Safety Science 62 (2014) 90–97

Contents lists available at ScienceDirect

Safety Science

journal homepage: www.elsevier.com/locate/ssci

Introducing a risk estimation index for drivers: A case of Iran

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ARTICLE INFO

Article history:
Received 25 January 2012
Received in revised form 10 July 2013
Accepted 7 August 2013

Keywords:
Driver's characteristics
Driving behavior
Personality trait
Drivers' at-fault accident and ticket rates
Driver's risk index

ABSTRACT

Objective: This paper intends to investigate the existing relationship between drivers' characteristics and their aberrant driving behavior (lapses, errors, and violations), accident and ticket rates. To achieve this, risky drivers s groups are identified with introducing driver's risk index (DRI).
Methods: 1769 questionnaires were collected from Iranian drivers to gain information on drivers' personality, age, gender, education, driving behaviors (lapses, errors and violations), accident and ticket rates. Four indicators were used to describe the driver's characteristics so that the whole combinations of driver's characteristics and their relationship could be taken into consideration. *K*-means clustering and a non-parametric test were implemented to group the combinations within the homogeneous categories based on driving behavior, accident and ticket rates.
Results: The mean age of respondents was 36.53 (Standard Deviation (*SD*) = 11.33) with mean driving experience of 10.50 (*SD* = 9.63) years. The mean kilometers driven was 24875.89 km (*SD* = 24658.73) for 3 years. Results of the significance test (*p*-values) showed that there are no differences among lapses and errors with pairwise comparison across the whole clusters, however, other factors showed the most significant differences for resulting clusters by $k = 4$. Consequently, an ordinal 4-level risk index from 1 "safe" to 4 "risky" were identified. Also, a validation was performed by 158 questionnaires in order to confirm the results.
Conclusion: These ordinal levels can be used as a driver's risk index (DRI) to assess the effect of driver's characteristics on safety. The risk index would help to identify and target high risk drivers with safety Prevention programs.

1. Introduction

Nowadays, the role of human factors in driving is increasingly drawing the meticulous attention of the researchers. Reduction of accidents and the resulted casualties, in particular, can be made with slight changes in driving behavior.

Iran has a noticeable rate of 36 casualties per one hundred thousand populations, (i.e., 27,000 per year) (Ayati, 2009). As the police have reported human failures as the main factor in more than 70% of accidents (PNC, 2011), this country requires crucial attempts to improve the driving behavior and culture. Through years, traffic researchers have been trying to identify the psychological factors that are thought to affect accidents (accident proneness, sensation seeking, thoroughness of decision making, etc.). Among such studies, investigating the association of five factors model (FFM) (Clarke and Robertson, 2005; Costa and McCrae, 1992; Lawton and Parker, 1998; Poropat, 2002), personality type-A (Boyce and Geller, 2002; Elander et al., 1993), attention deficit hyperactivity disorder (ADHD) (Barkley et al., 1996; Brandau et al., 2011; Di Scala et al., 1998) with accident involvement and driving behavior can be mentioned. Furthermore, the role of demographic factors (age, gender, education, etc.) and the involvement of certain individuals in accidents have been investigated in several studies (Dobson et al., 1999; Granié and Papafava, 2011; Oltedal and Rundmo, 2006; Parker et al., 2000). In another study Kim et al. (1995) showed that driver behavior and either alcohol or drug use act as a mediated link between driver's age and sex and both accident type and injury severity.

Drivers' risky behavior may be compensated with their attention and skill and causes no crash for their own. However, it would make traffic turbulence and danger for other drivers. Hence, in order to identify the relevance between the driving style and accident risk, a number of self-report instruments such as driving behavior questionnaire (DBQ) (Reason et al., 1990), driving style questionnaire (DSQ) (French et al., 1993), and driving behavior inventory (DBI), (Glendon et al., 1993; Gulian et al., 1989), have been developed, all of which focus on self-reported behavior, drivers' decision making and driver stress respectively (Özkan and Lajunen, 2005).

