The Distracted Behaviors of the Unlicensed Drivers: Effects of the Zone and Vehicle Type.

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Nowadays, Traffic Accidents (TA) have been considered a severe public health issue. In spite of the wide range of penalties to reduce the Unsafe Behaviors (UB), i.e. Unlicensed Driving (UD) and Distracted Driving (DD), many converging transportation studies related the degraded driving performance and increased TA and fatalities to the UB. When investigating the TA, these studies have examined effects of numerous parameters, however little attention has been paid to the driving license status of distracted drivers. This paper outlines a contribution to the existing knowledge and investigates the driving license status of the distracted drivers (technology-based distractions) involved in accidents using the Bayesian Network with a particular focus on the influence of the zone and the vehicle type.

The dataset for this study has been prepared from a 3-year period database (2016-2018) of accidents in Spain provided by the Spanish Transportation General Department. Results showed that the zone and the vehicle type seem to increase significantly the probability of being unlicensed when engaging in distracted behaviors. Indeed, the probability of being unlicensed when driving motor vehicle and having DD increases from 6.11% to 9.46% on the road and to 42.93% on highways. However, in the case of motorcycles, the probability of being unlicensed when presenting DD increases from 6.11% to 16.89% on the street, 27.42% on the road and to 73.11% on the highway.

Keywords: Distractions, Behaviors, Drivers, Unlicensed, Zone, Vehicle, Effects.

1. Introduction

Traffic Accidents (TA) have been considered a public health issue that poses heavy socio-economic costs to the countries in terms of human physical and psychological trauma, community and family losses, productivity losses, medical expenses and property damages (Drosu and Cofaru, 2017). This has led to consider provision of safe access, affordable and sustainable transport systems for all among the sustainable development goals by 2030 (Kumar et al., 2020). For many scholars, TA result of the components of the driving systems, i.e. vehicle, road infrastructure and road users, or their interactions (Bucsuházy et al., 2020). However, Drivers' Unsafe Behaviors Behind the Wheel (UBBW) are still being considered key factors that explain more variability in TA (Houston et al., 2003; Dahlen and White, 2006; González-Iglesias et al., 2012; Rowe et al., 2015).

Indeed, a study by (Hasan et al., 2014) has been found that the UBBW account for a large proportion of TA. Similarly, Seo et al. (2015) and Topol and Drahotský (2017) have confirmed that the UBBW have an adverse impact, directly or indirectly, on the entire traffic system.

For conceptual clarity, in this study, the UBBW entail (Vahedi et al., 2018): violation of rules and regulations (i.e. infringements, unlicensed

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driving, distractions), aggressive violations (i.e. aggressive driving), errors (i.e. misjudgments and observational failures in driving), lapses (i.e. limitations in memory and attention).

Many traffic safety studies (Sullman et al., 2002; Kang, 2013; Xiao, 2020) have estimated that only violations were found to be significantly correlated with, and predictive of, TA. That is because the driving performance of the drivers can be influenced easily by distractions. Moreover, according to the United States of California highway management departments, 89.95% of the total traffic accidents are due to UBBW while illegal driving modes is responsible for 85% of deaths (Hu et al., 2017).

Moreover, the attributes of the TA have long been the subject for extensive research which have been identified as important factors for an effective and efficient management of the traffic for instance, the occurrence time, type of the involved vehicle, the age and gender of the driver, the type of the road and the zone, the infrastructure, weather conditions…etc. (Šliupas, 2009).

Even though, little research has systematically investigated the distracted driving patterns characterizing neither the unlicensed drivers nor the influence of the attributes of the TA.

This study investigates the relationship between the distracted driving (DD) and unlicensed driving (UD). Then it focuses on how this relationship is affected by the zone (road, street, and highway) and vehicle type (motor vehicles and motorcycles) and their interactions.

The reminder of this paper is organized as follows, in the next section, we present data used in this study and introduce the methodology followed. In section 3, results of the study are presented and their interpretations and discussions are given in section 4. Conclusions of this study are drawn in section 5.

2. Materials and Methods

3.1 *Study Variables and Data acquisition*

Variables of the study, as have been previously discussed, are defined as follows:

- *The distracted driving:* in this study particular attention has been paid to technology-based distractions. Consequently, this variable entails all of the use of mobile phone, GPS, hands-fee, radio, Dvd, in-car internet and other similar distractions.

- *The driving license status:* this variable describes the driving license status of the distracted drivers: (i) Valid, which refers to a correct driving license and (ii) invalid, which includes inappropriate driving license, expired, cancelled, suspended, driving without driving license, total loss of points, allow under 125 cc.

- *The zone:* this variable describes the type of the road in which the TA took place. Three zones are considered in this study: (i) urban street, (ii) rural roads and (iii) highways.

- *The vehicle type:* this variable describes the type of the vehicles involved in the TA and includes: (i): motorcycles (i.e. motorcycles and mopeds over 125cc) (ii) motor vehicles (i.e. cars, vans, trucks and other terrain vehicles).

