feel the roadside accident prevention infrastructure is improper?	
27	Feeling_improper_ markings	How often do you feel the road markings are not proper?	

4. 2. PCA for Road Safety Questionnaire After trial and error, 15 out of 27 items made 6 principal components. They satisfied the cumulative covariance and eigenvalues criteria. Rotation method use was Equamax with Kaiser Normalization.

For the questionnaire's data, the Kaiser-Meyer-Olkin measure of sampling adequacy was found as 0.634, which is more than 0.5, as shown in Table 3. Hence, PCA analysis can be carried out for the questionnaire database.

From PCA, significant variation, i.e., 66.85%, was obtained with the first six principal components. Also, Eigenvalues for these components were more than 1. Hence, the other principal components were ignored for the PCA. The details of cumulative %variance is mentioned in Table 4.

From the scree plot shown in Figure 3, scree was observed near 1.0 Eigenvalue for the first 6 principal components. Hence, only the first six principal components were extracted for PCA. The results of the rotated component matrix are enumerated in Table 5.

TABLE 3. KMO and Bartlett's Test - PCA for Road safety questionnaire

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.634
Bartlett's Test of Sphericity	**Approx. Chi-Square**	810.943
	df	105
	Sig.	0.000

TABLE 4. Total Variance Explained - PCA for Road safety questionnaire

Component	**Initial Eigenvalues**			**Extraction Sums of Squared Loadings**			**Rotation Sums of Squared Loadings**		
	Total	**% of Variance**	**Cumulative %**	**Total**	**% of Variance**	**Cumulative %**	**Total**	**% of Variance**	**Cumulative %**
1	2.51	16.75	16.75	2.51	16.75	16.75	2.46	16.40	16.40
2	2.16	14.41	31.17	2.16	14.41	31.17	2.02	13.45	29.84
3	1.90	12.64	43.81	1.90	12.64	43.81	1.76	11.70	41.54
4	1.30	8.65	52.47	1.30	8.65	52.47	1.33	8.84	50.38
5	1.14	7.61	60.08	1.14	7.61	60.08	1.32	8.81	59.19
6	1.02	6.78	66.85	1.02	6.78	66.85	1.15	7.66	66.85
7	0.81	5.43	72.28						
8	0.78	5.21	77.49						
9	0.70	4.69	82.18						
10	0.59	3.91	86.08						
11	0.55	3.69	89.78						
12	0.50	3.34	93.12						
13	0.43	2.90	96.01						
14	0.39	2.61	98.63						
15	0.21	1.37	100.00						

Extraction Method: Principal Component Analysis.

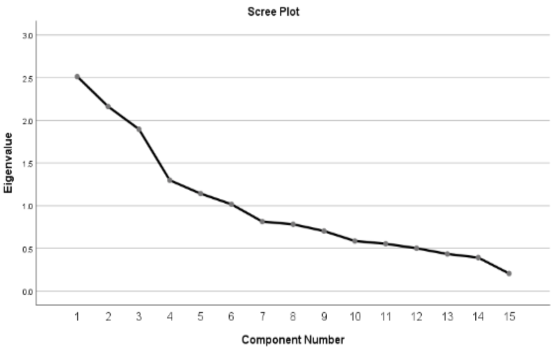


Figure 3. Scree plot - PCA for Road safety questionnaire

5. RESULTS

The final output results – significant contributing factors are given in Table 6:

From PCA, the following points can be deduced:

1. 1st principal component factor is explained by roadway factors like 1. Signal location and maintenance, followed by 2. Roadside accident prevention infrastructure, 3. Pavement maintenance, and 4. No safety crossing points in decreasing order.
2. 2nd principal component factor is explained by two driver personal characteristics factors 1. Driving experience, and 2. Driver's age.