Recent researches have addressed the driving behavior effect on accident involvement and its association with demographic factors

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0925-7535/$ - see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.ssci.2013.08.004

(Boyce and Geller, 2002; Dobson et al., 1999; Nordfjærn et al., 2010; Oltedal and Rundmo, 2006; Steg and Brussel, 2009; Sullman et al., 2002). A closer look at these studies reveals that these studies mostly focus on a special aspect of behavior, personality and/or demographic factors and they further investigate the existing relationships and their extent in viewpoint of psychology. Albeit several studies have been aimed at identifying risky drivers among different ages and/or gender groups (Brandau et al., 2011; Deery and Fildes, 1999; Ulleberg, 2001), this field calls for further research.

The main objective of this research study is to present an index for classification of risky drivers/individuals with taking their basic characteristics into account based on driving behavior, at-fault accidents and traffic fines especially tickets. Identifying the risky drivers makes it more possible to assess individuals' potential for risk taking and facilitate driver safety analysis. Therefore, some countermeasures such as more instruction, surveillance and special planning could be adopted to reduce the risk potential.

2. Method

The following steps were taken in this research:

1. Drivers classification.
2. Data collection.
3. Analysis and results

The first section involves the indicators defining in order to systematically assess the main driver's characteristics which affect safety from driving behavior, at-fault accidents and ticket rates.

In the second section, the data collection procedure is explained. This information includes four sorts of data: personality traits, driving behavior, demographic characteristics, driving at-fault accident and ticket rates data which are collected by self-reporting.

The last section embraces the obtained data analysis as drivers grouping is made by means of personality traits and demographic characteristics and then the cluster analysis is implemented on these groups to provide categories containing the homogeneous effects regarding driving behaviors (lapses, errors, and violations), at-fault accident and ticket rates. Consequently, driver risk index (DRI) is defined based on the obtained clusters and finally this index is evaluated via a set of additional data.

3. Drivers classification

3.1. Personality trait

Personality traits have proved to affect driving behavior and accident involvement (Sumer et al., 2005; Ulleberg and Rundmo, 2003). In particular, persons who behave type-A personality pattern have a high level of competitiveness, an obsessive ability to work hard and fast subjected to time-limit pressures , work overload, and a willingness to cut pauses brief to complete the tasks (Evans et al., 1987). Type-As have a very strong sense of urgency and are able to get lots of work done even in the presence of distractions (Greenberg and Baron, 2003). Type-A people undergo irritability, frustration and anxiety because of their overemphasis on idealistic targets and perfectionism. They usually lose their tempers, bother co-workers and commit aggressive and sometimes forceful acts (Greenberg and Baron, 2003). In contrast, type B people are different from those of type-A. They are relaxed, considerate, patient, content and understanding. They show a high level of tolerance to the defects of others and bring into play problem solving approaches instead of overwork methods to manage stressful and difficult issues (Evans et al., 1987).

In terms of traffic safety, an evaluation of relationships between age, personality and driving style revealed that driver age and type-A personality characteristics were significant predictors of vehicle speed and gap acceptance. Evans et al. (1987) survey of the bus drivers in India and the United States revealed that Type-A bus drivers had more monthly accidents than those of type B. Their finding was supported by Suls and Sanders (1988) who argued that type-A drivers are more likely to involve in accidents and to die from crashes and violence. It was also found that risk taking behavior and accident involvement are positively associated with neuroticism, Type-A behavior, sensation-seeking, and high levels of extraversion (Frone, 1998; Hansen, 1989; Sutherland and Cooper, 1991).

Type-A individuals are usually more erratic and careless during the task performance (Shahidi et al., 1991). Moreover, type-A was associated with risk taking and accident involvement (Sutherland and Cooper (1991)), perhaps owing to the accompanying heightened sense of time urgency (Frone, 1998). Another research pointed out that aggression seems to be negatively related to traffic safety attitudes (Ulleberg and Rundmo, 2003). Also, the type-A behavior pattern was proved to be connected with increased accident risks (Magnavita et al., 1997). Tay et al. (2003) demonstrated that drivers with type-A behavior pattern have higher rates of traffic violations and crashes. They take more risks, drive more erratically, and are present in more incidences of aggressive driving and speeding.

