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Factors Contributing to the Road Traffic Accidents in Sri Lanka

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Abstract

The impact of environmental and human factors has significant importance on the Road Traffic Accidents (RTAs) in Sri Lanka. Past studies have shown that neither the expansion of roads horizontally or vertically nor the reduction in the vehicle density is a solution to reduce RTAs. Therefore, this study is to determine the significant human factors associated with RTAs in Sri Lanka using data on RTAs during 2005 – 2019 obtained from the Department of Police, Sri Lanka, and suggest some solutions to reduce RTAs. The six reasons for major RTAs are overtaking, diversion, speed driving, alcohol consumption of driver, negligence of pedestrians, and mechanical fault of vehicles. About 85% of major RTAs were due to overtaking (32%), diversion (27%), and speed driving (25%). The percentage of RTAs under each of these variables is significantly higher ($p < 0.05$) than that of RTAs when the drivers have alcohol more than the minimum level (9%). The Exploratory factor analysis (EFA) and Conformity factor analysis (CFA) confirmed that reasons for RTAs can be classified into two latent factors, namely, 'lack of attention of the drivers' and 'negligence of the drivers. The two factors are invariant on the type of extraction method as well the type of orthogonal rotation. The fitted binary logistic model revealed that the significant variables on RTAs are negligence of the road conditions by the drivers, lack of attention of the driver, age of driver less than 18 years, and status of alcohol by the drivers. The odds of fatal accidents happening when the driver has a valid driving license are 4.3 times higher than that of a driver without a valid license. The inferences derived from this study can be easily used by Department of Police in Sri Lanka to reduce the RTAs in Sri Lanka. Drivers should be motivated to become well-disciplined drivers. The fines for the who do not adhere road rules need to be increased.

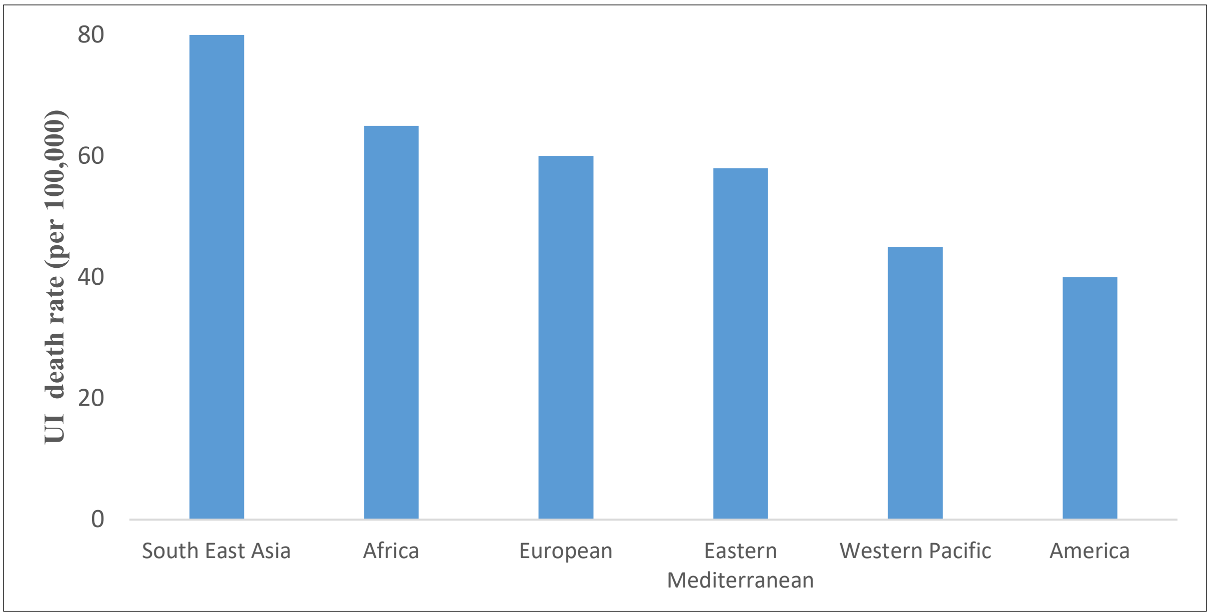
Keywords: Human factors, Road traffic accidents, Unintentional injuries.

