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Highlighting Traffic Accidents on Roundabouts Using MRSS-AHP Expert System

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Abstract

The frequency and severity of traffic accidents are causing growing concern. This study aims to develop a tool to improve the traffic safety level on roundabouts and identify the influence of traffic operations, geometric parameters, weather, and time of day on improving roundabout traffic safety. It is the first study to evaluate the performance of the integrated Median Ranked Set Sample (MRSS) and Analytic Hierarchy Process (AHP) with statistical analysis. A hierarchy tree of accident causes has been developed using data gathered from accident reports and relevant authorities. Then, the selected stakeholders' professionals prioritized the traffic accident causes using a MRSS and AHP. Moreover, traffic microsimulation software VISSIM was also used to extract traffic operation parameters for the analysis. Afterwards, Analysis of Variance (ANOVA) was used to validate the causes of traffic accidents. The results show that geometric design accounts for 36% of accidents at roundabouts, followed by traffic operation (22%). However, conflicting and queuing lengths are responsible for about 20% of traffic accidents. The tools developed, and the causes of accidents determined in this study will help geometric designers and city planners to take the necessary measures to minimize accidents and enhance traffic safety levels in urban areas.

Keywords: Traffic Accidents; Road Traffic Safety; Roundabout; AHP; Traffic Characteristics.

1. Introduction

Traffic accidents are caused by a complex interaction of three main factors: driver behavior, vehicles, and road conditions [1, 2]. Approximately, there are about 1.4 million human deaths reported annually as a result of traffic accidents worldwide. Thus, understanding the interactions between these factors and their combined influence is essential to reducing the negative impacts of accidents. Traditionally, roundabouts are introduced to facilitate traffic movement by eliminating or altering different conflicts and reducing the number and severity of accidents and vehicle speeds. However, increasing traffic has downgraded the safety and efficiency of roundabouts. Thus, it is urgent to investigate the traffic accidents at roundabouts in urban areas to improve the roundabouts' designs and operations to maintain their effectiveness. Traffic safety is a complex issue that requires a comprehensive evaluation of accident

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causes to establish an optimal combination of appropriate measures to save lives and reduce social and economic costs [3, 4]. Moreover, there is a need to evaluate and analyze aspects with varying importance levels using different processing methods.

The reasons behind traffic accidents may be categorized as (i) geometric, (ii) road conditions, (iii) climate conditions, (iv) vehicle characteristics, and (v) traffic movement direction and operation parameters [5–9]. Yet, the integrated effect of these factors has not been extensively explored [10]; thus, it is necessary to investigate them using a suitable tool. Moreover, some researchers investigated the likelihood of traffic accidents on rural and urban roads based on trip makers' perceptions. They used partial least squares analysis to classify the causes as either human (fatigue) or high speed on urban and rural roads, respectively. However, intersections and roundabouts represent a small part of the overall traffic and transportation system, but the accidents that occur at these spots constitute a significant percentage of the total accidents anywhere in the world. For this reason, it is crucial that the roundabouts are designed and operated carefully to improve vehicle traffic and reduce road crashes and their severity. The determination of traffic crash contribution factors was based on site inspections by traffic engineers [11]. For a single-lane roundabout, about 54% of the investigated crashes were at the entry and about 20% at the exit, which indicates the importance of geometric design factors like excessive radius of deflection of the entering approach or the small deviation angle. However, there is a demand to consider the weather and accident conditions that are usually reported by traffic police, as well as their judgments as an official expert. Thus, the combination of professional stakeholders (police and traffic engineers) with statistical tools will improve traffic accident causes as well as traffic safety. Furthermore, Bayesian logistic regression and finite mixture logite models were implemented to evaluate the traffic accident likelihood and severity using weather and real-time traffic data [4]. However, in order to improve traffic safety and our knowledge of pre-accident conditions, there is still much to be analyzed.