Given the aforementioned review, it can be inferred that type-A drivers are more likely to be high in driving behavior and accidents than type-B drivers, therefore it was decided to measure personality factors to differentiate between individuals who are extremely self-assertive and aggressive (type-A personality) and those who are relaxed and patient (personality type-B). So, drivers were separated by binary indicator. Thereby:

PI = a: type-A driver
PI = b: type-B driver

3.2. Age

Previous studies have indicated that certain age groups are more likely to be over-involved in traffic accidents than other groups. However, there are few studies which have surveyed the relationship between traffic accidents and driver maneuver variable among various age groups. A recent study demonstrated that young and middle-aged drivers involved in accidents have larger probability of being in urban areas (Abdel-Aty et al., 1998). Matthews and Moran (1986) and Shope (2006) in their studies showed that young male drivers (26 years old and younger) are over presented in traffic accidents because they are overconfident and overestimate their driving skills.

Driving skills are affected by various variables, particularly age (Laapotti and Keskinen, 1998; Lee et al., 2003) and experience (Duncan et al., 1991). Age and years of driving experience appear to have a significant negative relationship with errors, highway and aggressive violations (Davey et al., 2007; Lajunen et al., 1998; Sullman et al., 2002). In addition, lapses would predict the accidents involvement among elderly and female drivers (Dobson et al., 1999; Parker et al., 2000).

Considering several previous studies, in order to find the relationships between age and other factors such as accident involvement and driving behavior, different age intervals have been chosen based on the available information or convenience. For instance, different groupings (<25, 26–35, 36–45, 46–55, >55), (15–19, 20–24, 25–64, 65–79, >80), (18–25, 26–30, 31–39, >39), and

(below and above 50) were chosen by Shi et al. (2010), Abdel-Aty et al. (1998), Reimer et al. (2005) and Verschuur and Hurts (2008), respectively. Additionally, Constantinou et al. (2011) and Paus (2005), investigated young risky driving motives. They pointed out that young people are in their physical and cognitive state of perfection and may be more educated than older generations; hence they should be better able to consider the risks. Current neurophysiological evidence, however, suggests that the brain and particularly the prefrontal cortex regions connected with executive functions such as inhibition, reasoning and decision making, do not fully develop until the age of 25 (Paus, 2005). Using decision tree analysis on at-fault accidents frequency of drivers, Mohammadzadeh Moghadam (2013) found that the age categories below 25, between 25 and 50 and over 50 play important role in crash occurrence and its responsibility. Taking into account these references, it was decided to stratify the age into three groups for the age indicator as follows:

AGI = a: <25
AGI = b: 26–50
AGI = c: >50

3.3. Gender

Gender is one of the factors which have often found to be of important role relevant to driving behavior, type and frequency of accidents. Gender has regularly been reported to have a lot to do with risk behavior, more explicitly; males are further keen on taking risk than females. In addition, evolutionary procedure for males to become mature causes an adaptation that brings about tendency to take risks (Buss, 2004). Male drivers, mainly younger ones, are less attentive to obey the traffic rules (Yagil, 1998). Also, males consider traffic violations less dangerous than females. Whissell and Bigelow (2003), evinced that accidents could be explained as function of gender, also risky driving bears a more influential factor in male adolescents' injuries and deaths.

