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Research Paper

Relationship of Dangerous Behavior of Professional Drivers and Penalties on Accidents of Intercity Road Network

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Abstract

High rate of fatalities in road transportation has raised a world-wide effort to utilize appropriate strategies in order to reduce road accidents. In this regard professional drivers are of great concern due to their large size vehicles and high rate of passenger occupancy. Additionally, comparing to other users of network, planning for behavioral change among them is much more achievable due to their organizational and hence occupational dependency. This research proposes a validated questionnaire in order to measure the dangerous behavior of professional drivers of passenger cars, bus and trucks of intercity road network. Additionally, a structural equation model was developed that explored the causal relationship of dangerous behavior on accident. Further the model indicates that supervising drivers (through penalties) was able to mediate and indeed, reduce the effect of dangerous behavior on accidents previously experienced by respondents. In this study, Data collection was conducted among 603 drivers from 6th-21th September 2022, in Kermanshah, Iran. Results of this study suggests that behavioral change of drivers and adequate supervision on them reduce number of accidents on intercity road network.

Keywords: Professional drivers, Dangerous driving behavior, Road accident

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1. Introduction

Individual, vehicle, road, and environmental factors in a casual chain may result in fatalities in road traffic accidents. Sanchez-Mangas et. al. (2010) discussed that driving behavior and vehicle features are pre-collision factors, which determine the severity of the accident. Other factors including vehicle structure, restraint system, and protection equipment involved in accidents medical treatment affect the survival chance. Driving behavior which determine collision motion and level of damage (Ren, 2010) differs among drivers due to demographic factors, driving experience (Yan et. al. 2013) and also facilities and road characteristics (Pei, 2003).

Focusing on driving behavior among all, different scholars discussed it as a main contributor in road accidents (WHO, 2018; DGT, 2021). Risky behaviors such as exceeding speed limit are of high influencing factors which result in severe collision and human damage. Due to difficulties to explain human behavior (Megías-Robles et al., 2022) risk decision making models were applied to analyze human behavior in risky situations in previous studies (Navas et. al, 2019; Ventsislavova et. al.,2021) which have covered factors such as experience, motivation, memory, attention and learning (lerner et. al.,2015; Maldonado et. al., 2020; Pessoa, 2008).

Traffic in developing countries usually consists of different vehicle types with a variety of statistic and dynamic characteristics which occupy a same right of way. This becomes more serious in main roads connecting cities where freight transport has a greater share in comparison with urban transport. Hence, drivers of public transport and freight vehicles consisting of passenger cars (intercity taxi), buses and trucks gain special notice in safety policy making. A few reasons can be discussed in this regard: first; people usually expect professional drivers to drive in a defense mode. Because in addition to their class-1 driving license, professional drivers have to pass minimum requirements to get the permit to transfer cargo or passengers, so any mistake can treat their working permit. Therefore, they are required to avoid involvement in crashes. Second; passenger cars/buses are highly occupied and any collision may result in fatalities with a high rate. Third, trucks and buses with different characteristics and large size leave greater traffic effects. Fourth, any collision that a bus involves in can easily reduce public confidence and hence tendency for traveling by bus. This is in contrary with the general strategy of motivating people to use public transport instead of their private cars. And finally, professional drivers are more available to be monitored, supervised and trained in order to improve their driving behavior.

Based on the reason discussed above, this research focuses on evaluating the effect of dangerous behavior of professional drivers (bus, passenger car and truck drivers) on the number of accidents they have experienced during their professional driving. Additionally, the effects of supervising them which can change the tendency toward risk taking is also considered.

At the first step, an appropriate instrument was required to measure dangerous behavior as a latent variable. Different instruments in this regard were validated in previous scholars. For example, Mokarami et. al. (2019) developed two questionnaires; Driver Safety Culture Questionnaire (DSCQ) and; Public Transport Driver Behavior (PTDBQ). In their study, they measured two latent variables: organizational safety culture and unsafe behavior among urban bus drivers. Finally, the relationships of the two measured latent variable and number of accidents were explored through structural equation modelling. Another example is a study by Rowe et. al. (2022) in which the Early

Driving Development Questionnaire (EDD-Q) was validated for measuring safe behavior of new drivers. Bandyopadhyaya et. al. (2022) in their study developed a 27-item driver behavior questionnaire (DBQ) to measure long distance aberrations in a self-reporting process.