Recent studies ranked Multi-Criteria Decision-Making (MCDM) as the most important tool that is capable of reshaping traffic safety, especially where there is a threat to human lives as well as potential economic loss. Moreover, MCDM techniques have received growing attention worldwide for solving complex real-time problems because of their capacity to gather, structure, and analyze problems and prioritize alternative decisions [12]. However, the AHP method is used to handle MCDM problems by conducting pairwise comparisons, ranking, rating, and trade-off analyses. It overcomes the drawbacks of traditional traffic analytical measures, which usually consider a single factor. It has the capacity to assess and analyze the significant causes of traffic accidents with careful consideration of people, vehicles, and roads, as well as environmental factors [13]. Moreover, the AHP relies on informed judgments by experts and stakeholders, allowing efficient and concurrent processing of qualitative and quantitative data [14]. Furthermore, it is relatively easy to use and understand. Consequently, it has been applied to solve complex real-life multi-attribute and multi-stakeholder issues like traffic accidents. For instance, the AHP tool was used to evaluate and prioritize the best methods to control and minimize traffic congestion in Iran [15]. However, integrating the decision-making tools with the traditional statistical tools is one step on the track for improving traffic safety precautions measures.

The traffic safety performances of 21 European cities have been assessed using eleven evaluation indicators to decrease the number of fatal accidents. Three MCDM methods, namely Simple Additive Weighting (SAW), AHP, and Fuzzy Technique for Order Performance by Similarity to Ideal Solution TOPSIS [16], have been used to investigate the reasons behind traffic accidents. Moreover, Ngoc & Thanh used a combination of AHP and customer satisfaction index tools to propose a traffic safety strategy [17]. In addition, the overall highway safety level has been determined by implementing an Analytic Network Process (ANP) integrated with statistical analysis [18]. Real-time data were integrated with social networking indicators to improve traffic accident analysis and forecasting [19]. On the other hand, the accident severity index was investigated using temporal statistical data incorporated with the Geographic Information System (GIS) to ascertain accident hotspots using kernel density estimation [20, 21].

Factors concerning road geometry consist of the road, shoulder, median, and lane widths; these are the most significant causes of traffic accidents at three-leg intersections in Taiwan [22]. Only a regression model was implemented, and the traffic accident number was considered the dependent variable [21]. In a study to investigate the nature and causes of unsafe driving behavior at roundabouts, the entry radius was reported as the most influential parameter. More entry lanes at roundabouts will increase the conflict. However, uncertainty in the decision-making process defines the quality of personal knowledge concerning risk evaluation and ambiguity avoidance [23]. Decisions are complex and involve a lack of initial information and quantitative and qualitative factors; therefore, a comprehensive decision-making model is required [14].

Furthermore, implementation of the MCDM involves ambiguity and uncertainty regarding expert preferences. Recent technological advances have facilitated real-time data collection regarding traffic and weather conditions [10]. Such data was used to analyze accident likelihood. Accurate data availability and special statistical techniques such as the maximum likelihood method, integrated MCDM, and expert judgment are usually applied to increase confidence levels. Moreover, any decision should be justified based on the knowledge available at the time. However, MRSS is a modification of the Ranked Set Sample (RSS) technique. In MRSS, after the random selection of the strata, only the median observation is considered. Consequently, the ranking error is decreased, and the estimation efficiency will be improved [24]. Furthermore, it offers a representative tool to represent the research society without extensive observations.

The main goal of this article is to assess the criteria that influence traffic accidents and frequency at roundabouts in urban areas. This research will assist planning engineers and traffic authorities in implementing appropriate designs, decisions, and measures to save lives and reduce the number and severity of accidents. Moreover, it will provide a scientific instrument to rank the intersections based on their safety and efficiency using the AHP model. The rest of this study is organized as follows: Section 2 presents the collected data and its processing, stakeholder classification, and their preferences for processing techniques and tools. The results and discussion are shown in Section 3. It shows an example of stakeholders' preferences, the accident causes tree, as well as the results of the SPSS analysis of traffic accident causes. In addition, a summary of the key recommendations is also shown in this section. Section 5 presents the conclusion.

2. Research Methodology

2.1. Data Acquisition

Figure 1 schematically shows the data acquisition, classification, and analysis methods used in this research. The leading causes of accidents were selected based on literature reports and citations. The data were used to construct the accident cause tree; Figure 2 presents the main and sub-criteria of reported accident causes from literature as well as collected accident police reports. This research uses accident reports based on a two-year (2014–2015) average in three urban cities (Corum, Adana, and Konya) in Turkey. The selected intersections based on the available data are presented in Figure 3. The intersections (C_1 until C_{12}) were in Corum city, while (B_2 to B_6) and (K_1 to K_5) are in Adana and Konya, respectively. The digitally formatted reports included data about the time of day, weather conditions, speed, road geometry, number of fatalities and injuries, as well as the coordinates of accident locations. However, some accident reports have missing inputs. The proportion of such missing data for a particular variable was less than 1% of the total evaluated reports.

