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Investigation of factors affecting turn signal usage at modern roundabouts in State of Qatar

Deepti Muley[a,b]

[a]Qatar Transportation and Traffic Safety Center, College of Engineering, Qatar University, Doha, Qatar; [b]Department of Civil & Architectural Engineering, College of Engineering, Qatar University, Doha, Qatar

ABSTRACT

Drivers are expected to use turn signals to indicate other drivers of their intentions of taking turns, lane changing, merging or diverging indicating safe driving behaviour. This study investigated the rates of turn signal usage at multilane urban roundabouts along with factors affecting the usage. The results from data collected from four roundabouts in Doha city showed that the drivers have higher tendency of using turn signals while exiting the roundabout rather than while entering the roundabout. Further, turn signal usage at entry and exit of the roundabouts was affected by turn type, roundabout type, correct lane, vehicle type, age, type of clothes and distraction. Additionally, using correct lane affected turn signal usage only while exiting the roundabouts. The binary logistic regression models showed that the drivers wearing formal clothes, taking left or U-turn, using correct lane, driving without distraction, and traversing a roundabout located in recreation and commercial land use had higher odds of turn signal usage than their counterparts. The lower turn signal usage rates indicate that more emphasis should be provided on educating drivers highlighting safety implications. Further, traffic engineers can suggest additional strategies to improve turn signal usage based on the results. These findings can be applicable to other GCC countries exhibiting similar characteristics.

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safe maneuvers; indicator use; urban roundabouts; driver behavior; traffic safety

1. Background

Safe traffic manoeuvres are the basic need for efficient operations of any transport facility. Appropriate driver behaviour is the most essential element in ensuring safe performance. The drivers are expected to follow predefined traffic rules, which include maintaining speed limits, following lane disciplines, use of turn signals, slowing down at yield signs or stopping at the stop lines, etc. As the traffic flow is based on the car following theory, drivers tend to follow their preceding vehicle. This indicates that their driving is influenced by preceding driver's behaviour including turn signal usage

CONTACT Deepti Muley deepti@qu.edu.qa Qatar Transportation and Traffic Safety Center, College of Engineering, Qatar University, Doha, Qatar

impacting traffic safety. In Qatar, the driver negligence and lack of attention was major cause of crashes, resulting in around 45% crashes in past. Further, not having sufficient distance, causing rear end collisions, was the second largest factor, leading to around 20% crashes (Timmermans et al., 2019). The safety performance of intersections and roundabouts was comparable after controlling for various factors (Elzaher & De Albuquerque, 2021). The negligence in using turn signals while turning or lane changing can cause collisions which can be prevented (Isa et al., 2020). Turning without indication or using turn signal at roundabouts indicates driving discourtesy, which was reported as highly stressful (Scott-Parker et al., 2018). Furthermore, the driver awareness of proper turn signal usage is vital as crashes resulting from negligence were more than crashes due to distracted driving (Ponziani, 2012).

Generally, many studies explored driver behaviour and its impacts (Ellison et al., 2015; Hassan & Abdel-ATY, 2013; Mikoski et al., 2019) and also focused on specific aspects on driver behaviour, which included risky or aggressive driving behaviour (Haustein et al., 2022; Luo et al., 2023; Megías-Robles et al., 2022), mobile phone use or distractions (Haque & Washington, 2015; Li et al., 2021; Papadimitriou et al., 2019), seat belt use (Houston et al., 2002; Taylor & Daily, 2019; Watson & Austin, 2021), headways or gap acceptance (Pawar & Velaga, 2022; Rossi et al., 2020), etc. Very few studies focused on driver actions specifically while undertaking a turn that is use of turn signals or indicators. Lack of indications use or sudden changes in lanes or ambiguous indications affect the driving behaviour of adjacent vehicles Scott-Parker et al. (2018). For example, while merging they might merge after such vehicles (Shimojo et al., 2022).

Intersections are associated with higher risks of conflicts, violations, and crashes as they offer a decision point for drivers. Turn signals are basically used to alert the surrounding drivers intentions of lane change, turning movements and while overtaking, merging and diverging. Little evidence was found summarizing empirical studies addressing turn signal usage. In an earlier study, turn signal usage of left turning vehicles approaching signalised intersections along with their lane choice behaviour was studied in the U.S.A. The pairwise observations indicated that 25–40% of the leading vehicles failed to use turn signals. Further, dynamic data collection, where the driver was moving around recording data of randomly chosen vehicles indicator use and not use while taking a turn, was undertaken in Dayton, Ohio area (Ponziani, 2012). The data collected from this live study showed about 75% drivers used turn signals while turning. This study did not collect any information about environment and geometric factors and driver characteristics. Faw (2013) investigated the turn signal usage at intersections in British Columbia to obtain overall rate of 76% with values ranging from 54% to 95%. The turn signal usage was lower for right turning vehicles, heavy traffic volume, in presence of dedicated turning lane, and when following a vehicle not using turn signal.