To our best knowledge, any study has not been yet conducted to measure the dangerous behavior of professional drivers in intercity road network. At the first glance, passenger car vs. buses, similar to passenger vs. freight vehicles may varies in their characteristics but the common issue among them is their organizational and hence occupational dependency. This creates a potential to offer appropriate suggestion for policy makers based on data and analytical process, for a concentrated effort under the shelter of organizational responsibilities and goals. Moreover, differences in urban and intercity network make dangerous behaviour different in the two networks. For example, while passing a red light is an important violation in urban network, there in so traffic light in intercity network. Overall, this research aims to validate an instrument to measure dangerous behavior of professional drivers in intercity network and further to explore the relationship of dangerous behavior and penalties on accidents that professional drivers involved previously. The hypothesis of the study is: 1- dangerous behavior increases accident involvement of drivers and 2- penalties (a combination of tickets and any organizational action which may be originated from public reports) could mediate the dangerous behavior effect on accident involvement.

Worth to mention that number of accidents as the dependent variable were previously predicted through structural equation models in several studies, by different exploratory variables such as ability emotional intelligence and risky driving (Megias-robels et. al., 2022), organizational safety culture and unsafe behavior (Mokarami et al., 2019) and self-reported aberrations (Bandyopadhyaya et. al., 2022).

Next section explains the methodology of the study. Result is reported in section 3 and further discussed in section 4. Finally, conclusion is presented and suggestions, application and future study are offered.

2. Method

2.1. Study Area

Data of present study was collected by meeting the respondents in fuel stations/TIR parks/ on way restaurants of the Kermanshah province, Iran. Kermanshah is located in the west of Iran. Road network (intercity) consists of different classes of roads as is reported in table 1.

Table 1. Length of different road types in Kermanshah

Type of road	Total Length (KM)
Highway	416.78
Main Road	522.95
Minor Road	1891.4
Rural	5151

Share of different classes of intercity road network of Kermanshah province is given in figure 1.

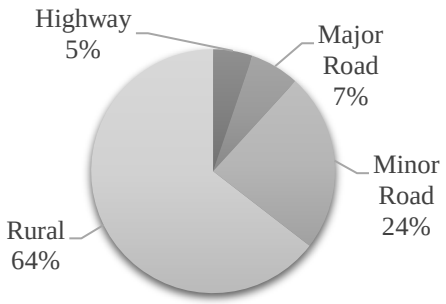

Figure 1. Share of different classes of intercity road network of Kermanshah province

Total length of highway plus main and minor road of Kermanshah rate it in 19th place among other 30 provinces of Iran.

Based on the report of the Iranian Legal Medicine Organization, 19.06 out of each 100000 people died due to road accidents in 2020. This value is 23.56 (intercity and urban) and 18.54 for intercity road accidents for Kermanshah province. In the intercity road

network of Kermanshah, one person dies in each 22 hours and more than one person is injured in each 2 hours.

On the other hand, five border points at the west of Kermanshah pass freight and passenger to/from Iraq (or third party). This means that road network of this province not only serves the regular freight and passenger of the province but also play a national and international role in country transportation. This clarifies the importance of safety monitoring in this province.

It should be noted that, however data was collected in Kermanshah, drivers are not necessarily from Kermanshah or do not necessarily live in Kermanshah and are not limited to drive in this province. Hence a sort of generality can be claimed in the sampling process.

2.2. Participants

A community sample of 603 drivers participated in this study. Participants were bus, public passenger car and truck drivers with valid permit obtained from Road Maintenance and Transportation (RMTO). RMTO is the responsible organization of intercity transportation in Iran which issues the required permit for working as a professional driver in intercity road network. This organization also supervise and trains professional drivers as well. Meantime RMTO is responsible for intercity road transportation safety.