The dataset to conduct this study has been prepared using three years (2016-2018) traffic accidents data provided by the Spanish General Directorate of Traffic (DGT). Frequencies are given in Table 1.

Table 1. The frequencies of the study variables

Variables	Year			Total Cases	(%)
	2016	2017	2018		
Technology-based distractions	323	369	347	1039	0.25
Driving License					
Valid	80758	79796	79499	2400053	58.85
Invalid	4566	5183	5578	15327	3.76
Vehicle Type					
Motor Vehicle	120831	120261	119755	360847	88.46
Motorcycles	16475	15294	15306	47075	11.54
Zone Type					
Street	53505	55326	55742	164573	40.36
Road	82498	79050	78146	239694	58.78
Highway	1267	1107	1130	3504	0.86

Source: Prepared by the authors using data provided by the DGT.

3.2 *Bayesian Network*

As sketched in Fig. 1, this study comes to investigate the driving license status of the distracted drivers. In a second time, the separate and combined influence of the zone and the type of the transport vehicle is analyzed. For this purpose, the Bayesian Network methodology is deployed to design the model of this study.

The Bayesian Networks are quantitative modeling tools usefully applied in many of the traffic accidents studies to address different aspects, for instance the seat belt use (Febres et al., 2020), the role of journey purpose (Febres et al., 2019), cyclist injury severity (Aldred et al., 2019) human fatigue (Akhtar and Utne, 2014), highway safety analysis (Mbakwe et al., 2016), human errors (Antão and Soares, 2019).

The Bayesian Networks provide graphic representations (Directed Acyclic Graph –DAG-) of complex systems with interrelated components then generate predictions without the need for pre assumptions (de Oña et al., 2011). This is by the mean of a set of conditional probability functions where the interrelations in the DAG are given in terms of the Joint Probability Distribution, Mathematically expressed as follows (García-Herrero et al., 2019):

$$P(x_1, x_2, \dots, x_n) = \prod_{i=1}^{n} P(x_i|\pi_i) \qquad (1)$$

Where x_i are the variables, π_i are the parents of the x_i, and the $P(x_1, x_2, \dots, x_n)$ presents the Joint Probability Distribution.

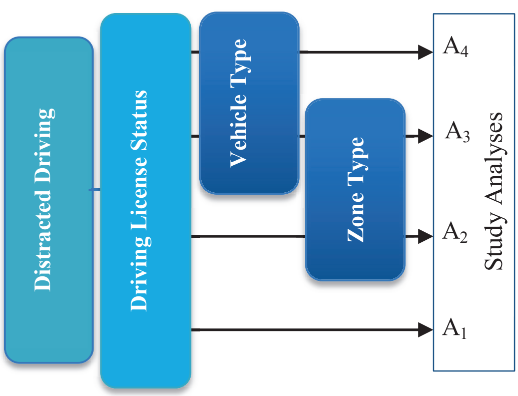

Fig. 1. The flowchart of the study analyses

The practicability of the study approach and the skill of the obtained model are evaluated using the Area Under the ROC (Receiver Operating Characteristic) Curve, named AUC. This latter obtained by a 10-fold cross-validation approach.

The cross-validation is a statistical method very commonly used to estimate the skill of machine learning models (Moreno-Torres et al., 2012). It consists of randomly partitioned the original sample into 10 equal size subsamples. One single subsample is therefore retained as the validation data for testing the model and the 9 remaining subsamples are used as training date. This cross-validation process is then repeated 10 times and in each time, one of the subsamples is used once as the validation data. The final estimation is obtained by averaging the 10 results (Anguita et al., 2012).

The measures of the AUC range between 0 and 1. The value 0 corresponds to wrong predictions of the model, value 0.5 reflects the random character of the obtained model and finally, value 1 implies that the model is reliable and gives perfect prediction.

4. Results

4.1 *The Bayesian Network Validation*

The AUC scores in the present study range between 0.70 and 0.96. These scores suggest that the obtained model has good performance and the approach and results of the study are reliable.

4.2 *Sensitivity Analysis*

The probabilities of the driving license status of the distracted drivers, computed using the Bayesian Network inference, are given in Table 2.

Table 2. Probabilities for the distracted driving considering the driving license status of the drivers

Variable	Driving License Status	
	Valid	Invalid
Technology-based distractions	90.94%	6.11%

Source: Computed by the authors.

According to this finding, the probability that the drivers involved in the TA are unlicensed doubles considering the fact that these drivers are distracted (from 3.76% to 6.11%).

4.2 *Sensitivity Analysis for the influential variables*

Table 3 and Table 4 below present the influence of the influential variables (the zone and the vehicle type, respectively) on the probabilities of the driving license status of the distracted drivers.

Results of Table 3 show that the probability that licensed drivers to engage in distracted driving increases on the street from 90.94% to 94.79%.

Moreover, these results show that the licensed drivers are less distracted on road and highway, where the probability decreases to 84.26% and 56.23% respectively.

In contrast, the probability of unlicensed drivers to have a distracted driving decreases on the street and increases on the road from 6.11% to 9.84% and more significantly on the highway from 6.11% to 43.77% (an increase of 37.66%).

