AUT Journal of Civil Engineering

AUT J. Civil Eng., 5(1) (2021) 69-78
DOI: 10.22060/ajce.2020.17422.5631

The effective factors on the safety culture of Hazmat drivers

A. Mahpour[1,*], M. Shafaati[2], A. Mohammadian-Amiri[3]

[1] Assistant Professor, Faculty of Civil, Water and Environmental Engineering, Shahid Abbaspour School of Engineering, Shahid Beheshti University, Tehran, Iran.
[2] PhD. Student, Faculty of Civil and Environmental Engineering, Tarbiat Modares University, Tehran, Iran.
[3] PDepartment of Civil Engineering, Faculty of Engineering,McMaster University, Hamilton, Canada.

ABSTRACT: Analyzing how safety culture influences the drivers' behavior is extremely important from the public-health point of view. It allows experts and researchers to propose preventive measures based on a multidisciplinary approach. In this regard, several studies have investigated the importance of safety culture and its effect on traffic safety. However, only a few studies have evaluated this issue in the drivers of heavy vehicles which carry chemical hazardous materials (HAZMAT). Thus, the main objective of this research is to obtain the effective parameters affecting the safety culture of HAZMAT drivers. The ultimate goal is to determine the priority of parameters and weigh them to provide insights into the factors leading to accidents in this type of vehicle. To address this goal, 339 questionnaires were obtained from the drivers whose jobs were carrying this type of material; subsequently, the results of the survey were analyzed using the Analytical Hierarchy Process (AHP). The weights were calculated in order to define a global score for each of contributing factors. The results showed that the priorities of the predefined contributing factors are social, psychological, legislation and law enforcement, public education, and economic respectively. The first and second factors are human-related. In a conclusion, human-related factors, are the most important factors in safety culture. Therefore, to improve safety, focusing on human-related factors is essential.

Review History:
Received: Nov. 25, 2019
Revised: Feb. 07, 2020
Accepted: Mar. 10, 2020
Available Online: Apr. 02, 2020

Keywords:
Safety Culture
Chemicals Hazardous Vehicles
Accidents
Iran.

1- Introduction

Hazardous materials are widely used in different sectors such as industry, mines, and agriculture. This type of material can cause a significant risk on the people's health and safety as well as the environment, due to their physical and chemical characteristics (Kara, 2003). The US Department of Transportation (US DOT) defines a hazardous material (HAZMAT) as any substance or material capable of causing harm to people, property, and the environment (Erkut et al. 2007). In most cases, the location of producing and consuming such a substance is not the same. As a result, they must be transported between two locations. This transporting makes the occurrence of disaster-related to HAZMAT quite possible. Because of the dangerous nature of such substances, considering the safety measures in each step of production, storing, and distribution would be essential. Previous experiences of the occurrence of traffic accidents involving such dangerous materials confirm the necessity of investigating these types of accidents. For example, the explosion of the tanker carrying Propane in July 1978 in Spain left 200 people dead and 120 injured (Reilly et al., 2012). Chlorine leakage in Ontario, Canada is another example that made 200000 people evacuate the region (Reilly et al., 2012). The explosion of a tanker carrying fuel (gasoline) in 1982 in Afghanistan caused 2700 people to die, and the rollover of the fuel tanker in Neishabour, Iran in 2003 left 295 dead and 460 people injured (Saffarzadeh et al., 2015). In the United States, in 2017, 4657 large trucks were involved in fatal crashes. 56422 and 102973 large trucks were involved in injury and PDO crashes respectively. Hazardous materials cargo account for 3 and 2 percent fatal and nonfatal crashes respectively. Flammable liquids consist of 63 percent of the hazardous material released in fatal crashes (FASCM., 2017). All of these statistics highlight the importance of the issue of HAZMAT (hazardous material) trucks.

Conventionally, the focus of safety analysis of heavy vehicles involving hazardous materials has been on investigating the relationships between the roadway and environmental conditions (e.g., weather conditions, the geometry of the freeway), traffic characteristics (e.g., speed, flow), driver characteristics (e.g., gender, age), and crash occurrence (Li et. al., 2009). However, there is still no consensus on how these parameters interact with each other. Thus, the relationship between the different aspects of drivers' characteristics and the safety of HAZMAT trucks should be understood. In this regard, knowing the behavioral, personality, and other aspects of humans can be useful for providing applicable schemes in order to decrease the injuries and fatalities of these types of accidents.

*Corresponding author's email: a_mahpour@sbu.ac.ir

Because of the importance of the human role, knowing the influential factors related to the driving culture is essential. Generally, culture accounts for how groups identify themselves and interact with their environment through developing, building, and using artifacts. The people's choice of driving is based on their values and beliefs, which are determined considering the appropriate use of vehicles. Moreover, driving itself changes how people understand time and space. It means that driving can alter peoples' perceptions and experiences of distance. Cars as material objects and driving as an embodied experience, therefore, reflect and reinforce the cultural identity. In the field of traffic safety, several studies have been conducted about the safety of HAZMAT vehicles (e.g. Oggero, et al., 2006; Wang et al., 2005; Yang et al., 2010; Zhao et al., 2009; Zhao, et al., 2012; Zhu, et al., 2016; Ronza, et al., 2007; Inanloo, et al., 2016; Chen, et al., 2018). However, few numbers of studies have evaluated the impact of driving culture on transporting hazardous materials. In the field of traffic, safety culture refers to public beliefs and attitudes that contribute to their compliance or noncompliance with traffic safety regulations. Traffic safety culture is mostly about the public with inputs from engineers, legislators, law enforcers, and other leaders (Bruner, 2015).

