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Relation between Driver's Characteristics and Roundabout's Accidents

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Abstract - The availability of roundabouts may reduce number and severity of intersection accidents. Still some accidents occurred in roundabouts. Solutions for such accidents could be conducted through implementing proper design features, the use of traffic signs, and by educating students in driving schools on roundabouts driving concepts. This paper aims to analyze statistically the effect of certain personal characteristics of drivers involved in roundabouts accidents in Tabuk city, Saudi Arabia. The study found that several factors such as roundabout location, accident time, vehicle type and certain driver's characteristics affect accident occurrence. Severity index in these roundabouts reach 14%, this represent a dangerous situation in the study area. And single drivers are more involved in accidents. The study proved that young drivers are higher than other age groups in accidents involvement especially those resulted in deaths. And native drivers had the highest contribution to death accidents.

***Keywords*:** Roundabouts, Traffic Accidents, Driver's Characteristics, Chi-Square Test.

1. Introduction

Some of the most common types of accidents such as right-angle, rear-end, and head-on collisions are available at traditional intersections. Roundabouts promote safety in different ways. With roundabouts, these types of serious accidents generally are eliminated because vehicles travel at low speeds without the crossing maneuver. The purpose of this paper is to concentrate on causes and solutions for traffic accidents on roundabouts and to study the effect of some personal characteristics of drivers involved in roundabouts accidents in Tabuk city, Saudi Arabia.

Several international roundabout studies indicated that number and severity of accidents decrease compared to intersections [1, 2, 3, 4]. One of the high priority transportation development projects in Canada is roundabout installations that are used to improve road safety and traffic flow [5]. Weber P. mentioned that roundabouts are usually constructed for one or more of three reasons: safety benefits, capacity benefits, or environmental benefits [6]. The respondents on a survey study in U.S agreed that roundabouts reduce delays, increase capacity, and improve safety [7]. Another study in U.S. has also verified that roundabouts reduced number of injury accidents [8].

A recent study showed that about 80% of accidents occurred on the entry lanes and the circulatory roadway [9]. In U.S, an accident reduction of about 40 percent on intersections converted from stop signs or traffic lights to roundabouts has been found and about 75 percent reduction in injury accidents [10, 11, 12]. Similarly, studies of intersections converted to roundabouts in Europe and Australia have reported between 35 to 60 percent reductions in all accidents [13]. In Maryland, a study at 38 roundabouts found that four types of accidents (run-off-road, rear-end, sideswipe, and entering-circulating) accounted for almost all accidents [14]. A review of fatal and injury accidents at roundabouts in Washington and Wisconsin found that motorcycle accidents and fixed object accidents were overrepresented [15].

2. Intersections and Roundabouts

An intersection is an area used for direction change. Intersections vary in complexity from simple intersection (three or four legs) to complex ones (multi-leg). Capacity at intersections is always lower than through sections of the road.

The basic types of at-grade intersections are three-legs, four-legs, and multi-legs (see figure 1 below). Three-leg intersections (T or Y) consist of three approaches. Three leg intersections could be un-channelized, flared, or channelized with divisional islands. Four-leg intersections (cross or scissors) consist of four approaches. It is usually channelized or flared. And it could be un-channelized in case of low turning volumes. Four leg intersections may be in staggered and/or

skewed shapes. Multi-leg intersections consist of five or more approaches. Multi-leg intersections should be avoided whenever possible.

