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Investigating Tailgating Driving Behavior and Related Accidents

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Abstract

The main object of this paper is to investigate tailgating driving behavior and related accidents in the Emirate of Abu Dhabi, United Arab Emirates. About 1,774 tailgating-related accidents that occurred between year 2010 and 2017 were analyzed. These accidents represent about 11.2% of total severe accidents and resulted 7.5% of total traffic accident fatalities. Two different logistic regression models were developed to find the explanatory variables affecting the occurrence and severity of tailgating accidents. The results showed that ten variables significantly affect the occurrence on tailgating accidents including speed limit, number of lanes, road type, intersection exists, vehicle type, working days and driver's characteristic (i.e., gender, age, occupation and nationality). The severity of tailgating accidents is significantly affected by five variables including the lighting condition where dark and bad lighting increases the severity of tailgating accidents. In addition, road parameters such as high-speed limit, low number of lanes and rural road types are positively affecting tailgating accident severity. However, the results showed that driver's demographic characteristics are not included as significant variables in the severity of tailgating accidents. More enforcement and education efforts to improve tailgating behavior of drivers are required.

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Keywords: Tailgating; traffic accident probability, accient fatality; drivers dempgraphics, accident regression model

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1. Introduction

Tailgating behaver takes place when a driver follows a front vehicle with insufficient vehicle headway distance which called unsafe following distance. This distance is defined as the distance that does not guarantee a follower driver stopping to avoid rear-end collision. Amkhalawansingh and Trick (2015) proved that the tailgating is a major cause of rear-end accidents. Tailgating could be avoided by maintaining enough headway distance, usually a "2 second headway time rule" is used to train drivers to maintain a safe distance (Monteiro et. al, 2015). Such safe following distance depends on many factors including drivers' awareness, attitude and experience, vehicle speed, vehicle type, visibility, road characteristics and weather conditions.

In the Emirate of Abu Dhabi (AD), the capital of United Arab Emirates (UAE), tailgating behavior is ranked as the third cause of traffic accidents. Table 1 shows the frequently of total severe accidents (i.e., accidents that result in at least one injury or fatality) and tailgating-related accidents that occurred during the last eight years (2010 – 2017). the table shows that tailgating represents in average about 11.2% of total traffic accidents. An about 39.5% reduction in the total accidents was occurred in 2017 compared to 2010, however a reduction of 17.3% only has been occurred in tailgating-related accidents. That means tailgating behavior needs more enforcement and public awareness. In this regard, deep investigation in the contributing factors that affect the occurrence and severity of tailgating accidents is required that is considered as the main objective of this paper.

Table 1: Frequency of Severe accidents in AD

Year	Total No. of severe accidents	Tailgating-related accidents	Percentage
2010	2538	249	9.8%
2011	2283	201	8.8%
2012	2055	220	10.7%
2013	2071	222	10.7%
2014	1864	228	12.2%
2015	1803	222	12.3%
2016	1738	226	13.0%
2017	1536	206	13.4%
overall	15,888	1,774	11.2%
% of change	-39.5%	-17.3%	

2. Literature Review

As reported in many prior studies, human error cause more than 90% of total traffic accident. Many studies talked the driver's behavior that lead to severe accidents such as speeding, failing to wear a seatbelt, driving while drowsy, alcohol and drug use and tailgating (Blows, et al. 2005; Petridou & Moustaki, 2000). Most previous studies that tackled the tailgating behavior addressed this issue to investigate the safe following distance or to find the proper headway time that prevent rear-end accidents occurrence. However, few researchers attempted to study the tailgating behavior based on tailgating accident data analysis.

Singh (2003) showed that rear-end collisions ranked the highest cause of traffic accidents which represented around third of total traffic accidents in 2006 in USA. In China, around 16.0% of all traffic accidents are caused by tailgating (National Traffic Administration, Ministry of Public Security, 2000–2005).