A study from developing country, Vietnam, found that around 70% (68.27%) car drivers used turn signals at intersections (Nguyen-Phuoc et al., 2019). Further, the binary logistic regression models implied that the drivers taking right turn, driving alone, travelling away from city centre, driving on weekdays, non-availability of dedicated car lanes, pedestrian crossing and traffic signals had lower tendency of using turn signals.

In addition to the signalised intersections, Lebbon et al. (2007) investigated proportion of vehicles stopping legally and using turn signal at the stop sign of T intersections in Michigan, U.S.A. The overall turn signal use was about 48% which was higher in the

presence of oncoming traffic (63%) compared to the situation when oncoming traffic was not present (43.7%).

A study investigated the turn signal usage at a four-legged signalised intersection located close to parking garage of a university campus in Ohio, U.S.A. (Clayton & Myers, 2008). Baseline turn signal usage of 68% observed with no difference in turn signal usage of left (36%) and right (37%) turning vehicles. Further, use of passive prompts encouraging turn signal usage increased turn signal usage from 68% to 89% and mediated prompts increased the turn signal usage from 59% to 85%, indicating effectiveness of interventions in increasing turn signal usage.

In addition to empirical studies, a questionnaire survey was conducted to explore factors affecting turn signal usage frequency (Nguyen-Phuoc et al., 2020). The structural equation model indicated that for car drivers, the beliefs, perceived risks and environmental factors affected the turn signal usage frequency but not the lifestyle behaviours. Further, a study based on outcomes from focus group interviews indicated that the use of turn signals while changing lanes was only about 40% in China (Zhang et al., 2006). The focus group results indicated that the Chinese drivers lack understanding of importance of turn signal usage while turning or changing lanes.

A naturalistic driving study of 108 drivers by Sullivan et al. (2015) to assess the use of turn signals suggested that 75% left turns and 71% right turns used turn signals. Further, road type, turn type, and the presence of vehicle ahead significantly affected the odds of turn signal usage and not the driver characteristics such as age and gender.

To the best of knowledge, only one study was found for single lane roundabouts on turn signal usage while exiting in the U.S.A. (Belz, 2017). It was found that when the drivers who do not use turn signals while exiting from main traffic stream had significant influence on entering vehicles from same approach affecting the roundabout performance.

Along with turn signal usage for cars, two studies from developing countries assessed turn signal usage rates for motorcycles also (Ariffin et al., 2020; Nguyen-Phuoc et al., 2019); for the purpose of this study, motorcycles turn signal usage were not reported as they form a very small portion of the total vehicle population in State of Qatar.

This study fills the gap in knowledge by presenting detailed analysis of turn signal usage at modern roundabouts considering various variables. The objectives of this study are to determine rates of turn signal use while entering and exiting the roundabouts and study internal and external factors governing the turn signal use. Further, to develop the models predicting probability of turn signal use based on various driver related, driving related, and roundabout geometric related factors. The scope of this paper is limited to the multi-lane modern roundabouts located in urban areas. Other intersection types are not considered. Further, only four wheeled vehicles were considered as the volumes for motorcycles were minimal.

The presentation of the study is further organized as; section 2 presents the methodology used along with the site details. Further, section 3 presents the results of rates of turn signal uses while entering/exiting the roundabouts and factors affecting them. Following, section 4 presents the models predicting turn signal usage while entering and exiting the roundabouts. Finally, section 5 summarizes the study results and proposes some directions of future research.

2. Approach

To get the drivers actual data related to turn signal usage, this study utilized direct field observation approach. Four busy roundabouts located in urban area in Doha city were selected for this study. The roundabouts were selected such that the driver details and vehicle movement details can be observed from a discrete location. Further, it was ensured that the selected roundabouts were located in different suburbs having different geometric layouts (shape, number of entry, exit and circulating lanes), sizes (inscribed circle diameter and central island diameter) and surrounding land uses to represent the roundabouts in Qatar. Details of geometry and surrounding land uses are provided in Table 1 and the layout of the roundabouts is shown in Figure 1. All roundabouts chosen were modern roundabouts having yield signs, road markings, and channelization in place. Two roundabouts can be classified as small roundabouts and other two as large roundabouts based on the inscribed circle diameter and number of circulating lanes. Al Meera roundabout has an oval shape central island while other three roundabouts had circular central island. Predominantly, Izghawa roundabout is in residential area, and Al-Khebra roundabout is surrounded by educational land use. Further, Aspire roundabout is in commercial and recreational area, while Al-Meera roundabout has residential and commercial area in the vicinity.

