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Assessment of turn signal use at two-lane roundabouts in Doha city

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Abstract

Turn signal and lane change indicators can be identified as an effective way for drivers to communicate with each other. Additionally, the use of turn signals has significant safety implications. This study explored the usage of turn signal indicators when approaching and leaving two-lane roundabouts. In total, 415 and 400 vehicles entering and exiting two roundabouts located in Doha city were observed, respectively. Results explained that overall 23% and 18% entering and exiting vehicles used turn signals, respectively. Younger (< 25years old) drivers tend to use turn signals significantly lesser compared to middle and old aged drivers. While entering and exiting, drivers turning left or making U-turns tend to use turn signals more compared to other turning movements. In addition, drivers wearing formal clothes used the turn signal more frequently as compared to drivers wearing casual or traditional clothes. The professional drivers displayed significantly higher tendency of using turn signal compared to sedan and SUV drivers. The outcomes of this study could assist the government authorities to devise policies and driver-training schemes aiming at improving the safety at roundabouts.

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1. Introduction

Communication with other road users, such as other drivers, cyclists, and pedestrians, is extremely important while driving. A proper communication is an indication of safe driving behavior which helps in improving traffic safety. There are different ways that drivers can communicate with each other, e.g., honking the horn, hand signals, hand waving, and use of turn and lane changing signals [1]. Failure to communicate through such means at the appropriate time, as well as ineffective or ambiguous communications, may result in serious crashes. Among these non-verbal communication methods, use of turn signals play an important role in informing other road users about the driver's intent. Accordingly, other road users can take actions and make the necessary adjustments in advance to avoid a potential collision. Although turn as well as lane changing signals have been identified as a feature that helps to avoid crashes, not all drivers use them in an effective or consistent manner [2].

Several previous studies have explored different aspects of turn signal use among drivers. The study by Papacostas [3] concluded that 25 to 40% of the left turning drivers at urban intersections did not use turn signals properly and that significantly affected the following through vehicle. A national survey conducted in the USA reported that 57% of drivers did not use turn signals while switching lanes [4]. This survey further indicated that, compared to males, the use of turn signal is higher among females. Further, younger drivers (18-24 years old) use turn signals less frequently when compared to older drivers (55-64 years old).

Sullivan et al. [5] studied the characteristics of the use of turn signals at intersections in Michigan, USA using naturalistic driving data. The results of this study suggested that the drivers are more likely to use turn signals when they turn left as compared to right. This observation is consistent with the findings of [1]. Road type was also found to be a significant predictor of the use of turn signals; however, age and gender were not significant predictors of the turn signal use [5]. Another observational study conducted in the US concluded that oncoming traffic significantly affect the use of turn signals. That is, the percentages of the use of turn signals were 63% and 43.7%, respectively, when the oncoming traffic was present and absent [6]. Nguyen-Phuoc et al. [7] investigated the factors affecting the use of turn signals at intersections by car and motorcycle drivers in Vietnam using the observations made at 24 sites. Their findings showed that the proportion of car drivers who use turn signals are significantly higher compared to the motorcyclists. They further mentioned that drivers tend to use signals more when making left turns than making right turns. Influence of demographic characteristics were also studied in this study and it was found that male car drivers tend to use turn signals more than the female car drivers. In addition, this study concluded that younger drivers, who are less than 30 years old, were less likely to use turn signals as compared to middle-aged and older drivers. Ariffin et al. [8] studied the turn signal use among Malaysian motorcyclists using naturalistic riding data and observed that significantly lower percentage, i.e., 41.1% of riders used turning signals when turning at intersections and changing lanes. This study further mentioned that the use of turn signals was significantly higher on urban roads as compared to suburban and rural roads. Similar observations have been reported in Sullivan et al. [5] and Nguyen-Phuoc et al. [7]. Clayton and Myers [9] investigated the influence of visual prompts on increased use of turn signals at intersections. In the experiment, they displayed a visual prompt that read "Please Signal and Drive Safely" using two approaches; (i) hung on a post (passive prompting) and (ii) held by a female researcher (mediated prompting). They discovered that under passive prompting and mediated prompting, 89% and 85% of drivers, respectively, used the turn signals. This was a remarkable increment when compared to the baseline where only 68% of drivers used turn signals.