Wang and Song (2010) examined tailgating behavior on rural roadway network. The vehicles that have headway time less than 2 seconds were considered as tailgaters. It was found that 61.0% of vehicles were tailgating during peak hours and 39.0% during non-peak hours. Furthermore, the vehicles on high-speed lane exhibited worst tailgating

situation. In another research, Wang and Song (2011) used a questionnaire survey to investigate the reasons behind tailgating behavior of drivers. The results indicated that the top three causes of tailgating are "the heavy traffic", "slow car ahead", and "drivers on rush situation". Dingus et al. 1997 proved that two factors are mainly responsible for rear-end accidents; inattention and tailgating behavior of drivers. Evans and Wasielewski found that the vehicles with headway less than one second has higher number of reported violations and accidents than vehicles with headways between one and two seconds.

Rama and Kulmala (2000) evaluated the effectiveness of Variable Message Signs that provide the safe following distance to the drivers. after comparing before and after insulation of the VMS, it was found that percentage of drivers with headway less than 1.5s was around 30% before using VMS which turned out to around 24% after using VMS. The study included that use of VMS improve traffic safety by decreasing mean speed and increasing following distance. Vogel (2002) investigated traffic accident prone junction in Sweden to determine the safety indicator by comparing headway time and time to collision TTC. Time to collision is calculated based on equation 1.

$$TTC_i = \frac{X_{i-1}(t) - X_i(t) - l_i}{Y_i(t) - Y_{i-1}(t)} \quad (1)$$

Where; Y_i: the speed of vehicle is i, X_i : the position of the vehicle, l_i : the length of the vehicle i and $i-1$:the vehicle ahead. The study recommended to use of time headway as a criterion for judging tailgating as it prevents occurrence of lower time to collision values.

One of the significant contributing factors for rear-end accidents is tailgating or failing to keep a safe distance (Hutchinson 2013). Baldock, et al. (2005) found that the rear-end accidents are more likely to occur near road intersections, during peak traffic hours and on straight roads. In addition, it was found that the drivers involved in these accidents are young, male and possess only a temporary drivers' license.

3. Data Collection

The used data in this paper was extracted from traffic accident database of AD traffic police department. Eight years accident data are extracted, from year 2010 to 2017. Accident reports include full information about at fault drivers' characteristics, basic accident information such as accident type, causes, surrounding environment and road conditions with specific description about how the accidents occurred. In addition, full information about the resulted in causalities. The injury-severity of traffic accidents is classified into four levels; slight injury, medium injury, severe injury and fatal. these levels are defined based on the medical reports attached to accident reports. A total number of 15,888 traffic accidents and 1,774 tailgating-related accidents during the study period are analyzed.

4. Accident Data Analysis

4.1. In terms of accident types

Table 2 shows a comparison between the frequency of tailgating-related accidents and other types of accidents. From Table 2, it can be clearly figured out that the tailgating behavior is the main cause of rear-end accident type where it is responsible for around 90% of total rear-end accident against 14.9% for other accident types.

Table 2: Accident Type for Tailgating and Other Accidents

Accident type	Tailgating related accidents		Other accidents	
	Frequency	Percentage	Frequency	Percentage
Rear-end collision	1611	90.8%	2099	14.9%
Right-angle collision	57	3.2%	2264	16.0%
Side collision	56	3.2%	2375	16.8%
Head-on collision	14	0.8%	565	4.0%
Pedestrian accident	12	0.7%	3088	21.9%
Run-off-road	17	1.0%	3430	24.3%
Others	7	0.4%	293	2.1%

4.2. In terms of accident severity

The total number of the four injury-severity levels resulted from tailgating accidents and other accidents are shown in Table 3. This table shows that tailgating accidents led to more severe injuries and fatality than that resulted from other types of accidents. However, in case of slight injuries, tailgating accidents have more cases than other accident types. The medium injuries have approximately near values for both tailgating and other accidents. Table 3 also shows the causality rates per accidents that have high value in tailgating accidents and fatality rates per 1,000 accidents that have lower value in case of tailgating accident compared to other accident types. These findings mean that tailgating accidents lead to more casualties, but the severity-injury of the casualties is lower compared to other accidents.