The empirical data was collected on a tabular form designed to collect details related to the driver, vehicle driven, and driving behavior. The driver related data included gender, age group, clothing type, accompanied, and type of distraction along with type of vehicle driven. The age of the drivers was divided in three categories; young (less than 25 years), middle (25 to 55 years), and elder (more than 55 years). The distraction mainly covers use of mobile phone and interacting with fellow passengers. Generally, type of clothes will reflect the trip purpose. In Qatar, people wear different types of clothes; the driver's clothes were classified as traditional clothes (Thoub for men or Abaya for female), formal clothes (western wear), or casual clothes. The vehicle type was divided into six categories, sedan cars and Sports Utility Vehicles (SUVs), high-end and normal cars, professional vehicles, and heavy vehicles. The specific details related to turn signal usage while entering and exiting were collected along with the classified type of following vehicle and correct lane usage. The type of vehicle driven as well as type of following vehicle while entering and exiting the roundabouts were noted. Four well-trained observers tracked a chosen vehicle and recorded all the details from an inconspicuous location. Pilot surveys were conducted to familiarize observers with the data collection process and maintain uniformity of information collected, specifically about age, distraction, and vehicle type. The pilot surveys were conducted until reliable datasets are obtained from

Table 1. Characteristics of selected roundabouts.

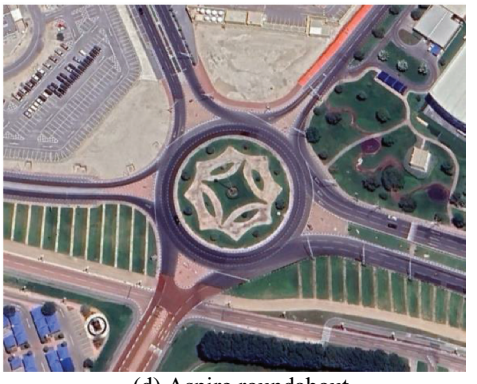
						N_e				
Site	Approach	N_c	N_a	D_{ic} (m)	D_{ci} (m)	North	East	South	West	North-West
Izghawa	North	2	4	52	35	2	2	2	1	-
Al-Khebra	South	2	3	43.5	26.5	-	2	2	2	-
Al-Meera	North	3	4	95–60	112–82	3	3	3	3	-
Aspire	West	3	5	95	70	1	3	2	1	2

N_c is number of circulating lanes, N_a is number of approaches, D_{ic} is inscribed circle diameter, D_{ci} is Central Island diameter, N_e is number of entry/exit lanes.

(a) Izghawa roundabout

(b) Al-Khebra roundabout

(c) Al-Meera roundabout



(d) Aspire roundabout

Figure 1. Layout of selected roundabouts. (a) Izghawa roundabout, (b) Al-Khebra roundabout, (c) Al-Meera roundabout, (d) Aspire roundabout.

all observers. The details of data collection can be found in Muley et al. (2022). The form used for data collection is provided in Appendix. It should be noted that the observers tracked a vehicle while entering and exiting the roundabout to get complete behavior. The data collection was undertaken until about 200 complete observations were collected from each site. It should be noted that the study excluded motorcycles as they were of negligible proportion.

The complete dataset was crosschecked and prepared for statistical data analysis. Basic statistical analysis was conducted using Chi-Square (χ^2) tests and calculating confidence intervals (CI). Further, advanced analysis was undertaken by developing Binary Logistic Regression (BLR) models. All analysis was conducted at 95% confidence interval.

3. Findings

3.1. Overview of turn signal usage

The analysis of overall data showed that out of 830 complete observations, only one-fourth drivers (215) used turn signal while entering and exiting the roundabouts. Out of these, around 88% were male and around 80% middle-aged drivers. Further, around 73% drivers were accompanied, 68% wearing casual clothes, and more than 90% were not

distracted. Following sections provide details of the turn signal use while drivers enter and exit the roundabouts considering driver, vehicle, roundabout and traffic-related attributes. While undertaking detailed analysis, the vehicle types were combined as sedan, SUV, luxury, and professional vehicles. The luxury cars contain high end sedan and SUV cars while the professional category includes heavy vehicles and vehicles driven by professional drivers such as taxi, vans, limousines, etc. The drivers driving high end cars and professional cars were separated as previous studies found out that the type and size of vehicles affect driving behavior (Dias et al., 2022). Further, the presence of following vehicle was also recorded because presence of surrounding vehicles affects driving behavior.

3.2. Factors affecting turn signal usage at roundabouts

Table 2 summarizes results of turn signal usage for various factors while entering the roundabouts. The summary of the results for turn signal usage while exiting the roundabouts is provided in Table 3. Overall, only 32% and 35% of drivers used turn signal indications while entering and exiting the roundabouts, respectively, indicating slightly higher percentage while exiting the roundabouts. The exiting vehicles turn usage was found to affect the gap acceptance of entering vehicles and in turn the efficiency and sustainability of the roundabout (Belz, 2017). The turn type was a significant factor affecting turn signal use with u-turning vehicles having highest proportion of 45.9% (95% CI: 37.7–54.1%) while entering and 51.4% (95% CI: 43.2–59.6%) while exiting the roundabouts. Nguyen-Phuoc et al. (2019) observed similar findings with lower turn signal usage by right turning vehicles at intersections in Vietnam. It should be noted that as per Qatari law drivers are not expected to use turn signal while entering when going straight at the roundabout. However, some drivers have used the turn signal while performing this maneuver. Similar results were obtained by Faw (2013) where right turning vehicles used turn signals lesser compared to left turning vehicles at intersections. This finding was contradicting to the findings by Clayton and Myers (2008) and Sullivan et al. (2015) where turn usage for left and right turning vehicles was similar. Additionally, the proportion of left turning vehicles using turn signals in this study was much lesser compared to the rate observed in Papacostas (1984) (37% vs. 60–75%). Further, the roundabout type also influenced the turn signal usage at entry and exit of the roundabouts with significantly higher proportion of 41.6% (95% CI: 36.8–46.3%) and 52.4% (95% CI: 47.6–57.3%) for larger roundabouts, respectively.