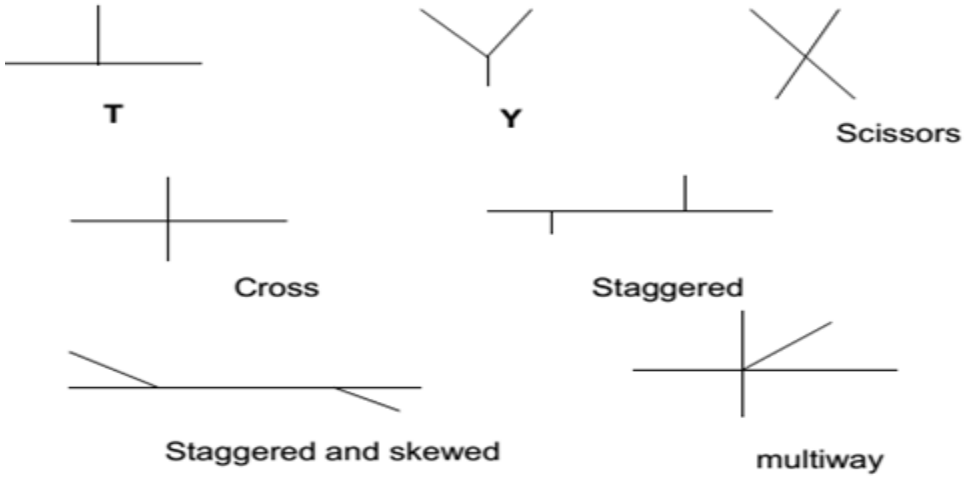

Fig. 1: Basic types of intersections [16].

A traffic circle is an intersection that provides a circular traffic pattern with significant reduction in conflict points. Roundabouts may differ in shapes and sizes, but all having counter-clockwise flow around the central island with speed reduction inside the roundabout. The Manual on Uniform Traffic Control Devices (MUTCD, 2010) describes three types of traffic circles: rotaries, neighborhood traffic circles, roundabouts [17]. Rotaries have large diameters that are usually greater than 100m, thereby allowing speeds exceeding 45km/h. Neighborhood traffic circles are used mainly at the intersections of local streets. They have diameters that are much smaller than rotaries and therefore allow much lower speeds. They consist of pavement markings and do not usually employ raised Islands. Roundabouts include Yield sign control at each approach. Separation of conflicting traffic movements is by pavement markings or raised islands.

3. Roundabouts Accidents: Causes and Solutions

Roundabouts demonstrated several safety benefits, however some accidents still occur. There are no head-on or right-angle accidents on roundabouts. But other types of accidents may occurred such as: run-off-road (usually vehicles colliding with the central island due to high speed), rear-end, sideswipe, and entering-circulating accidents. Entry-circulating crashes are usually the most common type of roundabout's accidents. Such accidents are mainly related to one or more of the following causes: At entry (failure to yield, loss of control at entry. rear-end), exit-circulating, runoff the circulatory road, loss of control at exit, pedestrian and bicycles involvement.

Preventive solutions for roundabout accident may start with implementing proper design features that encourage drivers to slow down. Limited center island can promote slower speeds and limiting driver's through vision to near roadways. Splitter islands separating the approach and exit lanes should extend far enough from the roundabout to provide refuge for pedestrian refuge, delineate the roundabout and control entry speed. Roundabout entrance shall be wide enough with wide exit also to maximize capacity. Sufficient sight distance shall be available on all roundabout legs. Other design features such as adequate curvature of approach roads and the alignment of approaching roads with the center island also may help in limiting speeds.

The use of traffic signs such as speed limit signs, yield signs, and roundabout ahead signs is expected to improve safety on roundabouts. Adequate pavement markings and lighting should be available to alert drivers to reduce their speeds. Educational solutions for drivers are promising ones in reducing roundabouts accidents. Choose the appropriate lane before entering roundabout especially in multi-lane the roundabouts. For example in two lane road

use the right lane to conduct straight or right movement and use the left lane to make left or u-turn. Avoid driving near heavy vehicles, usually large trucks and buses need extra lane to complete a turn in a roundabout.

4. Study Methodology and Observations

This research concentrated on studying traffic accidents on the most three dangerous roundabouts in Tabuk city, Saudi Arabia. The paper also aims to analyze the effect of certain driver's personal characteristics on accidents occurrence. The study area is shown in figure 2 below.