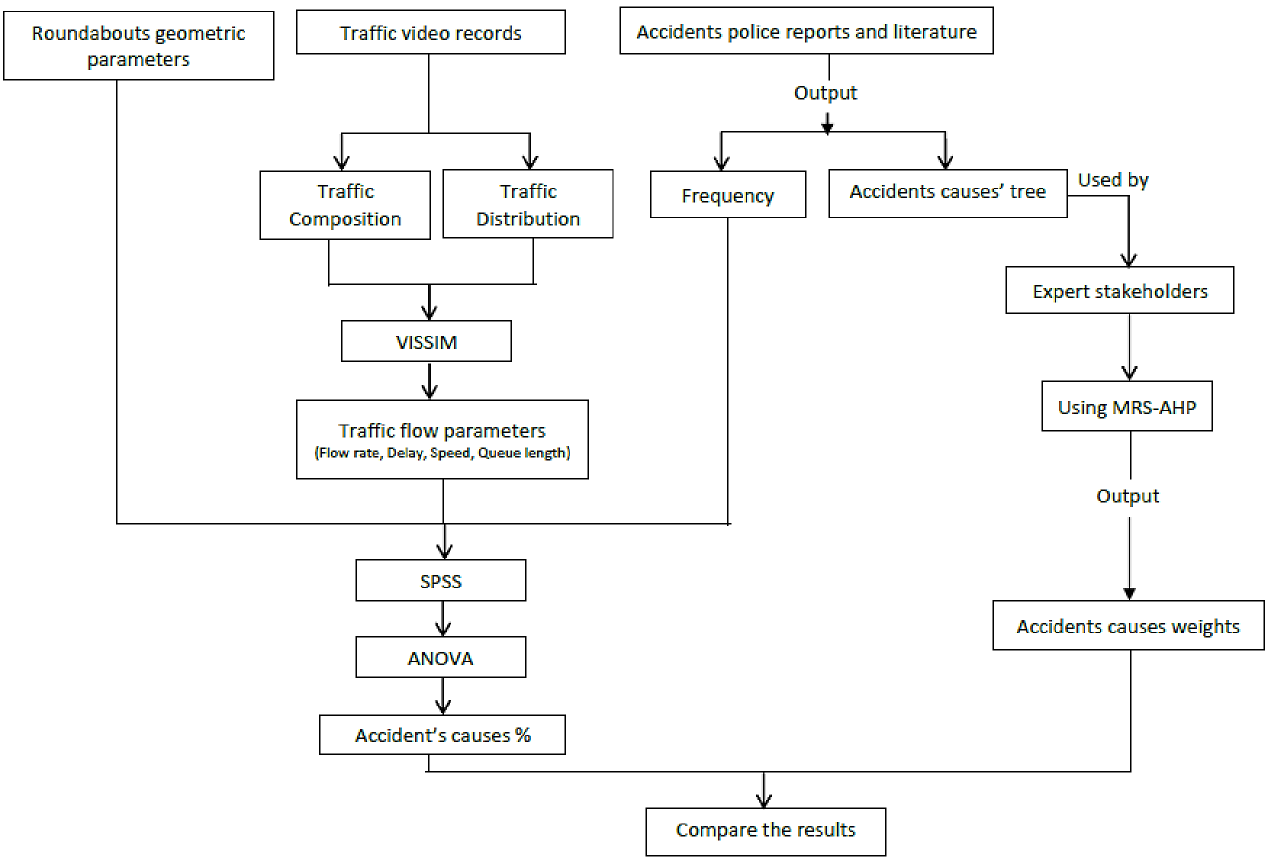


Figure 1. Schematic view of data collection, classification and analysis method

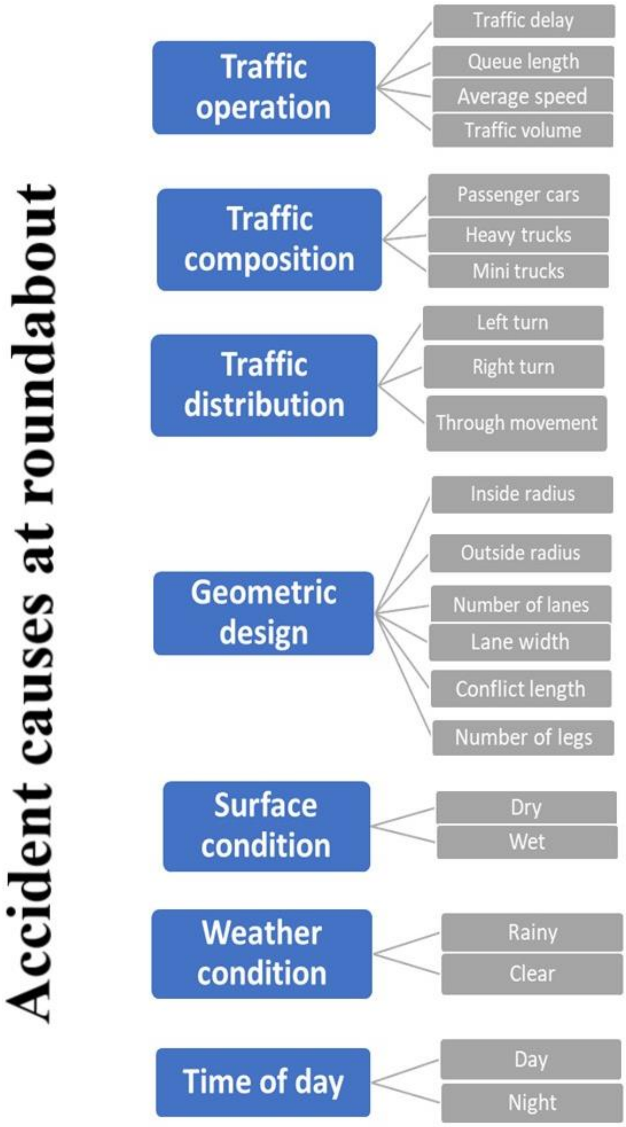


Figure 2. Main and Sub criteria of traffic accident causes from literature and police report

Figure 3. Satellite image of selected intersection

In addition, a classification of fatalities and injuries into three subgroups of drivers, pedestrians, and passengers is also available in the digitally formatted accident reports. Based on the above data on road crashes and the availability of actual traffic volume for the same period, twenty roundabouts most exposed to traffic accidents were selected for this study. Moreover, traffic volume data like vehicle composition (heavy, mini truck, and passenger car) and traffic distribution (right, left, and straight) were extracted from real-time video recordings. After determining the peak hour at each roundabout, the traffic counts were entered into the simulation software after the road characteristics were determined (lane width, number of lanes, as well as other geometric design parameters of the roundabouts). Due to the availability of traffic counts every 15 minutes, counts of vehicles that change at every 15-minute measurement interval have been entered into the VISSIM simulation. This means that the data is dynamically assigned. The VISSIM software was used to find the traffic flow parameters [25]. These parameters, for example, included the average traffic flow speed on the roundabouts in km/hour, the average length of the traffic queue at the approach legs in meters, and finally the traffic delay in seconds/vehicle. Finally, geometric design parameters such as inside and outside radius, number of lanes, conflict length, and number of legs for each roundabout have been collected from relevant authorities.

2.2. Stakeholder Selection, Ranking the Traffic Accident Causes

Clustering the traffic accident causes at roundabout starts with a literature review and police reports to determine and classify the accident causes into main- and sub-groups. A clustering analysis gathers common data into meaningful groups that are associated with or share properties. Consequently, the traffic accident data has been classified into seven main groups, representing the potential causes of accidents. Under each of these groups, sub-criteria are added to form a hierarchy tree, as shown in Figure 1. This classification aims to investigate and analyze the causes and frequency of traffic accidents at roundabouts. Further, the expert stakeholders were classified into three groups; each group includes three experts (one from the government, one from the private sector, and an academician). This step aims to have the experts' feedback segmented into groups of significant common characteristics and to reflect the impact of varicose interests on the accident causes evaluation based on operation, economic, and scientific aspects. Additionally, clustering analysis minimizes the uncertainty and risk of regenerating symmetric decisions by involving and analyzing the feedback from stakeholders with various backgrounds as well as conflict of interest stakeholders [26].

