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Research Paper

Evaluation of the effect of driving education and training programs on modification of driver's dangerous behaviors

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Abstract

In Iran, despite all efforts have been devoted to reduce crash frequencies, statistics indicate that the crash fatalities have recently been increasing. In more than 90% of accidents, human errors and misjudgements have been reported to be the main contributing factor. This has drawn significant attention to problems relating to driving style, which are generally formed by early-stage driver's education and training programs (DETPs). In this regard, in Iran, like any other jurisdiction, beginner drivers must participate in a short-term DETP before taking the driving license exam. The programs consist of two parts: classroom theory education and in-car practical training. This paper seeks to evaluate the effect of DETP on dangerous driving behaviours of drivers using Structural Equation Modelling (SEM). Accordingly, data relating to 510 drivers were gathered, regarding their demographics and attitudes about DETPs specifications. Results indicated that training can be more effective than education in reducing unsafe behaviours. In addition, human characteristics have been identified as an important factor in decreasing risky driving and this can easily fade the impact of a proper DETP. The related administrates also must consider more seriousness for the final exams and assessments of DETPs. Finally, the establishment of strict rules and punishments for traffic violations can be a successful way of increasing the efficiency of DEPTs.

Keywords: Education, Driver, Structural Equation Modelling, Safety, Training

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1. Introduction

In recent years, there has been considerable debate over the global number of deaths and injuries caused by road traffic crashes. Based on the latest report of the World Health Organization [Department of Violence & Injury Prevention & Disability, World Health Organization, 2018] annually over 1.35 million people die, and about 50 million are injured in traffic crashes. Evaluations stated that human behaviours have had a significant role in more than 94% of crashes. Driver's errors, misjudgements, inattentions, unconsciousness, violations, perceptions and among others are the leading causes of accidents [Asadamraji, Saffarzadeh and Tayeghani, 2017; Asadamraji et al., 2018, 2019; Mahpour et al., 2019; Amiri et al., 2020; Mahpour et al., 2020]. This worrying issue seems to be more critical among developing countries. Similarly, in Iran, according to national databases from March 2019 to March 2020, more than 15 thousand have been killed in traffic accidents. National reports indicate that annually the same number of people have been killed in traffic accidents in the last decade. To tackle this problem, various types of countermeasures have been employed by different organizations, such as black spot detection, promoting road safety facilities, increasing traffic fines, equipping roads with traffic enforcement cameras, broadcasting various educational programs from media, and among others. However, this has not brought notable reduction in the crash fatalities.

Recently, the attentions of experts and administrators have been shifted toward driving styles and behaviours as a cause of road crashes. The frequency of traffic violations is relatively high in Iran, and most of drivers do not pay attention to traffic rules, especially speed limits. This can be the main reason for the high frequency of crashes.

Traffic law enforcement has been introduced as a powerful tool to promote road safety [Christie, 2001]. Iran is a big and extended country with an area of more than 1.6 million square kilometres. In addition, the road network in Iran consists of about 88,873 kilometres rural roads. Therefore, it is hard to have a strict control on all rural roads, and drivers themselves must be more cautious while driving. This is where the importance of driver's education and training programs (DETPs) comes to the picture. In other words, to reach a safer road network, current early-stage DETPs can be suggested as a fundamental method.

DETP refers to classroom theory education and in-car practical training. The primary purpose of such programs is to make drivers ready for the license test. In addition, it is intended to learn proper driving behaviour to young drivers [Lonero, 2008]. Sometimes driver education has a broader and longer-term meaning. It is to provide situations for drivers to acquire knowledge about driving and road safety [Christie, 2001].

Driver training tries to prepare a person for controlling a car in complex situations. Driver education relates to teaching principles about traffic rules, vehicle specifications and among others [Rodwell et al., 2018]. Driver training in some countries can be divided into two parts as pre-license training and post-license training. Pre-license training is held before receiving a driving license. In such programs, basic driving skills are taught. The post-license program relates to promoting driving skills after receiving driving license. These programs help drivers to manage difficult

situations like skid handling, sudden braking, and hazard perception [Mayhew and Simpson, 2002]. Recently, new methods and technologies have been applied in DETPs to promote their effectiveness. Petzoldt et al., tried to apply a new method based on computer and a driving simulator to enhance driver's training. This method would be helpful to improve the cognitive skills of drivers such as hazard perception and then crash reduction [Petzoldt et al., 2013]. Kumfer et al., studied computer-based training methods for young drivers regarding rural roads. The computer-based education is more helpful in teaching driving behaviours compared to conventional methods. The results indicated that computer-based programs had enhanced the knowledge and awareness of students [Kumfer et al., 2017].

