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Investigation of the factors contributing to truck driver's involvement in an injury accident

Kamyon sürücüsünün dahil olduğu yaralanmalı kazalara etki eden faktörlerin incelenmesi

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Abstract

The study was aimed at identifying the factors contributing to truck driver's involvement in an injury accident in Kano, Nigeria using Logistic regression. 248 truck drivers were interviewed using a questionnaire and relevant information on their involvement in injury accident was collected. The result of the survey shows that 52.8% of the drivers were involved in an injury accident at least once in their professional carrier and 80% of the drivers were below the age of 40years. Results from the regression analysis found the Average distance traveled/week (p=0.0057), average driving hours/day (p=0.0232), sleeping on the wheel (p=0.0004), and presence of co-driver (p=0.0003) to be statistically significant in contributing to driver's involvement in an injury accident. Average distance traveled/week, sleeping on wheel and presence of co-driver were found to positively affect involvement in injury accident with OR values of 1.80, 3.61 and 3.94 respectively. The model was found to be good in classifying truck drivers' involvement in injury accident with a reasonable level of accuracy (70%). Increased safety awareness among drivers by conducting seminars and organizing training sessions regularly will help reduce the involvement of truck drivers in accidents.

Keywords: Accident, Injury, Logistic regression, Truck driver.

Öz

Bu çalışma, lojistik regresyon kullanarak Kano, Nijerya'da kamyon sürücülerinin karıştıkları yaralanmalı kazaların oluşumuna katkıda bulunan faktörleri tanımlamayı amaçlamaktadır. Çalışmada, 248 kamyon şoförü ile anket yapılmış ve yaralanmalı kazalara katkıları ile ilgili bilgiler toplanmıştır. Anketin sonucundau, sürücülerin %52.8'inin profesyonel kariyerlerinde en az bir kez yaralanmalı kaza geçirdikleri ve sürücülerin %80'inin 40 yaşın altında olduğu görülmüştür. Regresyon analizinden elde edilen sonuçlara göre; ortalama gidilen mesafe/hafta (p=0.0057), ortalama sürüş süresi/günü (p=0.0232), direksiyonda uyumak (p=0.0004) ve yardımcı sürücünün olması (p=0.0003) faktörlerinin sürücünün yaralanmalı trafik kazasına karışmasına istatistiksel olarak anlamlı katkılarda bulunduğu anlaşılmıştır. Gidilen ortalama mesafe / hafta, direksiyonda uyumak ve yardımcı sürücünün olması'nın OR değerleri sırasıyla 1.80, 3.61 ve 3.94 değerlerine sahiptir ve yaralanma kazaları artırıcı yönde etkilediği saptanmıştır. Bu model; kamyon sürücülerinin yaralanmalı trafik kazalarını incelemede başarılı bulunmuş olup, modelin kabul edilebilir bir güven seviyesinde çalıştığı görülmüştür (%70). Sürücüler arasında seminerler ve düzenli eğitimler tertip edilerek trafik güvenliği bilincinin arttırılması, kamyon sürücülerinin yaralanmalı trafik kazalarına karışmalarını azaltmaya yardımcı olacaktır.

Anahtar kelimeler: Kaza, Yaralanmalı, Lojistik regresyon, Kamyon sürücüsü.

1 Introduction

Road Traffic Accidents (RTA) has become an urgent problem in recent years due to an increasing number of vehicles and traffic density [1]. Several researchers have tried to establish a predictive model that identifies possible explanatory factors, such as traffic characteristics, road environment, and human error, for the probability of the traffic crash [2]. In Nigeria, RTA is among the major socioeconomic challenges claiming many lives and properties every year. In the year 2016, about 65,467 people were reported to have been involved in RTA, out of which 5053 died and 30105 suffered various degrees of injuries. 20.7% (n = 15,682) of the vehicles involved in the RTA were heavy vehicles [3].