A questionnaire was devised by asking experts to rank the causes of accidents at roundabouts and differentiate these based on the main and sub-criteria, including their impact on traffic accident causes, using pairwise comparisons. The odd-numbered rankings were used to determine the importance of the criteria, which range from 1 to 9. However, the stakeholder preferences were collected using pairwise comparisons, which are the fundamental blocks of the AHP tool. Then, the obtained expert's pairwise preferences were randomly grouped, as mentioned above, into three groups; Table 1 below shows an example of one of these preferences as well as the expert group. Each set of preferences consists of the responses of one academic, government, or private respondent. After that, these responses were ranked in increasing order, as shown in Table 2. Then, the MRSS technique is used to determine the represented preference or set of preferences [27]. The MRSS clustering and selecting technique may be summarized by the following equations:

i. If the sample size (n) is odd, then the median number and/or set can be chosen by the following Equation 1:

$$\left(\frac{n+1}{2}\right)^{th} \tag{1}$$

ii. However, this observation may be denoted as $X_{((n+1)/2:\,n)}$ and the general formula that express it is

$$X_{((n+1)/2\,:n)1},\ X_{((n+1)/2\,:\,n)2},\dots X_{((n+1)/2:n)\_n} \tag{2}$$

iii. If the sample size, n, is even, then the median is selected by

$$\left(\frac{n}{2}\right)^{th} \tag{3}$$

This observation can be denoted as $X_{((n)/2:\,n)}$ and the general formula is:

$$X_{((n)/2\,:n)1},\ X_{((n)/2\,:\,n)2},\dots X_{((n)/2:n)\_n} \tag{4}$$

Table 1. Pairwise comparison of traffic operation with surface condition

Sector	Private sector	Government	Academic
Group No I	5	1	7
Group No I	7	3	5
Group No I	5	1	5

Table 2. Ranked stakeholders' preferences

	Ranked preferences		
Group No I	1	5	7
Group No I	3	5	7
Group No I	1	5	5

In stratified sampling method, if the population is consisting from N units and divided into L non overlapping subpopulations each of N_1, N_2, ..., N_L units, respectively, such that $N_1 + N_2 + ... + N_L = N$. Thus, these subunits are called strata. To maximize the benefit from stratification, the size of the h^{th} subunit, denoted by N_h for h = 1, 2, ..., L, should be known. Then the sample drawn independently from each strata, producing samples sizes denoted by n1, n2, ..., nL, such that the total sample size is represented by Equation 5.

$$n = \sum_{h=1}^{L} N_h \tag{5}$$

The MRSS is an advanced tool derived originally from the RSS. The MRSS is advantageous (relative to the original RSS) because it minimizes ranking errors and enhances estimation efficiency [27]. After that, the preference sets obtained from the previous steps were subsequently applied in the AHP analysis for one more time to obtain the final weights of each main and sub-causes.

2.3. Analysis and Validation

The weights obtained by MRSS-AHP analysis for the main and sub-criteria were compared with the analysis of the causes of accidents using ANOVA to validate the results. However, in order to assess the goodness of the obtained MRSS-AHP results, the consistency ratio has been implemented. It can be calculated using the following equations:

$$CI = \frac{\lambda - n}{n-1} \tag{6}$$

$$CR = \frac{CI}{RI} \tag{7}$$

where, CR, and RI are consistency index, consistency ratio, and random index, respectively. However, RI can be obtained from the tables available in the literature.

3. Results and Discussion

The questionnaire was analyzed to obtain the weights of each main and sub-criterion. This step aimed to determine the weights of all main and sub-criteria. Table 1 represents an example of one of these comparison groups. Each group includes one expert from private, government and academic that has been randomly selected. The preferences of each cluster are almost the same. For instance, the government officers believe that the traffic operation has almost the same importance in causing the traffic accident at a roundabout as the surface road condition. While Table 2 represents a ranked preference and selected set of a pairwise comparison of traffic operation with the road surface condition.

The selected preference set is (5, 5, 5), and again, from the resulted set, one more median rank is performed. Then a final weight can be selected; the weight in our case is 5. However, if the set is (7, 1, 3), then the selected weight based on the ranked median set (1, 3, 7) will be 3. However, the resulted final preference (5) means that traffic operations are moderately more effective in causing traffic accidents at the roundabout. Finally, an AHP procedure was performed to finalize the weights of each main and sub-criteria.

These steps have been repeated for each pair-wise comparison to obtain the weight of each main and sub-criteria. The resulting criteria weights are shown in Table 3. Moreover, the overall weight is equal to one. These weights reflect each criterion's relative importance (impact) in contributing to the causes of accidents. Additionally, knowing the main causes of traffic accidents helps the authorities focus, implement mitigation measures, and implement interventions to minimize traffic accidents and their consequences [28].

