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RISK FACTORS AFFECTING FATAL VERSUS NON-FATAL ROAD TRAFFIC ACCIDENTS: THE CASE OF KARS PROVINCE, TURKEY

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Abstract: The aim of this paper is to determine risk factors affecting the fatal versus non-fatal accidents in a rural region of Turkey, during 2008-2012, considering variables associated with the individual, the environment, and the motor vehicle. A retrospective study was conducted by obtaining the data from the traffic police road accident reports between 2008 and 2012. A stepwise logistic regression analysis was performed to analyze the data and critical factors that contributed significantly to fatal versus non-fatal traffic accidents. The results revealed that the driver's age (OR = 1.09; 90% CI = 1.05 – 1.14), clear weather (OR = 0.11; 90% CI = 0.02 – 0.65), winter season (OR = 0.16; 90% CI = 0.03 – 0.75), straight (OR = 0.22; 90% CI = 0.05 – 0.91) or slight road curve/bend (OR = 0.17; 90% CI = 0.04 – 0.83), the driver's education (OR = 0.18; 90% CI = 0.04 – 0.85) and the purpose of the vehicle (OR = 0.20; 90% CI = 0.04 – 0.94) were the significant factors affecting road traffic accidents over the sample period.

Keywords: road traffic accidents, risk factors, logistic regression, fatal, non-fatal, Turkey.

1. Introduction

Road traffic injuries are one of the leading causes of mortality and disability; about 1.24 million people die each year as a result of road traffic accidents; between 20 to 50 million suffer from non-fatal injuries; and moreover, road traffic accidents are predicted to result in the deaths of 1.9 million people annually by 2020 (WHO, 2013a). Road traffic injuries and fatalities are notably increasing in low-and middle income countries; while current trends suggest that they will become the fifth leading cause of death by 2030, with the disparity between high- and low-income countries. Eighty per cent of road traffic deaths occur in middle-income countries that comprise 72% of the world's population. Half of the world's all road traffic deaths are among motorcyclists (23%), pedestrians (22%), and cyclists (5%), so-called 'vulnerable road users', and not surprisingly, higher proportion of them are the citizens of low- or middle-income countries (WHO, 2013b).

As a middle-income country in Southeastern Europe, Turkey suffers from traffic accidents and their negative outcomes. There has been an overwhelmingly very large increase in the number of road motor vehicles in Turkey during the last ten years, such that, the

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number of road motor vehicles has increased by approximately 90% (Turkish National Police, 2013a). In that period, more than 8.8 million road traffic accidents were occurred, almost 1.1 million of them were fatal or non-fatal which affected nearly two millions people. Specifically, 22 to 31 people were killed, and 1,340 to 1,574 people were injured per 100,000 vehicles (Turkish Statistical Institute, 2012a; Turkish National Police, 2013b).

Over the past years, a great number of studies have concentrated on manifold factors influencing fatal and non-fatal road traffic accidents and their injury severity. Recent studies emphasized pre-crash human factors, such as alcohol consumption (Kim et al., 1995; Reynaud et al., 2002; Cummings et al., 2006; Yannis et al., 2008; Arranz and Gil, 2009; De Boni et al., 2013); seat-belt or Helmet usage (Cooper and Salzberg, 1993; Kim et al., 1995; Cummings et al., 2006); pre-crash vehicle factors such as the type of tyres (Strandoth et al., 2012; Elvik et al., 2013); at-crash vehicle factors such tire blow-outs, mechanical defects of the motor vehicles (Martin and Laumon, 2005; Barengo et al., 2006; Alam and Spainhour, 2009); pre-crash environmental factors such as roadway features or defects (Shankar et al., 1995; Karlaftis and Golias, 2002; Lee and Mannering, 2002; Chen and Chen, 2011; Kartal et al., 2011); at crash environmental factors such as road parameters, traffic signs, street lights, curbs or rumble strips (Hijar et al., 2000; Carson and Mannering, 2001; Zhou et al., 2005; Kim et al., 2007; Bombom and Edino, 2009; Šliupas, 2009; Pulugurtha and Bhatt, 2010; Jiang et al., 2011; Mamčic and Sivilevičius, 2013) using various statistical methods including logistic regression. In some researches, age (Cooper, 1990; Abdel-Aty et al., 1998; Zhang et al., 1998; 2000; Awadzi et al., 2008; Alam and Spainhour, 2009), gender (Ulfarsson and Mannering, 2004; Islam and Mannering, 2006; Bener and Crundall, 2008; Majdzadeh et al., 2008), or both factors (Holubowycz et al., 1994; Massie et al., 1995; Chipman, 1995; Glendon et al., 1996; Laapotti and Keskinen, 1998; Jones and Jørgensen, 2003; Kaplan and Prato, 2012) are examined as specific risk factors.