The type of vehicle driven was also a significant factor affecting turn signal usage in both cases with professional vehicles having higher rates 45.1% (95% CI: 37.7–52.6%) and 47.4% (95% CI: 40.0–54.9%) and luxury vehicles showing lowest rates of 24.8% (95% CI: 19.8–29.9%) and 28.7% (95% CI: 23.4–33.9%) while entering and exiting the roundabouts, respectively. At modern roundabouts, advance warning signs are placed to inform drivers about lane allocation. Using incorrect lanes at roundabouts was found to cause discourteous interactions by Scott-Parker et al. (2018). The drivers using the correct lane allocated for the intended turn showed higher turn signal usage of 34.5% (95% CI: 30.9–38.1%) compared to those who did not use correct lane 22.2% (95% CI: 15.6–28.7%) while entering the roundabout. Similar results were obtained when vehicles

Table 2. Rate of signal use while entering roundabouts.

Parameter	n_v	n_{vu}	Rate (%)	95% CI	χ2	*p*	Φ
Overall	830	267	32.2	29.0–35.4			
Turn type					31.829	<.001	0.196
Left	297	111	37.4	31.8–42.9			
Right	206	51	24.8	18.8–30.7			
U-Turn	146	67	45.9	37.7–54.1			
Straight	181	38	21.0	15.0–27.0			
Correct lane					8.973	.003	0.104
Yes	672	232	34.5	30.9–38.1			
No	158	35	22.2	15.6–28.7			
Roundabout type					33.287	<.001	0.200
Small	416	95	22.8	18.8–26.9			
Large	414	172	41.6	36.8–46.3			
Vehicle type					23.117	<.001	0.167
Sedan	236	68	28.8	23.0–34.6			
SUV	133	49	36.8	28.5–45.2			
Luxury	286	71	24.8	19.8–29.9			
Professional	175	79	45.1	37.7–52.6			
Following vehicle					0.615	.433	
Yes	191	57	29.8	23.3–36.4			
No	639	210	32.9	29.2–36.5			
Gender					0.008	.929	
Male	741	238	32.1	28.8–35.5			
Female	89	29	32.6	22.7–42.5			
Age					10.336	.006	0.112
Young	179	40	22.4	16.2–28.5			
Middle	612	212	34.6	30.9–38.4			
Elder	39	15	38.5	22.5–54.4			
Type of clothes					26.022	<.001	0.177
Formal	76	41	54.0	42.5–65.4			
Casual	569	186	32.7	28.8–36.6			
Traditional	185	40	21.6	15.6–27.6			
Accompanied					0.274	.601	
Yes	248	83	33.5	27.6–39.4			
No	582	184	31.6	27.8–35.4			
Distraction					23.969	<.001	0.170
Yes	162	26	16.1	10.3–21.8			
No	668	241	36.1	32.4–39.7			
Lane change					2.428	.119	
Yes	46	10	21.7	9.4–34.1			
No	784	257	32.8	29.5–36.1			

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

exited the roundabouts with 38.1% (95% CI: 34.5–41.8%) and 22.5% (95% CI: 15.8–29.3%) turn signal usage when using and not using the correct lane.

The drivers' characteristics such as age, clothes and distraction also affected the rate of turn signal usage. The elder drivers exhibited the highest turn signal usage rates of 38.5% (95% CI: 22.5–54.4%) while entering the roundabouts and 38.7% (95% CI: 34.9–42.6%) for middle-aged drivers while exiting the roundabouts. Similar findings were noted by Nguyen-Phuoc et al. (2019) where the turn signal usage was lowest for young drivers at intersections. Further, drivers wearing formal clothes showed higher rates of turn signal usage of 54.0% (95% CI: 42.5–65.4%) and 60.5% (95% CI: 49.3–71.8%) while entering and exiting the roundabouts, respectively. Additionally, as expected, the non-distracted drivers showed significantly higher turn signal usage 36.1% (95% CI: 32.4–39.7%) and 38.8% (95% CI: 35.1–42.5%) compared to distracted drivers while entering and exiting the roundabouts. Furthermore, the gender, accompanied, lane change at the entry of

Table 3. Rate of signal use while exiting roundabouts.