There are several studies in which DETP has been reported as a proper method in promoting drivers' behaviours and reducing traffic crashes. Graduated driver licensing system (GDLS) is a multi-stage procedure for giving licensure. It has been proven that GDLS can be useful in reducing driver crash rates [Shell et al., 2015]. Brijs et al. evaluated the efficacy of DETPs before licensing test among young drivers in Belgium. They have announced that there is a relationship between traffic accidents of young drivers and DETP deficiencies. A post-license program in Belgium has been evaluated with the focus on risky driving behaviours, like speeding and drink driving. It was concluded that this program is a good starting point [Brijs et al., 2014].

A successful DETP is the one, which can promote driver's behaviour, skill, and knowledge and then improve driving styles. For a successful DETP, these features should be considered: program theory, program context, program standards, program products and processes, program organization, and program evaluation [Clinton, K.M. and Lonero, L, 2006]. A successful training program should teach drivers avoiding dangerous situations. Furthermore, it should be capable of learning skills to deal successfully with unavoidable hazards during driving [Beanland et al., 2013]. K.Alvaro et al. studied the effect of an educational program about sleep and fatigue during driving. Based on a practical test, they concluded that such education can help to increase the drivers' knowledge about rest and safety. This achievement can be beneficial in reducing crashes, which relate to the drowsiness while driving [Alvaro et al., 2018].

However, there are several studies, which have shown that DETPs do not have enough impact on reducing violations and traffic crashes, especially for young drivers [Haworth, N., Kowadlo, N., Tingvall, C, 2000; Ker et al., 2005; Elvik and Vaa, 2009; Thomas and Jones, 2014]. Christie evaluated the effect of driver training on crash reduction in a research in Australia. It was concluded that driver training has little influence on crash reduction [Christie, 2001]. Mayhew and Simpson tried to assess the safety value of DETPs. They concluded that DETPs would be more effective if considering critical factors relating to the driver's age and experience. In addition, experiences of novice drivers in traffic crashes must be documented to be applied for DETP [Mayhew and Simpson, 2002].

Thus, it can be stated that it is necessary to have an amendment about the context and applied methods in DETP for different categories of drivers in each society. Rodwell et al., concluded that changes must be done in

DETPs toward more social and contextual factors [Rodwell et al., 2018]. In another study, Mayhew evaluated the efficacy of driver's education programs on reducing traffic crashes. He concluded that the conventional programs are not successful in teaching skills of collisions avoidance. However, the author has reported that not only it is impossible to quit pre-licensing education programs but they also need to be enhanced in a manner that can reduce young driver's crashes [Mayhew, 2007].

Overall, a review of previous studies reveals that there is a shortage concerning the identification of the influence of DETPs' specifications on driving safe behaviour, considering drivers' characteristics and some details about driving records. For this purpose, a dataset relating to the experiences of various drivers was obtained by a questionnaire, and subsequently modelled using structural equation modelling (SEM). The main contribution of this paper, is to answer three research questions: 1) What is the relationship between DETPs' specifications and drivers' behaviour? 2) What would be the impacts of drivers' characteristics on driving behaviours? 3) Which variables in relation to driving records can be effective on drivers' driving behaviours? By answering to these questions, we can have a more precise statement about the influence of DETPs on drivers' behaviours, since the impact of drivers' characteristics and driving records have been recognized.

This section is followed by the research methodology. The results and their interpretation are described in detail in section 3, which would be followed by the conclusion.

2. Method

This study aims to determine the influence of DETPs' specifications on driving behaviour. Nevertheless, drivers' characteristics and some details about driving records can also affect drivers' behaviour. Thus, the impact of DETPs' specifications, drivers' characteristics and driving records should be evaluated at the same time.