Truck accidents are mostly associated with high severity. More than half of the truck crashes involve fatal or major injuries and the truck drivers were found to be at fault in at least 80 % of the cases [4]. Drivers of heavy vehicles have higher chances of been involved in a severe traffic accident because the weight of their vehicle makes the braking distance to be longer. The fatality rate and property loss of truck-related accident are also high [5]. Questionnaire studies on truck driver's involvement in RTA in Tanzania show that about 40% of drivers were victims of a traffic accident at least once during their career and 45% were involved in fatal crashes [6]. Catarino et al reported 37% involvement in RTA by truck drivers for a study conducted in Portugal [7]. Truck and heavy vehicle drivers constitute 20% of all worker fatalities in Australia during the previous decade [8]. Truck drivers and driver/Sales workers represent 17% of all occupational fatalities in the United States [5].

Hours driving, truck type (rigid or articulated), driving time (midnight, evening, morning), and drivers experience significantly affect truck driver's involvement in traffic crash [9]. The pattern of the truck driver's involvement in traffic accidents varies according to age, fatigue, distance travelled, driving experience, and vehicle type [5]. Another research

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identified distance travelled, driver training, employment type, payment method, vehicle type, scheduling practices, working hours as factors influencing the safety of truck drivers [10].

Several attempts were made using different methods to investigate the influence of driver's attribute, accident characteristics, road geometry, and traffic density on the severity of RTA [11]. Majority of the modeling approaches were framed in the discrete response models which include: binary response models (e.g., binary probit and binary logit), ordered discrete response models (e.g. bivariate ordered probit and generalized ordered logit), unordered multinomial discrete response models (e.g. multinomial logit, Markov switching multinomial logit, nested logit, and mixed logit); other less common approaches have also been used and include: artificial neural networks, and some data mining techniques such as the classification and regression tree analysis. The choice of methodological approach used in accident analysis depends mainly on the available data set, quantity and quality of the data, and other data-specific characteristics [12]. Despite the methodological evolution registered, which improved the statistical validity of findings, logistic regression models are still broadly employed in the identification of contributing factors to accident severity [11]. For example, Logistic regression was used to identify the factors behind fatal and non-fatal road crashes in Lahore, Pakistan. The model found Speeding and overloading as the major causes of fatal crashes [13]. Karacasu et al also used logistic regression and discriminant analysis in estimating the causes of traffic accidents in Eskisehir, Turkey and found the logistic regression to classify injury and non-injury accident with up 72% accuracy [14]. The influence of road features, vehicle attributes, environmental factors, crash characteristics and driver particulars on hit-and-run crashes in Singapore were found to be estimated efficiently using Logistic regression [15]. Logistic regression analysis was performed, with driver and crash characteristics as predictors of the crash category in quantifying sleep-related crashes on the low-speed road. A conservative p-value of 0.001 determined the statistical significance of the predictors [16]. Three level logistic regression models were built to test the association between driver, collision, roadway, and commercial vehicle risk factors; proximity to the nearest rest area, weigh station, or truck stop; and the outcome of a sleepiness/ fatigue-related at-fault commercial vehicle crash [17]. Effects of personality traits, mental illness and driving behaviour on driver's involvement in accidents were evaluated using Logistic regression and found anxiety and depression to significantly increase chances of involvement by 2.4 and 2.7 respectively [18]. Logistic regression was used to develop a model to examine the influence of the explanatory variable on the injury severity of motorcycle crashes in Carolina [19].

Analysis of road traffic accident in Kano metropolitan revealed that 3 people are killed and 18 more get injured for every 7 Road traffic accident reported, and 10% of all traffic accidents (n = 978) are truck related which happen to be more severe than other forms of RTA [20]. This is due to the commercial activities taking place in the state where a large number of trucks flows in and out of the state from all the northern states and the neighbouring countries of Niger, Chad, and Cameroun [21]. It is found to be necessary to investigate the factors contributing to the truck driver's involvement in an injury accident in the state in order to come up with safety countermeasures that will reduce truck driver's involvement in RTA. The objective of the research is to identify the factors that affect the probability of a truck driver's involvement in Injury accident in Nigeria.

Binary logistic regression was found to be suitable for this research because the model uses data from a variety of predictors to model the probability of each of the two possible outcomes which in this case are driver's involvement or non-involvement in an injury accident. Binary logistic regression has been successfully used to model factors and causes of various traffic accident problems with an acceptable level of accuracy [13]-[17].

