FACTORS AFFECTING STOPPING BEHAVIOUR AT SUBURBAN INTERSECTIONS

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Abstract: This study focused on how drivers dealt with intersections controlled by a stop sign at suburban in Al-Husn city at Irbid governorate, Jordan. The videotape was used at eight unsignalized intersections for one complete peak hour on weekdays. Any at-grade intersection that is not controlled by a traffic signal is defined as an "unsignalized intersection." The results showed that 48% out of 1,208 drivers took the decision to stop completely compared to 52% who chose to keep driving. Female drivers (75%) were observed to stop at intersections more frequently than male drivers. In terms of vehicle type, drivers of buses stopped more frequently than drivers of small passenger cars, which are road car, other than a motorcycle, that is designed to transport passengers. Driver age and compliance to a stop sign were found to be directly proportional to each other, but as the number of passengers in the vehicle increased, the rate of non-compliance also increased. Compliance was highest among leading vehicles, followed by following vehicles, and lowest among single vehicles. A binary logistic model showed that age, vehicle occupancy, and arrival pattern significantly affected stopping the behaviour. Gender and vehicle type were not significantly related to stopping the behaviour.

1　Introduction

One of the important objectives of installing stop signs is to regulate traffic streams at different approaches to an intersection. It is well-known that stop signs are very popular as traffic control devices (TCD) worldwide, including Jordan. According to the Jordanian Traffic Institute, the number of stop signs installed has increased rapidly in recent years. The value of stop signs cannot be overstated and is supported by law; as mentioned in the Manual on Uniform Traffic Control Devices (MUTCD), "regulatory signs shall be used to inform road users of selected traffic laws or regulations and indicate the applicability of the legal requirements."

However, if there is no respect to this sign and drivers violate the laws by crossing the intersection without stopping, many drawbacks could occur, such as accident frequency. For instance, data on road traffic accidents in Al-Husn city showed an increasing number of accidents at intersections controlled by stop signs due to the failure of drivers to stop at stop bars. Although many studies have been performed to examine stopping the behaviour, it remains unclear which factors influence drivers to stop or not stop before a stop sign.

This research aims to identify the factors that affect the compliance of drivers at selected intersections controlled by a stop sign in a suburban area at Irbid city in Jordan.

2　Literature review

Many studies were performed to check the main factors that led the drivers to decide whether to stop or not. Shaaban et al. [1] focused on driver behaviour at minor streets controlled by a stop sign. Several variables were studied, such as driver gender and age, peak and off-peak hours, the time of the week (weekday or weekend), and whether the intersection was located on residential or commercial land. Authors found that both male and young drivers were less likely to perform a complete stop. In terms of the influence of driver age toward violation of traffic laws, Devalla [2] showed that drivers aged less than 18 years (young drivers) were more likely to violate traffic laws such as exceeding the speed limit, driving in an aggressive way, and non-compliance with road and traffic signs. Arhin [3] et al. studied thirty unsignalized intersections to analyse driver compliance rate to the stop sign and found that compliance to the stop sign was high when the distance between the intersection and the nearest signalised intersection was short. Xiamei et al. [4] presented a new approach to classifying drivers' behaviour at intersections by using a special vehicle with a computer-vision technique to record full types of data. The authors found five different types of driver behaviour with different classes of risks for stopping behaviour when approaching the intersection. DeVeauuse et al. [5] studied vehicle compliance at a stop sign on a pedestrian crosswalk. They analysed different factors, such as how many pedestrians were using the crosswalk, pedestrian clearance, vehicle type, hour of the day, any day of the week. These factors were used at three different pedestrian crosswalks. The authors found that the total compliance percentage for stop signs was 22.8 for every 100 vehicles. The authors also noticed that compliance increased by 53% for every 100 vehicles if there was a pedestrian using a crosswalk.

3　Methodology

Eight suburban intersections located at al-Husn city were chosen to conduct the study. All the intersections were located far from any police enforcement. The camera's location was hidden to reduce the influence of driver behaviour. A total of 1,208 drivers were observed through videotape. Driver characteristics and vehicle

characteristics were observed by videotape during peak hours on weekdays.