Accordingly, the present study pursues a twofold objective. The main objective is investigating the influence of the safety culture of heavy vehicle drivers on the probability of road accident occurrence. The ultimate goal is understanding the importance of different factors which can result in an accident in HAZMAT vehicles. This study will focus on only human-related factors. To address the above-mentioned objectives, firstly, different parameters of the safety culture of the drivers of HAZMAT vehicles will be identified; subsequently, the influential factors will be prioritized.

In the following, a brief overview of past studies that were conducted in this area will be discussed. Subsequently, the data used in this research and the methodology of the study will be explained comprehensively. Finally, the results will be present, followed by the discussion and conclusion.

2- Literature review

The literature review includes two main parts. In the first part, some insights into the concept of safety culture as well as safety climate are provided. Then, after addressing the gaps of those studies, the main objective of the present paper will be emphasized again. In the second part, the studies related to the factors being considered in our study will be focused on.

2.1. Traffic safety culture

Traffic safety culture is a relatively new concept, which has recently gained attention in the field of traffic safety (Edwards et al., 2014). According to Nordfjærn et al., a comparison between Norway, Russia, India, Ghana, Tanzania, Uganda, Turkey, and Iran, demonstrated that Norwegians reported overall safer attitudes towards traffic safety and driver behavior than the others (Nordfjærn et al., 2014). Also, a comparison of traffic safety culture in China, Japan, and the US, showed that there is an emphasis on reducing risk in Japan's driving culture, which leads to a lower rate of crashes (Atchley et al., 2014). Zoghi et al. (2016) assessed the effects of culture on traffic safety. They found that in Iran, drivers tend to demonstrate aberrant driving behaviors.

There are some other studies in which, it has been focused on the drivers' alcohol or drug use for predicting driving safety (Loeb and Clarke, 2007; Walsh et al., 2004). A study in Saudi Arabia showed that aggressive and speedy driving affect the accident involvement significantly but drivers' attitude had no impact on accident occurrence (Mohamed and Bromfield, 2017). Research in the US showed that U.S. households endorsed most pro-safety items, especially those that involved alcohol-impaired driving (Girasek, 2013).

Safety climate is another concept related to the safety culture, which has recently drawn researchers' attention (Gehlert et al., 2014). It is defined as "road users' attitudes and perceptions of the traffic in a context (e.g., country) at a given point in time" (Özkan and Lajunen, 2011). Some studies suggested that there is a strong relationship between traffic violations, errors, and distraction, and safety climate factors (Wills et al., 2006). Accordingly, Zhang et al. figured out that traffic safety climate is directly predicted by personality traits (Zhang et al., 2018). It is crucial to mention that we have been inspired by the factors influencing safety climate to determine the factors affecting safety culture. Also, the role of the driver in truck-involved accidents have been analyzed in several studies., Cantor et al. found that driver age, weight, height, gender, employment stability, and previous violations are significantly connected with the likelihood of crash occurrence (Cantor et al., 2010).

Li et al. (2014) divided the effective factors on driving culture into two general categories including socio-economic components such as age, sex, graduations, and income on one hand, and attitudes, behaviors, and the driver's experiences on the other hand (Li et al., 2014). fig.1, illustrates, the relationship between the influential factors on the safety and driving culture in their study.

According to research conducted by Bruner (2015), it has been stated that the traffic safety culture consists of four components including Media, Education, Law and Rules, and Law enforcement (Bruner, 2015).

In the present paper, considering components introduced by (Bruner, 2015) and (Li et al., 2014), the main objective is to analyze the driving culture of hazardous material drivers. The components utilized in the presented paper have derived from the accumulation of components introduced by Bruner (2015). For example, the components of education and media are considered as public education, or age, sex, and graduation rate are categorized as societal characteristics. Also, parameters like attitude, behavior, and experience are considered psychological characteristics.

2.2. The importance of the considered factors

To the best of our knowledge, there is not any research in which the prioritization of the effective factors on the driving culture in the drivers of HAZMAT vehicles to have

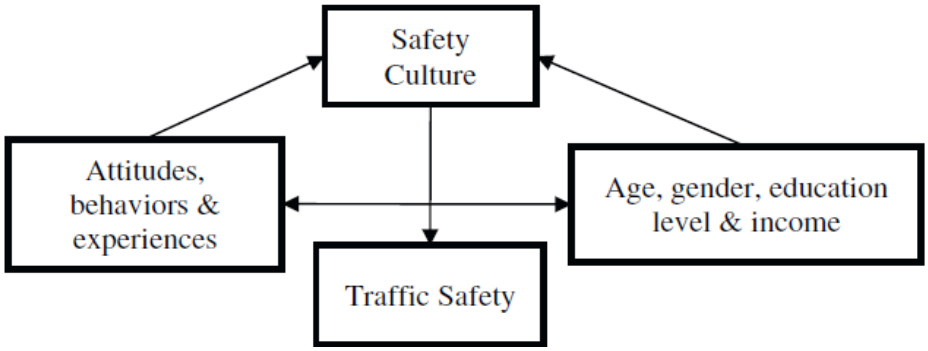

Fig. 1. The relation between the influential factors on the safety and driving culture (Li et al., 2014)

been done. However, the factors analyzed in this paper can be seen separately in the other studies. But, in this paper, it could be necessary to mention some studies that each of which has assessed the effectiveness of the factors determining the driving safety culture separately.