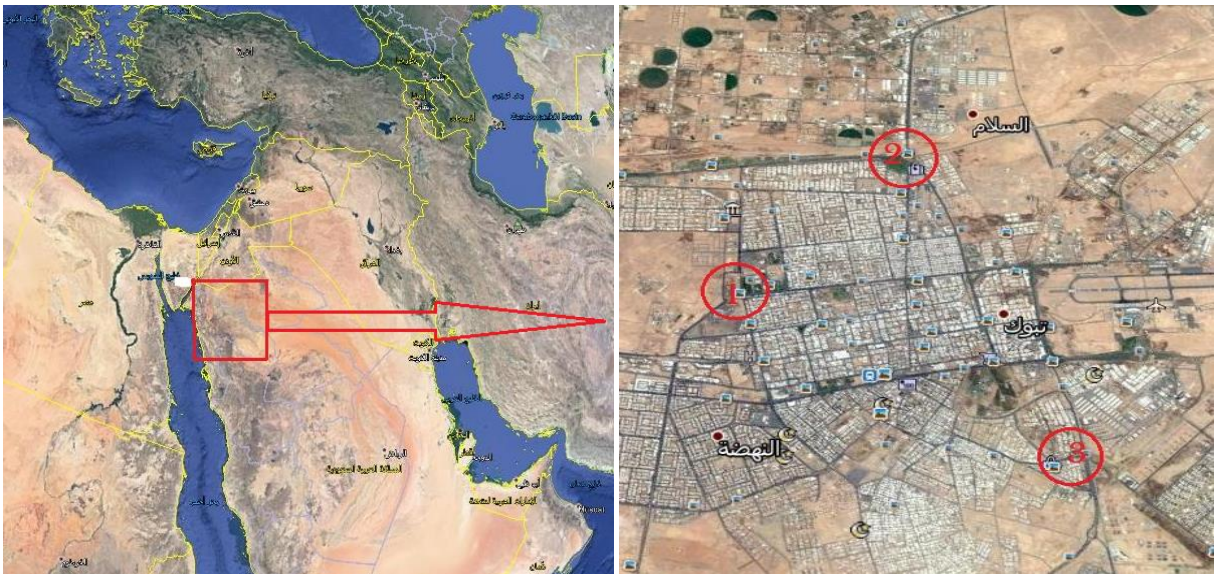

Fig. 2: Study Area.

An analysis of accidents severity, time, and vehicle type on the three roundabouts was carried out based on detailed accident descriptions and characteristics of involved drivers such as age, social status, nationality, and profession. Accidents statistics were gathered from traffic department in the city in 2014 before the new speed control system on roads (SAHER) fixed and in 2015 after the operational of SAHER (table 1).

Table 1: Accidents statistics.

Roundabout No.	2014	2015	Difference (%)
1	13	15	+15
2	25	28	+12
3	20	16	-20
Total	58	59	+2

Results from above table indicated that number of accidents increased in some roundabouts and decreased on others in 2015. This indicates that accidents on roundabouts did not affect with the speed control on roads. Similarly, accident's severity shown in table 2 indicated an increase in total number of injuries and deaths in the study area in 2015 compared to 2014. This may related to the increase number of vehicles working on the road in 2015.

Table 2: Accident's Severity.

Roundabout No.	Number of accidents on 2014			Number of accidents on 2015		
	PDO	Injuries	Deaths	PDO	Injuries	Deaths
1	10	3	0	8	7	0
2	16	7	2	17	7	4
3	16	2	2	10	5	1

High severity index (SI= number of deaths/ number of accidents) appeared in these roundabouts. For example, in roundabout 2 SI range from 8 to 14%. Figure 3 below shows that accidents on roundabouts 1 and 2 are more at night, on the opposite day accidents are more in roundabout 3. This is related to the location of each roundabout as roundabout 3 is near to schools zone.