Because there was no driver contact, age and sex were estimated based on the external appearance of the driver as they appeared on videotape. For vehicle characteristics, vehicle occupancy (i.e., the number of passengers inside the vehicle aside from the driver) and vehicle type (i.e., passenger car, bus, or others) were recorded, and vehicle type was recorded whether it was passenger car (PC), bus, or other types. Arrival patterns were recorded based on whether a vehicle was leading, following or solitary (i.e., alone in the road). Data were analysed using the Statistical Package for the Social Sciences (SPSS).

4   Result and Discussion
4.1   Gender
Altogether, less than half were observed to perform a complete stop before a stop sign (Table 1). Female drivers (75%) were observed to stop more frequently at a stop sign compared to male drivers (Table 2, Figure 1).

On the other hand, the vast majority of male and female drivers perform a complete stop. This may be explained by the fact that female drivers start driving at a later age than male drivers, and we know that driving needs skills and experience that a person acquires with time. As a result, females in our society felt all the time that they needed to be more careful, especially when they recognised the aggressive driving style of male**s**.

Table 1 Descriptive Statistics of the Dependent Variable

The Dependent Variable	Cases	Percentages
Stopping types		
0-No stop/rolling stop	632	52%
1-Complete stop	576	48%

Table 2 Percentages and Counts of Drivers vs Gender

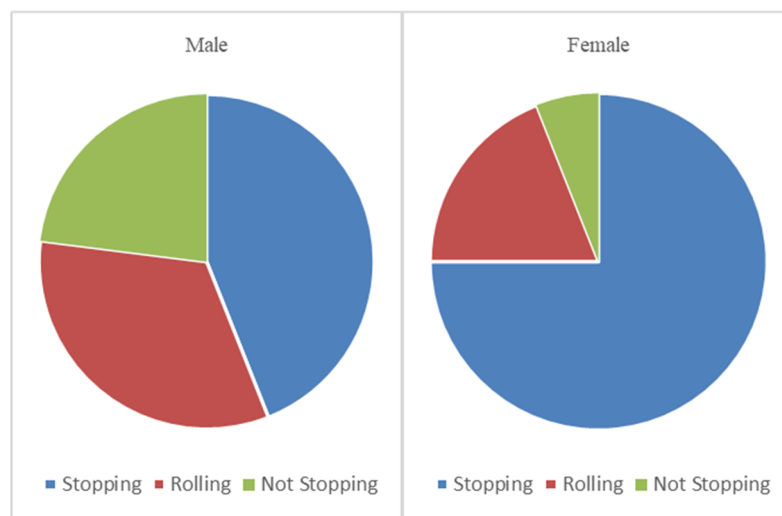| Gender	Stopping		Rolling		Not Stopping	
	Count	Percentages	Count	Percentages	Count	Percentages
Male	480	*44%*	352	*33%*	248	*23%*
Female	96	*75%*	24	*19%*	8	*6%*

Figure 1 Driver Gender vs Stopping Behaviour

4.2   Age group
The age group was estimated based on the external appearance of the driver. Table 3 and Figure 2 show the stopping characteristics of drivers (i.e., complete stop, rolling stop, or non-stop) based on the estimated age group. Older drivers (75%) were observed to perform a complete stop more frequently than middle-aged and young drivers.

Middle-aged drivers were observed to continue driving despite a stop sign more frequently than other age groups. The middle-aged group may be overlapped between both young and old, so if we ignore this class, it becomes obvious that as the age group increases, the awareness of the surrounding traffic culture improves. Old drivers are the best group regarding respect for the law.