2. Materials and Methods

2.1. General Traffic Information about Kars City

Kars is a city located in Northeast Turkey with a population of 304,821; an area of 10,127 square kilometers; and an altitude of 1768 meters including its province, 8 districts, and 382 villages (Governor of Kars, 2013). Fig. 1 depicts the road traffic map of the city. Kars city covers 736 kilometers of network length, 675 kilometers of total road including 499 kilometers of national, and 176 kilometers of provincial highway (Republic of Turkey General Directorate of Highways, 2013). As of December, 31, 2012, there are 94,797 registered drivers and 35,216 motor vehicles in Kars including 14,927 tractors, 9,257 automobiles, 5,854 single-unit trucks, 1,870 trucks, 1,641 minibuses, 1,126 motorcycles, 417 buses, and 129 special-purposed vehicles (Turkish Statistical Institute, 2012b; Turkish National Police, 2013c).

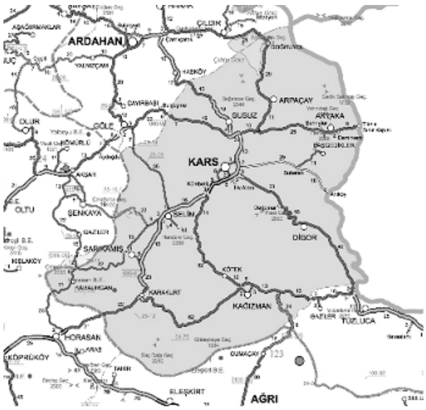

Fig. 1.
Traffic Highway Map of Kars
Source: General Directorate of Highways

The traffic accident data used in this study were obtained from road traffic accident reports of Traffic Services Branch Office and Regional Traffic Control Branch Office under the responsibility of Kars Provincial Police Department. The corresponding data involved 765 fatal and non-fatal road traffic accidents which occurred on Kars city and its central districts' roads during 2008-2012. The paper used a simple random sampling method to investigate the data of 765 traffic police-reported accidents, while the data were transformed and coded to a convenient computer-ready form. A fatal-injury accident is defined as an accident in which at least one person (driver, passenger or pedestrian) was killed at crash. A non-fatal injury accident refers to an accident in which at least one person was suffered injury but no fatalities were occurred.

2.2. Methods

Most studies have several explanatory variables, which they may be continuous as well as categorical. In that context, a good-fitting model will evaluate their effects on response variables, will include relevant interactions, and will provide smoothed estimates of response probabilities (Agresti, 2002). While an observation taking one of two possible forms on each individual is supposed, and if for the i^{th} individual, this observation is represented by a random variable, y; then without loss of generality code, two possible values of y by 1 and 0 can be defined as follows (Eq. (1)):

$$E(y) = \text{Prob}(y = 1) = \pi, \text{Prob}(y = 0) = 1 - \pi \qquad (1)$$

In Eq. (1), $y = 1$ and $y = 0$ are usually called a 'success', and 'failure', respectively, and such observations are considered as 'binary' (Cox, 1970).

For a binary response Y and a quantitative independent variable X, when $\pi(x)$ denotes the success probability, the logistic regression model has linear form for the logit of the corresponding probability as follows (Eq. (2)):

$$g(x) = \log\left(\frac{\pi(x)}{1-\pi(x)}\right) = x_i\beta \quad (2)$$

The left-hand side of Eq. (2) is called the log-odds ratio (OR), and the odds of response variable can be derived (Agresti, 1996):

$$\frac{\pi(x)}{1-\pi(x)} = \exp(x_i\beta) \quad (3)$$

The odds initially indicate how often something happens relative to how often it does not happen (Long, 1997). The log of the odds transformation performs the conversion of the probability estimates to a continuous unbounded variable. This variable will become the dependent variable in a linear model with the categorical definitions as independent variables (Hanushek and Jackson, 1977). In Eq. (3), for every one-unit increase in x, the odds will increase multiplicatively by e^{β}, namely, the odds at level $x + 1$ will equal to the odds at x multiplied by e^{β} Specifically, when $\beta = 0$, e^{β} will be equal to 1, and the odds do not change as x changes (Agresti, 1996).