2 Materials and method

Kano State is an industrial and business base centre in the Northern part of Nigeria as well as being the biggest city, in Nigeria. It has a population of 9,383,682 as at census 2006, and last known population is approximately 11, 087, 800 (the year 2011), this was 6.77% of Nigeria's population with an annual growth rate of 3.36 %. The state is bounded to the North West by Katsina State, to the South West by Kaduna and to the North East by Jigawa State, while to the South East by Bauchi State as shown in Figure 1. Road transportation is the dominant mode of transport which linked Kano with most of the neighbouring African cities. Convoys of heavy trucks, buses, and others connect it with various municipalities in Chad, Cameroon, Niger, and Republic of Benin [22].
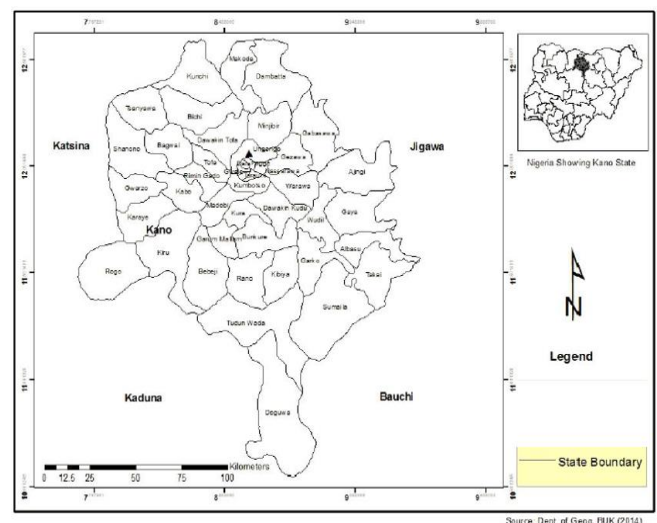

Figure 1. Map of Kano State.

The research was conducted in Kano State Nigeria by interviewing 248 male truck drivers in January 2018. Drivers of different truck categories were randomly selected and interviewed using a short-structured questionnaire. The demographic characteristics of the driver, type of the truck driving, driving experience, drivers' license, average distance covered in a week, average daily driving hours, whether the driver sleeps on wheels or not, presence of co-driver, and information on driver's involvement in injury accident were collected. The dependent variable Y represents truck drivers' involvement in an injury accident and is binary in nature.

$$Y = \begin{cases} 0, \text{if the truck driver is not involved in an injury accident} \\ 1, \text{if the truck driver is involved in injury accident} \end{cases}$$

The independent variables were categorical and are given values 1, 2, 3 as summarised in Table 1.

Table 1. Variable description and notations.

Variables	Notations	Description
Involvement in Injury Accident	Y	0 = not involved, 1= involved
Age	X_1	1=18 To 25, 2=26 To 30, 3=31 To 35, 4=36 To 40, 5=>40
Education	X_2	1=Informal Education, 2=Primary, 3=Secondary, 4=Diploma, 5=Degree
License	X_3	0=No, 1=Yes
Driving Experience	X_4	1=0 To 5, 2=6 To 10, 3=11 To 15, 4=16 To 20, 5=>20
Average distance/week	X_5	1= <2000km, 2=2000-4000km, 3= ≥4000km
Hours driving/day	X_6	1= <5hrs, 2=5-9hrs, 3 = >9hrs
Number of Days driving/week	X_7	1= ≤3 Days, 2= 3-4 Days, 3= ≥5 Days
Type of vehicle	X_8	1=Tanker, 2=Tipper, 3=Trailer, 4=Luxurious Bus
Sleeping on Wheel	X_9	0=NO, 1=YES
Hours sleeping/day	X_{10}	1=≤3HRS, 2=4HRS, 3= ≥6HRS
Co-driver	X_{11}	0=NO, 1=YES

2.1 Logistic regression

Logistic regression is used in modeling discrete response variables, especially for a binary response variable. The elementary principle of logistic regression is to obtain the probability of an event by studying the correlation between the dependant and explanatory variables. When the predicted probability of an event is at least 0.5, then it is regarded to be in the first group, i.e., event; else, as the second group, i.e., no event [23]. The independent variables can either be categorical or continuous in binary logistic regression. Binary logistic regression was used in testing the significance of the factors contributing to road accident when the dependent variable is binary [14],[15],[24]. In this study the independent variables are categorical and the response variables Y representing truck drivers' involvement in injury accident is binary and this makes binary logistic regression approach suitable for the study. The binary logistic regression model is expressed by equation 1.