Parameter	n_v	n_{vu}	Rate (%)	95% CI	Chi-square	p-value	Phi
Overall	830	293	35.3	32.0–38.6			
Turn type					32.029	<.001	.196
Left	297	116	39.1	33.5–44.6			
Right	206	56	27.2	21.7–33.3			
U-Turn	146	75	51.4	43.2–59.6			
Straight	181	46	25.4	19.0–31.8			
Correct lane					13.209	<.001	.126
Yes	679	259	38.1	34.5–41.8			
No	151	34	22.5	15.8–29.3			
Roundabout type					105.929	<.001	.357
Small	416	76	18.3	14.5–22.0			
Large	414	217	52.4	47.6–57.3			
Vehicle type					18.052	<.001	.147
Sedan	236	77	32.6	26.6–38.7			
SUV	133	51	38.4	30.0–46.7			
Luxury	286	82	28.7	23.4–33.9			
Professional	175	83	47.4	40.0–54.9			
Following vehicle					4.392	.036	.073
Yes	265	107	40.4	34.4–46.3			
No	565	186	32.9	29.0–36.8			
Gender					0.019	.891	
Male	741	261	35.2	31.8–38.7			
Female	89	32	36.0	25.8–46.1			
Age					12.500	.002	.123
Young	179	44	24.6	18.2–31.0			
Middle	612	237	38.7	34.9–42.6			
Elder	39	12	30.8	15.6–45.9			
Type of clothes					27.530	<.001	.182
Formal	76	46	60.5	49.3–71.8			
Casual	569	198	34.8	30.9–38.7			
Traditional	185	49	26.5	20.1–32.9			
Accompanied					3.357	.067	
Yes	248	76	30.7	24.9–36.4			
No	582	217	37.3	33.4–41.2			
Distraction					18.056	<.001	.147
Yes	162	34	21.0	14.7–27.3			
No	668	259	38.8	35.1–42.5			

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

roundabout, and presence of following vehicle didn't affect the rate of turn signal usage for both cases. Contrary findings were observed for intersections in Vietnam, where male drivers and accompanied drivers showed higher turn signal usage (Nguyen-Phuoc et al., 2019). The presence of following vehicle significantly affected turn signal use only at the exist of roundabouts with 40.4% (95% CI: 34.4–46.3%) drivers using the turn signal.

3.3. BLR for predicting turn signal usage

All the variables collected were coded and entered stepwise while performing the logistic regression analysis. The variable significance is tested at 95% confidence level. The models predicting turn signal use by a driver while entering and exiting the roundabouts are shown in Table 4. The Nagelkerke R^2 was 21% and 28% for turn signal usage while entering and exiting the roundabout, respectively, predicting more than 70% cases correctly. It should be noted that only significant variables are included in the model and presented here. For both cases, turn type, surrounding

Table 4. Model predicting turn signal usage at roundabouts.

	While entering the roundabout						While exiting the roundabout					
					95% C.I.						95% C.I.	
Parameter	β	*SE*	*p*	*OR*	Lower	Upper	β	*SE*	*p*	*OR*	Lower	Upper
Clothing*			<0.001						<0.001			
Formal	0.618	0.266	0.020	1.855	1.102	3.124	1.039	0.283	<0.001	2.826	1.624	5.917
Traditional	−0.742	0.216	<0.001	0.476	0.312	0.728	−0.642	0.213	0.003	0.526	0.347	0.799
Turn Type#			0.008						<0.001			
Straight	−0.454	0.276	0.101	0.635	0.370	1.092	−0.660	0.267	0.014	0.517	0.306	0.873
Left	0.035	0.233	0.879	1.036	0.656	1.636	−0.007	0.239	0.976	0.993	0.622	1.585
U turn	0.478	0.259	0.065	1.613	0.971	2.681	0.594	0.270	0.028	1.812	1.066	3.079
Correct lane^												
Yes	0.553	0.228	0.015	1.738	1.113	2.716	0.631	0.245	0.010	1.879	1.162	3.038
Distracted~												
Yes	−1.069	0.242	<0.001	0.343	0.214	0.552	−0.784	0.230	<0.001	0.457	0.291	0.716
Surrounding land use$			<0.001						<0.001			
Residential & commercial	−0.539	0.225	0.016	0.583	0.376	0.905	−0.407	0.221	0.066	0.666	0.431	1.027
Educational	−0.714	0.221	0.001	0.490	0.318	0.756	−1.846	0.249	<0.001	0.158	0.097	0.257
Residential	−1.789	0.280	<0.001	0.167	0.097	0.289	−1.874	0.270	<0.001	0.154	0.091	0.260
Constant	−0.281	0.338	0.405	0.755			−0.003	0.361	0.994	0.997		
− 2 Loglikelihood = 907.607 %		% correctly predicted = 72.4					− 2 Loglikelihood = 887.060			% correctly predicted = 71.3		
Chi Square = 12.292		Nagelkerke R^2 = 21.0%					Chi Square = 7.936			Nagelkerke R^2 = 28.2%		

* indicates Casual as Reference case, # indicates Right as Reference case, ^ indicates No as Reference case, ~ indicates No as Reference case, $ indicates Commercial & recreational as Reference case.

