

Improving the road network of Baghdad City to increase the safety of motorcyclists

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ABSTRACT

The increasing of population in Baghdad city with limited choices of transportation enforces people to choose motorcycle mode. This mode is preferable due to its simplicity and economically comparing with other modes of transportation, especially for low-income societies. The problem of this mode is the high accidents percentages. Accordingly, the city of Baghdad ` a challenge with increasing the motorcyclists in recent years. This problem is magnifying due to users who are not following traffic instructions. Besides that, the current road network did not get any modifications to handle this type of transportation. The absence of data related to the number of users and their characteristics decreases the problem's solution. This study is a trying to figure out this problem by discovering the motorcyclist characteristics through ` a questionnaire to about 500 users with different levels of educations and ages. The study revealed that the accidents are relatively high for most motorcyclists regardless their characteristics. The study recommended that the improvement of roads network should be started in the east part of the city where people are concentrated. The assessment of adding a lane for motorcyclists on a multi-lane roadway should be made before improving the whole city network.

Keywords: Motorcyclists, Accidents, developing countries, motorcycle lane

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1. Introduction

Motorcycle is one of the sustainable transport modes in some developing countries [21]. In some Asian countries, the percentages of two- and three-wheel vehicles were counted and they were more than 90%, 70% and 50% for Vietnam, Indonesia, and Malaysia, respectively [17]. [26] reported that China has the largest number of motorcycles (more than 100 million motorcycles) followed by India, Indonesia, and Vietnam with more than 80 million, 60 million and 30 million, respectively. Table 1 shows the overall total of registered motorcycles in the World in 2010. There are more than 400 million registered motorcycles around the world. Approximately 79% of these motorcycles were found in Asia, while almost less than 9% were found on the continent of Europe, and the rest were distributed among Middle East, Africa, South America, North America, and Oceania.

Table 1. The overall Total of Registered Motorcycles in the World in 2010 (Adopted from World Health Organization [35])

No.	Continent/ Region	Registered Motorcycles (2010)	(%) of total motorcycles	Motorcycles per 100 population	(%) of MCs of all vehicles
1	Asia	359,567,713	78.94	100.8	59.35
2	Middle East	13,240,634	2.91	28.35	25.21
3	Europe	38,767,389	8.51	43.9	9.56
4	Africa	7,938,939	1.74	10.35	22.88
5	South America	22,801,731	5.01	58.12	22.54
6	North America	12,395,764	2.72	23.82	3.86
7	Oceania	778,936	0.17	21.8	4.01
	Total	455,490,566	100	World's rate = 68.68	30% of all vehicles

Iraq is currently facing a phenomenon of increasing the numbers of motorcyclists [32]. Although motorcycle needs less space for driving and parking and less cost for financing, insuring and maintaining compared to other modes of transportation [21], it is more dangerous and less safe [15]. Researchers stated that motorcycles are the main cause of road congestion and traffic accidents and the major reason for death and injured [21]. Le and Nurhidayati (2016) also reported the importance of paying attention for road safety due to the increase in the numbers of motorcycles' crashes each year [26]. Le and Nurhidayati (2016) stated that the purpose of using motorcycle differs between developing countries and developed countries. People in developing countries use motorcycle as a means for passengers and goods transport purposes. While Commute and tour purposes are the main reason for using motorcycle in developed countries. In Iraq, the main purpose for using motorcycle is for delivery. In general, people use this mode of transport due to many reasons such as: good accessibility and lower cost for owning, maintaining, insuring, and financing compared to vehicles [21]. In addition, motorcycle needs less road and park space, but this mode of transport has the highest number of traffic accidents compared to other modes of transport. This is due to the task of driving the motorcycle; which is more difficult than that of vehicle. It requires physical co-ordinating and balancing through driving [23]. As a result, any drug or alcohol would affect the skills of motorcyclists more than that for car drivers. Another study focused on the behaviour of motorcyclists [31] who have considered the effect of users' ages and their experiences in driving safety. They used more than 4000 motorcyclists from around the UK. They found that users' age plays an important impact in accident numbers more than the effect of driving experience. Le and Nurhidayati (2016) reported that some of transportation agencies focused on traffic segregation through isolating motorcyclists from other road users. In Iraq, the main problem with using a motorcycle is the lack of compliance of its users with traffic laws that have been put in place for road users in urban regions. As a result, this study is an attempt to focus on the characteristics of motorcyclists in Baghdad city (the capital) and try to find a solution to the problem of increasing the number of road accidents.