Social factors play an essential role in road accidents. The reason is that the causes of motor vehicle collisions broadly depend on the characteristics of drivers (Rolison et al., 2013). In our study, social factors are related to the drivers' characteristics. For example, when it comes to "age," we can view risk-taking behavior, as one of the very reasons for the collisions in which young drivers are involved (Rolinson et al., 2013). In the case of older drivers, there are other reasons for getting involved in accidents. They might more often get involved in driver error especially at intersections and when making turns (Langford & Koppel, 2006) as they are lack perfect visual, cognitive, and mobility functioning (Hu et al., 1993; Janke, 1991).

In this paper, law-abiding, aggressive driving, and defensive driving have been analyzed. These factors are related to driver psychology. There is a large number of papers that have assessed the influence of this factor on driving. For example, agreeable people, since they are less aggressive, they show less risky behavior in driving (King and Parker, 2008). According to the study done by De Vries et al. (2017), the authors concluded that the more conscientious drivers are, the riskier driving behaviors they show in different driving scenarios (De Vries et al., 2017). It must be reminded that there are five big factors describing personality: conscientiousness, extraversion, agreeableness, openness, and neuroticism (Barrick and Mount, 1991). Clarke and Robertson (2005) found that the likelihood of a conscientious individual getting involved in an occupational accident is low (Clarke and Robertson, 2005). Verwey and Zeidel (2000), believe that less vigilance of extravert people may be especially detrimental in monotonous tasks such as long-haul driving, which truck drivers have to do (Verwey and Zeidel, 2000). Clark and Robertson (2005) reported a small positive correlation between openness and accident involvement. However, de Vries et al., 2017, believe that the conclusion achieved by Clark and Robertson receives scarce support. Dahlen and White, (2006) showed that higher neuroticism results in more aggressive driving behavior.

Many road accidents occur because of breaking the law. For example, drunk driving is outlawed in many countries. However, many accidents are due to the drivers consuming alcohol. Analyzing alcohol-related fatal crashes from 1993 to 2015 in the US showed that an increase in the number of factors associated with anti-alcohol community norms, values, attitudes, and beliefs results in a decrease in alcohol-related crashes at the country level (stringer 2018).

About economic factors, during the economic recession between 2007 and 2010, people's behavior changed in a way that results in fewer people being killed on the roads in the UK (Lloyd et al., 2015). Also, in the US, it has been proved that an increase in the inequality of income distribution, has reduced traffic fatalities (Noland & Zhou., 2017).

Another factor analyzed in this research is education. An investigation on the cycling education program in Australia showed that there was no evidence that the program improved safety-relevant cycling behaviors or experience of crashes (Hatfield, j., et al, 2019). However, some studies like (Maring and Van Schagen, 1990) believe that cycling education programs for children could reduce the frequency of injuries related to the bicycle.

Since the safety culture is a new concept, the factors influencing it, have not been exactly understood yet, especially among the drivers of HAZMAT vehicles. The reviewed studies have not considered all factors together. More importantly, they haven't done that by surveying the drivers themselves. Therefore, in this paper, by reviewing the literature related to the safety culture as well as safety climate, and also by considering the effective factors on accidents (human, environment, and vehicle), the objective

is to present a new conceptual framework. It has been done by surveying the drivers themselves. This framework aims to determine the effective factors on the safety culture.

3- Methodology

The main object of this paper is determining the weight of factors and prioritizing them. To achieve this goal, 339 questionnaires were obtained from drivers who are dealing with these types of materials; subsequently, the results of the survey were analyzed using the Analytical Hierarchy Process (AHP). Finally, to prioritize the contributing factors, the weights were calculated (fig.2).

Generally, several contributing factors influence the driver safety culture, among which the human and environment are the most important ones. According to both the literature and the authors' thoughts, the factors affecting the safety culture can be shown in fig.3.

Thus, the social, economic, and psychological characteristics are connected to the human-related factor, while education, legislation, and law enforcement are related to the environmental factor as shown in fig.4.

3.1. Analytical Hierarchy Process (AHP) method

The present paper uses the AHP method to prioritize the factors. The analytical hierarchy process (AHP), first introduced by Thomas L. Saaty (Fong & Choi., 2000), is described by Partovi (1992) as a "decision-aiding tool for dealing with the complex, unstructured and multi-attribute decision". Therefore, this approach is generally applied when there is a kind of decision-making situation where there are several alternatives, criteria, or factors, which can be quantitative or qualitative.