Table 3. The sensitivity analysis results of the influence of zone variable

Objective Variable	Influential Variable	Driving License Status	
	Zone	Valid	Invalid
Technology-based distractions	Street	94.79%	3.90%
	Road	84.26%	9.84%
	Highway	56.23%	43.77%

Source: Computed by the authors.

As regards the influence of the type of the vehicle engaged in the TA, results of Table 4 show that the probability that licensed drivers show distracted driving increases slightly (with 0.32%) in the case of motor vehicles and decreases from 90.94% to 80.25% (an increase of 10.69%) in the case of motorcycles riders.

In contrast, it has been found that the unlicensed motorcycles riders are more likely to have a distracted driving, where the probability increases significantly from 6.11% to 19.75% (a difference of 13.64%).

Table 4. the sensitivity analysis results of the vehicle type variable

Objective Variable	Influential Variable	Driving License Status	
	Vehicle type	Valid	Invalid
Technology-based distractions	Motor vehicles	91.26%	5.70%
	Motorcycles	80.25%	19.75%

Source: Computed by the authors.

4.2 *Sensitivity Analysis for the joint variables*

The joint influence of the zone and the vehicle type on the probabilities of the licensed/unlicensed drivers to engage in distracted driving is summarized in Table 5.

Results show that the probability of distracted motor vehicle drivers to be unlicensed increases on the road and more significantly on the highway (with 3.35% and 36.82%, respectively).

In contrast, in the case of distracted motorcycle riders, the probability of being unlicensed noticeably increases with 10.78% on the street, 21.31% on the road and 67% on the highway.

Table 5. The sensitivity analysis results of the joint effect of the influential variables

Objective Variable	Influential Variable		Driving License Status (%)	
	Vehicle type	Zone	Valid	Invalid
Technology-based distractions	Motor vehicles	Street	95.21	3.44
		Road	84.52	9.46
		Highway	57.07	42.93
	Motorcycles	Street	83.11	16.89
		Road	72.58	27.42
		Highway	26.89	73.11

Source: Computed by the authors.

5. Discussions

The present study, to our knowledge, is the first one that has interested in the investigation of the driving license status of the distracted drivers.

More broadly, it has been suggested that unlicensed drivers tend to also engage in other unsafe behaviors and distracting activities, such as talking to passengers, using the mobile phone, adjusting in-vehicle equipment (Boulagouas et al., 2020; McEvoy, 2006).

In line with this suggestion, results of the present study have estimated that the probability that the unlicensed drivers involved in TA increases two times provided that they have been distracted (from 3.76% to 6.11%).

Moreover, TA on the roads and highway are critical for the traffic safety because that section should be blocked to protect the safety of the highway users and the rescuers (Yu, 2013). The present study findings confirm that the probability that the unlicensed drivers to have distracted driving increases on the roads and highways. This finding is consistent with those of (Ayati and Abbasi, 2011) who confirmed that motorcycles play the largest role in the occurrence of TA on highways leading to severe injuries and deaths, this is on the one hand, and are more likely to engage in unsafe driving behaviors and violations (Abdul Manan and Várhelyi, 2015) on the other hand.

As reported by (McDowell et al., 2009), drivers in roads or highways are more likely to experience an unlicensed car driving. In this context, Hanna et al. (2010) suggested that the distracted and unlicensed driving on this particular zones could be linked to the fact that less public transport and taxi services are available in rural areas and considering the long distances, the likelihood of the unlicensed driver encountering the police is slim.

Furthermore, the roads and highways incite drivers and motorcycles riders speeding and engage in risky overtaking maneuvers (Jimenez et al., 2015; (Chen *et al.*, 2016).

Even though, in this study, the number of the motor vehicles involved in the accidents is seven times the number of the motorcycles, the probability that the unlicensed motorcycle riders to have distracted driving is higher (19.75%). In this context, a study in Malaysia (Abdul Manan and Várhelyi, 2012) has concluded that motorcycles involved in high number of TA fatalities and important percentage of them were unlicensed.

The unlicensed driving forms part of a profile of the regulatory misalignment which entails many other unsafe driving behaviors. This important finding calls for further in-depth investigations for a greater understanding of the needed improvements by the policy makers and road safety authorities with regard to the unlicensed driving.

6. Conclusions

The TA claim lives and result in important economic losses to the countries. Reduction in TA requires in-depth studies to determine factors that contribute to the occurrence and aggravate the severity seriousness of the TA.

In this paper, we have investigated the driving license status of the distracted drivers using Bayesian Network. Then, we have analyzed the effects of the zone and type of the vehicle involved in the TA. The dataset for this study were acquired from the Spanish Transportation General Department. The outputs have showed that both the type of the vehicle and the zone increase the probability that the distracted drivers to be unlicensed.

These findings give better understanding of the relationship between the distracted driving and the illegal driving while considering the potential effects of the zone and the type of the vehicle. Consequently they could be useful for policy makers to design and enhance various traffic safety policies and regulations to eliminate the unlicensed driving and prevent the distracted driving to increase safe driving and contribute to reduced accident rates.

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