land uses, clothing type, use of correct lane, and distraction were statistically significant ($p < 0.05$). All other variables such as gender, age group, vehicle type, following vehicle, roundabout type, and accompanied were not statistically significant predictors. These results are similar to Sullivan et al. (2015) where the turn type was significant and age and gender were not significant. As expected, the drivers taking U turn have almost 1.7 times odds of using turn signal compared to right turning vehicles. The odds for turn signal usage for the vehicles turning left were similar to the vehicles turning right while entering and exiting the roundabout. Further, when the vehicles were using correct lane they had 1.8 times higher odds of turn signal usage compared to vehicles not using correct lane while entering and exiting the roundabouts. Distraction reduces the focus from driving and poses safety risks (Li et al., 2021). Furthermore, the distracted drivers had significantly lower odds, around 0.4 times, of using turn signal compared to non-distracted drivers for both cases. Additionally, the drivers had higher odds of using turn signal, for both cases, when the roundabout was situated in commercial and recreational area. The odds of turn signal usage were lowest when the roundabout was surrounded by residential land use while entering and exiting the roundabout.

The odds of clothing type were determined considering casual clothes as a base case, the drivers wearing formal clothes had 1.8 and 2.8 times higher odds of using turn signal while entering and exiting the roundabouts, respectively. While the odds of drivers wearing traditional clothes were around half for both cases. Although type of clothes can give some idea about trip purpose, this aspect needs to be investigated in future studies by collecting information about trip purpose and state of mind of drivers.

4. Conclusions and future work

Appropriate turn signal usage contributes to safety as well as exhibits courteous driving behaviour. Lack of turn signal usage can lead to safety risks. This study assesses the influence of internal and external factors on turn signal usage of drivers along with rates of turn signal usage while entering and exiting modern roundabouts in Doha City. The overall rate of turn signal usage was found to be 32–35%. The drivers showed more tendency to use turn signal while exiting rather than entering. It was found that turn type, correct lane, roundabout type, vehicle type, age, type of clothes, and distraction significantly affected the rate of turn signal usage while entering and exiting the roundabouts. Additionally, presence of following vehicle affected turn signal use while exiting only. Further, gender of driver, whether driving alone or accompanied, and lane change at the entry did not affect turn signal usage significantly. The BLR models indicated that similar factors affected the probability of turn signal use at entry and exit of the roundabouts. The drivers wearing formal clothes, taking left or U-turn, using correct lane, driving without distraction, manoeuvring a roundabout in recreational and commercial area had higher odds of turn signal usage than their counterparts.

Overall, the turn signal usage rates at observed roundabouts in Qatar were lower compared to other countries. This study calls for better driver education and targeted law enforcement to improve the turn signal usage rates. Authorities can consider use of passive or mediated prompts to improve the turn signal usage as found effective by Clayton and Myers (2008). Further, public feedback along with effective interventions were found have positive effect on turn signal usage (Ludwig et al., 2002). In future, the role of type of following vehicle should be investigated as the sample size was not enough to study this aspect. Further, this study didn't consider the effect roundabout geometry, location (type of area), temporal and environmental factors such as weather conditions, time of day or type of day, and traffic-related factors such as traffic volume on turn signal usage. Furthermore, a survey for drivers to understand their perception and attitudes towards turn signal usage and reasons for not using them should be conducted. This will also help in devising measures to increase turn signal usage.

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References

Ariffin, A., Hamzah, A., Solah, S., Paiman, F., Syukri, M., Khalid, A., Isah, N., Anwar, K., Kassim, A., & Ishak, S. (2020). Turn signal use among motorcyclists in Klang Valley, Malaysia: A case study. *Journal Kejuruter SI*, *3*(1), 83–88. https://doi.org/10.17576/jkukm-2020-si3(1)-13

Belz, N. P. (2017). Investigating the role of exiting vehicles and turn indicator usage in gap acceptance at single-lane roundabouts. *Frontiers of Structural and Civil Engineering*, *11*(1), 8–16. https://doi.org/10.1007/s11709-016-0365-7

Clayton, M., & Myers, E. (2008). Increasing turn signal use by drivers exiting a university parking garage: A comparison of passive and mediated prompting. *Journal of Organizational Behavior Management*, *27*(4), 53–61. https://doi.org/10.1300/J075v27n04_03

Dias, C., Kharbeche, M., Muley, D., Kashem, A., Fahed, M. A., Iral, S. V., & Abdelfattah, N. (2022). Are professional drivers more aggressive than general drivers? A case study from Doha, Qatar. *Procedia Computer Science*, *201*, 16–23. https://doi.org/10.1016/j.procs.2022.03.005

Ellison, A. B., Greaves, S. P., & Bliemer, M. C. (2015). Driver behaviour profiles for road safety analysis. *Accident Analysis & Prevention*, *76*, 118–132. https://doi.org/10.1016/j.aap.2015.01.009

Elzaher, A. H., & De Albuquerque, F. D. B. (2021). Signalized intersections and roundabouts: An in-service safety performance evaluation in Abu Dhabi. *Transportation Research Procedia*, *52*, 268–275. https://doi.org/10.1016/j.trpro.2021.01.031