In his review, Ulleberg (2001), with the aid of cluster analysis concluded that males with high sensation seeking scores account for most risky driving among adolescents. Rosenbloom and Wolf (2002), presented a dangerous shift in males detection of danger on the road compared with females. Although few studies have failed to reach significance between gender and risky driving behavior (Boyce and Geller, 2002; Jovanovic et al., 2011), there is no doubt pertaining to the fact that males are more potential for driving violations (Reason et al., 1990; Rimmö, 2000; Verschuur and Hurts, 2008), risk taking, accident involvement (Constantinou et al., 2011; Laapotti and Keskinen, 1998; Oltedal and Rundmo, 2006; Ulfarsson and Mannering, 2004) and errors than females (Kontogiannis et al., 2002; Shi et al., 2010).

The existing evidence undoubtedly leads to the belief that gender is related to both risky driver behaviors and accident involvement. Therefore, the gender indicator consists of two categories:

GI = a: male
GI = b: female

3.4. Education

Previous researches indicated that Education level seems partly to be an effective factor on driving behavior and accident involvement. Dobson et al. (1999) examined the effect of education on driving behavior. To this end, women were divided into four levels of education (School certificate or less, High school certificate, Trade/Diploma certificate and University degree). The analysis revealed that the crude relative risk for accident is significantly high in women with tertiary education. Furthermore, seatbelt use among younger drivers is systematically varied by level of education attainment (Eiksund, 2009). In addition, as stated by Hoseth and Rundmo (2005) individuals with higher level of education demand less transport risk mitigation from authorities than those with lower level of education. This would reflect that the people with higher education are more likely to take risks.

Recently, Nordfjærn et al. (2010) through controlling age, gender, education and geographic areas demonstrated that gender, age and education cause stronger difference among drivers than type of geographic areas. Moreover, demographic characteristics are of great importance to making distinction in driver behavior in comparison with the circumstances of the traffic environment. Based on the above review and the educational process in Iran it was decided to establish three categories for indicating the education level of drivers:

ELI = a: High school or less
ELI = b: Trade/Diploma certificate
ELI = c: University degree

4. Data collection

4.1. Respondents and procedure

A range of 3000 drivers in Mashhad were asked to take part in a questionnaire-based survey, and a response rate of 59% (1769 drivers) was achieved from which 593 were women and 1176 were men, across different age groups. The respondents were randomly selected from different resources such as: gas stations queue, insurance office, college and high school students and their parents. The questionnaires were completed anonymously by those who agreed to answer, had driving license and were active drivers. Drivers' data was divided into two main parts. The former approximately encompassed 90% of data (1611 questionnaires) to define the indicators and accordingly apply the cluster analysis. The latter, containing the hold-out data (158 questionnaires) was further used to validate DDR.

4.2. Instruments

The questionnaire using for this study includes the following sections:

4.2.1. Personality trait

Personality traits can be defined as dimensions of individual differences that have a consistent pattern of thoughts, feelings and behavior (McCrae and Costa, 1990). Different models such as Type-A, which is referred to a behavior pattern including competitiveness, aggressiveness, and achievement striving (Price, 1983), Big five and NEO-five factor inventory (NEO-FFI), etc. exist to assess personality traits (Goldberg, 1993). In this paper, type-A was directly measured using the translated scale introduced by Friedman and Rosenman (1974) and Rosenman and Chesney (1982), which its reliability has been confirmed by several studies. The Type A/B personality pattern was assessed using the 25-item type A/B inventory as the scales were originally included yes/no format. The items were scored from 0 to 25 so that a score higher than 12 was associated with exhibiting Type A behavior pattern. In this study its internal consistency based on Cronbach's Alpha was 0.761.

4.2.2. Aberrant driving behavior

Driving behavior could be categorized and evaluated under a theoretically sound framework, which also appears to have practical importance. The Driving Behavior Questionnaire (DBQ) (Reason et al., 1990) seemed to be a promising turning point in constructing

a comprehensive model for everyday driving behavior (Ranney, 1994). The DBQ was built upon the main distinction between errors and violations, which were assumed to have different psychological origins and demand different modes of remediation (Reason et al., 1990). DBQ typically divides driving behavior within 3 directions. Errors are behaviors that fail to achieve the intended results (Reason et al., 1990) and cause a number of risks for driver's safety. Lapses include attention and memory failure, which are of less probability to cause serious accidents, whereas violations are "deliberate deviations from the practices believed necessary to maintain the safe operation of a potentially hazardous system" and are associated strongly with accidents involvement (Reason et al., 1990). Additionally, violations have been split into both aggressive, which have an emotional or interpersonal component, and ordinary with no aggressive motive but deliberate as yet (Constantinou et al., 2011; Kontogiannis et al., 2002).