Introduction

The severity level of road traffic accidents (RTAs) is subject to the cumulative influence of various factors. Road traffic injury is a significant cause of morbidity and mortality and is in the top 10 causes of death globally, leading to approximately 1.3 million deaths each year. Among populations aged 15–29 years, road traffic injuries are the leading cause of death (World Health Organization-WHO, 2017). Almost 75% of road traffic accident deaths affect males aged under 25 years. Road traffic injuries lead to significant morbidity, with global estimates of more than 20 million non-fatal road traffic injuries occurring each year. Unintentional injuries are experienced by 61 per every 100,000 people. Out of the 15 listed causes of death for people between 15 - 19 years of age, five are explicitly related to unintentional injuries, including RTAs, drowning, poisonings, falls, and burnings (WHO, 2017). While infectious diseases have significantly been reduced by prevention and early intervention methods adopted on a global scale, unintentional injuries remain a significant health-care problem and continue to increase (Chandran et al., 2010). Unintentional injuries can be held responsible for 6.6% of the universal mortality burden, and over 3.9 million lives are lost annually because of unintentional injuries. The death rate caused by unintentional injuries by the WHO region is portrayed in Figure 1.

Figure 1.

Unintentional injury (UI) death rate by WHO regions.



Source: Chandran et al. (2010)

The most significant rate of unconditional injuries was found in the Southeast Asian region causing 80 deaths per every 100,000 persons, and the lowest rate is seen in the American region causing 39 deaths per every 100,000 persons.

Table 1.

Percentage distribution of unintentional injury deaths (%) by WHO regions.

Causes	Africa	Europe	Eastern Mediterranean	Southeast Asia	Western Pacific	Other
Road Injuries	41	45	45	23	23	40
Drowning	13	7	9	6	8	16
Falls	4	12	8	14	9	16
Fires	10	2	9	4	14	2
Poisoning	8	7	5	19	7	7
Other	24	27	24	34	39	19

Source: Chandran et al. (2010)

Results in Table 1 indicate that among the causes of unintentional injury deaths, the highest percentages (> 40%) occurred due to road injuries in all regions except Southeast Asia. The above results confirm a significant impact of road injuries on unintentional injuries. Moreover, unintentional injuries can be held accountable for more than 138 million Disability-Adjusted Life Years (DALYs) annually (WHO, 2017). DALY is defined as the sum of years of potential life lost due to premature mortality and the years of productive life lost due to disability (WHO, 2017). Not only among the unintentional injuries but also the current trend claims that by the year 2023, injuries caused by RTAs are likely to hold third place as a leading cause of DALYs lost (Table 2).

Table 2.

DALYs for the ten leading causes of the global burden of disease.

Rank	Disease or Injury
1	Ischemic Heart Disease
2	Unipolar Major Depression
3	Road Traffic Injuries
4	Cerebrovascular Disease
5	Chronic Obstructive Pulmonary Disease
6	Lower Reparatory Infections
7	Tuberculosis
8	War
9	Diarrheal Disease
10	HIV

Source: WHO (2018a)