TABLE 5. Rotated component matrix - PCA for Road safety questionnaire

Sr.	Question	Component					
		1	2	3	4	5	6
1.	How often do you feel the signals are not properly located and maintained at intersections?	0.799					
2.	How often do you feel the roadside accident prevention infrastructure is improper?	0.797					
3.	How often do you feel that pavement is not maintained correctly?	0.746					
4.	How often do you feel no safe crossing points are provided on highways?	0.721					
5.	How much is the driver's driving experience on the highway in years?		0.907				
6.	Driver's age in years		0.899				
7.	How often do you use Mirrors while overtaking maneuvers?			0.815			
8.	How often do you use sidelights, headlights, and dipper while driving the vehicle night-time?			0.751			
9.	How often do you use hand signals (Driver) while driving the vehicle in day time?			0.677			
10.	Whether the driver wears a helmet/seat belt?				0.731		
11.	Whether you hold a valid insurance policy for the vehicle?				0.697		
12.	What is the age of the wheels of your vehicle?					0.707	
13.	At what frequency (km or Period of 3 months, six months, or Yearly) do you get your vehicle serviced					0.665	
14.	Which lane do you prefer for driving?					0.521	
15.	Whether the driver holds a valid driving license?						0.877

TABLE 6. Output interpretation of PCA for Questionnaire

Significance Level	Variable	Factor section in the Questionnaire
1	Feeling_improper_signals Feeling_roadsideinfra Feeling_improper_pavement Feeling_nosafetypoints	Roadway Environment
2	Driving_exp Age	Driver personal
3	Using_mirrors_overtaking Using_lights_dipper_nightime Using_handsignals_daytime	Regulation/ enforcement
4	Helmet_SB Valid_veh_insur_policy	Driver personal Vehicle
5	Age_vehicle Veh_service_freq Lane_preference	Vehicle Vehicle Regulation/ enforcement
6	Val_DL	Driver personal

3. 3rd principal component factor is explained by three regulation/enforcement factors 1. Use of mirrors while overtaking maneuvers 2. Use of sidelights, headlight, and dipper while driving the vehicle during night-time 3. Use of hand signals (Driver)

while driving the vehicle in the daytime in decreasing order.

4 4th principal component is explained by one driver's factor, helmet/seatbelt wearing, and the second vehicle factor, namely holding a valid vehicle insurance policy in decreasing order.

5 5th principal component is explained by two-vehicle factors, namely the age of wheels, vehicle service frequency, and one regulation/enforcement factor named lane preference.

6 6th principal component is explained by the driver's factor, namely holding a valid driving license.

Overall, Roadway environment characteristics namely improper signals, roadside accident prevention infrastructure, improper pavement, and no safe crossing points together show 16.40% of the variance of the questionnaire database, which is the maximum of six significant principal components. Driver's age and experience contribute 13.45% variance in the questionnaire database. Using mirrors while overtaking, using lights and dipper during night-time, and using hand signals during daytime constitute an 11.70% variance of the questionnaire database. Using helmets and seatbelts while driving and having a valid vehicle insurance policy contributes to an 8.84% variance in the database. Age of the vehicles, vehicle service frequency, and lane preference combinedly constitute an 8.81% variance in the database. Holding of valid driving license contributes to a 7.66% variance in the questionnaire database.

6. CONCLUSION

Driver's fault is the main factor for accident causation due to their risky behavior (1). Questionnaire survey by personal interview is conducted on a high- speed multi-lane highway stretch NH-47 to determine significant factors responsible for drivers' risky behavior on multi-lane NHs. The interview questionnaire comprised of the questions related to the drivers' demographics, attitude towards vehicle condition and maintenance, traffic regulations/ enforcement following attitude characteristics, and roadway environment characteristics of the NH. Principal component analysis (PCA) is applied to the questionnaire database, and significant category-wise variables for risky driving are identified.

The most significant variables from the principal component analysis for the highway are Roadway environment characteristics namely improper signals, roadside accident prevention infrastructure, improper pavement, and no safe crossing points; Driver's age and experience; Using mirrors while overtaking, using lights and dipper during night-time, and using hand signals during daytime; Using helmets and seatbelts while driving and having a valid vehicle insurance policy; age of the vehicles, vehicle service frequency, and lane preference in their decreasing significance based on the questionnaire database.

The authorities can take suitable measures to control the significant variables causing risky driving behavior, mainly roadway environment for the highway under consideration, followed by driver's attitude towards enforcement/ regulation, driver's attitude toward proper upkeep of the vehicle on National highways and reduce the number of accidents and fatalities scenarios on the high-speed multi-lane highways.