In this study a translated version of Manchester Driving Behavior Questionnaire (DBQ) including 28 items (Lawton et al., 1997; Shakerinia and Mohammadpoor, 2010) was employed to measure drivers behavior. However "drive when you suspect you may be over the legal alcohol drink" item was omitted since drinking alcohol is legally prohibited and causes law persecution in Iran.

For all these items there were six choices, running from 0 "never" to 5 "almost always". Mean scores for lapses, errors and violations were calculated for each respondent by averaging over the relevant items. Cronbach's Alpha was 0.725 for lapses, 0.737 for errors, 0.856 and 0.756 for ordinary and aggressive violations, respectively.

4.2.3. Demographic characteristics and driving history

Respondents were asked to indicate their age, gender, education, income, frequency of driving, the number of years of driving, the number of at-fault accidents, all ticket types during the last 3 years, and annual kilometers driven. The mean age of respondents was 36.53 (SD = 11.33) with mean driving experience of 10.50 (SD = 9.63) years. The mean kilometers driven was 24875.89 km (SD = 24658.73) for 3 years.

5. Analysis and results

5.1. K-means clustering

Cluster analysis is a branch in statistical multivariate analysis and unsupervised learning in pattern recognition (Jain et al., 2000). It is a method for classifying similar groups of a data set into the same cluster and dissimilar groups into different clusters. Clustering is a powerful data exploratory approach in forming data groups and revealing the feature structure information of a given data set. It is a data-driven procedure for classifying a datum in one of a few classes by looking at proximity and homogeneity in feature space. Conventionally, most clustering algorithms are procedures that minimize total dissimilarity. One of such algorithms is K-means clustering which has been used simply in several fields (Po et al., 2009). The K-means is a well-known non-hierarchical clustering method which requires the user to pre-specify the number of clusters present in the dataset. The K-means algorithm partitions a given set of data in a manner such that the squared-error function is minimized for a pre-specified number of clusters (Han and Kamber, 2006; Likas et al., 2003).

5.2. Mann–Whitney U test

In statistics, the Mann–Whitney U test (also called the Mann–Whitney–Wilcoxon test) is a non-parametric statistical hypothesis test for assessing either whether one of two samples of independent observations tends to have larger values than the other or two samples are obtained from a single population and/or to evaluate significant difference between two independent samples which cannot be assumed to obey a normal distribution. It is one of the most well-known non-parametric significance tests. The test involves the calculation of a statistic, usually called U, whose distribution under the null hypothesis is known. In the case of small samples, the distribution is tabulated, but for sample sizes above 20 there is a good approximation using the normal distribution (Mann and Whitney, 1947; Wilcoxon, 1945; Zeller et al., 2007).

5.3. Procedure

At the outset, to find out the combinations of drivers' characteristics (groups), using Excel spread-sheet package, the obtained data from drivers were represented based on their corresponding personality, age, gender and education indicators defined before, and sorted accordingly. Consequently, these four drivers' indicators constitute 36 possible combinations of driver's conditions. Then, the k-means cluster analysis (Euclidean distance) was implemented in five consecutive phases (k = 8, 7, 6, 5, 4) to classify these combinations into the homogenous categories based on the features below:

- Drivers' violations, lapses and errors,
- Drivers' at-fault accident rate (i.e., the number of at-fault accidents in the last 3 years per one hundred thousand km of driving) and ticket rate (i.e., the number of tickets in the last 3 years per one hundred thousand km of driving).