Faw, H. W. (2013). To signal or not to signal: That should not be the question. *Accident Analysis & Prevention*, *59*, 374–381. https://doi.org/10.1016/j.aap.2013.06.036

Haque, M. M., & Washington, S. (2015). The impact of mobile phone distraction on the braking behaviour of young drivers: A hazard-based duration model. *Transportation Research Part C: Emerging Technologies*, *50*, 13–27. https://doi.org/10.1016/j.trc.2014.07.011

Hassan, H. M., & Abdel-ATY, M. A. (2013). Exploring the safety implications of young drivers' behavior, attitudes and perceptions. *Accident Analysis & Prevention*, *50*, 361–370. https://doi.org/10.1016/j.aap.2012.05.003

Haustein, S., Humpe, A., & Gössling, S. (2022). Risky and anxious-aggressive drivers: A key barrier to traffic safety legislation in Germany. *Transportation Research Part F: Traffic Psychology and Behaviour*, *89*, 84–96. https://doi.org/10.1016/j.trf.2022.06.005

Houston, D. J., Richardson, J. R., & E, L. (2002). Traffic safety and the switch to a primary seat belt law: The California experience. *Accident Analysis & Prevention*, *34*(6), 743–751. https://doi.org/10.1016/S0001-4575(01)00074-4

Isa, M. M., Bakar, S. A., & Hashim, M. M. (2020). Initiatives to increase the use of vehicle turn signals. *Journal of the Society of Automotive Engineers Malaysia*, *4*(1), 101–105. https://doi.org/10.56381/jsaem.v4i1.55

Lebbon, A. R., Austin, J., Houten, R. V., & Malenfant, L. E. (2007). Evaluating the effects of traffic on driver stopping and turn signal use at a stop sign: A systematic replication. *Journal of Organizational Behavior Management*, *27*(2), 27–35. https://doi.org/10.1300/J075v27n02_03

Li, W., Huang, J., Xie, G., Karray, F., & Li, R. (2021). A survey on vision-based driver distraction analysis. *Journal of Systems Architecture*, *121*, 102319. https://doi.org/10.1016/j.sysarc.2021.102319

Ludwig, T. D., Biggs, J., Wagner, S., & Geller, E. S. (2002). Using public feedback and competitive rewards to increase the safe driving of pizza deliverers. *Journal of Organizational Behavior Management*, *21*(4), 75–104. https://doi.org/10.1300/J075v21n04_06

Luo, X., Ge, Y., & Qu, W. (2023). The association between the Big Five personality traits and driving behaviors: A systematic review and meta-analysis. *Accident Analysis & Prevention*, *183*, 106968. https://doi.org/10.1016/j.aap.2023.106968

Megías-Robles, A., Sánchez-López, M. T., & Fernandez-Berrocal, P. (2022). The relationship between self-reported ability emotional intelligence and risky driving behaviour: Consequences for accident and traffic ticket rate. *Accident Analysis & Prevention*, *174*, 106760. https://doi.org/10.1016/j.aap.2022.106760

Mikoski, P., Zlupko, G., & Owens, D. A. (2019). Drivers' assessments of the risks of distraction, poor visibility at night, and safety-related behaviors of themselves and other drivers. *Transportation Research Part F: Traffic Psychology and Behaviour*, *62*, 416–434. https://doi.org/10.1016/j.trf.2019.01.011

Muley, D., Dias, C., Umlai, A.-H., Alardah, H., Shah, M., Murtaza, M., & Abou-Sido, F. (2022). Assessment of turn signal use at two-lane roundabouts in Doha city. *Procedia Computer Science*, *201*, 79–86. https://doi.org/10.1016/j.procs.2022.03.013

Nguyen-Phuoc, D. Q., De Gruyter, C., Oviedo-Trespalacios, O., Ngoc, S. D., & Tran, A. T. P. (2020). Turn signal use among motorcyclists and car drivers: The role of environmental characteristics, perceived risk, beliefs and lifestyle behaviours. *Accident Analysis & Prevention*, *144*, 105611. https://doi.org/10.1016/j.aap.2020.105611

Nguyen-Phuoc, D. Q., Tran, A. T. P., De Gruyter, C., Kim, I., & Su, D. N. (2019). Turn signal use among car drivers and motorcyclists at intersections: A case study of Da Nang, Vietnam. *Accident Analysis & Prevention*, *128*, 25–31. https://doi.org/10.1016/j.aap.2019.03.012

Papacostas, C. (1984). Influence of leading vehicle turn signal use on following vehicle lane choice at signalized intersections.

Papadimitriou, E., Argyropoulou, A., Tselentis, D. I., & Yannis, G. (2019). Analysis of driver behaviour through smartphone data: The case of mobile phone use while driving. *Safety Science*, *119*, 91–97. https://doi.org/10.1016/j.ssci.2019.05.059

Pawar, N. M., & Velaga, N. R. (2022). Analyzing the impact of time pressure on drivers' safety by assessing gap-acceptance behavior at un-signalized intersections. *Safety Science*, *147*, 105582. https://doi.org/10.1016/j.ssci.2021.105582

Ponziani, R. (2012). *Turn signal usage rate results: A comprehensive field study of 12,000 observed turning vehicles*. SAE Technical Paper.