Traffic accidents are common because of increasing the number of motorcycles. There are several causes for such accidents, the most important of which are drinking alcohol or any illegal pharmaceuticals [34], losing of the control during driving, especially during bending in addition to manoeuvring movements [8].

In ref. [33] it was reported that more than 2% of global death was from traffic accidents and about 90% of these accidents occurred in developing countries. Moreover, [40] mentioned that road accidents will be increased up to 83% in 2030 in case of no solution has been added.

2.1 Motorcycles' Accidents in developed countries

A study in the United Kingdom from 1997 to 1999 [14] stated that motorcycles' users had accidents 9 times more than the car drivers. This finding is compatible with that obtained by other studies such as [23] and [15], et al. (2003). Another study from Great Britain [16] stated that in 2002, the number of death or severely injured due to motorcycles' accidents was about $150/10^8$ vehicle Kilometres. In addition, the number of injured persons due to motorcycles' accidents was nearly $560/10^8$ vehicle kilometres compared to about 50 cases for car users.

Horswill and Helman (2003) compared the behaviour of motorcyclists with that of car drivers using different measures. The results were that motorcyclists preferred faster speeds, smaller gaps and more overtaking than that used by car drivers.

Huang and Preston (2004) suggested significant relationships between types of motorcycle accidents, causes and preventive measures as shown in Figure 1.

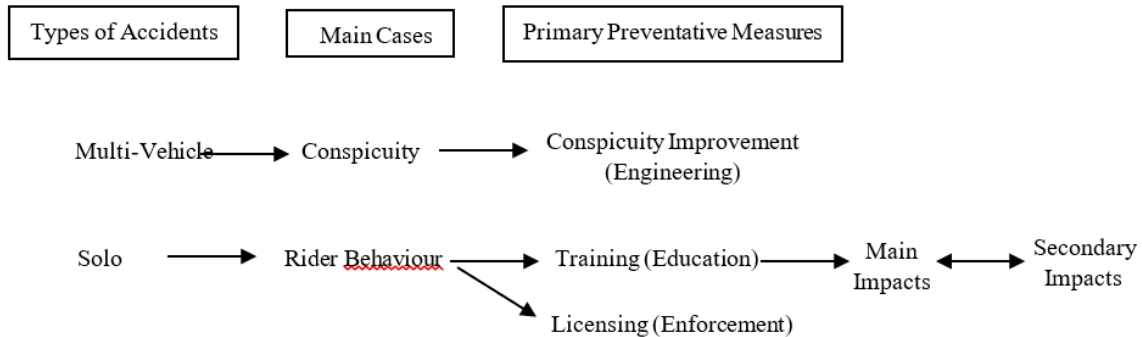


Figure 1: The relationships between types of motorcycle accidents, causes and preventive measures [16]

The research that focused on motorcycle accidents in New Zealand reported that the percentage of death of motorcyclists was about 20 % from the total road accidents [30].

Clarke et al. (2004) stated that young male are the main cause of motorcycle accidents, especially users of less than 25 years; which are representing about 70% of deaths caused by motorcycle accidents. Moreover, Clarke et al. (2004) mentioned that young male users are the main motorcycle users in terms of the number of journeys and the total distance travelled.

Kopjar (1999) focused on motorcycle accidents in Norway. He stated that most motorcyclists aged around 16 years representing about half the total number of injuries due to road accidents. Kopjar (1999) reported that such number of accidents is a big problem and needs an urgent solution from road safety experts.

Le and Nurhidayati (2016) reported that in developed countries like United States of America, United Kingdom and Japan, the number of motorcyclists is decreased each year.