Furthermore, since the clusters size was small in some cases and also normal distribution could not be assumed, to assess the significance of differences in lapses, errors, violations, accident and ticket rates' values and reach to the most significant clustering, Mann–Whitney U test was employed among obtained clusters for k = 8, 7, 6, 5 and 4.

The test was implemented in pairwise comparison manner to assess the difference in five features among clusters. For null hypothesis it was assumed that two samples were obtained from a single population and the vice versa for alternative hypothesis.

Results of the significance test (p-values) showed that there are no differences among lapses and errors with pair-wise comparison across the obtained clusters, however, other factors reach to the most significant differences for resulting clusters by k = 4, which was not the case while eight, seven, six and five clusters were taken into account. Therefore, lapse and error factors were excluded from the process. Again the clustering and afterward the significance test procedure were carried out based on violations, accident and ticket rates, which resulted in four final clusters representing driver's risk condition. Also, Pearson's correlations among violation, accident and ticket rates could be established in 1611 samples. The results showed that violations predicted at-fault accident and ticket rates with an overall correlation of 0.080 and 0.176, respectively, at-fault accident rates predicted ticket rates with overall correlations of 0.371 as well, which illustrated a positive consistency between the features.

5.4. Drivers' risk index (DRI)

Table 1 shows the 36 possible combinations of driver indicators incorporated in each cluster, the sample size (number of drivers), the mean violations and the at-fault accident and ticket rates for each combination. Results of the significant tests are summarized in Table 2. It is evident that there are significant differences among four clusters in terms of the ticket rate. Moreover, significant dif-

Table 1
Combinations of driver's condition indicators and their clusters.

Cluster	Driver indicator				Sample size	Violation value	At-fault accident rate	Ticket rate	Cluster's mean		
DRI	GI	AGI	ELI	PI					Violation	At-fault accident rate	Ticket rate
1	a	b	b	b	60	1.013	2.499	4.675	1.082	1.976	3.273
	a	c	b	a	43	0.727	1.156	2.249			
	a	c	b	b	23	0.740	3.423	3.834			
	a	c	c	a	51	0.928	0.947	4.761			
	a	c	c	b	48	0.759	0.834	6.032			
	b	a	b	b	27	1.040	2.220	1.980			
	b	a	c	b	26	1.240	2.491	1.571			
	b	b	a	b	26	0.550	0.664	3.638			
	b	b	b	a	39	0.743	3.093	2.525			
	b	b	b	b	32	0.764	2.876	2.235			
	b	b	c	a	34	1.008	1.058	0.927			
	b	b	c	b	36	0.944	1.672	2.855			
	b	c	a	a	26	2.130	1.218	3.304			
	b	c	a	b	24	1.730	3.321	4.216			
	b	c	b	a	30	2.100	0.887	4.020			
	b	c	b	b	33	1.087	2.897	3.653			
	b	c	c	b	44	0.897	2.343	3.174			
2	a	a	b	a	44	1.638	3.420	6.320	1.171	4.264	5.853
	a	b	a	a	101	1.265	5.145	5.566			
	a	b	a	b	36	1.177	4.617	7.809			
	a	b	b	a	94	1.134	3.234	6.348			
	a	b	c	a	48	0.947	3.251	5.485			
	a	c	a	b	76	1.141	3.268	5.749			
	b	a	b	a	31	1.250	3.841	5.863			
	b	a	c	a	32	1.263	8.190	4.553			
	b	c	c	a	29	0.725	3.414	4.980			
3	a	a	b	b	40	1.563	2.630	11.789	1.632	4.078	9.906
	a	a	c	a	74	1.848	6.788	10.886			
	a	a	c	b	61	1.788	3.500	8.833			
	a	b	c	b	100	1.432	3.230	9.800			
	a	c	a	a	107	1.470	6.950	10.143			
	b	a	a	b	23	1.770	2.270	8.786			
	b	b	a	a	27	1.552	3.179	9.108			
4	a	a	a	a	31	2.329	8.765	24.353	2.096	8.262	19.487
	a	a	a	b	26	1.570	9.132	16.123			
	b	a	a	a	29	2.388	6.889	17.984			

Table 2
Mann–Whitney *U* test *p*-values for ticket rate, violation values and at-fault accident rate.