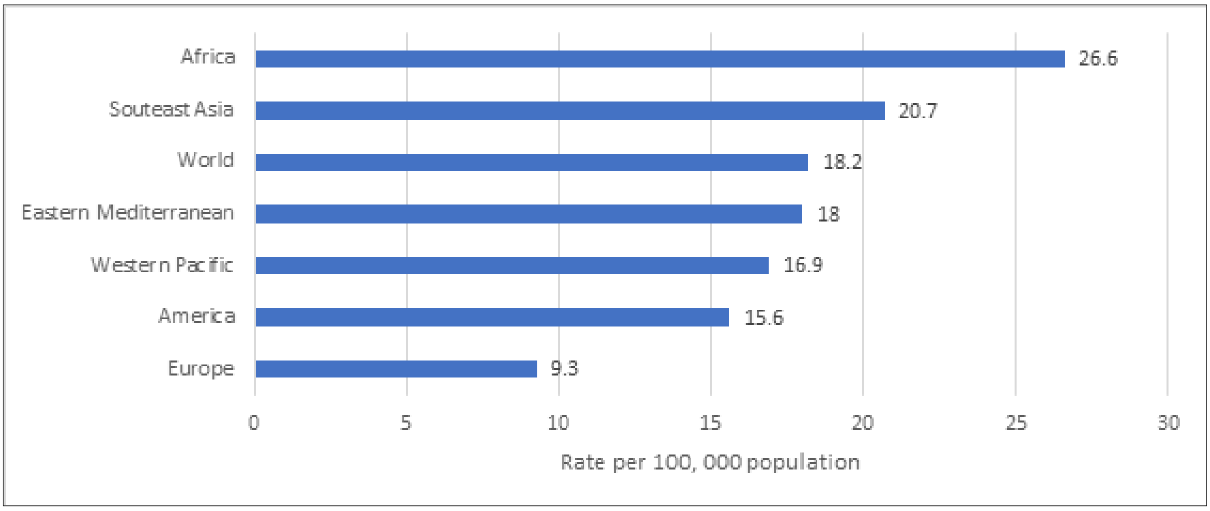
Lives that are annually lost due to RTAs have risen to 1.35 million as per the claims of the WHO (2018). This amounts to almost 3,700 persons losing their lives on the roads daily, and more people being left injured, disabled, or suffering from life-changing and long-lasting damages to their bodies. Losses of this nature take a massive toll not just on families but also on entire communities. The expenditures spent on emergency response and healthcare and the cost of human misery is massive.

Comparison of RTAs in Different Regions

Progress in reducing road traffic deaths over the last few years varies significantly among regions and countries. The two WHO regions, Africa and Southeast Asia, have exceeded the global rate of road traffic deaths (18.2 per 100,000) as the corresponding rates are 20.7 and 26.6 respectively (Figure 2). The lowest rate was observed in the Europe region.

Figure 2.

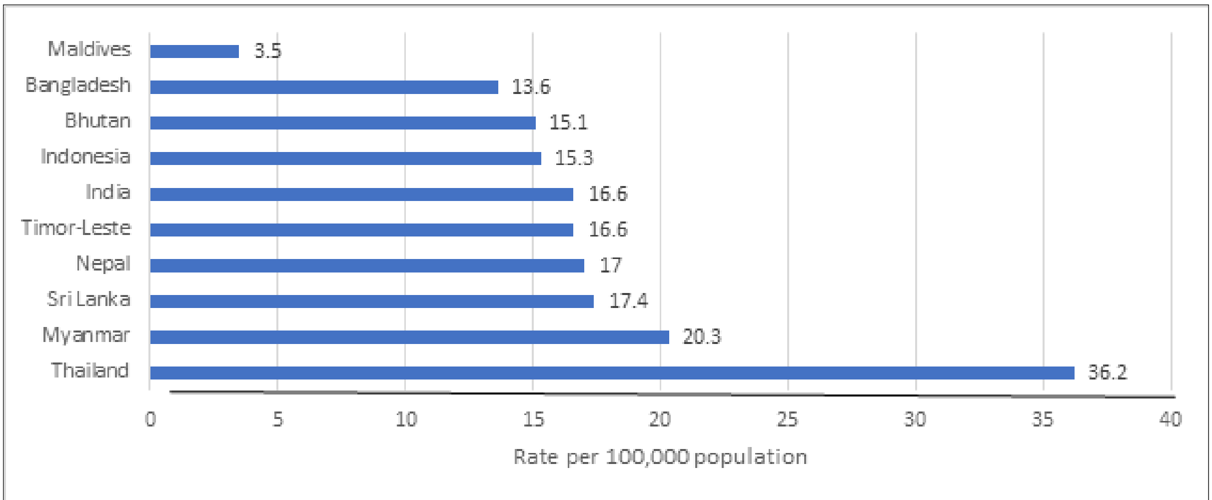
Rate of road traffic deaths by WHO regions.