2.2 Motorcycles' accidents in developing countries

Hsu, et al. (2003) stated that motorcycle comprises the main traffic rate in some Asian countries, especially in their metropolitan areas. [26] reported that 79% of registered motorcycles in the world are found in Asia. The study of Hsu, et al. (2003) included three countries with different economic income levels. Taiwan; which is a country with a highly-income level compared to Vietnam with a low-income level. While, Malaysia is a country of a middle-income level. Le and Nurhidayati (2016) reported that Taiwan and Malaysia have faced a problem in road safety due to increasing the number of motorcycles.

Hsu, et al. (2003) used statistical data to show that using motorcycles was the cause of most accidents in Malaysia. Figure 2 shows that nearly half the accidents in Malaysia were due to using motorcycle. It is important to mention that the percentage of death due to motorcycle was the highest among other modes of transportation [15]. In addition, Hsu, et al. (2003) reported that the number of deaths in Vietnam has risen rapidly in the last years. This was due to the quick rise in the number of motorcycles. Figure 3 shows traffic accident by modes of transport from 2000 to 2001. In Taiwan, statistical data of 2001 proved that motorcycle death was more than 50% from the total death resulted by transport accidents [15].

The problems of motorcycle can be considered as: instability, absence of safety, quickness and [21], [26]. Therefore, some actions should be taken into account to control such problems i.e. decrease numbers of accidents and develop the motorcycles' safety. These include: decreasing the interaction with other modes of transportation through appointing a specific lane for motorcycle usage [12], limiting the speed of motorcycle and limiting the usage of motorcycles in particular areas. Moreover, registering motorcycles and driving license for motorcycles users [29].

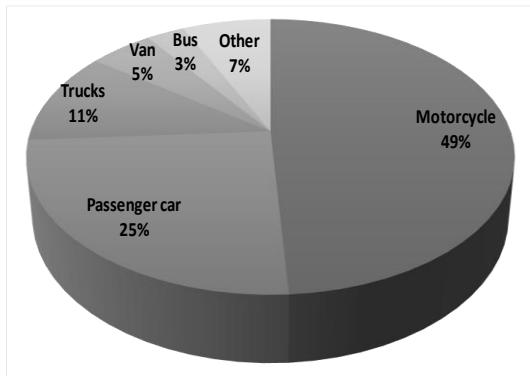


Figure 2. Percentage of accidents by vehicle type of Malaysia in 1997 (adopted by Hsu, et al., 2003)

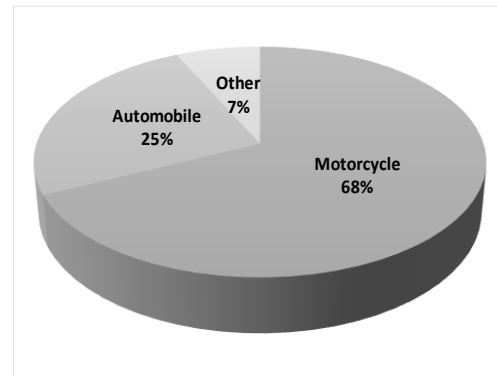


Figure 3. Traffic accident by modes of transport in Vietnam from 2000 to 2001 [15]

To recognize the causality of accidents in Thailand, a comprehensive study [18] was undertaken into account. They studied closely more than 960 collisions to know the causes of accidents. The result of this study was that alcohol is the main cause for accidents in Thailand, with about 400 drinking riders. The riders in this type of accident have lost control of their motorcycles and run off the road. Such accidents were repeated at night, especially on weekends.

Le and Nurhidayati (2016) reported that in Asian countries like Thailand, Taiwan and Indonesia, the number of motorcyclists is increased each year. In Karbala, one of the provinces of Iraq, the main reason for death was the head injury for motorcycle [11]. 240 patients in Al-Hussein Hospital were used in Al-Anbari study [11] from the beginning of January to the beginning of September 2008. The study recommended using helmet, limiting the speed of motorcycle and obeying traffic roles.

Tanzania is one of the African countries, which is affected by motorcycles' accidents. The statistical data showed that death due to motorcycles' accidents was too high in Tanzania. It was about 30 deaths per 100000 people [35]; which is equal to more than 50% of the total road accidents [4].