Stepwise logistic regression procedure enables a useful and effective data analysis tool and employing a stepwise procedure can provide a fast and effective means to screen a large number of variables, and to fit a number of logistic regression equations simultaneously. Any stepwise procedure for selection or deletion of variables from a model is based on a statistical algorithm that checks for the importance of variables (Hosmer and Lemeshow, 2000). In this study, because the dependent variable is a binary or dichotomous variable, the stepwise logistic regression is an appropriate technique, which is developed to predict a binary dependent variable as a function of independent variables. This technique is frequently used in road safety where the dependent variable is binary (Chipman, 1995; Zhang et al., 1998, 2000; Shon and Shin, 2001; Al-Ghamdi, 2002; Reynaud et al., 2002; Jones and Jørgensen, 2003; Yau, 2004; Sze and Wong, 2007; Awadzi et al., 2008; Majdzadeh et al., 2008; Tay et al., 2008; Kartal et al., 2011; De Boni et al., 2013; Drucker et al., 2013).

3. Results

This study investigates the effects of twenty-one factors on fatal versus non-fatal road traffic accidents in Kars during 2008-2012, as shown in Table 1, which also indicates the mean, standard deviation. In this study, except for age, all variables were qualitative, where age was interpreted as a continuous variable. In order to clarify the results, most of the variables were defined as dummy variables, which take only 0 or 1. Gender, nationality and seat belt factors were also omitted because of the dominancy of male and Turkish drivers, respectively. The traffic police mentioned that they had any opportunity to recognize the seat-belt status of the driver at crash, and they have coded the status as ‘unknown’, so security factors were omitted from the model. Similarly, because pedestrians’ information was unclear in the reports, it was excluded and only drivers’ information was included.

Table 1

Descriptive Statistics of Variables

Variable	Description	Mean	S.D.
Accident type (Q)	Dependent variable (non-fatal = 0; fatal = 1)	0.029	0.167
(1) Season (Q)	Spring = 1; Otherwise = 0	0.191	0.393
	Summer = 1; Otherwise = 0	0.277	0.448
	Autumn = 1; Otherwise = 0	0.320	0.467
	Winter = 1; Otherwise = 0	0.212	0.409
(2) Hour (Q)	00:00-05:59 = 1; Otherwise = 0	0.065	0.247
	06:00-11:59 = 1; Otherwise = 0	0.261	0.440
	12:00-17:59 = 1; Otherwise = 0	0.379	0.485
	18:00-23:59 = 1; Otherwise = 0	0.294	0.456
(3) Weather (Q)	Clear = 1; Otherwise = 0	0.668	0.471
	Cloudy/Rainy/Foggy = 1; Otherwise = 0	0.264	0.441
	Snowy/Stormy = 1; Otherwise = 0	0.068	0.252
(4) Time of day (Q)	Night time = 1; Day time = 0	0.357	0.479
(5) Site (Q)	Formal settlement = 1; Informal settlement = 0	0.601	0.506
(6) Occurance of accident (Q)	Overturn/Falling person, animal or object from the vehicle/ Skidding from the road = 1; Collision = 0	0.461	0.499
(7) Number of vehicle(s) (Q)	Single vehicle = 1; Multi-vehicle = 0	0.361	0.481
(8) Divided highway (Q)	Divided highway = 1; Undivided highway = 0	0.659	0.474
(9) Road surface (Q)	Dry/Dusty =1; Otherwise = 0	0.677	0.468
	Wet/Puddle/Oil on the pavement = 1; Otherwise = 0	0.152	0.359
	Snowy/Icy = 1; Otherwise = 0	0.171	0.377
(10) Direction of the road (Q)	Two-way = 1; One-way = 0	0.797	0.402
(11) Working on the road (Q)	Available = 1; not available = 0	0.103	0.305
(12) Road lane line (Q)	Available = 1; not available = 0	0.604	0.513
(13) Horizontal route (Q)	Straight road = 1; otherwise = 0	0.782	0.252
	Slight road curve/Bend = 1; Otherwise = 0	0.180	0.385
	Hard road curve/Bend with or without rail = 1; Otherwise = 0	0.038	0.191
(14) Vertical route (Q)	Slight slope/Steep slope/Over the hill slope = 1; No slope = 0;	0.363	0.481
(15) Side walk (Q)	Available = 1; not available = 0	0.207	0.405
(16) Age (C)	Age of the driver	36.24	10.88
(17) Education level (Q)	Education level of the driver		
	Primary education = 1; otherwise = 0	0.492	0.500
	Secondary education = 1; otherwise = 0	0.310	0.463
	Higher education = 1; otherwise = 0	0.199	0.399
(18) Alcohol use (Q)	Drunk = 1; otherwise = 0		
		0.142	0.350
(19) Type of vehicle (Q)	Auto = 1; otherwise = 0		
	Single-unit truck/truck/bus = 1; otherwise = 0	0.516	0.500
	Others (i.e. motorcycle, tractor, ambulance, military vehicle)	0.384	0.487
		0.099	0.299
(20) Purpose of vehicle (Q)	Private = 1; otherwise = 0		
	Commercial = 1; otherwise = 0	0.724	0.447
	Others (i.e. security, military, agricultural) = 1;	0.184	0.388
	otherwise = 0	0.081	0.273
(21) Contributing circumstance (Q)	Speeding = 1; otherwise = 0		
	Inattention and negligence = 1; otherwise = 0	0.545	0.498
(Q) = Qualitative variable	Others (i.e. violating transition rule, rear-end collision/	0.184	0.388
(C) = Continuous variable	improper lane changing/lane rape, lack of tecnical	0.325	0.469
	requirements) = 1; otherwise = 0		