Source: WHO (2018a)

Figure 3.

Rate of road traffic deaths by countries in the Southeast Asian region.



Source: WHO (2016)

According to Fig. 3, there is a significant variation in the fatality rate across the region, varying from 3.5 per 100,000 in Maldives and 36.2 per 100,000 in Thailand. The rate of road traffic deaths in Sri Lanka (17.4) is lower than the corresponding rate in the Southeast Asian region (20.7). A comparison of population density, road density, and vehicle density in three leading countries concerning Sri Lanka, Myanmar, and Thailand is shown in Table 3.

Table 3.

Comparison of population and road density among three selected countries in the Southeast Asian region.

Country	Population Density (Per square km)	Road Density (km/100 sq.km)	Vehicle Density (Per square km)
Sri Lanka	346	173.9	109.73
Myanmar	82	5.6	10.03
Thailand	136	35.24	72.10

Source: The World Bank (2019)

The results in Table 3 confirmed that Sri Lanka has the highest rate of population density, road density, and vehicle density among those three countries. Furthermore, the vehicle population ratio, defined as the number of registered automobiles per 1000 persons, is a prominent indicator of exposure to the risk of RTAs (WHO, 2015). According to the report given by the Department of National Planning in Sri Lanka (2017), it was found that 3,000km of Sri Lanka roads within the national road network have surpassed the traffic volume of 10,000 vehicles per day. Roads situated in urban areas also exceed their service capacity during peak hours. More vehicles flock to the roads due to new trips generated through economic activity.

These results suggest that the Measures such as moving freight to other modes of transportation like railway should be taken to avoid the rapid deterioration of rehabilitated roads and the added pressure to the road network system created by increasing freight transportation. A large fraction of the roads found in urban areas and link roads remain mere two-way single carriageway roads. The capacity of these roads in one direction is limited to 1,140 automobiles per hour. The impossibility of expanding roads horizontally because of other landscape developments in urban areas remains a significant problem. Thus, neither the expansion of roads nor the reduction in the number of automobiles is a solution to reduce.

Furthermore, traffic accident has been a result of many interacting factors. Most the accident causes classification systems to have been focused on the errors and actions of the participant that immediately led to the conflict. The actual reasons why the driver failure occurred are not considered. Furthermore, some researchers (De Winter and Dodou, 2010; Ferguson, 2003) have attempted to establish the relative weight of vehicle, road, and human factors as causes of road accidents. These studies confirmed that though the past studies reflect the driver's behavior is the most prominent contributory factor on RTAs, detailed analyses were not reported. A better understanding of various contributory factors to RTAs can result in better policies and measures for their reduction and management.

On view of the above, the objective of this study is to identify significant factors influencing RTAs in Sri Lanka and give recommendations to minimize RTAs.

Materials and Methods

Secondary data

The Police Department Sri Lanka have identified 25 causes for RTAs. Those 25 causes have been classified into seven variables: overtaking, speed driving, diversion, alcohol consumption of driver, mechanical faults of vehicle, negligence of pedestrians, and others. This study consists of the number of RTAs in Sri Lanka with respect to the seven variables from 2005 to 2019 obtained from the Police Department Sri Lanka.

Statistical analyses

The basic exploratory data analyses, exploratory factor analysis (EFA), conformity factor analysis (CFA), and binary standard regression analysis were carried out.

Results and Discussion

Main causes for RTAs

Table 4 describes the mean values of each observed variable along with the standard error (SE) of the mean, the corresponding percentages with respect to the total of seven causes (column 2), the corresponding percentages with respect to the total of first six causes (column 3), and % variability contributed from each cause with respect to the total variability of the seven causes (column 4) based on data over 15 years, 2005 - 2019.

Table 4.

Some statistics of the seven main causes for RTAs (based on 2002-2019).