Rossi, R., Meneguzzer, C., Orsini, F., & Gastaldi, M. (2020). Gap-acceptance behavior at roundabouts: Validation of a driving simulator environment using field observations. *Transportation Research Procedia*, *47*, 27–34. https://doi.org/10.1016/j.trpro.2020.03.069

Scott-Parker, B., Jones, C. M., Rune, K., & Tucker, J. (2018). A qualitative exploration of driving stress and driving discourtesy. *Accident Analysis & Prevention*, *118*, 38–53. https://doi.org/10.1016/j.aap.2018.03.009

Shimojo, A., Ninomiya, Y., Miwa, K., Terai, H., Matsubayashi, S., Okuda, H., & Suzuki, T. (2022). How impressions of other drivers affect one's behavior when merging lanes. *Transportation Research Part F: Traffic Psychology and Behaviour*, *89*, 236–248. https://doi.org/10.1016/j.trf.2022.06.007

Sullivan, J. M., Bao, S., Goudy, R., & Konet, H. (2015). Characteristics of turn signal use at intersections in baseline naturalistic driving. *Accident Analysis & Prevention*, *74*, 1–7. https://doi.org/10.1016/j.aap.2014.10.005

Taylor, N. L., & Daily, M. (2019). Self-reported factors that influence rear seat belt use among adults. *Journal of Safety Research*, *70*, 25–31. https://doi.org/10.1016/j.jsr.2019.04.005

Timmermans, C., Alhajyaseen, W., Al Mamun, A., Wakjira, T., Qasem, M., Almallah, M., & Younis, H. (2019). Analysis of road traffic crashes in the State of Qatar. *International Journal of Injury Control and Safety Promotion*, *26*(3), 242–250. https://doi.org/10.1080/17457300.2019.1620289

Watson, C. E., & Austin, R. A. (2021). Differences in rural and urban drivers' attitudes and beliefs about seat belts. *Accident Analysis & Prevention*, *151*, 105976. https://doi.org/10.1016/j.aap.2021.105976

Zhang, W., Huang, Y.-H., Roetting, M., Wang, Y., & Wei, H. (2006). Driver's views and behaviors about safety in China—What do they NOT know about driving? *Accident Analysis & Prevention*, *38*(1), 22–27. https://doi.org/10.1016/j.aap.2005.06.015

Appendix

Driver turn signal use while entering roundabouts				
Roundabout name:				
Street Name:			Coordinates:	Area:
No of lanes	RT	LT	TH	Type of control:
Advance warning signs (Y/N)				
Date:			Time From: to	Traffic patrol (Y/N)
Weather			Peak/off peak	

Choose a vehicle when its at around 300-400 m distance from roundabout entry point
Collect age group wherever possible (Y-Young <25, M-Middle 25 to 55, E-Elder >55)
Clothing type F – Formal, C – Casual, T – Traditional
Other visible distractions can be eating, talking, etc
Vehicle type: S1, S2, V1, V2, P, H – see explaination in Variables sheet
Following vehicle type: Use same classification S1, S2, V1, V2, P, H, if no Vehicle write N

	Driver related observations						Vehicle related observations		Turn details			
Vehicle number	Gender (M/F)	Age group (Y, M, E)	Accompanied (Y/N)	Clothing type (C, F, T)	Using phone (Y/N)	Other distraction (Y/N)	Vehicle Type (S1, S2, V1, V2, P, H)	Following vehicle type (S1, S2, V1, V2, P, H, N)	Turn type (L, R, U)	Correct lane used (Y/N)	Lane change (within 300 m distance) (Y/N)	Indicator used (Y/N)
1												
2												
3												
4												
5												

Variables explanation

Gender	Age group	Accompanied	Clothing type	Using phone	Other distraction	Vehicle Type	Following vehicle	Turn type	Lane used	Lane change (within 300 m distance) (Y/N)	Indicator used
Male	Y-Young <25	Y	F – Formal	Y	Y	S1	Y	L	Y	Y	Y
Female	M-Middle 25 to 55	N	C – Casual	N	N	S2	N	R	N	N	N
	E-Elder >55		T – Traditional			V1		U			
						V2					
						P					
						H					
S1	Sedan T1	High end Sedan cars like mercedes, BMW, volvo, audi, lexus, infinity, sports cars, etc									
S2	Sedan T2	Normal sedan cars like toyota, mitsubishi, Nissan, Kia, Honda, Hyundai, etc									
V1	SUV T1	High end four wheel drives like Lexus, Land cruiser, Mercedes, BMW, range rover, land rover, etc									
V2	SUV T2	Normal four wheel drives like Kia, Mitsubishi, etc									
P	Professional	Karwa taxi, Vans, pickups, limosine etc									
H	Heavy	Trucks, trailers, mini buses, buses, etc									