Table 3 Percentages and Counts of Drivers vs Age Group

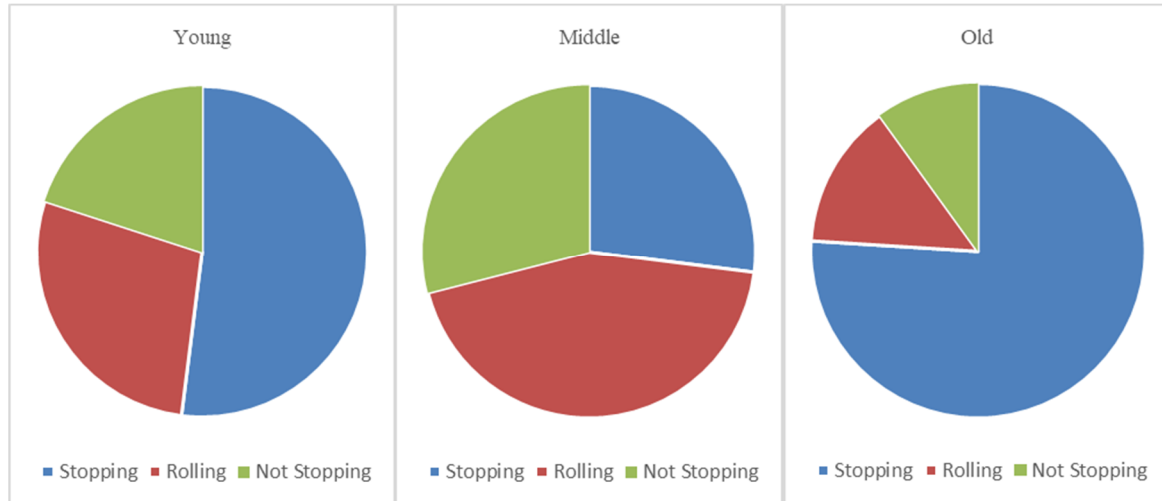| Age Group	Stopping		Rolling		Not Stopping	
	Count	Percentages	Count	Percentages	Count	Percentages
Young	344	52%	184	28%	128	20%
Middle	108	27%	168	44%	112	29%
Old	128	76%	24	14%	16	10%

Figure 2 Age Group vs Stopping Behaviour

4.3 Occupancy

Table 4 and Figure 3 show the stopping characteristics of drivers based on vehicle occupancy. Again, single-occupied vehicles were observed to stop more frequently than vehicles with more than one occupant.

Table 4 Percentages and Counts of Drivers vs Occupancy

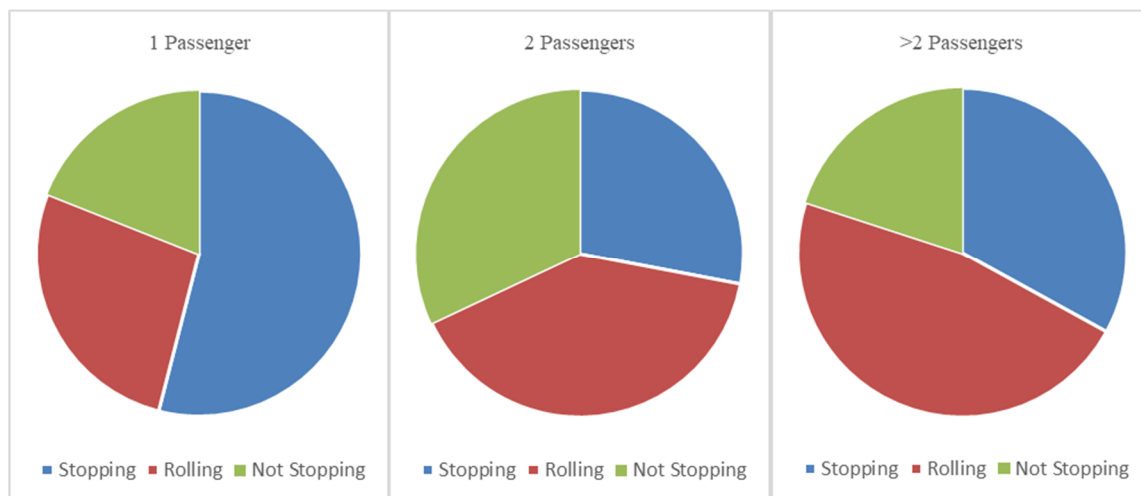| Occupancy	Stopping		Rolling		Not Stopping	
	Count	Percentages	Count	Percentages	Count	Percentages
1	480	54%	240	27%	168	19%
2	56	28%	80	40%	64	32%
>2	40	33%	56	47%	24	20%

Figure 3 Occupancy vs Stopping Behaviour

4.4 Vehicle type

Table 5 and Figure 4 show the stopping characteristics of drivers based on vehicle type. Passenger cars stop more frequently at unsignalized intersections than buses and other vehicle types.

The observed data shows that PC is less likely to stop completely than buses or other vehicles. It may be because trained drivers drive buses. In Jordan, most bus drivers were classified as professional and well-trained drivers, and they were most likely to respect the law.