$$\text{Logit (p)} = Ln \left(\frac{p}{1-p}\right) = b_0 + b_1x_1 + b_2x_2 + \ldots, + b_ix_i \qquad (1)$$

p is the probability of driver been involved in injury accident, b_0 is the intercept, b_i are the model coefficients of the independent variables, and x_i are independent variables.

The Odd ratio (OR) is equal to exp (b_i); OR is the factor indicating how an independent variable increases or decreases chances of the truck driver's involvement in injury accident when all other variables remain unchanged. Values greater than 1 indicate increase and OR values less than 1 indicates a decrease when the value of the corresponding independent variable increases by a unit [9],[13],[14].

3 Results

The descriptive statistics of the respondents and their involvement in injury accident was given in Table 2. 52.8% of the drivers interviewed were involved in an injury accident and 47.18% were not involved. 68% of those involved in injury accident are youth between the age of 26-40 years, 53% have obtained secondary school certificate. 81% have drivers' license, 66% covered at least 2.000 km in a week. 58% of the drivers sleep at least 6hrs a day and 88% have co-drivers. proportion levels of the study variables were presented in Figure 2.
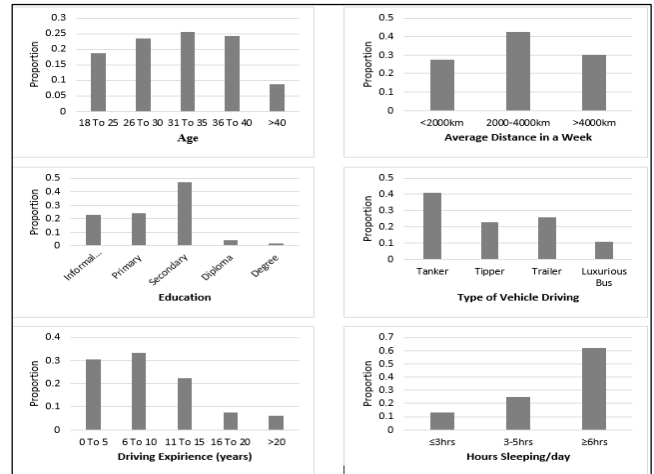

Figure 2. Study variables.

Figure 3 and 4 show the graphical assessment of the fit to the binary logistic model developed in the study. The graphs show that the model appears to fit the data reasonably.

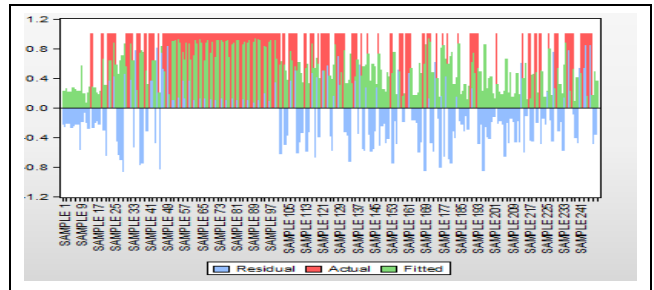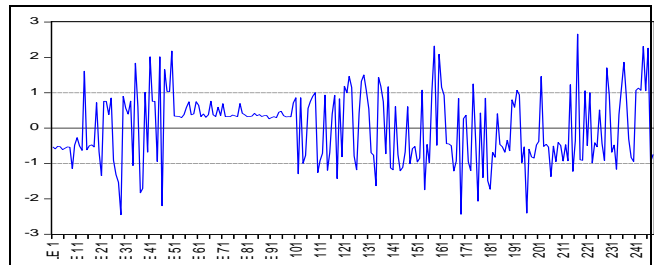Figure 3. Actual, fitted and residual.

Figure 4. Standardized (Pearson) residual.

Binary logistic regression analysis was performed to determine the statistical significance of the predictor variables and the rates at which they increase or decrease the chances of diver's involvement in an injury accident. The result was summarised in Table 3 and the goodness of fit of the model in Table 4.