The geometric design is the most significant contributor to traffic accidents at roundabouts, with a weight of 36.65%, followed by traffic operations, with a weight of 22.6%. In comparison, the least significant contributory factors are time-of-day and traffic distribution, with weights equaling 5.8% and 6.8%, respectively. Also, many studies have reported geometric design as a significant contributor to accidents at roundabout intersections [11].

Building roundabouts than signal-free intersections in urban areas with conditions like (i) Speed limit (maximum speed of 50 km/h), (ii) Inscribed circle diameter ranging from 13 to 24 m, (iii) Circular roadway width of 4.5–6 m, and (iv) Only single-lane entries and exits are capable of reducing traffic accidents by 29%.

Final sub-factor scores are determined by multiplying major criteria weights with sub-criterion weights, as shown in Table 3. Conflicting length at roundabouts, queue length, and rain are other major contributory factors to traffic accidents, with weights of 12.6, 10.1%, and 10%, respectively. Although roundabouts reduce drivers' exposure to conflict time and the percentage of vehicles in conflict compared to signalized intersections [29]. The assessment of traffic collisions in the three selected cities indicated a remarkable reduction in fatal accidents. For instance, no accidents were classified as fatal. On the other hand, there was a very high percentage of accidents resulting in injuries. For example, 0.97% of accidents were classified as damage only, while 99.03% caused injuries. Regrettably, the total number of injuries reached 1,718. The percentages of injured drivers, pedestrians, and passengers were 38.82%, 4.71%, and 56.46%, respectively. Furthermore, accidents were classified based on the number of vehicles: single-vehicle, two-vehicle, and more-than-two-vehicle collisions accounted for 24.6%, 68.4%, and 7.0% of overall accidents. Table 4 shows the primary statistics concerning the geometric designs of the assessed roundabouts. Conflicts at roundabouts are still a significant cause of accidents. This is due to roundabout geometric design [11], like radius, small deviation angle as well as large roundabout roadway width.

Table 3. Weights of main and sub-criteria concerning accidents at roundabouts

Main Criteria	Sub-Criteria and Weights	X_i	Final Weights
Geometric Design (36.6%)	Inside Radius (0.239)	X11	0.087
	Outside Radius (0.055)	X12	0.020
	No of lanes (0.046)	X13	0.017
	Lane width (0.076)	X14	0.028
	No of legs (0.241)	X15	0.088
	Conflicting Length (0.343)	X1٦	0.126
Traffic Operation (22.6%)	Queue Length (0.446)	X1	0.101
	Traffic Delay (0.094)	X2	0.021
	Traffic Volume (0.154)	X3	0.035
	Average speed (0.306)	X4	0.069
Weather Condition (11.4%)	Rainy (0.875)	X17	0.1
	Clear (0.125)	X18	0.014
Surface Condition (9.7%)	Wet (0.9)	X22	0.088
	Dry (0.1)	X21	0.009
Traffic Composition (7.1%)	Passenger car (0.07)	X9	0.005
	Heavy Truck (0.78)	X8	0.055
	Mini Truck (0.15)	X10	0.011
Traffic Distribution (6.8%)	Left Turn (0.751)	X6	0.051
	Right Turn (0.081)	X5	0.006
	Through movement) (0.168)	X7	0.011
Time of day (5.8%)	Day (0.125)	X19	0.007
	Night (0.875)	X20	0.051
	Sum (SI)		1.00

Table 4. Geometric data statistics

Parameters	Average	Standard Deviation	Minimum	Maximum
Inside radius (m)	15.0	10.7	5.8	37.5
Outer Radius (m)	25.7	10.6	14.8	49.2
No of Lanes	2.0	0.3	2.0	3.0
Lane Width (m)	5.1	0.7	4.1	6.5
Conflicting Length (m)	32.0	16.6	16.3	68.1
Entry width (m)	8.6	1.3	6.8	10.7
Exit width (m)	10.6	4.1	7.7	22.1
Entry Angle (°)	70.7	8.1	48.5	82.8
Deviation Angle (°)	29.1	11.5	15.3	58.3