Table 5 Percentages and Counts of Drivers vs Vehicle Type

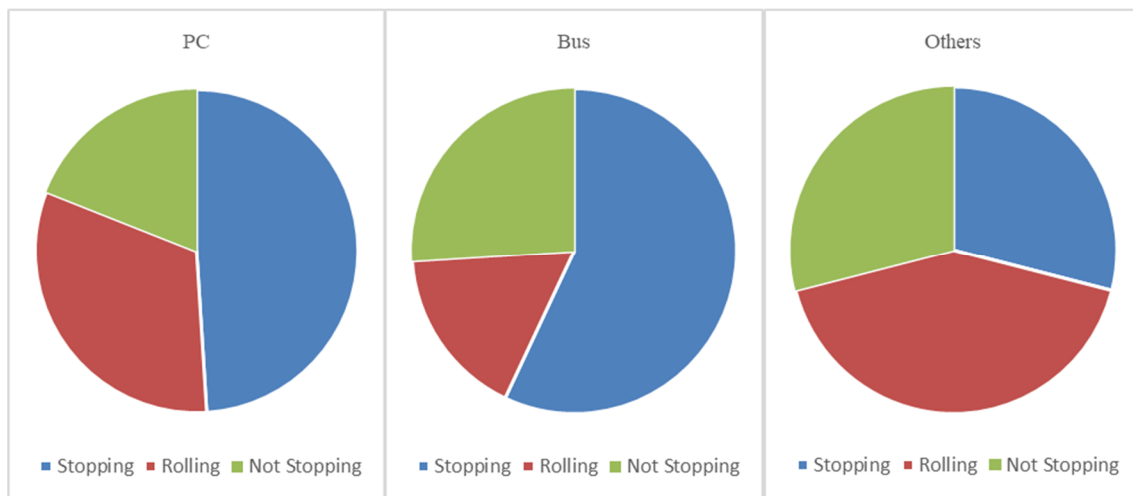| Vehicle Type	Stopping		Rolling		Not Stopping	
	Count	Percentages	Count	Percentages	Count	Percentages
PC	432	49%	288	32%	168	19%
Bus	104	57%	32	17%	48	26%
Others	40	29%	56	42%	40	29%

Figure 4 Vehicle Type vs Stopping Behaviour

4.5 Arrival pattern

Table 6 and Figure 5 show the stopping characteristics of drivers based on arrival patterns. Leading vehicles were found to completely stop more frequently at stop signs, followed by following vehicles, and lastly, single or solitary vehicles.

This could be explained by the fact that when single vehicles enter the intersection, they have extra time to see the entire intersection clearly if the vehicles going in different directions exist or not.

Table 6 Percentages and Counts of Drivers vs Arrival Sequence

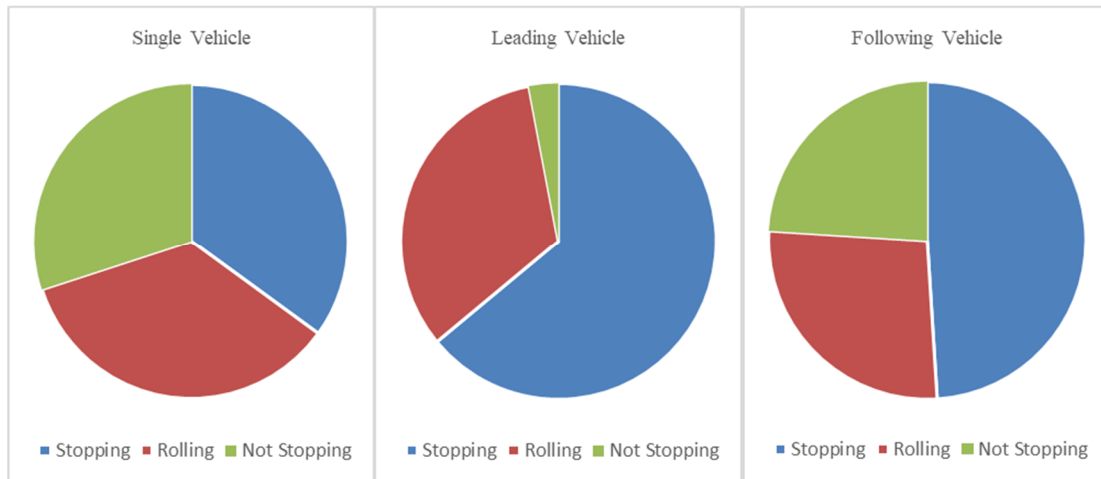| Arrival Pattern	Stopping		Rolling		Not Stopping	
	Count	Percentages	Count	Percentages	Count	Percentages
Single Vehicle	136	35%	136	35%	112	30%
Leading Vehicle	168	64%	88	33%	8	3%
Following Vehicle	272	49%	152	27%	136	24%