[43] explained the reason for such high number of motorcycle accidents comparing to other mode of transport, especially in low- and medium-income countries. This was related to motorcycles' users who need more balance through driving. Accordingly, they are more affected to road conditions than other types of drivers [23]. In ref. [24] stated that motorcycles' users are more affected on road condition than users of other mode of transport. Accordingly, more studies are needed to focus on the motorcycle accidents and their reasons [10]. This may help to improve new strategies to decrease these highly number of accidents.

3. Case of the study

This study is dedicated to study the motorcyclist's characteristics in Baghdad city, the capital of Iraq; which is one of Middle East countries with an area of approximately 450,000 square kilometres. The popular mode of transport in Iraq is motor vehicles [3]. Despite the resources and wealth that exist in this country, the economic situation is deteriorating continuously as a result of wars and foreign policies, which has led a segment of people to use a new mode of transportation that did not exist in Iraq in the previous years; which is a motorcycle. The problem with this mode of transport is the big number of traffic accidents. The death rate for motorcyclists is approximately 35 per 10^8 miles of travelled road compared with 2.57 per 10^8 miles for vehicle users [42].

Motorcycles have not received sufficient attention [38], especially in terms of conducting the necessary reports to determine their numbers, growth rate, accidents, as well as the cause of these accidents and possible solutions to reduce these accidents. In addition, motorcyclists in Iraq do not wear helmets and do not follow traffic controls and regulations that designed to protect road users.

A questionnaire survey was used in this study as this method seemed to be the most appropriate way to collect personal data related to motorcyclists and to reach the research targets [22]. Mainly, there are two kinds of questionnaires, structured questionnaire, and unstructured questionnaire. Persons who are responsible for data collection usually prefer using structured questionnaire than unstructured questionnaires due to easier data management and less discrepancies [1]. The mixture of the two mentioned kinds of questionnaires is the quasi-

structured questionnaire, which is commonly used in scientific research [1]. As a result, the mixture of the two questionnaires was used in this study to fulfilment the requirements of this study.

3.1 Sample size

Following many associations interested in people counts, Baghdad city population is around 7.5 million people on 2022, as shown in Figure 3, about 85% of this number live in urban areas and quarter of them are male with range of age between 15-60 years (motorcycle possible user). By assuming that 25% of that possible user having motorcycle the resulting estimated number of users become 398,438 say 0.4 million. Accordingly, and by using the statistical sample size calculation (calculator, 2022) website with confidence level of 95%, the resulting sample size is 385 cases.

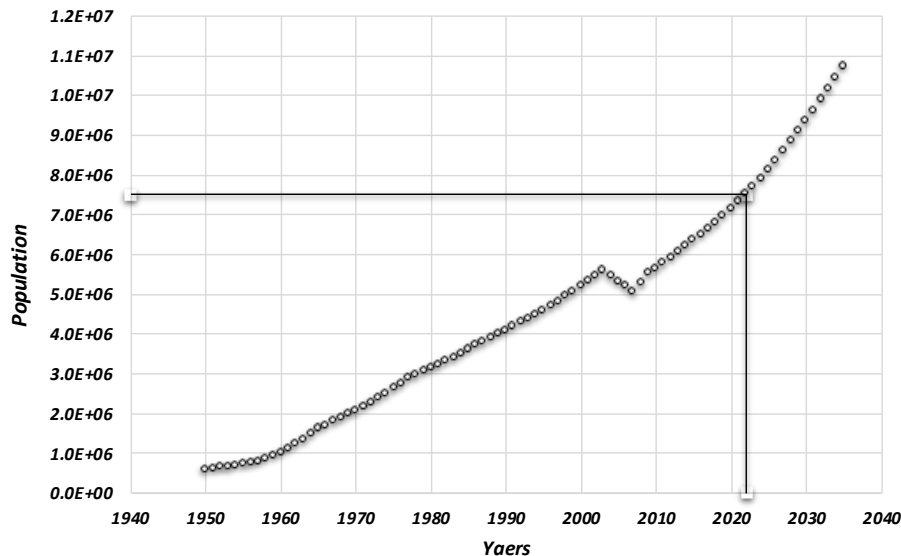


Figure 4. Baghdad City population [41]

3.2 Questionnaire

A questionnaire was prepared and distributed to about 500 motorcyclists. About ninety percent of filling form of questionnaire were adopted in this study because the rest were ignored due to insufficient filling data. So, around 450 cases of motorcyclists were used in this study. The main parts of distributed questionnaire are presented as follows:

3.2.1 Motorcyclists characteristics

This part of questionnaire is about the driver's qualities, which include the age of the driver, the driver's education, number of daily travels, reason for using motorcycle.