Of the total sample, 224 participants were passenger car drivers, 263 were truck drivers and the 116 remaining were bus drivers. All drivers were men aging from 27 to 61 years old (Mean=41.24, SD=12.08). It should be noted that 792 questionnaires were initially distributed of which 603 returned with less than 20% missing data. Respondents were divided into groups A and B including 302 and 301 members randomly. Results of t-test and χ^2-test confirmed no significant difference between the two groups. Data of group A was used for Exploratory Factor Analysis (EFA) and the results were confirmed by Confirmatory Factor Analysis (CFA) using data of group B. worth to mention that final analysis was accomplished applying the total data.

2.3. Data Collection Procedure and Measures

Data collection procedure was done in a 15-days period from 6th-21th September 2022. In different times of the day drivers who referred to Tir-parks/ fuel stations/ on way restaurants were randomly invited to respond the questionnaire. Participation was voluntary but participants were compensated with ice-cream and cookie. At the first part of the questionnaire age, time with permit from RMTO (in month), annual driving kilometer, number of accidents during professional driving, number of driving tickets, number of being complained by public or reprimanded by RMTO were asked. It should be explained that public are able to call 141 and report any violation and unsafe behavior of professional drivers to RMTO. RMTO on the other hand has legal right to penalize the offender driver. Hence, along with traffic tickets by the police, a total of three parts (public, RMTO and Police) supervise driver's behavior. Total number of "penalties" applied in next sections refers to any kind of penalty obtained by police or RMTO. Direct count of reports by public are not considered inhere for two reasons: first; it may lead to an action taken by RMTO and hence does not require to be counted independently. Second; public do not necessarily evaluate situations professionally and may make mistake in assessing violation of a driver. Hence, any action by RMTO, which may originate by public reports, are included in data as an adding number to "penalties".

Worth to mention that the severity of the accidents might be considered as dependent variable. This variable can be measured by adding up number of fatal/ injury/ damaging accidents each of which weighted by a proper weight. But this might mislead the results. For example, consider two scenarios: in the first scenario, exceeding speed limit consequent to collision to a pedestrian. In the second scenario,

a similar dangerous behavior results in collision to another vehicle. In the first accident vulnerability of the pedestrian results in death but in the second scenario, safety equipment of the vehicle saves human lives. Though, other characteristics rather than dangerous behavior of the driver effect the result and severity of the accident and should not be ignored in the modelling process. The focus of this research is on causal relationship between dangerous behavior and occurrence of the collision regardless of severity of the accident. Thus, number of total accidents is considered.

Second part of the questionnaire aims to evaluate dangerous behavior of drivers. This part includes items suggested by a team consisting of 10 experts from RMTO, 12 police officers and 10 professional drivers. Items were designed in a chain of interview process and literature review. An initial list including 29 items was prepared. Response to each item was provided in a 5-point Likert scale from 1 (Never) to 5 (Always).

2.4. Validity and Reliability of the Instrument

Half of the police officers and RMTO experts reviewed the items for any grammatical/ wording problems and miss understandings. The other half were asked to assess Content Validity Index (CVI) and Content Validity Ratio (CVR) of the instrument. Inter-Class Correlation (ICC) was applied for checking the relevance of the items. Additionally internal consistency was evaluated by the Cronbach's α. Prior to EFA and CFA, Kasier-Mayer-Olkin (KMO) was assessed. PCA with a varimax rotation was next performed in order to determine the factors of the items. CFA was then applied to confirm dimensions of EFA. Finally, qualification of the measurement model was assessed by different fit indices, which are reported in next section.

2.5. Data Analysis

Following descriptive analysis, structural equation model (SEM) was applied to determine the relationships between variables. A series of multiple linear regression were tested to describe the causal relationship between latent variable and number of penalties with number of accidents divided by (Annual driving distance* Time with license from RMTO (year) as the dependent variable. Alternative indices performed to evaluate the modal fit.