Cause	Mean (SE Mean)	% With respect to the total of seven	% With respect to the total of six	% With respect to the total variance
Overtaking	5,861 (480)	16.5	31.6	12.4
Diversion	5,024 (204)	14.5	27.0	12.6
Speed driving	4,606 (484)	13.3	24.8	2.2
Alcohol consumption of the driver	1,610 (84)	4.5	8.7	0.4
Negligence of pedestrians	1,006 (113)	2.9	5.4	0.2
Mechanical faults of the vehicle	453 (66)	1.3	2.5	0.7
Others	16971 (1151)	47.8	-	71.4
Total	34,631	100.0	100	100

Of those seven causes, ‘others’ contribute 48% while rest of six causes contributes 52%. Nevertheless, according to the Police Department Sri Lanka, the impact of the RTAs due to first six causes is considerably high compared with the impact of the RTAs due to others. Therefore, to compare the percentages of RTA due to known causes, the individual percentages were computed ignoring due to ‘others’ as shown in column 3 in Table 5.

Of the first six causes, 84% of RTAs were due to overtaking (32%), diversion (25%), and speed driving (27%). Similar trends were also observed for annual data separately too. The percentage of RTAs due to alcohol consumption of drivers is 8.7%. As more details of each cause are not available, it is reasonable to assume the causes due to overtaking, diversion, speed driving, negligence of pedestrians, mechanical faults of the vehicle are not due to alcohol consumption of the driver. In fact, there was no significant correlation between alcohol consumption of the driver and negligence of pedestrians and between alcohol consumption of the driver and mechanical faults of the vehicle (Table 5). Furthermore, the correlations between alcohol consumption of the driver and overtaking, diversion and speed driving are weekly significant. Thus, we can compare percentages independently.

By comparing each percentage, it was found that the percentage of RTAs due to alcohol consumption of drivers is significantly less than ($p < 0.05$) that for due to speed driving, diversion, and overtaking. Furthermore, it is reasonable to assume that the RTAs due to overtaking, diversion, speed driving, negligence of pedestrians, and mechanical faults of the vehicle are not due to alcohol consumption of the driver. Thus, by comparing the rates of RTAs between the drivers with alcohol and drivers without alcohol (or below the minimum level), it can be concluded that the proportion of RTAs by the drivers with more than minimum limit of alcohol is significantly less than the proportion of RTAs by the drivers having no alcohol consumption or below the minimum level of alcohol consumption.

Thus, a question would arise, can the RTAs be reduced by imposing higher fine rates for drivers having more than the minimum level of alcohol? Can we impose higher fine rates for overtaking, diversion and speed driving?

Table 5.

Correlation matrix among seven variables related to RTAs.

	Speed driving	Diversion	Alcohol consump-tion of the driver	Mechani-cal faults of the vehicle	Negli-gence of pedestri-ans	Others
Overtake	.878**	.890**	.560*	.610*	.685**	-.577
	(0.000)	(.000)	(.030)	(.016)	(0.005)	(0.036)
Speed driving		.889**	.566*	.777**	.838**	-.745**
		(0.000)	(0.028)	(0.001)	(0.000)	(0.001)
Diversion			.562**	.616*	.650**	-.438
			(0.030)	(0.014)	(0.009)	(0.103)
Alcohol consumption of the driver				.321	.285	-.096
				(0.243)	(0.303)	(0.735)
Mechanical faults of the vehicle					.948**	-.852**
					(0.000)	(0.000)
Negligence of pedestrians						-.909**
						(0.000)

(Parenthesis indicates the p-value for the significance of the correlation coefficient)

Results in Table 6 indicate a strong significant correlation among most of the pairs within the seven causes confirming that data can be used to find common factors to represent seven correlated variables.