Similar studies may be further conducted on other rural and urban high-speed multi-lane highway stretches with greater sample sizes. Comparisons can be made for significant factors responsible for risky driving behavior under different traffic, vehicle composition, vehicle condition and demographics of the road users of the multi-lane high-speed highways.

7. REFERENCES

1. Singh, S. K. "Road Traffic Accidents in India: Issues and Challenges." ***Transportation Research Procedia***, Vol. 25, (2017), 4708-4719. https://doi.org/10.1016/j.trpro.2017.05.484
2. Wei, Z. "Effects of deceleration on secondary collisions between adult occupants and vehicle in frontal crash accidents." ***International Journal of Engineering, Transactions B: Applications***, Vol. 34, No. 12, (2021), 2658-2664. https://doi.org/10.5829/IJE.2021.34.12C.11
3. Vaziri, M. "A comparative appraisal of roadway accident for Asia-Pacific countries." ***International Journal of Engineering, Transactions A: Basics***, Vol. 23, No. 2, (2010), 111-126.
4. Al Haji, G. *Towards a road safety development index (RSDI)*. ***Development of an international index to*** measure road safety performance." PhD diss., Linköping University Electronic Press, 2005.
5. Jang, T. Y. "Analysis on reckless driving behavior by log-linear model." ***KSCE Journal of Civil Engineering***, Vol. 10, No. 4, (2006), 297-303. https://doi.org/10.1007/bf02830784
6. Wegman, F., and Oppe, S. "Benchmarking road safety performances of countries." ***Safety Science***, Vol. 48, No. 9, (2010), 1203-1211. https://doi.org/10.1016/j.ssci.2010.02.003
7. Wegman, F., Aarts, L., and Bax, C. "Advancing sustainable safety. National road safety outlook for The Netherlands for 2005-2020." ***Safety Science***, Vol. 46, No. 2, (2008), 323-343. https://doi.org/10.1016/j.ssci.2007.06.013
8. Papadimitriou, E., and Yannis, G. "Is road safety management linked to road safety performance?" ***Accident Analysis & Prevention***, Vol. 59, (2013), 593-603. https://doi.org/10.1016/j.aap.2013.07.015
9. Sucha, M., Sramkova, L., and Risser, R. "The Manchester driver behaviour questionnaire: self-reports of aberrant behaviour among Czech drivers." ***European Transport Research Review***, Vol. 6, No. 4, (2014), 493-502. https://doi.org/10.1007/s12544-014-0147-z
10. Ismeik, M., Al-Kaisy, A., and Al-Ansari, K. "Perceived risk of phoning while driving: A case study from Jordan." ***Safety Science***, Vol. 78, (2015), 1-10. https://doi.org/10.1016/j.ssci.2015.02.011
11. Chen, T., Zhang, C., and Xu, L. "Factor analysis of fatal road traffic crashes with massive casualties in China." ***Advances in***

Mechanical Engineering, Vol. 8, No. 4, (2016), 1-11. https://doi.org/10.1177/1687814016642712