Analysis was conducted using SPSS 27(IBM Corporation, USA) and IBM SPSS Amos 27.0 software.

3. Results

3.1. Descriptive Analysis

Descriptive analysis of demographic and occupational variables and Pearson's correlation with dependent variable are reported in table 2.

Table 2. Statistics of study variables

Variable	Mean	Standard Deviation	Pearson's correlation with dependent variable
Age (year)	41.24	12.08	-0.21**
Time with permit from RMTO (year)	15.24	4.75	0.32**
Annual driving distance(km)	71320	25710	0.35*
Number of penalties	3.25	1.92	0.28*
Dependent variable	1.87	1.34	-

*p<0.05, **p<0.01

As shown in table 2, age was negatively correlated with the dependent variable. This may happen because of inducing risk aversion among older drivers. However other variables were significantly positively correlated with number of variables. Positive correlation between number of penalties and the dependent variable suggests that drivers who involved more accidents, have been already penalized for their violations. However, continuing violation

and dangerous behavior, along with the accidental and randomness nature of crashes, finally lead to more accidents during their professional driving.

3.2. Validity and Reliability of the Instrument

According to the Lawshe method (1975) CVR is required to be ≥0.62 and CVI is required to be greater than 0.75. Considering the result of CVI and CVR, a total of 21 items from the initial 29 items were qualified to remain in the instrument. The mean CVIs, mean CVRs of the measures were 0.83 and 0.72 respectively. ICC was 0.81, which falls in the range of 0.75 and 0.9 and hence reflects good reliability (Koo and LI, 2016).

Additionally, the result of Cronbach's α coefficient was 0.92 which revealed excellent internal consistency.

Moreover, KMO was 0.834 which confirmed the qualification of the data for factor analysis. Four factors with eigenvalues over 1 were revealed by EFA. The factors explained 54.7 percent of the total variance. Factors were named based on the content of the sub-items. It should be noted that 5 items were disqualified and removed. Next CFA confirmed the revealed factors. Results are shown in table 3. Figure 2 presents the structure of the analysis. Goodness-of-fit of the CFA was assessed by different indices namely comparative fit index (CFI), root mean square error of approximation (RMSEA), standardized root mean square residual (SRMR), results of which are reported in table 4.

3.3. Structural Equation Model

SEM was applied to explore the relationship between dangerous behavior and penalties with the dependent variable (number of accidents divided by (Annual driving distance* Time with license from RMTO (year)). A positive association between dangerous behavior and accident (β=0.24, $p<0.001$) was explored. In addition, while penalties showed a significant positive effect on accident, it significantly mediated the relationship between dangerous behavior and accidents. The structure of the model and standard coefficient and errors are shown in figure 3. Results of t-test confirmed the significance of the coefficient at 95% CI.

Table 3. Factor Analysis Result

Factor	Item	Variance explained	Correlation	Coronach's α
Driving violations	1. Exceed speed limit	24.17	0.623	0.83
	2. Crossing solid line		0.634	
	3. Sudden braking		0.601	
	4. Stopping/ parking in dangerous location		0.584	
Traffic interaction	5. Overtaking other vehicles	12.03	0.612	0.74
	6. Not-observing right-of-way of other vehicles		0.591	
	7. Using and blocking speed lane		0.603	
Spatial carelessness	8. Sudden lane change	10.79	0.574	0.71
	9. Deviation to left		0.593	
	10. Not observing safe distance from front/lateral vehicle		0.623	
Self-engagement	11. Driving while sleepy	7.71	0.674	0.68
	12. Using mobile cell		0.521	
	13. Arguing with another driver/ passengers/ co-driver		0.624	
	14. Talking to passengers/co-driver		0.631	
	15. Head necking		0.592	
	16. Drinking/eating		0.582	

Table4. Fit indices for CFA

Index	χ^2	df	χ^2/df	P-value	CFI	RMSEA	SRMR
Value	3.13	1.04	0.254	0.254	1.00	0.008	0.011

Moreover, results of fit indices, containing goodness-of-fit index (GFI), adjusted of goodness-of-fit index (AGFI), Normed fit index (NFI), comparative fit index (CFI) along with RMSEA and SRMR are reported in table 5 which confirm an acceptable fit of the model.