3.2.2 Accidents

This part of the questionnaire relates to the number of accidents the motorcyclists suffered from and the seriousness of these accident. The severity of accidents was divided into three categories: low severity, medium-severity, high severity. A number of questions were asked to inquire about the reason behind the severity of accidents such as: 1. Following traffic instructions; 2. driving with the direction of traffic; 3. wearing helmets; 4. choosing a specific lane to drive a motorcycle; 5. choosing a speed limit.

3.2.3 Safety

This is the last part of questionnaire, which relates to the safety requirement from the driver's point of view. A number of answers was collected that relates to: 1. Motorcycle's safety degree; 2. Accident protection measures; 3. Dangerous streets for driving by motorcyclists.

4. Motorcycle accidents

The characteristics of motorcyclists, mentioned earlier, have been linked to the severity degree of accidents that have experienced by the users as follows:

4.1 Accident's severity with percentage of motorcyclists

The relationship between accidents severity with percentage of motorcyclists is as shown in Figure 5. It is clear from Figure 5 that about 19% of motorcycle users didn't have any traffic accident. This may be due to their safe driving and committed to traffic instructions and controls. It is important to mention that the highest percent of motorcyclists (about 35%) have exposed to accidents of low severity degree. While, the lowest percentage of motorcyclists (nearly 15%) have affected by some accidents of high degree of severity. In addition, about 30% of motorcycle users have suffered from accidents of medium severity.

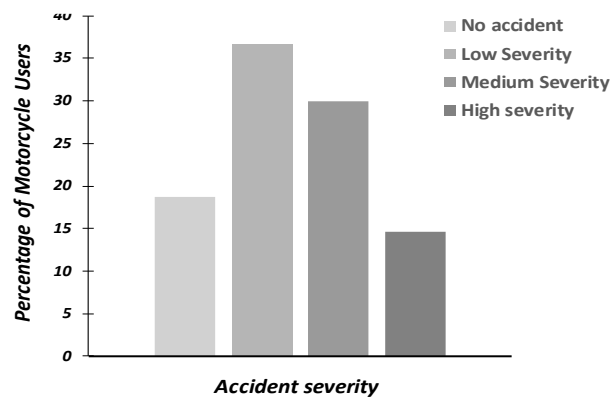


Figure 5. Relationship between severities of accident and percentage of motorcycle users

4.2 Accident severity with age of motorcyclists

The ages of motorcyclists were divided into 4 categories: under 20 years, 20 - 29 year, 30 - 39 year, higher than 40 years. The average of each category has been used to relate the ages of motorcyclists with the severity of accidents as shown in Figure 6.

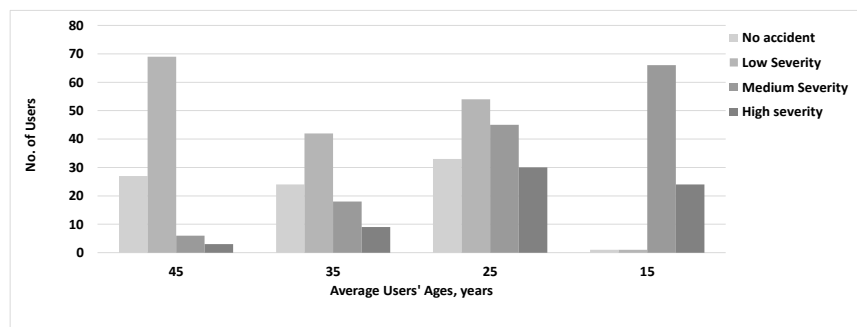


Figure 6. Relationship between severity of accidents with average users' ages

For the case of no accident, figure 4 shows that the highest number of motorcyclists was the 25-year age group with 10 motorcyclists. This was followed by a group category of 45 year and then the age of 35-year. For accidents of low severity, the highest number of motorcyclists (more than 20 persons) was the 45-year age group followed by a group category of 25 year (more than 15 persons) and then the group category of 35-year. For accidents of medium severity, the highest number of motorcyclists (more than 20 persons) was the 15-year age group followed by a group category of 25 year (equal to 15 persons) and then the group categories of 35-year and 45-year. For accidents of high severity, the highest number of motorcyclists (equal to 10 persons) was the 25-year age group followed by a group category of 15 year (8 persons) and then the group categories of 35-year (3 persons) and 45-year (1 person).