The AHP considers a set of alternative possibilities among which the best one is to be made using different evaluation criteria. The AHP allocates a score to each option based on the decision maker's pair-wise comparisons of the choices according to that criterion. The higher the weight, the more significant the corresponding criterion. The higher the score, the better the performance of the option about to the considered criterion. In the end, the AHP combines the criteria weights and the options scores to define a global score for each option, which is followed by a consequent ranking. The global score for a particular option is a weighted sum of the scores it achieved about all the criteria (Saaty, 1980).

Figure 2. Research flowchart

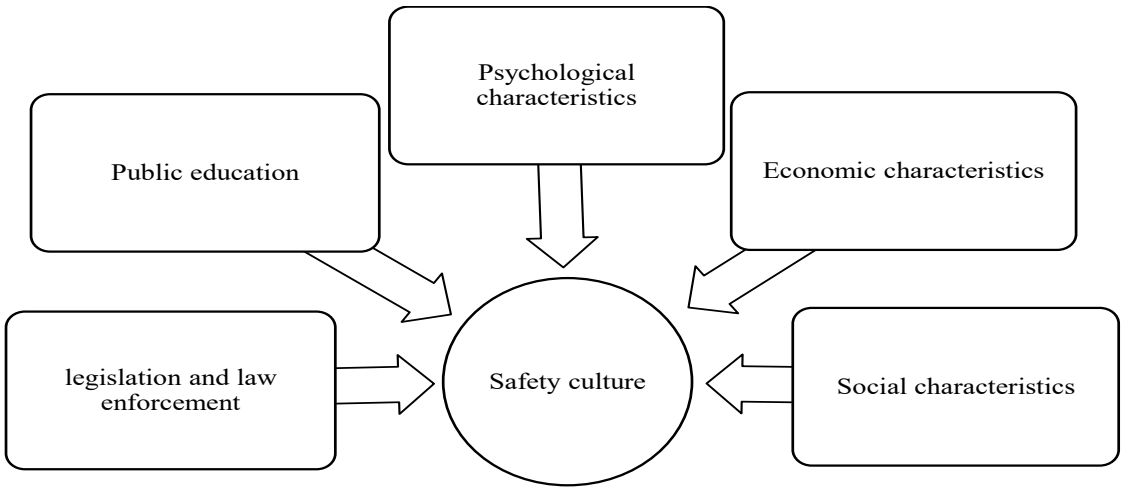

Fig. 3. The effective and defined components on the safety culture

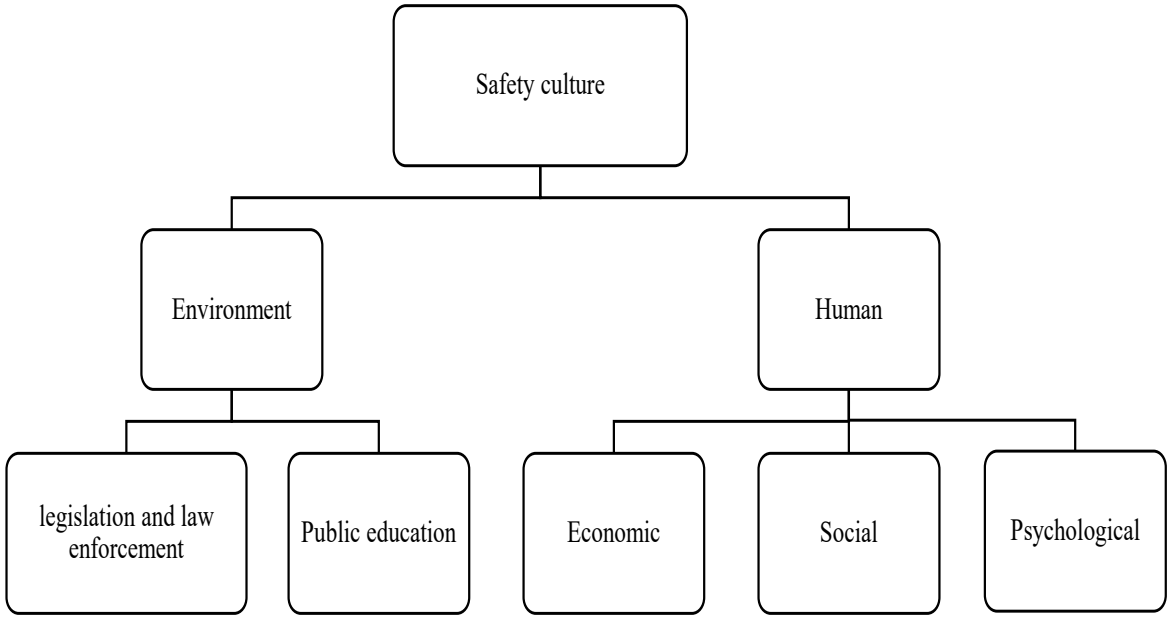

Fig. 4. The effective components of the driving culture

3.2. Questioning

Questionnaires can be beneficial in understanding cultural and economic variables, in a particular population. To pursue this objective, after determining the contributing factors to the driving culture, a standard and specified questionnaire were designed.