Feature	Ticket rate				Violation value				At-fault accident rate			
Cluster	1	2	3	4	1	2	3	4	1	2	3	4
1	–				–				–			
2	0.000	–			0.133	–			0.000	–		
3	0.000	0.000	–		0.007	0.002	–		0.005	0.299	–	
4	0.002	0.009	0.017	–	0.012	0.018	0.117	–	0.002	0.018	0.033	–

Table 4
T-test *p*-values for ticket rate, violation values and at-fault accident rate.

Feature	Ticket rate				Violation value				At-fault accident rate			
Cluster	1	2	3	4	1	2	3	4	1	2	3	4
1	–				–				–			
2	0.048	–			0.151	–			0.005	–		
3	0.006	0.056	–		0.000	0.019	–		0.001	0.166	–	
4	0.000	0.000	0.050	–	0.000	0.000	0.078	–	0.000	0.002	0.039	–

ferences are found among four clusters regarding violations and at-fault accident rate barring between clusters 1 and 2, 3 and 4 in terms of violations, which are significant at the 85% level, respectively. As such at-fault accident rate between clusters 2 and 3, for which the difference is significant at the 70%. It means that there is a less distinct difference between clusters 2 and 3 based on at-fault accident rate but they can be clearly distinguished by means of ticket rate and violations. Consequently, four distinct ordinal categories of drivers ranging from 1 "safe" to 4 "risky" were identified which makes it possible to evaluate individuals/drivers respecting their risk making potential via demographic and personality characteristics.

Table 3
Violation, at-fault accident and ticket rates values by driver's risk index.

Cluster number (DRI)	Sample size	Average of violation values	Average of at-fault accident rate	Average of ticket rate
1	46	0.924	1.407	3.175
2	47	1.134	3.093	6.026
3	33	1.605	4.308	11.556
4	32	2.075	7.256	19.585

5.5. Validation

The 158 left questionnaires were recorded in database and analyzed to evaluate the accuracy of driver's risk index. For this purpose, the drivers' index was initially identified based on the prior study (Table 1) with demographic and personality characteristics. The results are reflected in Table 3 together with violations, at-fault accident and ticket rates' values for each category. Then, the *t*-test was applied on those values to assess the index accuracy at

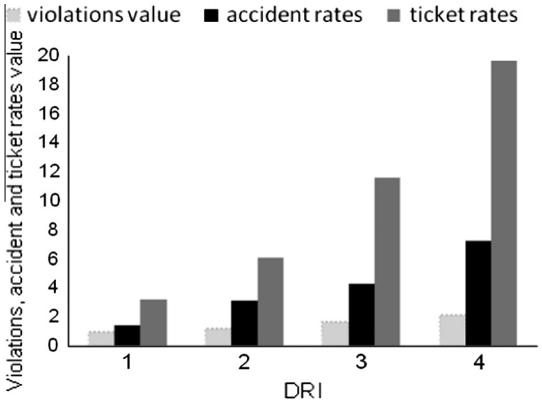

Fig. 1. Consistency of driver's risk index with violation, at-fault accident and ticket rates values for 158 drivers.

Table 5
Driver's risk index for women.

Age group (year)	Personality type					
	Type A Education level			Type B Education level		
	High school or less	Trade/ Diploma certificate	University degree	High school or less	Trade/ Diploma certificate	University degree
<25	4	2	2	3	1	1
26–50	3	1	1	1	1	1
>50	1	1	2	1	1	1

Table 6
Driver's risk index for men.