Table 3: Injury Severity Levels of Accidents

Injury-severity level	Tailgating-related accidents		Other accidents	
	Frequency	Percentage	Frequency	Percentage
Slight	1438	44.0%	8551	36.5%
Medium	1467	44.9%	10629	45.3%
Severe	192	5.9%	2167	9.2%
Fatal	171	5.2%	2094	8.9%
Causality rate per accident	1.84		1.66	
Fatality rate per 1,000 accident	96.39		120.32	

4.3. In terms of at fault drivers' characteristics

Demographic characteristics of at-fault drivers involved in tailgating accidents and other types of accidents are summarized in Table 4. Male drivers seem to drive close to the front vehicle. As a result, male drivers have higher percentage of tailgating accidents compared to female drivers. with regard of drivers age, young drivers seem to involve in tailgating accidents more than older drivers. However, other characteristics of drivers such as years of driving experience, education level and nationality have no significant differences between tailgating and other accident types.

Table 4: Demographic Characteristics of at-Fault Drivers Involved in Tailgating accidents

Variables		Tailgating-related accidents		Other accidents	
		Frequency	Percentage	Frequency	Percentage
Gender	Male	1612	92.3%	12463	89.7%
	Female	135	7.7%	1428	10.3%
Age group	18~25	515	29.5%	3747	27.0%
	26~35	664	38.0%	5019	36.1%
	36~45	322	18.4%	2699	19.4%
	>45	236	13.5%	2030	14.6%
Years of experience	< 3	654	36.9%	6447	45.7%
	3 ~ 6	418	23.6%	2833	20.1%
	6 ~ 9	271	15.3%	1686	11.9%
	> 9	431	24.3%	3148	22.3%
Education level	Low	1042	59.6%	8432	60.8%
	Medium	564	32.3%	4317	31.1%
	High	142	8.1%	1111	8.0%
Nationality	Emirate	601	34.7%	4684	34.0%
	Asian	700	40.4%	5548	40.2%
	Arabian	399	23.1%	3178	23.0%
	Others	31	1.8%	379	2.7%

4.4. In terms of road and environmental conditions

Table 5 shows the frequency of tailgating and other types of accidents classified based on the characteristics of roads and environmental condition. This table indicated that tailgating accidents tend to be occurred on rural roads and on roads with high posted speed limit. This finding proves the dangerous situation of driving very close to a front vehicle with a high speed (i.e., 80 km/h or more). Table 5 also shows that the percentage share of tailgating accidents decreases with increasing number of lanes. That may occur due to the flexibility of drivers to do overtaking maneuvering to avoid slow vehicles ahead in case of big number of lanes. On the other hand, other parameters such as road surface, light condition and weather condition seem have no significant impact on the frequency occurrence of tailgating accidents.

Table 5: Characteristics of Roads and Environmental Condition of Tailgating-Related accidents and other accidents Types

Variables		Tailgating related accidents		Other accidents	
		Frequency	Percentage	Frequency	Percentage
Road type	Urban	514	32.4%	4652	37.3%
	Rural	1073	67.6%	7825	62.7%
Road speed limit	40	96	5.4%	3489	24.7%
	60	476	26.8%	4959	35.1%
	80	351	19.8%	1932	13.7%
	100	379	21.4%	1840	13.0%
	120	472	26.6%	1894	13.4%
No. of lanes	2	456	34.0%	5326	50.5%
	3	437	32.6%	3059	29.0%
	4	396	29.5%	1888	17.9%
	5 or more	52	3.9%	277	2.6%
Intersection-related location	at/near intersection	116	6.5%	2754	19.5%
	others	1658	93.5%	11360	80.5%
Light condition	day time	1148	64.7%	8098	57.4%
	Night with good light	543	30.6%	4854	34.4%
	Night without light	83	4.7%	1153	8.2%
Road surface condition	Dry	1686	95.0%	12726	90.2%
	Wet	31	1.7%	259	1.8%
	Sand-covered	52	2.9%	873	6.2%
	not paved	5	0.3%	256	1.8%
Weather condition	Clear	1693	95.4%	13545	96.0%
	Rainy	26	1.5%	243	1.7%
	Fogy	50	2.8%	237	1.7%
	Stormy	5	0.3%	89	0.6%