To create the database, the experience of drivers in Iran was extracted by a well-developed questionnaire from January to June, 2019. To determine the sample size, Equation 1 was used [Johnson and Wichern, 2002].

$$n >= N\left[1+\frac{N-1}{pq}\left(\frac{d}{Z_{\frac{\alpha}{2}}}\right)^2\right]^{-1} \quad (1)$$

Where;

n: Sample size, number of drivers for data collection

N: Population size, number of total drivers in Iran (about 42 million)

Z: 1.96 for 95% confidence level,

p,q: The quality characteristics which are to be measured. Where no previous experience exists then the value of p is taken as 0.5 and q=1-p=0.5,

d: the desired level of precision and is considered 5%.

Based on this equation more than 385 drivers must be surveyed. We have assessed 510 drivers and they have been selected by random.

In the questionnaire, first, demographics and related information about driving experiences were asked, as indicated in Table 1.

In this table, the impact of enforcement on drivers' behaviour was declared by themselves and based on their personal

experiences. Education acceptance refers to the amount of manifested care by a person regarding DETP. Items such as their presence in most of the sessions, having enough concentration during classes, being active in the discussions, having enough motivation for learning, trying to ask relevant questions, and among others have been considered for identification of education acceptance by each participant.

Table 1. Demographics and related information about driving experiences

Variable	Details
Age (year)	18-80
Education	Less than Diploma Diploma B.Sc. M.Sc. Ph.D.
Monthly income (US Dollar)	100-10000
Average daily driving duration (minute)	<30 30-60 60-120 120-180 >180
Driving experience (year)	Less than 1 1-3 3-6 6-10 >10
Average number of vehicle occupants during driving (person)	1-5
Impact of enforcement on driver's attitudes and behaviour (percent)	0-100
Education acceptance	0-100

Afterwards, questions about quantity and quality of DETPs are posed as demonstrated in Table 2. In this table, amount of profitability, amount of seriousness, and exactingness and amount of diversity of DETP were reported by drivers, based on their viewpoint about such programs.

Table 2. Variables relating to DETP

Variable	Category
Amount of theoretical education received before driving license test (session)	1-5 5-10 10-15 15-20 >20
Amount of practical training received before driving license test (session)	1-5 5-10 10-15 15-20 >20
Amount of profitability of theoretical education perceived by drivers (percent)	0-100

Amount of profitability of practical training educations perceived by drivers (percent)	0-100
Amount of seriousness and toughness in the theoretical exams of driving license test (percent)	0-100
Amount of seriousness and toughness in the practical exams of driving license test (percent)	0-100
Amount of diversity in the methods and tools applied in the theoretical education (percent)	0-100
Amount of diversity in the methods and tools applied in the practical training (percent)	0-100

Driver's behaviour is a latent variable, in order to measure it dangerous driving experiences such as the frequency of accidents in the recent three years, the frequency of driving violations during a week, and the number of near-crashes during a day are considered in the model.

To address the study objectives, different modelling techniques can be employed among which SEM was selected. We have latent endogenous and latent exogenous variables in the proposed model. In addition, there are interrelationships between variables. SEM is highly capable of dealing with latent and observed variables simultaneously. It can be used to solve complex problems in which there are simultaneous relationships between variables and multitude of hypotheses. SEM can estimate direct and indirect relationships between exogenous and endogenous variables.

SEM, as a statistical method, has been applied in the various studies in transportation engineering [Eboli and Mazzulla, 2012; Sadia, Bekhor and Polus, 2018; Zhao et al., 2019; Zong et al., 2019; Behnood et al., 2020; Nadimi, Sangdeh and Amiri, 2020]. Golob reviewed the application of SEM in travel behaviour modelling in more details. SEM can replace multiple regression, path analysis, factor analysis, multivariate regression, and covariance analysis [Golob, 2003].

There are two types of variables in SEM, which are endogenous and exogenous. Endogenous variables are the variables to be determined by the model. Exogenous variables are known before solving SEM. Endogenous variables would be determined based on their relationships with exogenous variables and interactions between endogenous variables. Endogenous variables would be determined as presented in Equation 2 in SEM [Zong et al., 2019].

$$\eta = B\eta + \Gamma\xi + \zeta \qquad (2)$$

Where;

η : Endogenous variable,

ξ : Exogenous variable,

B : Interactions between endogenous variables,

Γ : Direct effect of exogenous variables on endogenous variables

ζ : Influence of the exogenous variables on the endogenous variables, which cannot be explained by the model (residual error).