(Q) = Qualitative variable

(C) = Continuous variable

Table 2

Logistic Regression Estimation Results of Risk Factors Affecting Fatal vs Non-Fatal Road Traffic Accidents

Variable	OR	Std. Err.	Z	p-value	[90% C.I.]
(1) Season (base Spring)	0.41	0.307	-1.19	0.234	
Summer	0.38	0.263	-1.40	0.162	0.12 – 1.40
Autumn	0.16	0.148	-1.95	0.052***	0.12 – 1.19
Winter					0.03 – 0.75
(2) Hour (base 00:00 – 05:59)	0.93	1.325	-0.05	0.959	
06:00 – 11:59	0.32	0.427	-0.86	0.392	0.09 – 9.72
12:00 – 17:59	0.43	0.442	-0.82	0.411	0.04 – 2.85
18:00 – 23:59					0.08 – 2.33
(3) Weather (base Snowy/Stormy)	0.11	0.120	-2.04	0.041**	
Clear	0.50	0.503	-0.69	0.490	0.02 – 0.65
Cloudy/Rainy/Foggy					0.09 – 2.63
(4) Time of day	2.21	2.137	0.82	0.413	
Night Time					0.45 – 10.9
(5) Site	0.99	0.752	-0.01	0.995	
Formal Settlement					0.29 – 3.45
(6) Occurance of accident	0.34	0.276	-1.33	0.184	
Overturn/Falling person, animal or object from the vehicle/ Skidding from the road					0.09 – 1.29
(7) Number of vehicle(s)	1.67	1.717	0.50	0.620	
Single vehicle					0.31 – 9.07
(8) Divided highway	2.13	1.453	1.11	0.266	
Divided Highway					0.70 – 6.54
(9) Road surface (base Wet/Oil on the Pavement)	1.55	1.611	0.43	0.670	
Dry/Dusty	0.40	0.509	-0.72	0.472	0.28 – 8.55
Snowy/Icy					0.05 – 3.24
(10) Direction of the road	0.41	0.319	-1.15	0.252	
Two-way					0.11 – 1.48
(11) Work on the road	0.66	0.760	-0.36	0.720	
Available					0.10 – 4.37
(12) Road lane line	1.87	1.103	1.07	0.286	
Available					0.71 – 4.93
(13) Horizontal route (base Hard road curve/Bend with or without rail)					
Straight road	0.22	0.189	-1.76	0.078***	
Slight road curve/bend	0.17	0.165	-1.85	0.065***	0.05 – 0.91
(14) Vertical route					0.04 – 0.83
Slight slope/Steep slope/Over the hill slope	2.71	1.731	1.56	0.118	
(15) Side walk					0.95 – 7.75
Available	0.19	00	-1.10	0.273	
(16) Age	1.09	0.287	3.67	0.000*	0.02 – 2.30
(17) Education level(base Higher Education)		01			1.05 – 1.14
Primary education	0.39	0.027	-1.25	0.210	
Secondary education	0.18		-1.82	0.069***	0.12 – 1.34
(18) Alcohol use		0.293			0.04 – 0.85
Drunk	1.80	0.171	0.71	0.476	
(19) Type of vehicle (base Others)					0.47 – 6.92
Auto	2.34	1.473	0.80	0.422	
Single-unit truck/truck/bus	3.66		1.26	0.207	0.41 – 13.3
(20) Purpose of vehicle (base Others)		2.471			0.67 – 19.8
Private	0.20	3.767	-1.71	0.088***	
Commercial	0.27		-1.23	0.217	0.04 – 0.94
(21) Contributing circumstance (base Others)		0.188			0.05 – 1.55
Speeding	2.15	0.286	0.75	0.454	
Inattention and negligence	2.39		0.82	0.411	0.40 – 11.6
Number of observations = 765		2.208			0.42 – 13.7
Log likelihood = -71.163		2.533			
Logistic regression X^2 = 57.18					
Prob > X^2 = 0.0056		1			
Pseudo R^2 = 0.2866					