5. Accident Involvement Modelling

For deep understanding the contributing factors affect the tailgating-related accidents, two regression models are developed, one for accident occurrence and the other for accident severity. Binary logistic regression modelling technique is the best choice for investigating variables affecting the occurrence and severity of traffic accidents. This model predicts the probability that an observation falls into one of two different categories of a dependent variable. The logistic regression model can be written as follows (Agresti, A. 2002).

$$E(\mathrm{Y/X}) = \pi(\mathrm{x}) = \frac{e^{\beta_0 + \beta_1 x}}{1 + e^{\beta_0 + \beta_1 x}} \quad (2)$$

Table 6 shows the explanatory variables that used to develop the two models. The statistical software package SPSS is used to estimate the models' parameters.

Table 6: Description of explanatory variables considered in the developed two regression models

Variables	Description
Speed_Limit	A continuous variable
Property_Damage	= 1 if a road property damage occurred
	= 0 if case of no property damage
Intersection	= 1 if the accident occurred at/near an intersection
	= 0 if the accident occurred at a straight section of the road
Vehicle_Type	= 1 in case of light vehicle
	= 0 in case of heavy vehicle
No._of_lanes	A continuous variable
Day_of_the_week	= 1 during working weekdays
	= 0 during weekend days
Gender	= 1 for at-fault male drivers
	= 0 for female
Road_type	= 1 in case if urban roads
	= 0 in case of rural roads
Day_Time	= 1 during day time
	= 0 during night time
Experience_years	A continuous variable
Occupation_type	= 1 in case of drivers who working as drivers
	= 0 in case of other types of occupations
Nationality	= 1 in case of local drivers (emirate drivers)
	= 0 for other nationalities of drivers
Dri_License_Source	= 1 in case of driving license issued from AD
	= 0 in other cases
Drv_Age	A continuous variable
Road_Surface	= 1 in case of dry road surface
	= 0 in other cases of road surface
Light	= 1 in case of good light condition
	= 0 in other cases
Education_level	= 1 in case of high educated drivers (university graduated)
	= 0 in other cases
Marital_Status	= 1 in case of married drivers
	= 0 in other cases
Weather	= 1 in case of clear weather condition
	= 0 in case of rainy/fogy/stormy weather condition

5.1. Tailgating accident occurrence model

In accident occurrence model, the dependent variable is taken as the occurrence of tailgating accident (i.e., = 1 in the tailgating accidents and = 0 in other accident types). the total 15,888 accident data are involved on the modelling process. Table 7 shows the output results of the estimate binary logistic regression model. From this table, it is found that that 10 explanatory variables are significant affect the occurrence of tailgating accidents at significant level of 95%. the explanatory variables are arranged in ascending order. Road characteristics that significantly affect the occurrence of tailgating accidents are the speed limit, number of lanes, road type, intersection exists. vehicle type also showed significant impact where heavy vehicle is more probability to involve in tailgating accidents than small vehicles. Drivers characteristic such as gender, age, occupation and nationality are significantly affecting the

occurrence of tailgating accidents. Local drivers are more likely to be involved in tailgating accidents than other nationalities. In addition, tailgating accidents are likely to be occurred in working days more than in weekend days.