Table 5. Goodness-of fit indices for SEM

GFI	NFI	RMSEA	CFI	SRMR
0.97	0.93	0.021	0.99	0.024

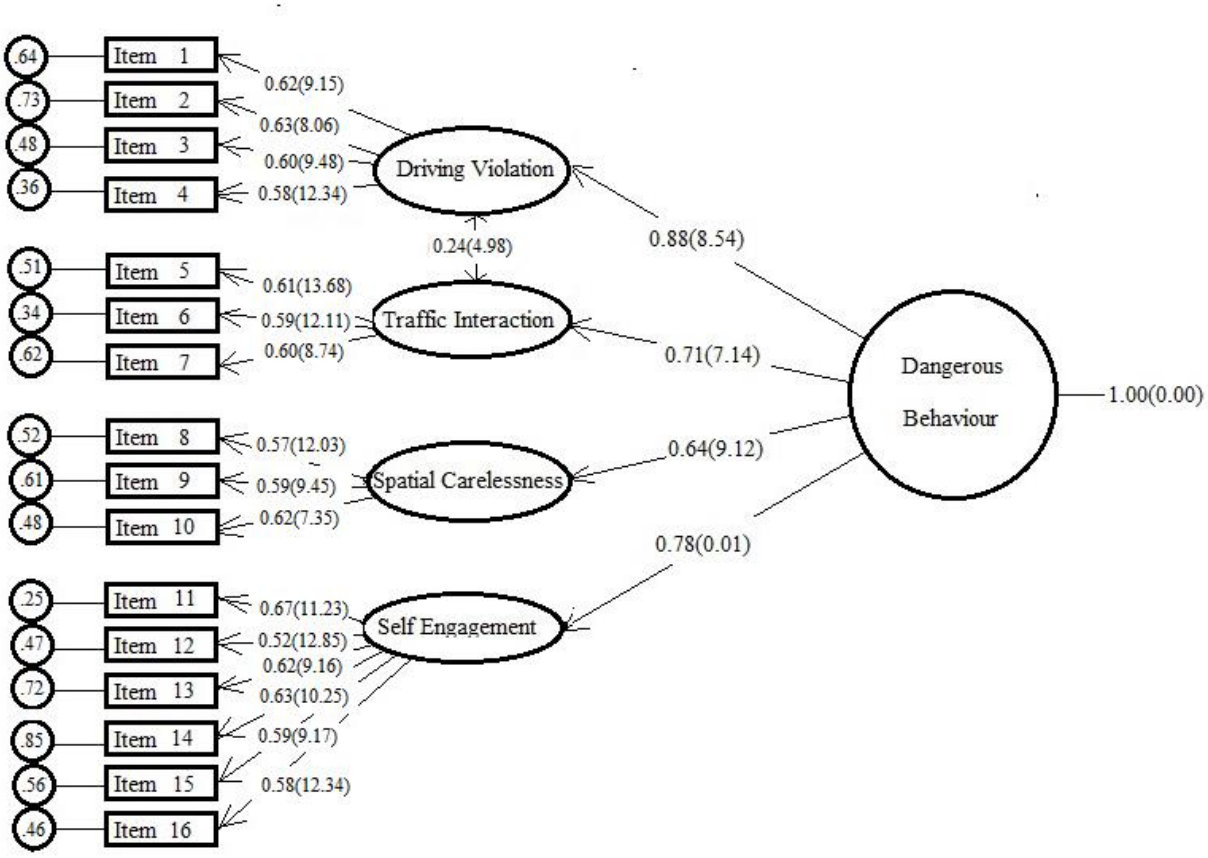

Figure 2. Confirmatory Factor Analysis for the latent variable: Dangerous Behavior

4. Discussion

The aims of present study were:

1. To validate a questionnaire for a self-report dangerous behavior of professional (passenger/freight) vehicle drivers of intercity road network.
2. To measure the latent variable of "dangerous behavior" from provided instrument which depicts the main factors that construct dangerous driving behavior.
3. To explore the association of dangerous behavior on accident
4. To explore the mediating role of penalties on accident to support the reducing role of supervising drivers on number of road accidents.