Table 2. Data Summary of the Predictor Variables(n=248).

Variables	Label	Respondents	Involvement in Injury Accident (%)	
		%	Involved	Not Involved
Involvement in accident	Yes	52.82		
	No	47.18		
	18 To 25	18.55	20.61	16.24
	26 To 30	23.39	20.61	26.50
Age	31 To 35	25.40	25.19	25.64
	36 To 40	24.19	22.14	26.50
	>40	8.47	11.45	5.13
	Informal Education	22.98	20.61	25.64
	Primary	24.19	19.08	29.91
Education	Secondary	46.77	53.44	39.32
	Diploma	4.44	5.34	3.42
	Degree	1.61	1.53	1.71
	No	18.55	12.98	24.79
License	Yes	81.45	87.02	75.21
	0 To 5	30.65	29.77	31.62
	6 To 10	33.47	29.01	38.46
Driving Experience	11 To 15	22.18	21.37	23.08
	16 To 20	7.66	11.45	3.42
	>20	6.05	8.40	3.42
	<2000km	27.42	22.90	32.47
Average distance/week	2000-4000km	42.34	32.83	52.99
	>4000km	30.24	44.27	14.53
	< 5hrs	35.48	35.88	35.04
Average Driving Hours/day	5-9hrs	37.50	41.22	33.33
	>9hrs	27.01	22.90	31.62
	≤ 3 Days	9.68	6.87	12.82
Number of Days Driving/Week	3-4 Days	30.65	22.90	39.32
	≥ 5 Days	59.68	70.99	47.01
	Tanker	40.73	51.15	29.06
Type of Vehicle	Tipper	22.98	16.79	29.91
	Trailer	25.81	22.14	29.91
	Luxurious Bus	10.48	9.92	11.11
Sleep on Wheel	No	66.13	49.62	84.62
	Yes	33.87	50.38	15.38
	≤3hrs	13.31	13.74	12.82
Sleeping Hours	4hrs	24.60	28.24	20.51
	≥6hrs	62.10	58.02	66.67
	No	25.40	11.45	41.03
Co-Driver	Yes	74.60	88.55	58.97

Table 3. Results of binary logistic regression analysis.

Variable	coeff b	S.E.	Wald	p-value	Odd Ratio	lower	upper
Intercept	-3.15331	1.3579	5.3922	0.02023	0.04271		
Age	0.03395	0.1570	0.0468	0.82882	1.03454	0.7604	1.4073
Education	0.03044	0.1687	0.0326	0.85679	1.03091	0.7406	1.4348
Licence	0.54275	0.4144	1.7151	0.19032	1.72073	0.7637	3.8768
Driving Experience	0.14630	0.1755	0.6947	0.40457	1.15754	0.8205	1.6328
Average Distance travelled/Week	0.58808	0.2125	7.6543	0.00566*	1.80052	1.1870	2.7310
Average driving Hours/day	-0.50380	0.2220	5.1502	0.02324*	0.60423	0.3910	0.9336
Number of Days Driving/Week	0.46623	0.2939	2.5163	0.11268	1.59397	0.8959	2.8356
Type of Vehicle	-0.04141	0.1552	0.0712	0.78958	0.95944	0.7078	1.3004
Sleeping on wheel	1.28431	0.3639	12.454	0.00042*	3.61216	1.7701	7.3711
Co-driver	1.37093	0.3770	13.223	0.00028*	3.93902	1.8813	8.2471
Sleeping Hours/Day	-0.02421	0.2243	0.0116	0.91406	0.97609	0.6288	1.5149

*: Statistically significant.

Table 4. Binary logistic regression analysis goodness of fit results.