12. Qin, X., Shen, Z., and Wehbe, N. "Predicting collision risk between trucks and interstate overpasses." ***Journal of Transportation Engineering***, Vol. 142, No. 8, (2016), 04016026. https://doi.org/10.1061/(ASCE)TE.1943-5436.0000848
13. Batool, Z., and Carsten, O. "Attitudinal segmentaion of drivers in Pakistan: The potential for effective road safety campaigns." ***Accident Analysis and Prevention***, Vol. 114, No. February, (2018), 48-54. https://doi.org/10.1016/j.aap.2017.05.027
14. Ajzen, I. "The Theory of Planned Behavior." ***Organizational Behavior and Human Decision Process***, Vol. 50, (1991), 179-211.
15. Fountas, G., Pantangi, S. S., Hulme, K. F., and Anastasopoulos, P. C. "The effects of driver fatigue, gender, and distracted driving on perceived and observed aggressive driving behavior: A correlated grouped random parameters bivariate probit approach." ***Analytic Methods in Accident Research***, Vol. 22, (2019), 100091. https://doi.org/10.1016/j.amar.2019.100091
16. Cordellieri, P., Sdoia, S., Ferlazzo, F., Sgalla, R., and Giannini, A. M. "Driving attitudes, behaviours, risk perception and risk concern among young student car-drivers, motorcyclists and pedestrians in various EU countries." ***Transportation Research Part F: Traffic Psychology and Behaviour***, Vol. 65, (2019), 56-67. https://doi.org/10.1016/j.trf.2019.07.012
17. Mokarami, H., Alizadeh, S. S., Rahimi Pordanjani, T., and Varmazyar, S. "The relationship between organizational safety culture, unsafe behaviors, and accidents among public transport bus drivers using structural equation modeling." ***Transportation Research Part F: Traffic Psychology and Behaviour***, Vol. 65, (2019), 46-55. https://doi.org/10.1016/j.trf.2019.07.008
18. Parishad, N., Aghabayk, K., Rezaei, R., Samerei, A. an., and Mohammadi, A. "Validation of the Driver Behaviour Questionnaire in a representative sample of drivers in Australia." ***Civil Engineering Infrastructures Journal***, Vol. 53, No. 1, (2020), 161-171. https://doi.org/10.22059/ceij.2019.283780.1593
19. Aghabayk, K., Mashhadizade, L., and Moridpour, S. "Need safer taxi drivers? Use psychological characteristics to find or train!" ***Sustainability (Switzerland)***, Vol. 12, No. 10, (2020), 1-11. https://doi.org/10.3390/su12104206
20. Jollife, I. T., and Cadima, J. "Principal component analysis: A review and recent developments." ***Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences***, Vol. 374, No. 2065, (2016). https://doi.org/10.1098/rsta.2015.0202
21. Syms, C. Principal components analysis. ***Encyclopedia of Ecology*** (2nd ed.). New York: Springer Berlin Heidelberg. https://doi.org/10.1016/B978-0-12-409548-9.11152-2

Persian Abstract

چکیده

در کشورهای در حال توسعه مانند هند، بزرگراه های ملی پرسرعت Multilane (NHs) قربانی نرخ بالای تصادفات هستند. شبکه بزرگراه ملی هند تنها ۲ درصد از شبکه جاده های هند را شامل می شود، اما ٤٠ درصد از ترافیک را حمل می کند که منجر به تصادفات رانندگی در بزرگراه های ملی می شود. همانطور که در مطالعات گذشته مشاهده شد، رانندگان به دلیل رفتار پرخطر خود، عامل اصلی ایجاد تصادفات هستند. از این رو، برای تعیین عوامل مهم ایجاد کننده رفتار مخاطره آمیز رانندگان در بزرگراه های پرسرعت چند بانده، نظرسنجی مصاحبه شخصی از طریق پرسشنامه برای کاربران جاده NH-47 شامل پاسخ به اطلاعات جمعیت شناختی رانندگان، نگرش نسبت به وسیله نقلیه انجام گردید. شرایط و نگهداری، مقررات ترافیکی/اجرای ویژگی‌های نگرش، و ویژگی‌های محیط راه. تجزیه و تحلیل مؤلفه اصلی (PCA) برای متغیرهای پرسشنامه اعمال شد و متغیرهای دسته بندی قابل توجهی برای رانندگی پرخطر شناسایی شدند. پانزده متغیر مهم به رفتار رانندگی پرخطر از پایگاه داده پرسشنامه توسط PCA کمک کردند. آنها ویژگی های محیطی جاده مانند سیگنال های نامناسب، زیرساخت های پیشگیری از تصادفات کنار جاده ای، روسازی نامناسب و عدم وجود نقاط عبور ایمن هستند. سن و تجربه راننده؛ استفاده از آینه در هنگام سبقت گرفتن، استفاده از چراغ و چراغ در طول شب و استفاده از سیگنال های دستی در طول روز. استفاده از کلاه ایمنی و کمربند ایمنی هنگام رانندگی و داشتن بیمه نامه معتبر خودرو؛ عمر وسایل نقلیه، فرکانس سرویس وسیله نقلیه، و اولویت خط در کاهش اهمیت آنها بر اساس پایگاه داده پرسشنامه. مسئولان می توانند اقدامات مناسبی را برای کنترل متغیرهای مهم ایجاد کننده رفتار پرخطر رانندگی در بزرگراه های چند بانده با سرعت بالا و کاهش سناریوهای تصادفات در بزرگراه های چند بانده انجام دهند.