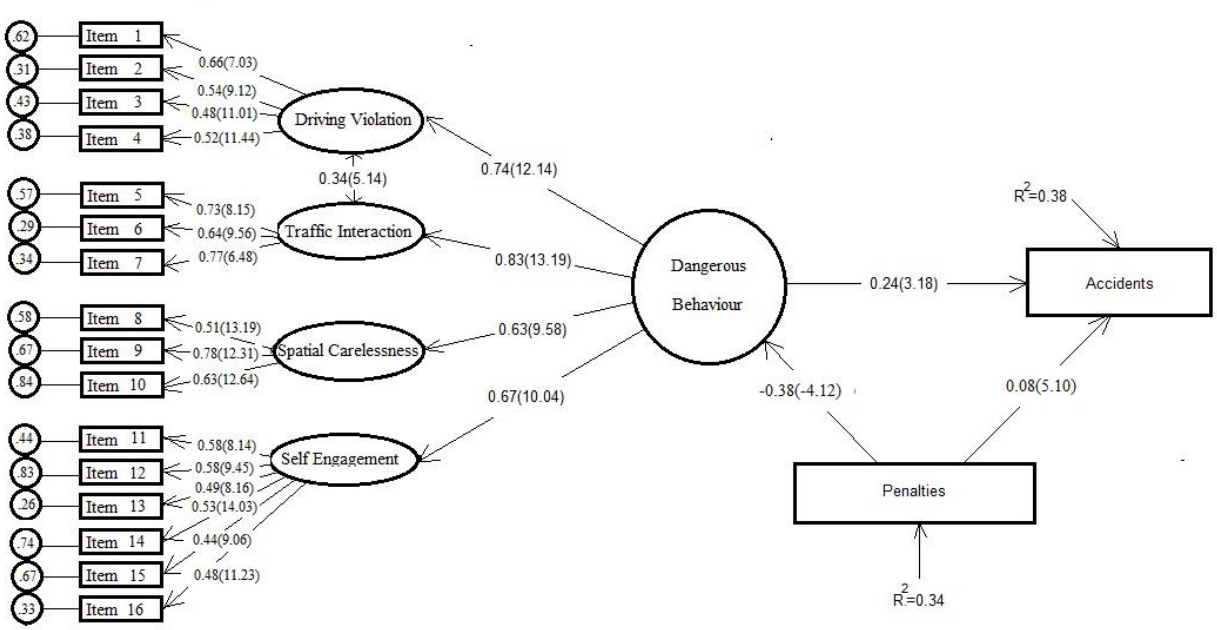

Figure 3. Structural equation model of study

χsquare=70.64; df=74; p=0.5714; RMSEA=0.000

Dangerous behavior of drivers is regarded as a strong cause of road traffic fatalities and injuries (Dotse and Rowe, 2021, Ge et. al., 2023). However, determining dangerous behavior as a latent variable would not be possible through a direct measurement. While different technological instruments are provided, in vehicle or on road, they are not yet able to cover all behaviors of drivers. For example, public vehicles (bus, passenger cars and trucks) are equipped to black box in Iran. Speed cameras are also provided approximately every 2.5 kilometers of each highway and main road. These kinds of equipment provide worthy data especially about speed, however driver's dangerous behavior such as sudden lane change or not observing right of way of other vehicles cannot be determined; hence self-reported questionnaires are practical ways for researchers to assess the behavior of the drivers (hill et. al., 2023). This research has successfully validated a questionnaire which can be used among professional drivers for intercity transport in Iran. Results indicates that four main factors construct the dangerous behavior of professional drivers. The first and second factors with the highest explained variance consist of those behaviors which usually effects on the severity of the potential collision. Exceed speed limit, the strongest item is well known as main contributor to accident. More severity is experienced duo to higher energy release and hence more fatalities (Siskind et al., 2011; Donaldson et al., 2006), vulnerability of pedestrians (Hussain et al., 2019) and less time to react properly (William et al, 2006; Aarts & Van Schagen 2006). Moreover, crossing solid line, especially on two-way roads increases the risk of face-to-face collision, which similar to high speed, can lead to severe collision and high rate of fatality. Sudden brake and stop/park in inappropriate location are other measures of first factor. Hard braking was previously determined as an accident leading factor as well. For instance, according to Desai et. al. (2020) there were approximately 1 crash per mile for every 147 hard-brake in summer 2019 in India.

While measures of the first factor generally relate to a driver independent behavior, second factor consists of measures in which a driver shows a dangerous behavior while interacting

with other vehicles. Overtaking, not observing right-of-way and blocking speed way are the three measures of this factor. It seems that such behaviors annoy other drivers and may motivate them to show an unsafe behavior in return. For example, trucks and buses are not expected to block speed way. If drivers of such large size vehicles do not allow other drivers to overtake, they may be incensed to overtake from right hand side. Worth to mention that most calls to 141 is related to those behaviors of professional drivers that had annoyed other drivers. Measures of the second factor include those behaviors that may lead to an accident in which the main culprit (the violator professional driver) may not necessarily involves. Worth to mention that a significant correlation was explored between the first and the second factor which seems logic. For example, a driver may exceed speed limit and at the same time block the speed way.