Identification of latent factors on RTAs

The significance of Bartlett's test of Sphericity for the seven variables () ratified that the true correlation matrix is significantly different from the identity matrix. The KMO statistic of the seven variables (0.78) is greater than the recommended value of 0.6 for sample adequacy. These results confirm that the observed data satisfied the basic requirement for EFA. The results of the JB normality test for each variable concluded that all the variables are not significantly deviated from normal distribution at the 5% level. Thus, the common factors can be extracted using Maximum Likelihood Factoring (MLF) as well in addition to Principal Axis Factoring (PAF) and Principal Component Factoring (PCF) to justify the results are invariant of the type of extraction method. Furthermore, as the variances of the variables are unevenly distributed, EFA was carried out for the standardized data. It was found that only two eigenvalues (are greater than one. Thus, according to Kaiser's rule (Kaiser, 1960), two common factors can be used instead of initial seven variables, and the two factors accounted for 91.1% of the total observed variance-covariance matrix.

Extraction and rotation of factors

Factors were extracted using the PCF method followed by PAF and MLF and rotated to make them meaningful. The three types of rotation used are Varimax, Quartimax, and Equamax. It was found that two common factors were invariant of the type of extraction method as well type of orthogonal rotation. The final commonalities of all variables were close to one. Out of the three types of extraction methods and three types of rotation methods, PCF with the Varimax rotation method is more popular and efficient (Peiris, 2018). Therefore, the factor score coefficient was obtained for the combination of PCF and Varimax rotation method (Table 6). The rotated two factors contribute 50% and 41% respectively of the total variance of the original system.

Table 6.

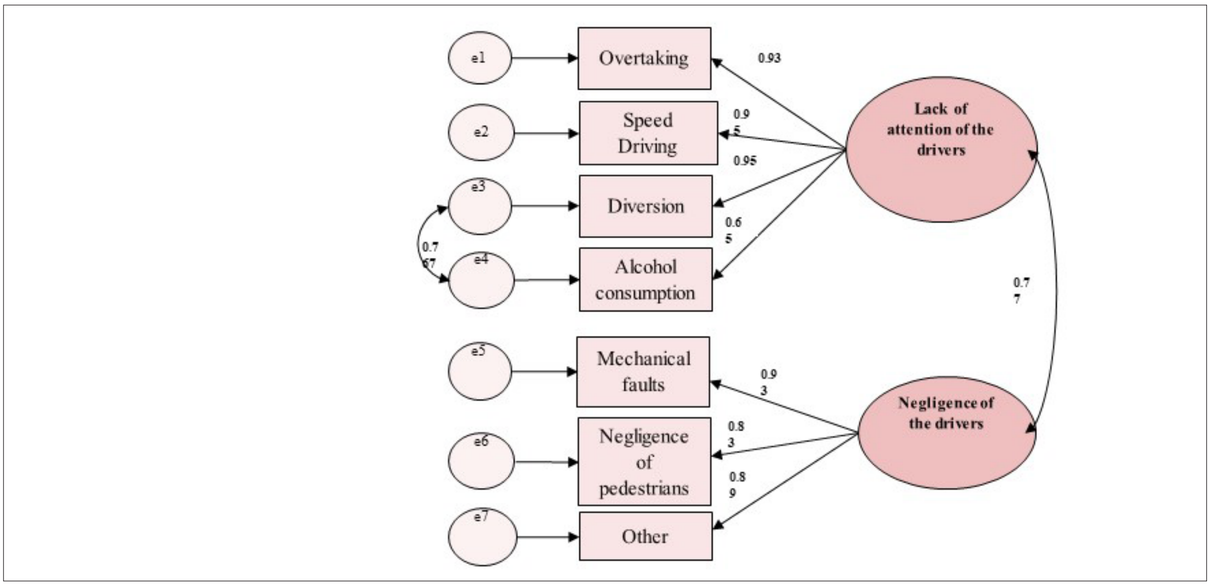
Eigen scores and factor score coefficient of the selected two factors.