4.3 Accident severity with wearing helmet

Although using a motorcycle may put its user at risk of accident, very few number of motorcyclists in Baghdad wear a helmet to protect their heads from danger in case of a traffic accident. It is important to note that the design of the helmet is not suitable for the hot weather of summer in Iraq, so it is important to design a helmet that can be used in countries with hot weather. Results obtained from questionnaire showed that about 65% of motorcyclists were not wearing helmet in Baghdad.

4.4 Accident severity with safety rules

Recently, Baghdad was exposed to many accidents due to motorcyclists who do not follow traffic instructions. Since following the traffic instructions is essential and important to save the lives of road users. Neglect the knowledge of traffic instructions is a failure by both of the driver and the Iraqi traffic agencies. This study focused on the motorcyclists who follow traffic rules and the percentages of the accidents they have experienced. Accordingly, questionnaire showed that 75% of motorcyclists know the traffic instructions and have not had accidents. About 50% of motorcyclists had accidents of no severity, while motorcyclists who had accident of medium severity and high severity equal to 38% and 45%, respectively, as shown in Figure 7.

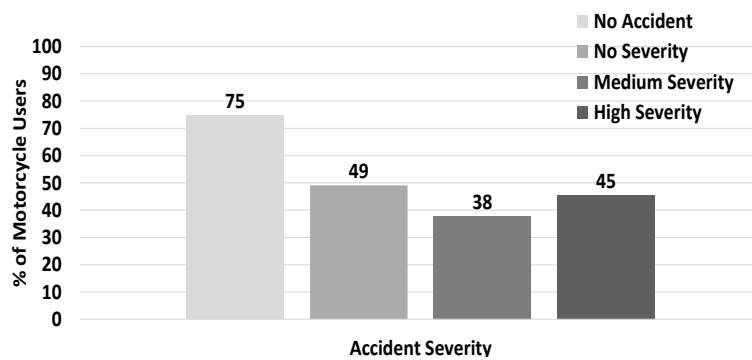


Figure 7. Relationship between percentages of motorcyclists who are knowing safety rules and accidents severity

4.4 Accident severity with driving direction

One of the questions asked to motorcyclists is whether they are driving with vehicles' direction or reversing the direction of the vehicles. Driving against traffic direction is contrary to traffic laws and is a common situation in Iraq and can be considered a very important reason for increasing the number of traffic accidents on the streets of Baghdad. In questionnaire, motorcyclists were divided into three types: motorcyclists who are usually driving with traffic direction, i. e. obeying traffic rules, motorcyclists who are usually driving against traffic direction and motorcyclists who sometimes drive with traffic direction and sometimes drive against traffic direction. The relationship between accidents' severity and number of motorcyclists who are driving with traffic direction, against traffic direction and sometimes with traffic direction and sometimes against traffic direction is shown in Figure 8.