Third factor contains measures that represent carelessness of drivers to keep the vehicle in a single lane or in a safe distance from other vehicles. Such situation may again lead other drivers (especially unexperienced ones) to fail safe driving.

Finally, the last factor consists of measures that reflect those behaviors that disturb sight, hearing and overall attention of the drivers. Similar behaviors were previously mentioned by other researchers as well (De Winter & Dodou, 2010, 2016; Mokarami et al., 2019). Although these behaviors are categorized as dangerous behavior which can increase the risk of collision, they can be restricted by co-drivers. Co-drivers for bus and trucks are mandatory in Iran, however, the driving task is mostly performed by the main driver in practice. Herein image processing of in-vehicle camera can be used as a supervising instrument. Sharing driving task with co-driver offers enough time for eating, drinking, using phone cell, corresponding to passengers and even sleeping. Obviously, this solution cannot be applied in passenger cars where only a single driver is responsible.

CFA presented acceptable exploratory correlation between factors and the latent variable, confirming with the result of the t-test. Thus, overall good validity and fitness was obtained for the structure.

Worth to mention that while the initial measures were provided of which 16 final items were extracted, drivers were the ones who committed such behaviors. They, as professional drivers, assess self-behaviors as dangerous. Therefore, the initial step to persuade them for behavioral change had been previously taken, and that is adequate consciousness for behavioral change necessity. Herein providing information about the effect of their behavior on fatalities and injuries along with adequate training, effective fining and appropriate supervising would be useful solutions to persuade drivers for safe driving.

Further this research has explored the effect of dangerous behavior of drivers on accidents they had previously experienced. Acceptable goodness-of-fit of indices confirmed the capability of the structure to present causal relationship of the latent variable with accidents. Moreover, this study found evidence about the mediation role of the penalties. As clarifies by the structure, more dangerous behavior leads to more accidents. More penalties also increase accident. This shows that more risk-taking drivers, which got more penalties, were more involved in accidents, however penalties in return by limiting dangerous behavior finally mediates its effect on accident frequency. In another word, dangerous behavior of drivers, if not totally, at least partially avoid dangerous behaviour and in the absence of these penalties more accidents were expected due to dangerous behaviour of professional drivers.