The use of turn signals by exiting vehicles at single-lane roundabouts were explored by Belz [10]. Their findings indicated that the entry decisions of the drivers are largely affected by the use of turn indicators by the departing vehicles from the roundabouts. Such situations could significantly affect the performance and efficiency of roundabouts.

It can be noted that there is little information available about the use of turn signals at roundabouts. Furthermore, no comprehensive studies on turn signal use (in general) from the Middle East region have been reported. Given the characteristics of the entry and exit maneuvers that mainly depends on the priority rules, the use of turn signals at roundabouts is extremely important. Therefore, the current study aims at exploring the turn signal use at two-lane roundabouts in Doha city. The two objectives of this study are; (a) determine the rates of turn signal use by drivers while entering and exiting two-lane roundabouts and (b) determine the factors affecting turn signal use while entering and exiting two-lane roundabouts. A comprehensive understanding of the turn signal use can assist the government authorities to devise policies and driver-training schemes aiming at improving the safety at roundabouts.

This paper is structured as follows; data collection procedures and analysis methods are discussed in Section 2. Then in Section 3, results are discussed in detail. Finally, in Section 4, conclusions and directions for further studies are presented along with limitations of this study.

2. Data collection procedure

2.1. Study sites

Two two-lane roundabouts from Doha city, State of Qatar, located in sub-urban areas, were selected for the purpose of this study. Izghawa roundabout is located in Izghawa and is at the intersection of Gharafat Al Rayyan Street and Alghazlaniya Street. While Al-Khebra roundabout is located in Al Maamoura and is on the intersection of Al Maadeed Street and Al Erbayyat Street. Izghawa roundabout is having four approaches and Al-Khebra roundabout is having three approaches. The details of roundabout are shown in Fig. 1 and Table 1. Further, the Izghawa roundabout is located in the residential area while Al-Khebra roundabout is having a school, mosque and playground in the vicinity. Both roundabouts are having yield signs at approach and road markings to guide the drivers.

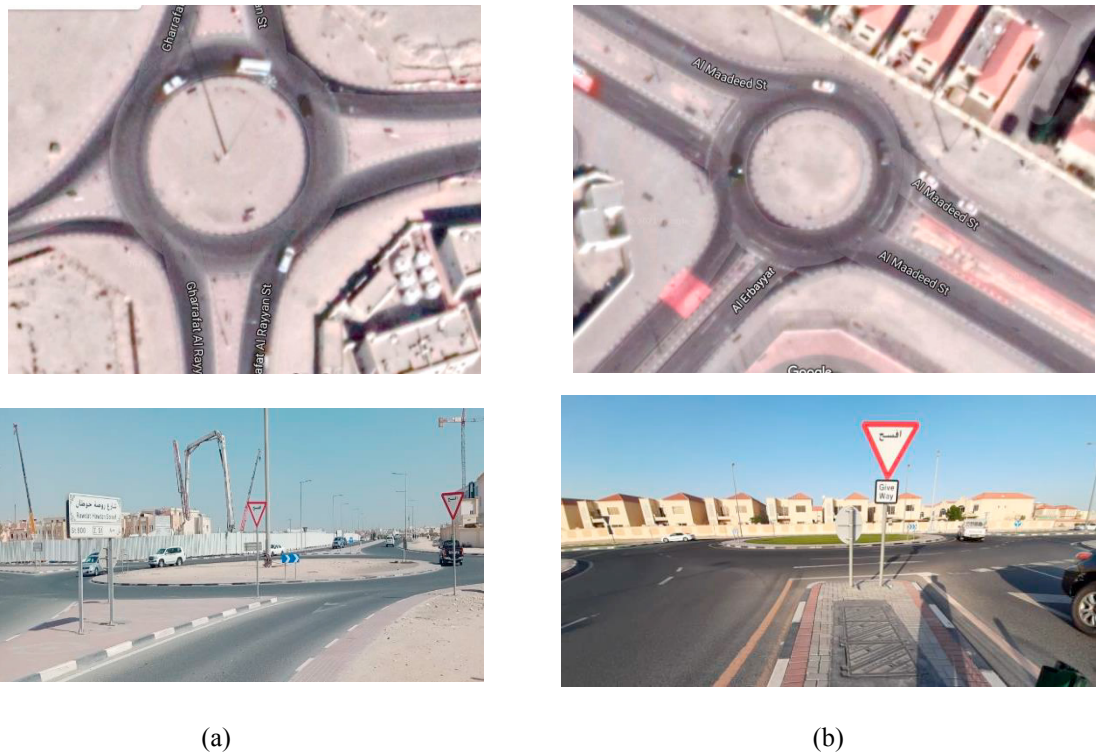


Fig. 1. (a) Izghawa roundabout; (b) Al-Khebra roundabout.