Variables	Eigen scores		Factor score coefficient	
	Factor 1	Factor 2	Factor 1	Factor 2
Overtaking	.773	.482	.270	-.002
Speed driving	.675	.699	.161	.116
Diversion	.892	.400	.354	-.069
Alcohol consumption	.915	-.018	.478	-.254
Mechanical faults	.301	.898	-.086	.302
Negligence of pedestrians	.313	.935	-.090	.314
Others	-.073	-.965	.222	-.392

Based on eigen scores of the rotated factors it can be easily confirmed that Factor 1 (say, F1) can be formed with a linear combination of overtaking, speed driving, diversion, and alcohol consumption of the driver. Factor 2 (say, F2) can be formed with a linear combination of the mechanical fault of the vehicle, negligence of pedestrians, and others (say, F2). The factor loadings of the selected variables with factors are high (> 0.8) with exception of 0.675 for speed driving, indicating that those variables have a significant impact on the two factors. The F1 and F2 can be named as; 'lack of attention of the drivers' and 'negligence of the drivers ' respectively. In order to confirm the identified model, CFA was carried out (Fig. 4).

Figure 4.

Standardized parameter estimates for 2–Factor model identified by CFA.



Results in Fig. 4 indicate that all the variables of the two factors got high loading (> 0.8) with an exception for alcohol consumption (0.6). The coefficients of the standardized residual covariance, which indicates the standardized differences between the proposed covariance based on the model and the observed covariance matrix computed based on the collected data, were almost tend to zero. It was also found that model Chi-Square statistics based on the conformity factor model is significant ($p< 0.05$), confirming the validity of the model. Furthermore, it was found that the root mean square error was not significantly different from zero, and both comparative fit index (CFT) and TLI are close to one confirming the 2-factor model is appropriate. Thus, it can be concluded the factors influencing RTAs in Sri Lanka are due to 'lack of attention of the drivers (F1)' and 'negligence of the drivers (F2)'. The two factors can be defined as follows.

$$F1 = 0.270 * \left[\frac{\text{overtaking - 5861}}{1860}\right] + 0.161 * \left[\frac{\text{speed driving - 4606}}{1875}\right] + 0.354$$

$$* \left[\frac{\text{diversion - 5024}}{790}\right] + 0.478 * \left[\frac{\text{alcohol consumption - 1610}}{327}\right] \text{.......... (1)}$$

$$F2 = 0.302 * \left[\frac{\text{mechanical fault of vehicle - 453}}{254}\right] + 0.314$$

$$* \left[\frac{\text{negligence of pedestrians -1006}}{438}\right] - 0.392 * \left[\frac{\text{others -1691}}{4455}\right] \text{.......... (2)}$$

Based on the coefficients of the variables within two factors, it can be concluded that the factor1 is heavily influenced by the alcohol consumption of drivers followed overtaking. The factor 2 is influenced in a similar level by all three variables.

Binary Logistic Regression Model

The goal of using the binary logistic regression model is to model the accident severity of the RTAs (fatal vs non-fatal) and explanatory variables which describe the road, human, and vehicle. Of the RTAs reported during 2005-2019, it was found that 5.8 % is fatal and 94.2% is non-fatal. Thus, the dependent variable, y, status of the RTA is a binary variable such that the category of y=1 (fatal accidents) and y = 0 (non-fatal accidents). The significance of the Hosmer and Lemeshow test statistic concludes that the fitted model is significant at a 5% level. The overall predictive power of the model is very high at 94.2%. The output is shown in Table 7, and the corresponding model is shown in equation (1).

Table 7.

Properties of the parameters for the best fitted binary logistic model.

Variables	B	S.E.	Wald	DF	Sig.	Exp(B)
Validity of License (VL)	1.468	.074	391.34	1	.000	4.343
Alcohol Test (AT)			879.93	2	.000	
Over legal limit	-.025	.047	.29	1	.586	.975
Not tested	.420	.015	824.88	1	.000	1.523
Attitude of the driver (AD)	.160	.012	175.86	1	.000	1.174
Age of the driver (Age)			27.62	3	.000	
18 - 40 years old	.016	.032	.25	1	.621	1.016
40 - 60 years old	-.008	.034	.05	1	.816	.992
< 18 years old	.105	.036	8.31	1	.004	1.110
Constant	3.182	.035	8389.34	1	.000	.042