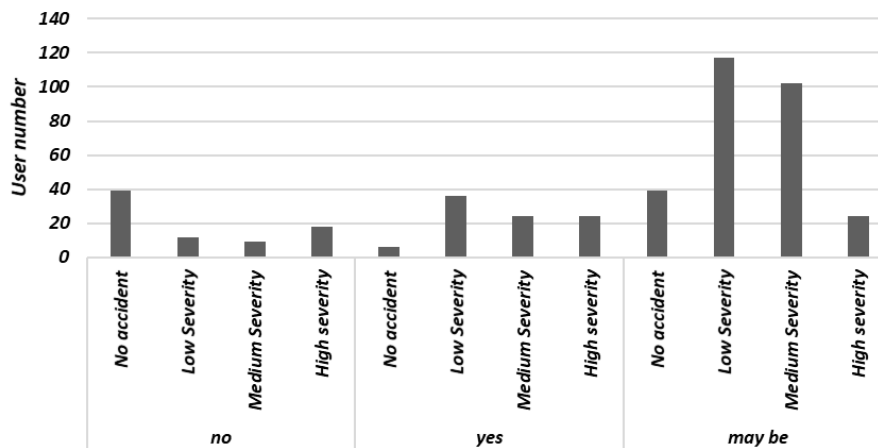


Figure 8. Relationship between number of motorcyclists who are driving against traffic direction and accidents' severity

5. Road's network improvements

As presented earlier, the high percentages of accidents regardless the characteristics of motorcyclists needs urgent separation for motorcycles' movement from other traffic. This means improving the roads network by creating a separate lane for motorcyclist. Because of limited area for this modification, the roads should be selected carefully and precisely. To do so, the distribution of people in Baghdad city and their density should be taken into account to select at least two or three roads to be modified in the first stage. Figure 9 shows Baghdad city with ten urban zones divided by Tigris River, six zones are on the east side (Rasafa) and four zones are on the west side (Karkh). The population numbers, percentages, and densities per km² are shown for each zone in addition to the name of the zone. According to figure 9, the population are concentrated in east side of about two third of population number with high density reach to more than 25,000 capita/km² in Al-Sadr City and about 10,000 capita/km² for each of Palestine, AL-Adhamiya and Baghdad AL-Jadida zones.