As mentioned before, the variables used in this paper correspond to three main factors: 1. Human, 2. Environment, 3. Vehicle. The economic, social, and psychological variables can be related to human factors, and legislation and law enforcement, as well as, public education can be related to environmental factors. There is no need to consider the factors relating to vehicles, as the study has been limited to the drivers of chemical hazardous vehicles. Since the accidents in which the hazardous vehicles are involved are potentially much more severe, the drivers of this type of vehicle were surveyed. They were asked to compare the five effective factors mentioned in Fig.3, by pair-wise comparison. As an example, they were asked to compare the factor 'age' as a social factor to the "education" they received as a "public education" factor. This comparison was aimed at prioritizing the factors related to the safety culture of HAZMAT drivers.

To compare the factors pair-wise, drivers should weigh them, stating which of the two factors are more important to them. Therefore, the drivers compare every pair of those five factors.

3.3. The sample sizes

Sample size refers to the number of participants or observations included in a study. The size of a sample influences two statistical properties: 1) the precision of our estimates and 2) the power of the study to conclude.

Determining the optimal sample size is an essential part of this study. It is a critical step in the design of a planned research protocol. Using too many participants in a study is expensive and but the sample size should be big enough so that it can be compatible with the entire population reliably. Hence, using formula 1, the minimum number of observations should be determined (Hensher, 2005).

$$n = \frac{Npq\left[\Phi^{-1}\left(1-\frac{\alpha}{2}\right)\right]^2}{a^2(N-1)+pq\left[\Phi^{-1}\left(1-\frac{\alpha}{2}\right)\right]^2} \quad (1)$$

Where N is the population size, $\Phi^{-1}\left(1-\frac{\alpha}{2}\right)$ is the inverse function of the cumulative distribution for the standard distribution, and α is the precision level. p is the actual ratio of choosing an option in the population, and it is the amount of the attribute in the population and q= p-1. The total number of the hazardous material drivers is equal to 30634 but according to the statistical yearbook published by the Iranian road maintenance and transportation organization, the total number of truck drivers in Iran is equal to 471290 people, so hazardous material drivers are 6.5 percent of the total number of drivers. Also, the allowed error is 1 percent. If the population size is not determined, for gaining the sample size, the formula 2 is used (Hensher, 2005):

$$n = \frac{pq\left[\Phi^{-1}\left(1-\frac{\alpha}{2}\right)\right]^2}{a^2} \quad (2)$$

According to formula two, by considering the 95 percent of reliability, the term $\Phi^{-1}\left(1-\frac{\alpha}{2}\right)$ is equal to 3.23 and the minimum sample size would be 327 observations, as shown in the following:

$$n = \frac{0.065\times 0.935\times 2.32^2}{0.01^2} = 327 \quad (3)$$

4- Results and discussion

4.1. The statistical description of the data

The population is the total number of hazardous material drivers who drive in Tehran. The survey was conducted with the drivers participating in the educational classes set up by the Iranian road maintenance and transportation organization, being asked to answer certain questions. The sample was provided randomly, and the number of observations was 391.

Firstly, the information about the population should be analyzed. The used population, are the total hazardous material drivers in Tehran, but the information about them is not accessible. Thus, it is assumed that the drivers' characteristics of cargo vehicles are homologous to that of the drivers of HAZMAT vehicles. In table 1, the drivers' characteristics of driving cargo vehicles have been presented in terms of age groups, graduations, work experience, and marital status.

4.2. Developing the mathematical model

The AHP method has been used to prioritize and determine the importance of the efficiency measures and indexes of the infrastructures of freight transportation; subsequently, the obtained information was imported to the Expert Choice software, which resulted in the level of importance and the weight of each factor, as follows:

1- The first priority: The social factors (age, graduations, and others) (with the weight of 0.274)
2- The second priority: The psychological factors (law-abiding, aggressive driving, defensive driving) (with the weight of 0.208)
3- The third priority: The legislation and law enforcement (with the weight of 0.201)
4- The fourth priority: Public education (with the weight of 0.183)
5- The fifth priority: The economic factors (income, wealth, and others) (with the weight of 0.134)

Since the operating discipline is done by humans, a true claim can be made in which the most important and influential factor is the humanitarian factor. Besides, the results achieved in this part are genuinely confirmed by the fact that humanitarian factors have the most significant share in the occurrence of road accidents all over the world.

4.3. Discussion

Firstly, it should be noticed that the data has been gathered by surveying the drivers themselves. One might argue that drivers are not the ones who are able to analyze the complex problem of the safety of HAZMAT vehicles in the best way, so this data wouldn't be reliable. In spite of that, as the drivers carry the HAZMAT, their lives are always at risk. They actually touch the danger in their everyday lives. Therefore, it seems that the drivers are not only uninformed about the problem but also are quite knowledgeable even more than engineers and experts. Hence, asking them about their own safety is a logical thing to do.