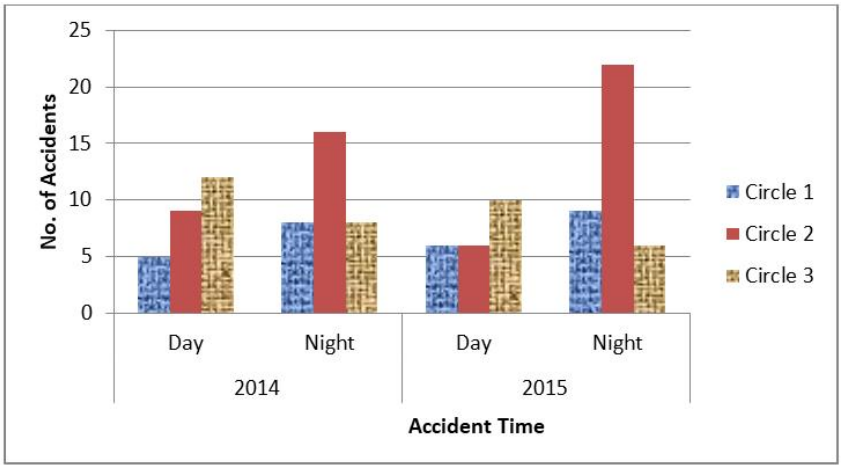

Fig. 3: Time of accidents.

Vehicle types involved in traffic accidents in roundabouts were also analyzed. Number of involved passenger cars is more in roundabout 3 since it is near CBD area. While heavy vehicles accident are high in roundabout 1 and 2 since they are located in the city ring road with heavy industrial areas. No difference in involvement percentage of small to heavy vehicles in 2014 and 2015.

Table 3: Type of vehicle involved in accidents.

Roundabout No.	Vehicle type (2014)		Vehicle type (2015)	
	Passenger car	Heavy vehicle	Passenger car	Heavy vehicle
1	4	9	5	10
2	7	18	8	20
3	16	4	13	3

Table 4 represents the social status of drivers involved in roundabout's accidents. It's appeared that mainly single drivers are more involved in accidents.

Table 4: Social status of drivers involved in accidents.

Roundabout No.	Involved drivers (2014)		Involved drivers (2015)	
	Married	Single	Married	Single
1	3	10	4	11
2	7	18	9	19
3	6	14	3	13

Age of driver's participating in traffic accidents in roundabouts is shown in table 5 below. In the three roundabouts young drivers (less than 19 years) is higher than other age groups in accidents involvement in both 2014 and 2015. This is due to lack of driving experience for such young drivers.

Table 5: Age of drivers involved in accidents.

Roundabout No.	Driver's age (2014)				Driver's age (2015)			
	<19	19-30	30-50	>50	<19	19-30	30-50	>50
1	8	2	2	1	6	5	3	1
2	12	8	3	2	13	9	4	2
3	9	6	2	3	6	5	3	2

Job of driver's participating in traffic accidents in roundabouts is shown in table 6 below. As expected and due to each roundabout location, higher percentage of involvements was for students in roundabout number 3, while labors and private companies' drivers are more involved in roundabout 1 and 2.

Table 6: Profession of drivers involved in accidents.

No	Driver's job (2014)				Driver's job (2015)			
	Student	Labor	Governmental employees	Companies employees	Student	Labor	Governmental employees	Companies employees
1	3	4	2	4	3	5	3	4
2	4	9	5	7	7	10	5	6
3	10	2	5	3	8	3	3	2

Figure 4 represents nationality of drivers involved in roundabout's accidents. It's appeared that native drivers are more involved in traffics accidents.