Goodness of Fit	Value	Degree of Freedom	p
Chi square test	75.053	11	0.0000
Hosmer and Lemeshow test	5.149	8	0.7420
-2-Log-likelihood	267.958		
Percent correct	70.967		
McFadden R²	0.2188		

4 Discussion

The results show that 52.8% of the truck drivers surveyed had been involved in an injury accident higher than 40% obtained in Tanzania [6] and 37% in Portugal [7]. The result also indicates that 80% of the truck drivers involved in road injury accident were youth below the age of 40 years. This is due to the fact that more than half of Nigeria's population are less than 30 years old [25] with a national median age of 18.3 [26]. Also, 87% have obtained a driver's license. A high percentage of involvement of truck drivers with a license in injury accident implies a problem in the procedure for issuing the license as explained by a research where a similar scenario was observed in Pakistan [13]. It is clear that fatigue contributes to the involvement of truck drivers in an accident since 44% of the drivers involved in the injury accident traveled at least a distance of 4000km a week and 70% drive for at least 5days in a week and 64% drive for more than 5hours in a day. This agrees with research which concludes that 20-50% of commercial drivers were involved in the accident due to fatigue [27]. Articulated trucks (tanker and trailer) accounts were more involved in injury accident than other truck drivers. This is in agreement with research in Australia which revealed that driving articulated vehicle increases drivers chances of been involved in a traffic accident [9]. The Tanker driver's involvement in more injury accident than other truck drivers may be associated with the hazardous material they transport causing their accident to be more severe. The result indicates that the more experienced the driver is, the less likely his involvement in an injury accident, this is similar with a result conducted in West Australia that says truck drivers with at least 10years experience are 52% less likely to be involved in a road accident than less the less experienced [9]. It can also be observed that 88% of those involved in injury accident have co-

drivers, this is because majority of the co-drivers are novice drivers with little experience and mostly without driver's license. 50% of those involved in injury accident had slept on the wheel at least once, which is low compared 71.8% involvement in an injury accident on low-speed roads by research conducted by Filtness et al [16].

The result in Table 4 shows that the binary logistic regression model is capable of classifying up to 70.967% of the accidents correctly. The goodness of fit results of the model shows that the model was significant since the p-value for Hosmer and Lemeshow test was found to be greater than 0.05. The McFadden R2 value of 0.2188 for the model also signifies very good fitness as it falls between range (0.2-0.4) that describes a very good fit of the model [28].

The results in Table 3 indicate that average distance/week, average driving hours/day, sleeping on the wheel, and presence of co-driver were found to have a p-value less than 0.05 and are therefore considered statistically significant. The OR values for Sleeping on the wheel, presence of co-driver, average distance covered in a week, driving experience, age, education, license, and number of days driving in a week are greater than 1.00, this indicates that these variables have a positive effect on drivers' involvement in an injury accident. Karacasu et al also found OR values of level of education, to positively affect the type of accident [14].

5 Conclusion

The survey of 248 truck drivers in Kano state Nigeria on their involvement in injury accident was modeled using a binary logistic regression. The result revealed that sleeping on wheel, presence of co-driver, average distance covered in a week, driving experience, age, education, license, and number of days driving in a week have a positive effect on driver's involvement

in an injury accident. Average distance traveled by drivers in a week, average driving hours/day, sleeping on the wheel, and presence of co-driver were found to be statistically significant. Fatigue was found to be the major factor contributing to the driver's involvement in an injury accident in the state, and therefore policymakers should increase safety awareness among drivers by conducting seminars and organizing training sessions regularly. The result shows that drivers with driver's license are more involved in traffic accident and OR values had a positive value greater than 1. This is because most of the drivers studied are young, less experienced and they sometimes underestimate the potential risks associated with driving situations. Also, the procedure for issuing driver's license is not efficient and drivers do not usually undergo any driving test and they easily get a license by paying some bribe. The government should, therefore, sanitize the procedure and should punish anyone involved in undermining the procedure. The instructors should also be more trained to assess the applicant's ability. It can be concluded that the involvement of drivers having co-drivers in injury accident which was supposed to reduce fatigue is by employing novice and inexperienced drivers as co-pilots. This should also stop and proper enforcement should be observed to reduce the problem. Binary logistic regression was found to be good in classifying truck driver's involvement injury accident with a reasonable level of accuracy (70%). Experience is a significant factor in drivers' involvement in accident but in this research the respondents were randomly selected as such aged and drivers with at least 15-years of driving experience were not fully represented making experience to make fewer impacts on the model, therefore appropriate representation of each group should be employed with more data in future studies.

6 Acknowledgment

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