The outcome of the present paper is somewhat consistent with the fact that more than 90 percent of accidents are due

Table 1. The drivers' characteristics of cargo vehicles in Tehran province to the middle of the year 2017

Characteristics	Categories	Share in the sample	Share in the population*
Age	To 25-year-old	1.5	0.5
	25 to 29-year-old	5.5	4.5
	30 to 39-year-old	32	36
	40 to 49-year-old	25	29
	More than 50-year-old	36	30
Graduations	Illiterate	0	0
	Reading and writing	1.5	1.5
	Elementary school	15	17
	Guidance school	43	51.5
	High school graduate	30	25
	Associated degree	7	2.5
	Bachelor degree	3.5	2.5
	Master degree and higher levels	0	0
	Religious schools	0	0
Work experience	To 5 years	20	15
	5 to 9 years	18	22
	10 to 14 years	23	25
	15 to 19 years	13	11
	20 to 24 years	11	9
	More than 25 years	15	18
Marital status	Married	80	85
	Single	20	15

to human factors. The interesting thing though is that not only the analysis of accident data shows that human factors accounting for the most fatalities, but also it is viewed as the most important factor by the drivers themselves, in this case, the drivers of hazardous material vehicles. It seems that the most important factors are those that are related to the drivers. As it was shown by the AHP method, social and psychological factors are first and second factors respectively, both being related to the drivers' characterizations. Therefore, in order to improve the safety of this group of drivers, it should be more focused on improving their ability to cope and deal with dangerous situations. One could argue that the economic factor is defined as a human-related factor, and this factor has appeared in the last priority, so our emphasis on the importance of human factors is not reasonable. Nevertheless, the authors believe that although economic factor has something to do with the drivers themselves, it is mostly the economic situation of the country which determines this factor. In fact, the drivers themselves don't have the political power so that they could change the economic situation. Some papers related to truck-involved crashes, somehow verify the findings of this study. For example, Islam and Hernandez in their study concluded that the human-related factors significantly influence the severity (Islam & Hernandez., 2013). In other research, emotional factors have been found to be associated with higher severity of crashes (Zhu & Srinivasan., 2011). Similarly, in our paper, the social and psychological factors are on the top priority and emotional factors are connected to these two factors. Shen et al. (2014) also suggested that human errors and vehicle defects could be viewed as the main reason for Hazmat crashes. As it can be seen, the findings of the present research, are almost supported by several studies. However, to the authors' knowledge, there is not any similar research to this paper, meaning that the prioritization of factors has not been done for the drivers of HAZMAT vehicles. It has not been done for the other drivers based on the safety culture as well. Therefore, it is not easy to compare this study to other studies and to conclude robustly if this study is consistent with the other studies or not.

5- Conclusion and suggestions

The accidents in which hazardous chemical vehicles getting involved reflect the importance of analyzing the factors leading to the occurrence of such accidents. Regarding the significance of human roles, knowing the contributing factors influencing the driving culture is quite essential. The literature review shows that a few studies have identified and prioritized the factors that affect the driving culture of hazardous chemical drivers. Therefore, in the present study, as a trial for enhancing the precision of the results, a questionnaire was designed, and the drivers were asked to participate, resulting in 339 completed questionnaires.

Afterward, the outcome was imported to the Expert Choice software, which is capable of conducting AHP. The results showed that the first to fifth priorities of the predefined contributing factors are: social (such as age, graduations, and others with the weight being equal to 0.274), psychological (attitude, law-abiding, aggressive driving, and defensive driving with the weight being equal to 0.208), legislation and law enforcement (with the weight being equal to 0.201), public education (with the weight being equal to 0.183), and economic (income, wealth, and others with the weight being equal to 0.132) respectively.

Therefore, it's safe to conclude that when it comes to the safety culture of this group of drivers, according to their opinions, human factors are very essential to grab experts as well as researchers' attention. For future studies about this topic, some suggestions are listed below:

- The issue of the driving culture can be analyzed by assessing the influential factors on the safety culture of the drivers of the non-HAZMAT vehicles so that a perspective within the safety culture will be achieved.
- It is suggested to use other decision-making methods such as Topics, Electra, Vikor, and so on, to analyze the influential factors on the driving culture of hazardous chemical drivers.
- It is suggested to use the factor analysis method and structural equation modeling to know the amount of influence each factor has on the driving culture of hazardous chemical drivers.
- It is also suggested to use fuzzy logic among the ranking methods.

References

[1] Atchley, P., Shi, J. and Yamamoto, T., 2014. Cultural foundations of safety culture: A comparison of traffic safety culture in China, Japan and the United States. Transportation research part F: traffic psychology and behaviour, 26, pp.317-325.

[2] Barrick, M.R. and Mount, M.K., 1991. The big five personality dimensions and job performance: a meta-analysis. Personnel psychology, 44(1), pp.1-26.

[3] Bruner, A.M., 2015. Initial framework for improving the traffic safety culture in kansas (Doctoral dissertation, University of Kansas).

[4] Cantor, D.E., Corsi, T.M., Grimm, C.M. and Özpolat, K., 2010. A driver focused truck crash prediction model. Transportation Research Part E: Logistics and Transportation Review, 46(5), pp.683-692.

[5] Chen, J., Zhang, M., Yu, S., Wang, J., 2018. A Bayesian Network for the Transportation Accidents of Hazardous Materials Handling Time Assessment, Procedia Engineering 211, 63–69.

[6] Clarke, S. and T Robertson, I., 2005. A meta-analytic review of the Big Five personality factors and accident involvement in occupational and non-occupational settings. Journal of Occupational and Organizational Psychology, 78(3), pp.355-376.