Table 1. Characteristics of selected roundabouts

Roundabout name	No of approaches	Inscribed circle diameter (m)	Central island diameter (m)	No of entry/exit lanes			
				North	East	South	West
Izghawa	4	52	35	2	2	2	1
Al-Khebra	3	43.5	26.5	-	2	2	2

2.2. Data recording

The data recording was done using a well-designed data collection form which has two sections; one for roundabout details and another as vehicle details. In the first section, roundabout details such as type of area, number of entry/exit lanes, details of signs and markings, presence of police patrol etc. were recorded. In the second section, three datasets were observed; driver details including gender, age group, accompanied, type of clothing, and distraction, vehicle details which included type of vehicle driven and type of following vehicle if available, and turn details such as turn type, and indicator use. Broad categories of age group were defined as young (<25 years), Middle (25 to 55 years) and elder (>55 years) drivers. Driver distraction was recorded as Yes or No. The distractions recorded for the driver included use of mobile phone, eating, talking with fellow passengers, grooming or reaching to other passenger seats.

The data recording was done by a group of five undergraduate students, who are co-authors of this paper, using paper based form. Some pilot runs were undertaken to familiarize the students with data collection process and ensure uniformity and completeness of data recording among them, specifically for selection of driver age and vehicle type. Once the students were able to record all the selected parameters uniformly, the main data collection process was initiated. The student observers selected approaching vehicles randomly and recorded their details in the form. If they were unable to record all the details expected, then that observation was removed from analysis. At each roundabout two observers were placed; one recorded driver details and other recorded vehicle and turn details in co-ordination. It should be noted that the data were collected for vehicles on all approaches. This process was repeated until around 200 complete observations were recorded for each roundabout. Only complete samples were considered for further analysis. It should be noted that all the data was recorded from inconspicuous or discreet locations so that the drivers and their driving behavior were not affected by the data recording process. After completion of the data recording process in the field, all the data was compiled and crosschecked for accuracy.

2.3. Data analysis

The recorded data was coded to conduct statistical analysis using IBM SPSS 28.0. For each variable, 95% confidence interval was calculated. Further, Chi – square (χ^2) test was applied to check if the differences in turn signal usage are statistically significant or not. If the difference is significant then the strength of association was determined using Phi (ϕ) value.

3. Results

This section presents the results of the turn signal usage by drivers while entering and exiting two studied roundabouts using the rate of turn signal use by driver characteristics (gender, age group, type of clothes, accompanied, and distraction), and vehicle characteristics (turn type and vehicle type) along with roundabout type. The overall analysis for turn signal usage showed that only 55 drivers (13.25%) used turn signals while entering and exiting the roundabouts. These comprised of 5.5% female drivers, around 80% middle aged drivers, and 65% drivers taking a right turn. Table 2 and Table 3 shows the descriptive statistics of the sample of the turn signal usage rates along with 95% confidence interval and statistical significance of the rate of turn signal use among the subgroups using Chi-Square statistic for vehicles entering and exiting the roundabouts respectively.

3.1. Turn signal use while entering roundabouts

In total, 415 vehicles were observed when they were entering the roundabout in which an overall turn signal usage rate of 23.1% was observed. Higher proportion of male drivers used the turn signal 24.1% (95% CI: 19.7–28.4%) compared to female drivers 13.2% (95% CI: 1.9–24.4%). Nguyen-Phuoc et al. [7] also found that male car drivers tend to use turn signals more than the female car drivers. However, the difference in this study was not statistically significant. In this study, lower proportion of young drivers (15.9%) used turn signal compared to drivers in other age groups. Nguyen-Phuoc et al. [7] also concluded that younger drivers, who are less than 30 years old, were less likely to use turn signals as compared to middle-aged and older drivers. However, these outcomes contradict the findings of Sullivan et al. [5] who stated that age and gender were not significant predictors of the turn signal use.