Furthermore, comparing the load factors suggests:

1- Obviously, all dangerous behaviors do not necessarily result in a collision, hence the rate

of getting penalties is higher than occurrence of a crash. Two reasons can be discussed in here. First; there are several sorts of observing a driver: Public, police and RMTO. This increase the probability of being blamed by a single, even a slight, dangerous behavior. Occurrence of a crash on the other hand, is generally the result of a chain of causes. Second; all penalties are not necessarily realistic because they are based on judgment of public, expert of RMTO or police officers. However, number of accidents is a simple count of deterministic situations.

2- Number of penalties showed an increasing direct effect on accidents. This suggest that risk taking drivers involve more in accidents. Albeit, risk taking behaviour could not be measured by just one item "number of penalties", however more risky behaviour increases the probability of being penalized. However negative significant relation of penalties on dangerous behaviour, while mediating the effect on accident, remains a total negative effect of penalties on accident frequency. This result confirms that more penalties will limit drivers in dangerous behaving and successfully decrease accident frequency.

3- While penalties have a decreasing effect by mediating the relationship of dangerous behavior on accidents, the load factor is very small in comparison effect of the dangerous behaviour. From one point of view, this means that penalties are not adequate and thus not capable enough to prevent accidents. This calls for a stricter supervision on professional drivers. This could be in the form of discover more violation or in the form of reacting them. Violation may be explored but disregarded by police officers and RMTO. From another point of view a comprehensive plan, rather than penalties, is required for behavioral change. Cooper (1997) mentioned previously that drivers with more tickets were more likely to be involved in future accidents. Such results reflect the failure of penalties such as fine tickets, as the unique tool, and represent the necessity of novel solution in which other preventing/persuading strategies are applied. For example, motivation the sense of responsibility of drivers could be an effective way. The reason is that, it may be impossible to supervise all behaviors of drivers in all locations and all times due to many technological and economical limitations, and all of them are not categorized as "violation". Hence self-control is required to protect drivers' behavior in a safe and defense driving frame.

Furthermore, as the validated instrument is a self-reported scale, it is highly dependent on the self judgement of the respondent on behaving and driving experience. Therefore, focusing on professional drivers which provide a rather homogenous community could be regarded as the strength of this study. This, at the same time explains that why a new instrument was required although several previous instruments had been provided. Nevertheless, because initial items and further choosing among them and next validating the instrument were totally conducted by professional drivers and related experts, the final instrument best suits for such drivers. A same justification could be discussed for the type of the network under study. Driving characteristics in urban network differs from intercity networks and so do the dangerous behaviors and violations. For example, crossing red light, stopping out of bus stop are of meaningful violations in urban network which are not included in the questionnaire. Hence the instrument well suits for intercity networks.

5. Conclusion

This study has presented a reliable and valid instrument that measures the behavior of professional drivers as a latent behavior. While different instruments have been validated previously by other researches, to our best knowledge, it is the first time that the behavior

of professional drivers (passenger car, bus, truck) in intercity network has been focused.

Further modelling process of this research has indicated the role of dangerous behavior on accident. Moreover, the mediating role of penalties on the relationship between dangerous behavior and accidents was indicated. Public reports which lead to RMTO action as well as official police tickets has been recognized as effective tool for supervising professional drivers. Results showed that supervising drivers can significantly reduce rate of accidents, however present penalties are not adequate. In addition to increase strict supervision, novel strategies are required to motivate drivers for behavioral changes such as providing adequate information about the effect of dangerous driving on the total fatalities, injuries and financial losses. Additionally, number of penalties was considered in this study. a more realistic sight could be obtained by considering number of penalties. This can better reveal that more violation is needed to be discovered or a heavier penalty is required to be applied for a better result. Next study would focus on this issue.

The result of this study may be of concern of policy makers for safe transportation on intercity road network and mainly for RMTO in Iran through organizational role on intercity Iranian professional drivers.

6. Acknowledgement

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