**Significant at 1% level **Significant at 5% level ***Significant at 5% level*

Table 2 indicates the estimation results for the final stepwise logistic regression model. Based on p-values, 7 variables from 24 factors were found to be significant or marginally significant. Number of observations was 765, with a log likelihood value of -71.163 and chi-square was equal to 57.18. As shown in Table 2, fatal road traffic accidents in Kars were more likely to occur with respect to the driver's age (OR = 1.09; 90% CI = 1.05 – 1.14), where the corresponding variable was marginally significant. Fatal road traffic accidents were 89% less likely to occur when the weather was clear (OR = 0.11; 90% CI = 0.02 – 0.65). Additionally, fatal traffic accidents were 84% less likely to occur in winter (OR = 0.16; 90% CI = 0.03 – 0.75). Kars has a continental climate and the weather is usually rainy or snowy throughout the year, even in the spring and summer, for that reason vehicles are also well-prepared for the negative effects of the weather conditions. In that context, the impacts of season and weather factors on the occurrence of fatal and non-fatal road traffic accidents are not surprising.

The results showed that horizontal route factor had an impact on the probability of fatal and non-fatal road traffic accidents. Herein, when an accident was occurred at straight road (OR = 0.22; 90% CI = 0.05 – 0.91) or slight road curve/bend (OR = 0.17; 90% CI = 0.04 – 0.83), it was less likely to occur a fatal accident. Furthermore, the driver's education level had impact on the probability of occurrence of fatal road traffic accidents. They were less likely to occur when the driver's education level was secondary (OR = 0.18; 90% CI = 0.04 – 0.85). The results also showed the significant impact of the purpose of the vehicle (OR = 0.20; 90% CI = 0.04 – 0.94) on fatal versus non-fatal road traffic accidents. One unit increase in private vehicle variable had a 0.20 decreasing impact on the likelihood of fatal accidents against non-fatal accidents.

The variance inflation factor (VIF) facilitates to measure how much multicollinearity has increased the variance of a slope estimate (Stine, 1995). In practice, since VIF is less than 10, the researchers can suggest that no variables cause the multicollinearity problem in the analysis. In Table 3, VIF values of independent variables used in this study were presented to ensure that there was not a multicollinearity problem among these independent variables, where all VIF values, including the mean VIF, are less than 10.