Hosmer and Lemeshow Test Statistic: $\chi^2_6 = 1370.9$ ($p = .000$)

The results in table 8 indicate that the variables; validity of the license, alcohol test, attitude of drivers, and age of the driver are significantly associated with the severity of accidents when all the variables are taken into consideration simultaneously. Based on the results in the 7th column of Table 8, the fitted model for the odds ratio for the occurrence of fatal accidents is given in equation (3), where p is the probability of fatal accident.

$$\left(\frac{p}{1-p}\right) = 0.042 + 4.343^{*}\ VL + 1.523^{*}\ AT(\text{not tested}) + 0.975^{*}AT(\text{over legal limit}) + 1.174^{*}AD + + 1.110^{*}Age(< 18) + 1.016^{*}Age(18\text{-}40) + 0.992^{*}Age(40\text{-}60) \quad ...... (3)$$

The odds of fatal accidents happening when the driver has a valid driving license are 4.3 times higher than drivers without a valid license when all other variables in the model are fixed. This is controversy statement and from this finding we do not claim drivers should not have a valid license. This could be due sample size problem. The percentage of fatal accidents among those who have valid license is 5.9% out of 528.011 drivers against the percentage of fatal accidents among those who do not have valid license is 1.0% out of 20,067.

The odds of fatal accidents when an alcohol test is not tested is 1.5 times higher than that of no alcohol or below the legal limit. In fact, the percentages of fatal accidents due to over legal limit, no alcohol or below legal limit and not tested are 3,2%, 4.1% and 6.6% respectively. Moreover, the odds of accidents due to the driver's lack of attention are 1.17 times higher than that it occurs due to negligence of the road users. The odds of accidents for less than 18 years old drivers are 1.1 times that of age more than 60 when all other variables in the model are fixed.

Conclusions, Recommendations and Suggestions

Conclusions

The six causes influence on RTAs with high gravity in Sri Lanka are overtaking, diversion, speed driving, alcohol consumption of driver, mechanical faults of vehicle, and negligence of pedestrians. Of these about 85% are due to overtaking, diversion, speed driving. The percentage of RTAs due to alcohol consumption above minimum level is less than that of due to overtaking, diversion, speed driving. The seven causes can be grouped into two factors namely, ' lack of attention of the drivers' and the 'negligence of the drivers'. These two factors were confirmed by the conformity factor analysis. The lack of attention of the drivers is associated with overtaking, speed driving, Diversion and Alcohol consumption of drivers. The negligence of the drivers is associated with mechanical fault of vehicle, negligence of pedestrians and others.

Among the human characteristics, accidents due to negligence of the road users, accidents due to the lack of attention of the driver, and age of driver less than 18 years, can be identified as human factors contributed to the occurrences of RTAs. Thus, it can be recommended that various measures should be implemented to improve the discipline of the drivers. The odds of fatal accidents happening when the driver has a valid driving license are 4.3 times higher than drivers without a valid license when all other variables in the model are fixed. The odds of fatal accidents when an alcohol test is not tested is 1.5 times higher than that of no alcohol or below the legal limit. The odds of accidents for less than 18 years old drivers are 1.1 times that of age more than 60 when all other variables in the model are fixed.

Recommendations

- The inferences derived from this study can be easily used to reduce the RTAs in Sri Lanka.
- Drivers should be motivated to become well-disciplined drivers.
- The rates of fine for those who do not adhere road rules need to be increased
- Popularize educational programs, with an

emphasis on increasing driver's vigilance on pedestrians and the danger of not using signals etc.

Suggestions

- Lane driving should be strictly followed.
- Drivers should be encouraged to use signals.
- Pedestrians should be educated on the use of sidewalks, safe road crossing procedures, and watchfulness while crossing roads.
- Traffic signalization, pedestrian bridges, and pavement tunnels are good alternatives to prevent pedestrian accidents as it allows pedestrians to cross the road without coming to contact with vehicles.
- Use stops signs at the intersection between main road and sub road.
- Establish speed reduction methods to ensure pedestrian safety.

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