Drivers turning left or making U-turn showed higher prevalence of turn signal usage compared to other turning movements due to the complexity of the movement; this difference was statistically significant ($\chi^2=20.488$, $p<0.001$, $\phi=0.222$). Further, drivers driving at four legged roundabout (Izghawa) used turn signal lesser compared to the drivers at three legged roundabout (Al-Khebra), the reasons need to be investigated further. The type of clothes also affected the turn signal usage rates significantly with highest turn signal usage of 51.3% (95% CI: 34.5–68.2%) by drivers wearing formal clothes followed by drivers wearing casual or traditional clothes. Further, the drivers who were alone in the car showed higher prevalence of turn signal usage. Further, distracted drivers used turn signal significantly lesser (6.3%, 95% CI: 0.84–11.8%) compared to non-distracted drivers (27.0%, 95% CI: 22.2–31.8%). This is obvious as distractions reduces drivers' attention towards driving. The turn signal usage also significantly varied based on the type of vehicle driven. The professional drivers showed more tendency of using turn signal compared to drivers of sedan and SUV vehicles.

Table 2. Rate of signal use while entering two-lane roundabouts

Description	n_v	n_{vu}	Rate (%)	95% CI	Chi-square	p-value	Phi
Overall	415	96	23.1	19.1–27.2			
Turn type							
Left	136	40	28.9	21.1–36.6	20.488	<0.001	0.222
Right	157	38	24.4	17.5–31.2			
U-Turn	53	16	30.8	17.8–43.7			
Straight	69	2	2.9	1.2–6.9			
Roundabout name							
Izghawa	200	27	13.5	8.7–18.3	20.144	<0.001	0.220
Al-Khebra	215	69	32.1	25.7–38.4			
Gender							
Male	377	91	24.1	19.7–28.4	2.341	0.126	
Female	38	5	13.2	1.9–24.4			
Age							
Young	115	19	15.9	9.0–22.8	3.91	0.141	
Middle	277	71	25.7	20.5–30.9			
Elder	23	6	26.1	6.7–45.5			
Type of clothes							
Formal	38	20	51.3	34.5–68.2	24.581	<0.001	0.243
Casual	299	67	22.5	17.8–27.3			
Traditional	78	9	11.5	4.3–18.8			
Accompanied							
Yes	266	57	21.2	19.2–33.5	1.294	0.255	
No	148	39	26.4	16.2–26.1			
Distraction							
Yes	80	5	6.3	0.84–11.8	15.886	<0.001	0.196
No	335	91	27.0	22.2–31.8			
Vehicle type							
Sedan	145	28	19.4	12.9–26.0	14.546	<0.001	0.188
SUV	189	36	19.0	13.4–24.7			
Professional	79	31	39.2	28.2–50.2			

n_v is the number of vehicles observed, n_{vu} is the number of vehicles using turn signal

3.2. Turn signal use while exiting roundabouts

A dataset of 400 vehicles were obtained after data cleaning for vehicles exiting the roundabouts. An overall turn signal usage rate of 18.3% (95% CI: 14.4–22.0%) was observed, which was lower than the overall turn signal usage for entering vehicles. The turn signal usage was significantly affected by the type of turn undertaken with higher turn signal usage (around 25%) by drivers taking a right turn or u-turn while exiting. Further, the roundabout type didn't affect turn signal usage when vehicles were exiting unlike when the vehicles were entering the roundabout. In addition, gender of the driver also did not affect the turn signal usage significantly while exiting the roundabouts. This finding is in line with Sullivan et al. [5] who mentioned that gender is not significant predictors of the turn signal use. However, age of the drivers affected turn signal usage significantly showing higher prevalence of turn signal usage by middle aged drivers (21.6%, 95% CI: 16.6–26.6%) compared to young (10.0%, 95% CI: 4.3–15.7%) and elder (17.4%, 95% CI: 0.6–34.2%) drivers. These outcomes indicate that younger drivers use turn signals significantly less, which is consistent with the finding of [4] and [7].