Table 3
Variance Inflation Factors of Independent Variables

Variable	VIF	1/VIF
(1) Season		
Summer	1.94	0.515
Autumn	1.97	0.509
Winter	2.26	0.442
(2) Time		
06:00-11:59	6.87	0.146
12:00-17:59	7.24	0.138
18:00-23:59	4.35	0.230
(3) Weather		
Clear	5.70	0.175
Cloudy/Rainy/Foggy	5.14	0.195
(4) Time of day		
Night Time	3.10	0.323
(5) Site		
Formal Settlement	2.25	0.445
(6) Occurance of accident		
Overturn/Falling person, animal or object from the vehicle/Skidding from the road	2.41	0.415
(7) Number of vehicle(s)		
Single vehicle	3.57	0.280
(8) Divided highway		
Divided Highway	1.75	0.571
(9) Road surface (base Wet/Oil on the Pavement)		
Dry/Dusty	3.70	0.270
Snowy/Icy	2.87	0.348
(10) Direction of the road		
Two-way	1.61	0.622
(11) Work on the road		
Available	1.16	0.863
(12) Road lane line		
Available	1.53	0.655
(13) Horizontal route (base Hard road curve/Bend with or without rail)		
Straight road	5.34	0.187
Slight road curve/bend	4.89	0.204
(14) Vertical route		
Slight slope/Steep slope/Over the hill slope	1.51	0.664
(15) Side walk		
Available	2.05	0.489
(16) Age	1.15	0.871
(17) Education level(base Higher Education)		
Primary education	2.17	0.460
Secondary education	1.95	0.513
(18) Alcohol use		
Drunk	1.24	0.806
(19) Type of vehicle (base Others)		
Auto	4.47	0.224
Single-unit truck/truck/bus	4.18	0.239
(20) Purpose of vehicle (base Others)		
Private	3.59	0.279
Commercial	3.33	0.300
(21) Contributing circumstance (base Others)		
Speeding	3.68	0.272
Inattention and negligence	2.04	0.489
Mean VIF	**3.12**	

Table 4
Goodness of Fit Statistics

Number of observations	765
Number of covariate patterns	758
Pearson $X^2(724)$	405.88
Hosmer-Lemeshow $X^2(8)$	2.16
Prob > X^2	0.98

4. Conclusion

The Eastern regions of Turkey are relatively underdeveloped and exposed to chronic economic and financial problems. In recent years, automobiles and various types of trucks had also produced in the occurrence of fatal and/or non-fatal road traffic accidents. The great number of motor vehicles involved in the road traffic is one of the common issues of traffic safety in Turkey and the rural regions. Otherwise, Kars city suffers from unfavorable weather conditions; where average number of rainy days exceeds ten days in a month with average total amount of rainfall ranging between 20.3 and 77.2 kilograms/square meters in a year. In addition, as a result of continental climate, Kars city is one of the coldest cities in Turkey, such that the number of snowy days exceeds 120 days (Turkish State Meteorological Service, 2013). In that context, weather conditions tend to negatively affect fatal and/or non-fatal road traffic accidents.

By the courtesy of various regional development projects and Turkish governors' dominancy, roadways and the road traffic have been remarkably improved during the last five years in Northeast Turkey. However, there are still significant regional disparities between the West and the East. The Eastern regions survive with economic difficulties that inherently have an impact on the road traffic. Despite optimistic development efforts, the corresponding territories still need qualified roadways to overcome the lack of countrywide essential transition. Decision makers should concentrate on more durable roadway construction ventures, namely, asphalts and other traffic infrastructures do not negatively affected by weather conditions in a little while. From a different perspective, more educated traffic personnel and conscious drivers will be probably helpful to create a more favorable traffic environment.

According to the results of this study, age variable was highlighted as a marginally significant risk factor affecting fatal road traffic accident against non-fatal. Since driver's age particularly increases the probability of occurrence for fatal road traffic accidents, the crucial roles of both policy makers and young drivers' parents revisit. In this sense, parents may preemptively avoid adolescents to drive before permitted by the relevant legislation. Similarly, traffic security laws may be re-arranged by deterrent regulations to preclude the satisfaction of inexperienced young drivers. Since most of the traffic users properly respect traffic safety regulations, an important step may be surpassed. Nevertheless, decision makers should draw attention to the poor reporting of road traffic accidents. For instance, risk factors such as seat belt and alcohol use of the traffic users should be more efficiently reported to determine the virtual reasons of the road traffic accidents more precisely. On the other hand, road traffic accidents in Turkey are considered as fatal accidents when one of the traffic users is fatally injured when the accident occurs and the elapsed time period in the hospital is ignored in contrast to the procedure applied in many developed countries. In that circumstance, the number of actual fatally injured traffic users is not properly illustrated. Emerging countries should adapt their traffic legislation to developed countries to reach better traffic reporting standards and thus achieving an improved traffic safety policy.

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