Age group (year)	Personality type					
	Type A Education level			Type B Education level		
	High school or less	Trade/ Diploma certificate	University degree	High school or less	Trade/ Diploma certificate	University degree
<25	4	2	3	4	3	3
26–50	2	2	2	2	1	3
>50	3	1	1	2	1	1

95% level. Table 4 shows these analysis results endorsing its accuracy. As shown in Fig. 1, the increase of violation, at-fault accident and ticket rates' values congruent with the driver's risk index, also confirm the drivers risk condition tested in Table 4.

6. Conclusion

This study introduces the driver risk index (DRI) and its calibration procedure on the foundation of demographic and personality subdivisions as the indicators which could affect the driver's behavior and her/his driving at-fault accident and ticket rates. 1769 questionnaires were collected and a database was made to study the association between the human/driver factors and the aforementioned features. Regarding the clustering and significant test results, an ordinal 4-level driver's risk index (DRI) scale was introduced. Tables 5 and 6 present the DRI values for the whole combinations of personality type, age and education levels for women and men, respectively. Violations, at fault accident and ticket rates were found to increase with DRI value on the sample of drivers. The resulting DRI can be used to judge the safety related to drivers with reference to their characteristics. Accordingly, it could be possible to assess drivers' risk on the basis of their demographic and personality characteristics.

It would be concluded that both younger type-A and B men and also younger type-A women with lower level of education are the most risky groups. Close scrutiny of these results demonstrates that women risk potential is totally lower than that of men. Also women with personality type-B are safer than type-A though this conclusion is less rigorous for men. The analysis shows that there is almost a declining trend in DRI across the whole categories with the increase of age. The drivers with intermediate education are less risky compared with those of lower and higher education level through controlling personality type throughout age groups. Furthermore, all elderly drivers with middle education level are the safest individuals as well as middle age women except those having low education. Moreover, according to previous studies (Matthews and Moran, 1986; Shope, 2006) the results confirm that youth are most at-risk drivers that would be in great need of special attention and management. Compliant with previous researches (Magnavita et al., 1997; Suls and Sanders, 1988; Sumer et al., 2005; Tay et al., 2003; Ulleberg and Rundmo, 2003), owning the personality type-A has meaningful effect on driving behavior (e.g. violations) and at-fault accident and ticket rates. Apparently university degree neither directly means higher driving skills nor affects the crash risk in general although its combination with the other characteristics of drivers could well determine their DRI. As can be seen in Table 5 and 6, despite the preceding researches (Magnavita et al., 1997; Suls and Sanders, 1988; Sumer et al., 2005; Tay et al., 2003; Ulleberg and Rundmo, 2003), type-B personalities in some cases are more risky than others especially in respect of young men with high and intermediate education level and high school or less educated young women. As an important result, low education groups especially the youth, considerably affect safety based on their own high DRI, which should be considered by government and safety authorities as a challenge in the planning and developing the infrastructure of education. Also, graduated licensing and other forms of exposure constraints seems to be fairly promising to tackle this problem and can be gradually removed as the drivers mature and their DRI decreases. The obtained results can be applied in the safety planning and management (e.g. with attending training classes in the driving licensing procedure, the different risk among drivers groups may be compensated in the field of drivers safety operation). One of the main applications of the index is in the budgeting; this index would be facilitating the safety budget allocation among several gender, age and educational groups to promote safety.

It is worth mentioning that frequency of all types of the tickets is taken into account for each driver in this study. However, each type of tickets has a different impact to driving risks but because of two reasons it is determined to employ all types of tickets: (1) drivers better remember the number of tickets rather than the causes, (2) of literature review, it turned up that using either total tickets number or those of different type categorically, do not significantly affect frequency prediction or evaluation of the driver risk. Nevertheless, needless to say that any interpretation or conclusion regarding DRI here has to be with attention to the mentioned reasons for the tickets to prevent misunderstanding.

Acknowledgments

We would like to express our deep appreciation to Reihaneh Izadifar for her review. Special thanks are due to Techno-Economic Road Safety Research Center of Ferdowsi University of Mashhad for providing the necessary facilities in the data collection process.

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