Table 7: Tailgating accident occurrence model outputs

Variables	B	S.E.	Wald	Sig.	Odd ratio Exp(B)
Constant	-4.218	.375	126.676	.000*	.015
speed_limit	.021	.002	177.656	.000*	1.021
property_damage	-1.112	.091	151.013	.000*	.329
Intersection	-1.253	.146	73.966	.000*	.286
No._of_Lanes	.260	.036	50.971	.000*	1.297
Vehicle_Type	-.685	.109	39.786	.000*	.504
Day_of_the_week	.440	.086	25.968	.000*	1.553
Road_Type	-.370	.085	18.758	.000*	.691
Occupation_Type	.264	.093	8.084	.004*	1.302
Gender	.396	.139	8.082	.004*	1.486
Nationality	.217	.096	5.170	.023*	1.243
Ivh_Drv_Age	-.010	.005	3.745	.053	.990
Dri_License_Source	-.152	.081	3.570	.059	.859
Lighting	.286	.174	2.702	.100	1.331
Day_Time	.100	.076	1.708	.191	1.105
Road_Surface	.210	.165	1.636	.201	1.234
Education_Level	.125	.128	.958	.328	1.133
Weather_Condition	.095	.188	.257	.612	1.100
Marital_status	.019	.076	.060	.807	1.019
Experience_years	.001	.008	.035	.852	1.001

***Significant at level = 0.95 ($\alpha < 0.05$)**

Table 8: Tailgating accident severity model outputs

Variables	B	S.E.	Wald	Sig.	Odd ratio Exp(B)
Constant	-2.894	1.018	8.076	.004*	.055
Lighting	-1.022	.351	8.503	.004*	.360
speed_limit	.010	.004	5.083	.024*	1.010
No._of_Lanes	-.212	.095	4.944	.026*	.809
property_damage	.445	.210	4.469	.035*	1.560
Road_Type	.494	.243	4.136	.042*	1.638
Ivh_Drv_Age	.020	.012	2.621	.105	1.020
Gender	.781	.536	2.119	.145	2.183
Intersection	-.870	.619	1.976	.160	.419
Day_of_the_week	.320	.233	1.895	.169	1.377
Marital_status	-.254	.190	1.796	.180	.775
Nationality	-.335	.251	1.778	.182	.715
Dri_License_Source	-.185	.190	.956	.328	.831
Education_Level	-.274	.368	.554	.457	.760
Weather_Condition	.244	.476	.263	.608	1.276
Day_Time	-.087	.187	.217	.641	.917
Road_Surface	.140	.392	.129	.720	1.151
Vehicle_Type	-.082	.247	.110	.740	.921
Occupation_Type	.059	.223	.071	.790	1.061
Experience_years	.004	.019	.049	.826	1.004

***Significant at level = 0.95 ($\alpha < 0.05$)**

5.2. Tailgating accident severity model

In accident severity model, the dependent variable was taken as the severity level of the accident (i.e., = 1 in case of fatality and severe injury and = 0 in case on medium and slight injury only accidents). Thus, tailgating-related accidents only involved in the modeling development (i.e., the 1,774 reported accidents). Table 8 shows the output results of the binary logistic regression model. It is found that only five variables showed a significant impact on the severity of tailgating accidents including lighting condition which that was not shows as a significant variable in accident occurrence model. the other four variables are speed limit, number of lanes, road type and existence of property damage. All driver's demographic characteristics are shown as not significantly affect the severity of tailgating accidents.

6. Conclusion and recommendations

This paper provided a comprehensive analysis on tailgating-related accidents by using accident data from year 2010 to 2017. A total number of 15,888 traffic accidents including 1,774 tailgating related accidents were analyzed in terms of road, environmental and drivers' characteristics. Two separated binary logistic regression models are used to examine the contributing variables affecting the occurrence and severity of tailgating-related accidents.

Traffic accident occurrence model showed that four parameters of road characteristics significantly affect tailgating accident occurred; speed limit, number of lanes, road type and intersection exist. Tailgating accidents are likely to be occurred in working days more than in weekend days. In addition, vehicle type also showed significant impact where heavy vehicle is more probability to involve in tailgating accidents than small vehicles. furthermore, driver's characteristic such as gender, age, occupation and nationality are significantly affecting the occurrence of tailgating accidents.