Figure 5 Arrival Pattern vs Stopping Behaviour

4.6 Statistical analysis

Binary logistic regression was performed to identify factors that influence drivers' stopping behaviour who completely stopped at a stop sign compared to those who did not. It is familiar in the transportation field to use the binary model because it shows the decision to choose one among a group of different independent alternatives. As the driver reached the intersection, they were to choose to make a complete stop (let it (i)) or not make a stop (let it (j)). The form of the binary logistic model is [6] (1):

$$Prob[Yi = 1\ making\ a\ complete\ stop] = \frac{Exp(\alpha + \sum \beta i x i)}{1 + Exp(\alpha + \sum \beta i x i)]} \quad (1)$$

Where βi is the coefficient associated with the independent variables; xi is the value of the independent variables; α is the constant estimated by the model.

SPSS was used to perform a chi-square test to determine the correlation between independent and dependent variables. The summarised results for the chi-square test are shown in table 7, with a value of the level of confidence to be 95%.

Table 7 Results of Chi-square test

Independent Variables	β	Exp (β)	Stranded Error	p-value
Constant (α)	-2.583	-	1.816	0.001
Gender	-0.081	0.922	0.087	0.351
Age	0.133	0.875	0.059	0.025
Vehicle Occupancy	0.085	1.089	0.044	0.05
Vehicle Type	1.639	5.15	0.999	0.101
Arrival Pattern	-1.109	0.33	0.632	0.039

According to statistical analysis, gender does not affect the stopping behaviour because of the estimated model with a p-value of 0.351 (which is more than 0.05). At the same time, age has an important rule for deciding on the driver with a p-value of 0.025. Regarding vehicle occupancy, the estimated p-value is 0.05, which significantly affects the driver's behaviour. Finally, vehicle type doesn't significantly affect driver behaviour with a p-value of 0.101.

So, according to the above results, and taking into account the variables that significantly affected the stopping behaviour and ignoring the weak variables, the binary model could be as shown in equation (2).

$$Yi = \frac{Exp(-0.159 + 0.026x1 + 0.189x2 - 2.785x3)}{1 + Exp(-0.159 + 0.026x1 + 0.189x2 - 2.785x3)} \quad (2)$$

$R^2 = 0.806$
Where:
Y_i: Probability to make a complete stop.
x_1: Driver Age.
x_2: Vehicle Occupancy.
x_3: Arrival Pattern.

A log transformation logit (π) was used to model the dependent variable, which is the stopping behaviour. The resulting coefficient's explanation is according to the transformation of the coefficient to exponential form, which is defined as odds ratio as shown in equation (3) and Table 8.

$$Odds = \frac{P(event)}{P(no\ event)} \quad (3)$$

$$P(no\ event) = 1 - P(event)$$

Table 8 Model Results

Dependent Variable	Independent Variable	Classes of the variable	Coefficient	P-value	Odds ratio
Making a complete stop	Driver Age	Young	Reference	-	-
		Middle	-0.398	< 0.0001	0.672
		Old	-0.357	< 0.0001	0.821
	Vehicle Occupancy	1	Reference	-	-
		2	0.256	0.082	0.365
		>2	0.270	0.038	0.462
	Arrival Pattern	Single	Reference	-	-
		Leading	-0.322	0.004	0.632
		Following	0.221	0.001	0.265

5   Conclusion

This study focused on the main factors affecting stopping behaviour at unsignalized intersections in Jordan. The data were collected at eight different intersections located in a suburban area. Results showed that 52% of 1,208 drivers observed by videotape completely stopped before a stop sign, while 48% did not. Older drivers had the lowest violation rate compared to other age groups. Drivers appeared to have less of a tendency to cross the stop bar as they got older. Single and following vehicles had similar rates of violation, while a vehicle with one passenger showed the most respect to law compared to other types of occupancy.

A stop bar should be installed clearly at unsignalized intersections so drivers can detect it easily and make the right decision to stop. On the other hand, traffic violations should be monitored using new technologies in transportation, such as sensors or cameras.

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