[7] Dahlen, E.R. and White, R.P., 2006. The Big Five factors, sensation seeking, and driving anger in the prediction of unsafe driving. Personality and Individual Differences, 41(5), pp.903-915.

[8] De Vries, J., de Koster, R., Rijsdijk, S. and Roy, D., 2017. Determinants of safe and productive truck driving: Empirical evidence from long-haul cargo transport. Transportation research part E: logistics and transportation review, 97, pp.113-131.

[9] Edwards, J., Freeman, J., Soole, D. and Watson, B., 2014. A framework for conceptualising traffic safety culture. Transportation research part F: traffic psychology and behaviour, 26, pp.293-302.

[10] Erkut, E., Tjandra, S.A. and Verter, V., 2007. Hazardous materials transportation. Handbooks in operations research and management science, 14, pp.539-621.

[11] Fong, Patrick Sik-Wah, and Sonia Kit-Yung Choi. "Final contractor selection using the analytical hierarchy process." Construction management and economics 18.5 (2000): 547-557.

[12] Gehlert, T., Hagemeister, C. and Özkan, T., 2014. Traffic safety climate attitudes of road users in Germany. Transportation research part F: traffic psychology and behaviour, 26, pp.326-336.

[13] Girasek, D.C., 2013. Gauging popular support for traffic safety in the United States. Accident Analysis & Prevention, 50, pp.1112-1117.

[14] Hatfield, J., Boufous, S., & Eveston, T. (2019). An evaluation of the effects of an innovative school-based cycling education program on safety and participation. Accident Analysis & Prevention, 127, 52-60.

[15] Hensher, D.A., Rose, J.M. and Greene, W.H., 2005. Applied choice analysis: a primer. Cambridge University Press.

[16] https://www.fmcsa.dot.gov/safety/data-and-statistics/large-truck-and-bus-crash-facts-2017

[17] Hu, P.S., Young, J.R. and Lu, A., 1993. Highway crash rates and age-related driver limitations: Literature review and evaluation of data bases (No. ORNL/TM-12456). Oak Ridge National Lab., TN (United States).

[18] Inanloo, B., Tansel, B., 2016. A transportation network assessment tool for hazardous material cargo routing: weighing exposure health risks, proximity to vulnerable areas, delay costs and trucking expenses, Journal of Loss Prevention in the Process Industries, 40, 266-276.

[19] Islam, M., & Hernandez, S. (2013). Large truck–involved crashes: exploratory injury severity analysis. Journal of Transportation Engineering, 139(6), 596-604.

[20] Janke, M.K., 1991. Accidents, mileage, and the exaggeration of risk. Accident Analysis & Prevention, 23(2-3), pp.183-188.

[21] Kara, B.Y., Erkut, E. and Verter, V., 2003. Accurate calculation of hazardous materials transport risks. Operations research letters, 31(4), pp.285-292.

[22] 22. King, Y. and Parker, D., 2008. Driving violations, aggression and perceived consensus. Revue Européenne de Psychologie Appliquée/European Review of Applied Psychology, 58(1), pp.43-49.

[23] Langford, J. and Koppel, S., 2006. Epidemiology of older driver crashes–identifying older driver risk factors

and exposure patterns. Transportation Research Part F: Traffic Psychology and Behaviour, 9(5), pp.309-321.

[24] Li, M.D., Doong, J.L., Huang, W.S., Lai, C.H. and Jeng, M.C., 2009. Survival hazards of road environment factors between motor-vehicles and motorcycles. Accident Analysis & Prevention, 41(5), pp.938-947.

[25] Li, W., Gkritza, K. and Albrecht, C., 2014. The culture of distracted driving: Evidence from a public opinion survey in Iowa. Transportation research part F: traffic psychology and behaviour, 26, pp.337-347.Ayyub, B.M., 2014. Risk analysis in engineering and economics. Crc Press.

[26] Lloyd, L., Wallbank, C. and Broughton, J., 2015. A collection of evidence for the impact of the economic recession on road fatalities in Great Britain. Accident Analysis & Prevention, 80, pp.274-285.

[27] Loeb, P.D. and Clarke, W.A., 2007. The determinants of truck accidents. Transportation Research Part E: Logistics and Transportation Review, 43(4), pp.442-452.

[28] Maring, W., & Van Schagen, I. (1990). Age dependence of attitudes and knowledge in cyclists. Accident Analysis & Prevention, 22(2), 127-136.

[29] Mohamed, M. and Bromfield, N.F., 2017. Attitudes, driving behavior, and accident involvement among young male drivers in Saudi Arabia. Transportation research part F: traffic psychology and behaviour, 47, pp.59-71.

[30] Noland, R.B. and Zhou, Y., 2017. Has the great recession and its aftermath reduced traffic fatalities? Accident Analysis & Prevention, 98, pp.130-138.

[31] Nordfjærn, T., Şimşekoğlu, Ö. and Rundmo, T., 2014. Culture related to road traffic safety: a comparison of eight countries using two conceptualizations of culture. Accident Analysis & Prevention, 62, pp.319-328.