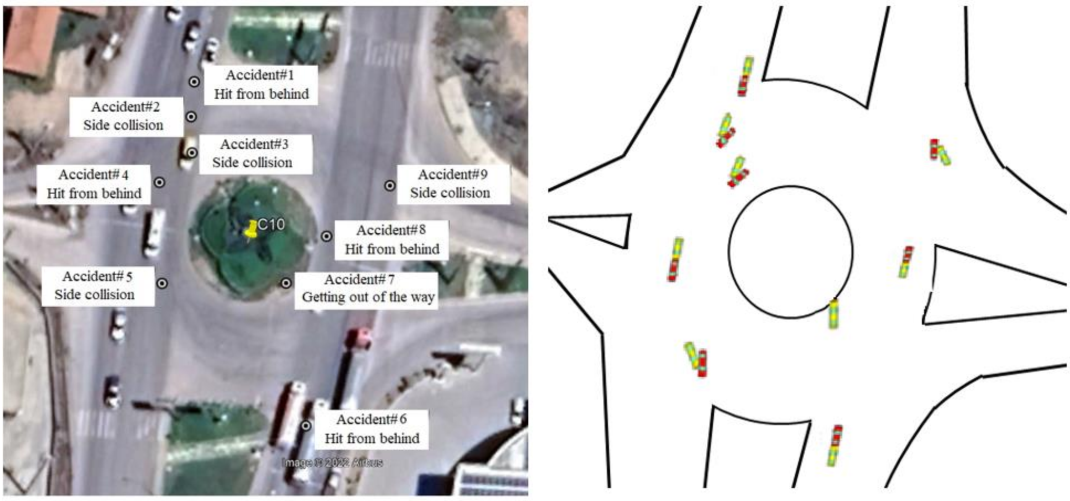
Table 5 presents the most frequent causes of accidents at the assessed roundabouts. An analysis of driver errors indicated that illegal parking, overturning, wrong merging, and diverging were the primary driver errors that caused accidents. Nonetheless, the most frequent types of accidents are side collisions and hits from behind, with shares of 49.6% and 17.7%, respectively. On the other hand, illegal parking on circulating roadways caused 6.2% of the total accidents, while collisions with pedestrians accounted for 9.7%. Finally, in addition to the previously cited errors, brake failure and other driver errors resulted in out-of-the-way movement and overturning, accounting for about 9.7% of all accidents. Most of these errors can be prevented by enforcing traffic laws and enhancing driver behavior. However, such results have been reported in a study performed by Alshannaq & Imam (2020) [30]. They reported the drivers' behaviors and/or absence of clear lane marking as the major causes of traffic accidents at roundabouts.

Table 5. Distribution of crash causes

Collision Type	% of Collision
Overturning	6.2%
Getting out of the way	3.5%
Hit from behind	17.7%
Side collision	49.6%
Collision with a parked vehicle	6.2%
Collision with fixed object	7.1%
Pedestrian collision	9.7%

Figure 4-a presents the most dangerous roundabout (K1) regarding the number of accidents and injuries. The reported accidents varied between a side collision, a collision from behind, and a collision with a fixed object at a rate of 9 accidents and a total of 22 severe, medium, and light injuries. Moreover, Figure 4-b showed a new accident type, which included a vehicle getting out of the way and entering the central island (accident number 7).

(a)



(b)

Figure 4. a) Types of crashes at the roundabout (K1), b) Types of crashes at the roundabout (C10)

Stepwise regression analysis was carried out to validate the results obtained from the AHP analytical method. Statistical analysis showed that all regression parameters were statistically significant at a 95% confidence level, with a coefficient of multiple determination of 0.91 (R^2 =0.83, Adj. R-Sq=0.56, F-Value 2. 9). The model summary is presented in Table 6. In this model, -, X_{11}, X_{13}, X_{14} and X_{16} are geometric parameters that explained about 39%, compared to 36.6% by the AHP method. On the other hand, X_1, X_2, X_3 and X_4 are traffic operation parameters that also explained around 24%, compared to 22.7% by the AHP. Finally, X_6 represented the traffic distribution (left turn), X_8 and X_{10} traffic composition (heavy truck and mini truck respectively), and X_{22} road surface condition. However, almost same results have been reported by various researches [4, 11, 16].

Table 6. Statistical model summary

R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
0.913[a]	0.833	0.547	1.246	0.833	2.914	12	7	0.082

a. Predictors: (Constant), X16, X4, X22, X10, X14, X2, X8, X13, X6, X3, X1, X11

The last three independent parameters (X_6, X_8, and X_{22}) in the statistical analysis together explained about 32%, compared to 35% by the AHP method. In conclusion, the general model in the statistical analysis explains the issue of traffic accidents at the roundabouts by 91%, including all the parameters in the AHP except time of day, which is removed from the model. The analysis of variance and regression coefficients is presented in Table 6. Moreover, the ANOVA values of the model are presented in Table 7. Moreover, Figure 5 indicates that the implementation of the regression analysis in this study is not illogical since the observed and expected cumulative probabilities are almost identical. Minor result biases can be neglected. However, the ANOVA outcomes support the outcomes obtained from the integrated MRSS-AHP model that has been developed in this study.