Further, the type of clothes affected the turn signal usage significantly. Drivers wearing formal clothes used the turn signal more compared to drivers wearing casual or traditional clothes. Furthermore, whether the drivers were alone in the vehicle or accompanied by someone didn't affect the turn signal usage significantly. As expected distracted drivers (5.2%, 95% CI: 0.1–10.3%) used the turn signal at significantly lower rate compared to the non-distracted drivers (21.3%, 95% CI: 16.7–25.8%). The professional drivers driving heavy vehicles or vans / pickup vehicles used turn signal more compared to normal drivers driving sedan or SUV cars.

4. Conclusions

Two two-lane roundabouts were observed to record the turn signal usage by drivers in Doha city. A total of 415 and 400 vehicles were observed while entering and exiting the roundabouts respectively. Overall, only 18% to 23% drivers used turn signal while using a roundabout. This shows that significant improvements are needed to remove the ambiguity for other drivers while traversing the roundabout. Strategies should be devised and tested to improve the turn signal usage based on the factors affecting turn signal use. Drivers should be reminded of safety implications through some messages or sign boards and encourage them to use turn signal. Further, police enforcement can be added at random places to improve turn signal usage. An analysis of factors affecting turn signal usage showed that type of clothes, distraction, and vehicle type affected turn signal use while entering as well as exiting the roundabouts. While the type of turn undertaken, drivers wearing formal clothes, driving without any distraction, and drivers of professional vehicles showed more prevalence of using turn signal usage compared to their counterparts. In addition, type of roundabout also showed significance in rate of turn signal use by drivers when the vehicles were entering the roundabouts. Further, age group was significant in determining turn signal usage when drivers were exiting the roundabouts. Gender and accompanied or driving alone did not significantly affect the drivers' rates of turn signal usage while entering as well as exiting the roundabouts.

The main limitation of this study is limited sample size and selection of only two two-lane roundabouts. To study overall turn signal usage, other locations where turn signal usage is expected, such as on or off ramps, intersections, etc., should be investigated to get more insights into turn signal usage. In addition, drivers age was determined approximately from observations. This study does not consider other factors influencing turn signal usage such as driving experience, state of driver, familiarity of the area. Further, the data collection for this study was undertaken at two sites/locations only, in future data from more locations and more drivers need to be recorded, especially for elder and female drivers, to get more insights into turn signal usage by drivers. Further, various sizes and geometric features need to be considered in future studies. These results can help in improving the turn signal usage and driving behavior which can contribute to improved road safety.

Table 3. Rate of signal use while exiting two-lane roundabouts

Description	n_v	n_{vu}	Rate (%)	95% CI	Chi-square	p-value	Phi
Overall	400	73	18.3	14.4–22.0			
Turn type							
Left	126	15	11.9	6.2–17.6	16.978	<0.001	0.206
Right	153	40	26.1	19.1–33.2			
U-Turn	52	13	25.0	12.8–37.2			
Straight	69	5	7.2	1.0–13.5			
Roundabout name							
Izghawa	200	35	17.5	12.2–22.8	0.151	0.698	
Al-Khebra	200	38	18.8	13.3–24.3			
Gender							
Male	366	69	18.7	14.7–22.8	1.048	0.306	
Female	34	4	11.8	0.35–23.2			
Age							
Young	112	12	10.0	4.3–15.7	6.161	0.046	0.124
Middle	265	57	21.6	16.6–26.6			
Elder	23	4	17.4	0.6–34.2			
Type of clothes							
Formal	36	19	51.4	34.0–68.8	38.459	<0.001	0.310
Casual	292	51	17.6	13.2–22.0			
Traditional	72	3	4.2	0.6–8.9			
Accompanied							
Yes	261	44	21.0	14.1–27.9	1.043	0.307	
No	138	29	16.6	12.0–21.2			
Distraction							
Yes	78	4	5.2	0.1–10.3	11.182	<0.001	0.167
No	322	69	21.3	16.7–25.8			
Vehicle type							
Sedan	140	20	14.4	8.5–20.3	19.289	<0.001	0.220
SUV	182	25	13.7	8.7–18.8			
Professional	76	27	35.5	24.5–46.5			

n_v is the number of cars observed, n_{vu} is the number of cars using turn signal

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