[32] Oggero, A., Darbra, R.M., Muñoz, M., Planas, E., Casal, J., 2006. A survey of accidents occurring during the transport of hazardous substances by road and rail. Journal of Hazardous Materials, A133, 1–7.

[33] Özkan, T. and Lajunen, T., 2011. Person and environment: Traffic culture. In Handbook of traffic psychology (pp. 179-192). Academic Press.

[34] Partovi, Fariborz Y. "Determining what to benchmark: an analytic hierarchy process approach." International Journal of Operations & Production Management 14.6 (1994): 25-39.

[35] Reilly A, Nozick L, Xu N, Jones D. Game theory-based identification of facility use restrictions for the movement of hazardous materials under terrorist threat. Transportation research part E: logistics and transportation review. 2012;48(1):115-31.

[36] Rolison, J.J., Hanoch, Y., Wood, S. and Liu, P.J., 2013. Risk-taking differences across the adult life span: a question of age and domain. Journals of Gerontology Series B: Psychological Sciences and Social Sciences, 69(6), pp.870-880.

[37] Ronza, A., Vílchez, J. A., Casal, J., 2007. Using transportation accident databases to investigate ignition and explosion probabilities of flammable spills, Journal of Hazardous Materials 146(1–2), 106-123.

[38] Saaty T. L., 1980. The Analytical Hierarchy Process, Tata McGraw Hill, New York.

[39] Saffarzadeh, M., Seyedabrishami, S., Hasanpour, S., 2015. 'Route Evaluation for Hazardous Material Based on Risk Analysis: Case Study of Tehran-Mazandaran Roads', Quarterly Journal of Transportation Engineering, 7(1), pp. 73-86.

[40] Selatahneh, H., Shariat Mohaymani, A., Esmaili, A. and Ghiaseddin, 2015, M., Evaluation of professional driver's behavior by Manchester Driver Behavior Questionnaire (MDBQ)- Case Study of Tehran Province, The 14th International Conference on Traffic and Transportation Engineering, Tehran, Iran.

[41] Shen, X., Yan, Y., Li, X., Xie, C., & Wang, L. (2014). Analysis on tank truck accidents involved in road hazardous materials transportation in China. Traffic injury prevention, 15(7), 762-768.

[42] Stringer, R.J., 2018. Exploring traffic safety culture and drunk driving: An examination of the community and DUI related fatal crashes in the US (1993–2015). Transportation research part F: traffic psychology and behaviour, 56, pp.371-380.

[43] Verwey, W.B. and Zaidel, D.M., 2000. Predicting drowsiness accidents from personal attributes, eye blinks and ongoing driving behaviour. Personality and individual differences, 28(1), pp.123-142.

[44] Walsh, J.M., Gier, J.J., Christopherson, A.S. and Verstraete, A.G., 2004. Drugs and driving. Traffic injury prevention, 5(3), pp.241-253.

[45] Wang, Y.H., Tong, S.J., Chen, B.Z., 2005. Risk analysis on road transport system of dangerous chemicals. China Safety Science Journal 15 (2), 8–12 (in Chinese).

[46] Wills, A.R., Watson, B. and Biggs, H.C., 2006. Comparing safety climate factors as predictors of work-related driving behavior. Journal of safety research, 37(4), pp.375-383.

[47] Yang, J., Li, F.Y., Zhou, J.B., Zhang, L., Huang, L., Bi, J., 2010. A survey on hazardous materials accidents during road transport in China from 2000 to 2008. Journal of Hazardous Materials 184 (2010), 647–653.

[48] Zhang, Q., Ge, Y., Qu, W., Zhang, K. and Sun, X., 2018. The traffic climate in China: The mediating effect of traffic safety climate between personality and dangerous driving behavior. Accident Analysis & Prevention, 113, pp.213-223.

[49] Zhao, L., Wang, X. and Qian, Y., 2012. Analysis of factors that influence hazardous material transportation accidents based on Bayesian networks: a case study in China. Safety science, 50(4), pp.1049-1055.

[50] Zhao, L.J., Wu, P., Xu, K., 2009. Statistic analysis and countermeasures on dangerous chemical accidents in China. China Safety Science Journal 19 (7), 165–170 (in Chinese).

[51] Zhu, T., Zhao, L., Wang, X., 2016. Road transportation accident analysis of HAZMAT based on Bayesian network, Journal of Safety and Environment 16(2) p. 53-60.

[52] Zhu, X., & Srinivasan, S. (2011). A comprehensive analysis of factors influencing the injury severity of large-truck crashes. Accident Analysis & Prevention, 43(1), 49-

57.

[53] Zoghi, H., Aftabi, H. and Hooshangi, S., 2015, Investigating the Effects of Culture on Traffic Safety A Comparative Study of the Traffic Safety Culture of Iran, China and Japan, The 1st Congress on Civil and Environmental Engineering, Qazvin, Iran.

HOW TO CITE THIS ARTICLE

A. Mahpour,M. Shafaati ,A. Mohammadian-Amiri, The effective factors on the safety culture of Hazmat drivers, AUT J. Civil Eng., 5(1) (2021) 69-78.

DOI: 10.22060/ajce.2020.17422.5631