The relationship between latent and observed variables is as Equations 3 and 4.

$$x = \Lambda_x\xi + \delta \qquad 3)$$

$$y = \Lambda_y\eta + \varepsilon \qquad (4)$$

Where;

x: Observed exogenous variables,

Λ_x: Effect of the latent exogenous variables on the observed ones,

y: Observed endogenous variables,

Λ_y: Effect of the latent endogenous variables on the observed ones.

Exogenous variables, which have been described in Tables 1 and 2 are reduced to latent exogenous variables as the driver factor, driving factor, training factor, and education factor. Table 3, demonstrates exogenous and endogenous variables in the proposed SEM.

Table 3. Variables in the proposed SEM

Variable	Type	Name	Factor	Type	Name
Age	Observed exogenous variable	HF_1	Human factor	Latent exogenous	HF
Education	Observed exogenous variable	HF_2			
Income	Observed exogenous variable	HF_3			
Enforcement impact	Observed exogenous variable	HF_4			
Education acceptance	Observed exogenous variable	HF_5			
Driving experience	Observed exogenous variable	DF_1	Driving factor	Latent exogenous	DF
Driving duration	Observed exogenous variable	DF_2			
Vehicle occupants	Observed exogenous variable	DF_3			
Amount of education	Observed exogenous variable	EF_1	Education factor	Latent exogenous	EF
Education profitability	Observed exogenous variable	EF_2			
Education exam seriousness and exactingness	Observed exogenous variable	EF_3			
Education diversity	Observed exogenous variable	EF_4			
Amount of education	Observed exogenous variable	TF_1	Training factor	Latent exogenous	TF
Education profitability	Observed exogenous variable	TF_2			
Education exam seriousness and exactingness	Observed exogenous variable	TF_3			

Education diversity	Observed exogenous variable	TF_4			
Crash frequency	Observed endogenous variable	DBF_1	Driver's behaviour factor	Latent endogenous	DBF
Traffic violations	Observed endogenous variable	DBF_2			
Near crashes	Observed endogenous variable	DBF_3			

Here, 510 drivers have participated in the survey and have filled self-administrated questionnaires. Descriptive analysis of different characteristics of surveyed drivers are in Table 4.

Table 4. Sample characteristics

characteristics	Statistics
Age (year)	18-25 (22.5%), 25-30 (11.7%), 30-45 (41.1%), 45-60 (18.8%), 60-70 (3.5%), 70-100 (2.3%)
Education	Less Than Diploma (9.2%), Diploma (25.4%), B.Sc. (36.6%), M.Sc. (22.8%), Ph.D. (6.1%)
Income (Dollar)	<=100 (25.1%), 100-300 (34%), 300-600 (32.6%), 600-800 (4.2%), >800 (4%)
Average daily driving duration (minutes)	<=30 (23.2%), 30-60 (25.1%), 60-120 (16.9%), 120-180 (34.7%)
Driving experience (year)	1-3 (16.7%), 3-6 (15.3%), 6-10 (12.9%), >10 (16.7%)
Average number of occupants	1 (25.8%), 2 (38.7%), 3 (19.5%), 4 (16%)
Education acceptance	0-10 (3.5%), 10-20 (1.6%), 20-30 (1.4%), 30-40 (2.6%), 40-50 (4.9%), 50-60 (5.9%), 60-70 (12.7%), 70-80 (17.6%), 80-90 (13.8%), 90-100 (35.9%)
Impact of enforcement	0-10 (4.5%), 10-20 (1.9%), 20-30 (3.3%), 30-40 (4.5%), 40-50 (9.9%), 50-60 (6.3%), 60-70 (14.6%), 70-80 (14.6%), 80-90 (12.2%), 90-100(28.4%)

3. Results

The model was developed using AMOS Graphics software. Amos is a well-known software for developing SEM models using techniques such as the general linear model and common factor analysis. AMOS, by providing visualized SEMs, is a user friendly software that enhances the modification of the model. The model run time is also short [L. Arbuckle, 2007].