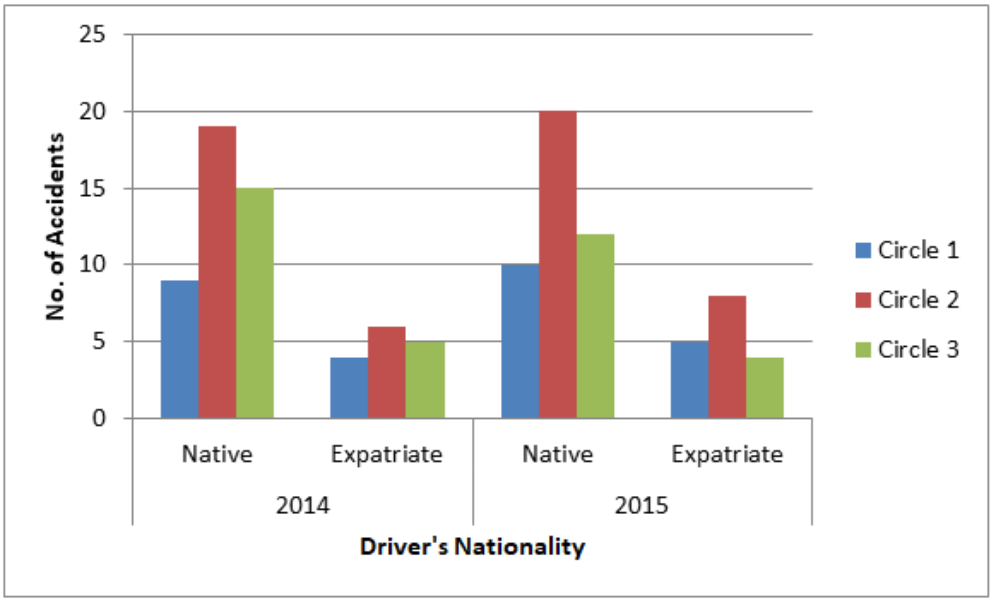

Fig. 4: Nationality of drivers involved in accidents.

5. Statistical Analysis

Data collected was statistically analyzed through contingency tables and chi-square (χ^2) test. The null hypothesis (H_0) used in any contingency table was "no relationship" between the driver's personal characteristics and accident's severity. The confidence level used in all tables was 90% and consequently, H_0 was rejected in any table with P-value less than 0.1. The χ^2 of each cell was compared to 2.7 to determine which cell(s) of the table statistically contributed in the rejection of H_0, which is the tabulated χ^2 at 90% confidence with 1 degree of freedom. Any cell with χ^2 greater than 2.7 indicates that the cell contributed in the rejection of H_0 of the contingency table under consideration. The effect of driver's age, social status, nationality, and profession on accident severity was statistically tested. Sample of analysis on driver's age in roundabout 2 in 2014 is presents in table 7 below.

Table 7: Effect of driver's age on accident severity.

Driver's age	Count	PDO	Injuries	Deaths
<19	Observed	6	4	2
	Expected	7.68	3.36	0.96
	χ^2	*0.37*	*0.12*	***1.23***
19-30	Observed	7	1	0
	Expected	5.12	2.24	0.64
	χ^2	*0.69*	*0.69*	*0.64*
30-50	Observed	1	2	0
	Expected	1.92	0.84	0.24
	χ^2	*0.44*	*1.60*	*0.24*
>50	Observed	2	0	0
	Expected	1.28	0.56	0.16
	χ^2	*0.41*	*0.56*	*0.16*

The data analysis also suggested that the drivers with less than 19 years old in the study area had the highest contribution to death accidents. Further analysis of the data showed that expatriates had the lowest involvements in death accidents, while native drivers had the highest contribution to death accidents. All of this suggested that expatriate drivers who are non familiar with the local driving environment are less involved in death accidents while they are more involved in property damage accidents, this may related to their driving low speed and pay more attention to the road. Student's drivers had also the highest involvement in death accidents compared to other job categories.

6. Conclusion

This research paper studies traffic accidents in three dangerous roundabouts in Tabuk city, Saudi Arabia. The paper aims to analyze statistically the effect of certain driver's personal characteristics on accidents occurrence. Roundabouts accidents could be related to several reasons. Countermeasures for such accidents could be conducted through implementing proper design features, the use of traffic signs, and through educating students in driving schools on roundabouts driving concepts.

It is concluded that several factors such as roundabout location, accident time, vehicle type and driver's characteristics affect accident occurrence. It is appeared that an increase in number of sever accidents (deaths and injuries) on roundabouts in 2015 compare to 2014. Heavy vehicles accidents on roundabouts resulted in more injuries and deaths. And mainly single drivers are more involved in accidents. The study proved that young drivers are higher than other age groups in accidents involvement especially those resulted in deaths. And native drivers had the highest contribution to death accidents. This research can be expanded by including other variables in the analysis such as the roundabout geometry and other driver's personal characteristics. Overall, it is recommended that these roundabouts are analyzed in the long run to investigate the long-term safety effects.

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