Table 7. ANOVA table of the model

Model		Sum of Squares	df	Mean Square	F	Sig.
	Regression	54.326	12	4.527	2.914	0.082[a]
1	Residual	10.874	7	1.553		
	Total	65.200	19			

a. Predictors: (Constant), X_{16}, X_4, X_{22}, X_{10}, X_{14}, X_2, X_8, X_{13}, X_6, X_3, X_1, X_{11}

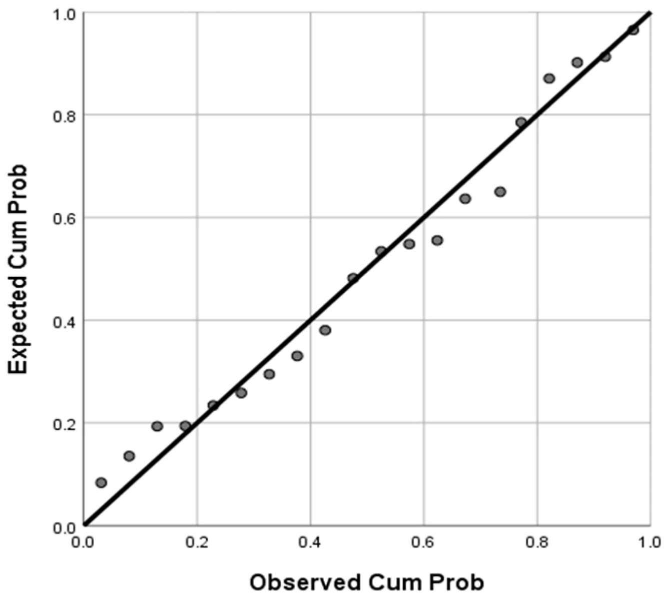


Figure 5. Normal P-P plots of regression standardized residual, (SPSS output)

4. Conclusion

Traffic accidents are a critical issue, especially considering the surge in vehicle numbers, accident victims, and related injuries. Though roundabouts reduce congestion at intersections, soaring traffic volumes cause them to become traffic accident hotspots. Most of the reported causes of traffic accidents were collected from the literature and categorized into primary groups. Each main group includes sub-criteria that share common linkages. AHP is the MCDM method capable of simultaneously handling quantitative and qualitative data. AHP was used in this study to determine most causes of accidents at roundabouts. The results were then validated using the ANOVA tool. Furthermore, the outcomes of MRSS and AHP are almost identical with the ANOVA analysis. The geometric design, represented mainly by the conflicting length and number of legs at the roundabout, is the leading cause of traffic accidents, followed by traffic operation, represented by queue length. Furthermore, the wet road surface also increases the accident potential at roundabouts. To reduce the number of accidents and resulting casualties at roundabouts, it is essential to determine the leading causes of accidents. Hence, this study will help decision-makers and local authorities design, manage, and control traffic appropriately at intersections and roundabouts. However, to improve traffic safety at the current roundabouts, it is recommended to reduce the allowable vehicle speed and apply traffic monitoring and inelegant management methods to segregate vehicles in time and space. While for future and under-construction roundabouts, special attention should be given to the geometric design, especially the lane width, entrance, and exit of the roundabout conflicting length.

5. Declarations

5.1. Author Contributions

Conceptualization, G.S., M.E., M.F.A.S., and M.A.; methodology, G.S. and M.K.Y.; software, G.S.; formal analysis, G.S. and M.K.Y.; data curation, G.S.; writing—original draft preparation, G.S., M.E., M.F.A.S., and M.A.; writing—review and editing, G.S., M.E., M.F.A.S., and M.A. All authors have read and agreed to the published version of the manuscript.

5.2. Data Availability Statement

The data presented in this study are available in the article.

5.3. Funding

The authors would like to express gratitude to their institutes for the financial support they provided to publish the article.

5.4. Institutional Review Board Statement

The study was conducted in accordance with the Declaration of Helsinki, and approved by the Institutional Review Board (or Ethics Committee) of Aqaba University of Technology (protocol code AUT-22-011-03 and date of approval 18 October 2022)

5.5. Conflicts of Interest

The authors declare no conflict of interest.

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