The calibrated model and the standardized coefficients between exogenous and endogenous variables are displayed in Figure 1.

All of the coefficients have been obtained at a significance level of 0.05 or above.

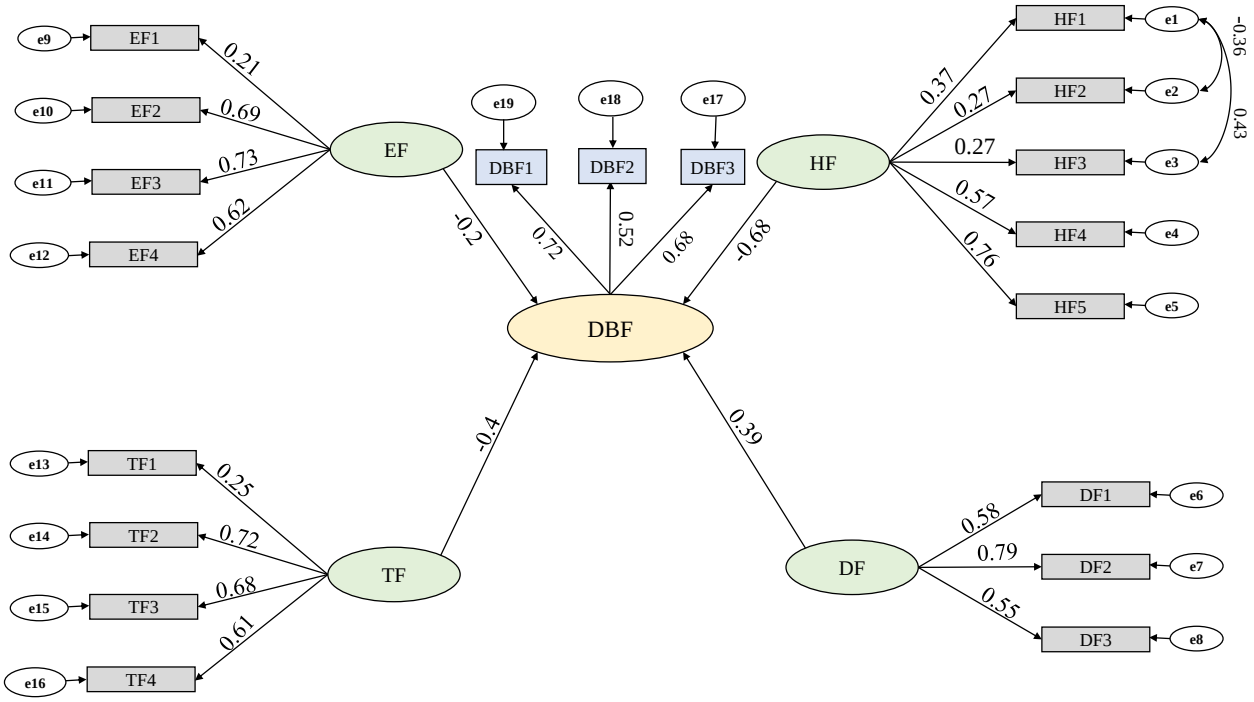

Figure.1. Standardized coefficients between variables

To obtain more information about the role of human characteristics on risky behaviours, descriptive analysis has been done. In Table 5, the most critical categories for age, education, income, educability, and enforcement impact are presented.

In Table 6, measures of goodness of fit are presented. In addition, in this table the cutoffs for evaluation of the results are discussed. Comparing the model outputs with the cutoffs, indicate that the calibrated model is acceptable.

Table 5. The most critical categories of human characteristics from DBS point of view

Variable	Age	Income	Education level	Education acceptance	Enforcement impact
Category	18-25	<=100	Less than Diploma	0-10	0-10

Table 6. Measures of fit for the calibrated SEM

Measure	Value for the proposed model	Cutoffs	
CMIN/DF	4.627	Less than 3	Good
		3 to 5	Moderate
		More than 5	Weak
GFI	0.957	More than 0.95	Good
		0.9 to 0.95	Moderate
		Less than 0.9	Weak
RMSEA	0.047	Less than 0.05	Good
		0.05 to 0.08	Moderate
		More than 0.1	Weak
Pclose	0.981	Pclose close to 1 indicate a very good fit	
CFI	0.974	CFI values close to 1 indicate a very good fit	
NFI	0.973	NFI values close to 1 indicate a very good fit	
TLI	0.964	TLI values close to 1 indicate a very good fit	

4. Discussion

Based on Figure 1, it can be concluded that driver's characteristics have the most impact on reducing unsafe behaviours. It seems that regardless of DETP details, human characteristics are more critical in the occurrence of risky behaviours. Previously, also drivers' illegal behaviours have been introduced as a source of reducing safety [Zhao et al., 2019].