Regarding severity of tailgating accidents, it was found that five variables have significant impact on the including lighting condition, speed limit, number of lanes, road type and existence of property damage. However, driver's demographic characteristics were shown as not significantly affect the severity of tailgating accidents.

The findings highlighted the importance of enforcing the tailgating behavior of drivers especially on rural roads. More education and awareness campaigns are needed to inform drivers about the seriousness of this behavior especially it is coupled with high speed. Such awareness campaigns should be focuses on local, male and young drivers. In addition, good lighting condition of roads should be provided in the locations of frequency tailgating accidents occurrence.

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References

Agresti, A., 2002 Categorical data analysis 2nd ed. Hoboken, New Jersey.

Baldock, A.D. Long, V.L. Lindsay, A.J.McLean, Rear end crashes, Report CASR 018,Centre for Automotive, Safety Research, University of Adelaide, 2005, (Retrieved onJan 5, 2014 from Available: http://digital.library.adelaide.edu.au/dspace/bitstream/2440/36417/1/CASR018.pdf).

Blows, S. Ameratunga, Ivers, R. Q., Lo, S. K., & Norton, R. 2005. Risky driving habits and motor vehicle driver injury. Accid Anal Prev, (4), 619 – 624.

Dingus, Thomas A., et al. 1997. Human Factors Field Evaluation of Automotive Headway Maintenance Collision Warning Devices. Human Factor 39 (2), pp. 216-229.

Evans, L., Wasielewski, V. 1982. Accident-involved drivers exhibit riskier everyday driving behavior?". Accident Analysis and Prevention, Vol. 14, pp. 57-64.

Hutchinson, T.P. 2013. Tailgating, Centre for Automotive Safety Research, University of Adelaide, 2008. (Retrieved on June 1, 2013, available:http://casr.adelaide.edu.au/publications/researchreports/CASR046.pdf).

Monteiro, N. M., Alogun, S. K., Kote, M., Tlhabano, K. N. 2015.2015. Stationary tailgating in Gaborone, Botswana: the influence of gender, time of day, type of vehicle and presence of traffic officer. IATSS Research, Vol. 38, Issue 2, pp. 157-163.

National Traffic Administration Bureau, Ministry of Public Security, 2000–2005.Statistic of Road Traffic Accident in People's Republic of China. China Statistical Year book.

Petridou, E. Moustaki, M. 2000. Human factors in the causation of road traffic crashes. European Journal of Epidemiology; 16 (9), 819 – 826, 2000.

Rama, P., Kulmala, R. "Effects of variable message signs for slippery road conditions on driving speed and headways". Transportation Research Part F: Traffic Psychology and Behavior 3 (2), pp. 85-94, 2000

Ramkhalawansingh, R. C., Trick, L. M. 2015. Too close for comfort: evaluating a reward-based approach to increase drivers' headway". Proceedings of the Eighth International Driving Symposium on Human Factors in Driver Assessment, Training and Vehicle Design, Salt Lake City, Utah, USA.

Singh, Santokh. 2003. Driver Attributes and Rear-end Crash Involvement Propensity." NHTSA Technical Report no. DOT HS 809 540.

Vogel, K., 2002. A comparison of headway and time to collision as safety indicators. Accident Analysis and Prevention, Vol. 35, Issue 3, pp. 427-433.

Wang, J., Song, M. 2001. Assessing drivers' tailgating behavior and the effect of advisory signs in mitigating tailgating, Proceedings of the Sixth International Driving Symposium on Human Factors in Driver Assessment, Training and Vehicle Design, Lake Tahoe, California, USA.

Wang, J., Song, M. 2010. Sudying the Tailgating Issues and Exploring Potential Treatment. Journal of the Transportation Research Forum, Vol. 49, No. 3, pp. 69-86.