Among the variables, which relate to the human factor, amount of education acceptance is the most influential variable. Therefore, it is important to make drivers' mind ready before participating in DETPs. Drivers should take such programs more serious and understand that DETPs can help the society to reduce traffic crashes and their adverse effects, subsequently.

When we have a driver with low education acceptance, then it would be hard to change

his/her unsafe behaviours just with the help of DETP. Hirsch et al., concluded that driver education in the licensing process has not been successful in promoting novice male drivers' behaviour because such drivers do not show enough motivation toward learning from DETPs [Hirsch, Maag and Laberge-Nadeau, 2006]. For such drivers, other countermeasures like enforcement can be more effective, as the impact of enforcement had been reported to be significant on reducing dangerous driving behaviours.

From SEM outputs, also it can be concluded that training can be more effective than education to reduce driver's risky behaviours and so it has more effectiveness. This means that, drivers pay more attention to practical items than theoretical ones. Thus, in the DETPs, more focus should be directed to practical training. In addition, it should be tried to teach theoretical points in the form of practical items to create more influence on drivers.

Perceived profitability of the DETP and seriousness in the final exams had the most impact on reducing unsafe behaviours among the variables, which relate to DETP details. It is necessary to perform DETPs in a form that drivers consider the items as useful materials for their driving task. In addition, more seriousness and toughness must be considered in the exams and assessments, which are held at the end of the DETPs. Now, in Iran, we do not have enough seriousness in the theoretical exams for driving license. Most of the questions are known before the exam (mostly distributed on the internet) and overall, the exam is easy. In addition, in the practical exam, all of the necessary driving skills are not assessed and a routine test is conducted. Duration of DETP has the least effect on its effectiveness. Thus, quality of DETP (namely diversity and profitability) is more important than its quantity (duration) to promote its effectiveness.

Driving factor also has the same impact as training factor on risky behaviours. Among the variables, which relate to driving factor, the average daily duration of driving mostly relates to dangerous driving. This means that as driving duration increases, it is also expected to see more dangerous driving behaviours.

5. Conclusion

Driver education refers to classroom theory education and in-car practical training. The main purpose of such programs is to make drivers ready for the license test. Pre-license training is held before receiving a driving license in which necessary driving skills are taught. This early-stage DETPs can form different driving styles, which can affect the safety level of a given society. The fact that human errors play an important role in crashes makes this issue even more critical. As a result, the importance of these programs in societies like Iran, where traffic safety is a problematic issue, cannot be disregarded.

To deal with this problem, the present study employed a capable modelling technique, called SEM, to determine the impact of DETPs on dangerous driving behaviours, besides driver's characteristics and driving records. Accordingly, 510 drivers were interviewed, where their experiences and attitudes about DETPs were collected. The model outputs provided interesting insight into the importance of different elements, which relate to DETPs and driving behaviours of different drivers.

The results indicated that driver's characteristics are the most critical parameters, which can reduce unsafe driving behaviours. We need to increase the educability of the society (especially teenagers and low-income groups) in relation to DETPs. For this purpose, some of the topics in

relation to traffic education and training can be inserted in their high-school courses. In addition, more novel methods must be designed and then used for the DETP of these groups.

Furthermore, legislative and administrative organizations must establish more strict rules for traffic violations, since concern about traffic enforcement can decrease dangerous behaviours.

The SEM outputs about DETPs implied that practical training could be more influential on promoting driving behaviours compared to classroom theory education. DETPs should be held in a manner that drivers perceive its content profitable; otherwise, they would forget such educations. In addition, more seriousness is necessary for final exams and assessments in DETPs.

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