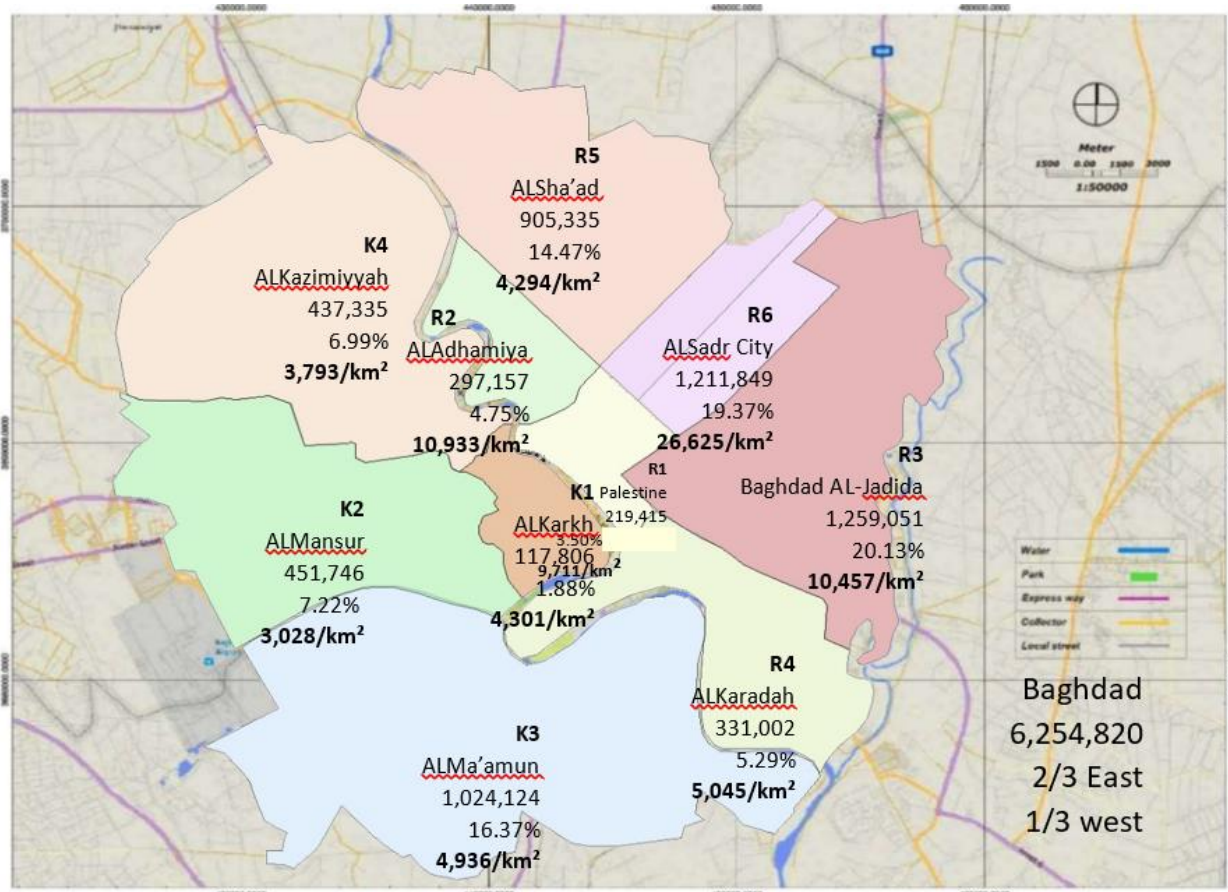


Figure 9. Distribution of population in zones of Baghdad City and their densities [7]

5.1 Lane allocating

Despite the importance of motorcycles, mentioned earlier, there are some issues related to the safety basis of road users. This is due to the mix traffic and the design of the transportation infrastructure [37]. Le and Nurhidayati (2016) reported that some of transportation agencies focused on traffic segregation through isolating motorcyclists from other road users. Le and Nurhidayati (2016) stated that the safety of motorcyclists, although important, has not been sufficiently important, especially in some Asian countries. This is because researchers stated that the percentage of death in 2010 in Asian countries was about 80% from the total death of the world [39]. Nevertheless, to increase road safety for motorcyclists and other road users, it is important to focus on allocating a special lane for motorcyclists in some major roads to decrease the interaction between motorcycles and vehicles in the road infrastructure. This solution is important beside other solutions such as limiting motorcyclists speed and limiting the using of motorcycles in some specific areas. In this study and according to the result of questionnaire, the number of accidents were too high for all age groups. The interaction between motorcycles and vehicles was the reason for these accidents, especially in bad weather and in night time. It is important to mention that the current network of Baghdad is out of any treatment for this type of transport, despite it includes some roads which can be used to allocate a special lane for motorcycles.

5.2 Proposed improvements

In this study, two streets have been chosen in Baghdad to allocate a special lane for motorcycles. These roads are Palestine Street and Al-Rabie Street, which were chosen due to many reasons: they include service streets, contain multi number of lanes and they are long streets, i. e. connect many areas between them.

6. Discussion

The questionnaire included different types of motorcyclists based on their ages and level of education. The results revealed that accidents percentages are high for all users. This means that the problem is not related to the property of motorcycles' users. In other words, the network should be improved to be able to handle this type of transportation with acceptable level of serviceability and with minimum interaction with other modes that use the roads network [33].

The problem of the huge number of motorcycles' accidents in Baghdad must be faced with a number of solutions to reduce the interaction between motorcycles and vehicles. One of the best solutions is the allocation of a special lane for motorcycles.

7. Conclusion

- From the results obtained in this study, only 19% of motorcyclists in Baghdad didn't have any traffic accident. It is also important to mention that the highest percent of motorcyclists (about 36%) have exposed to accidents of low severity degree. While, the lowest percentage (nearly 15%) have affected by some accidents of high degree of severity. In addition, about 30% of motorcycle users have suffered from accidents of medium severity.
- The accidents severity has a strong relation with the users' age. The percentages of no accident and low severity accident were about 25% and 45% for group age over 35 years, respectively. While they were 20% and 33% for a group age of 25 year. For group age of 15 years, the percentages were less than 1% for no and low severity accidents.
- Motorcyclists that are not wearing helmet is about 65% of all users included in the questionnaire.
- Questionnaire showed that 75% of motorcyclists know the traffic instructions and have not had accidents. 49% of motorcyclists had accidents of no severity, while motorcyclists who had accident of medium severity and high severity were equal to 38% and 45%, respectively.

8. Recommendations

Based on the results of this study, the rate of accidents was relatively high for all motorcyclists despite of their characteristics; which means that the problem is related to the roads network. Therefore, the improvement of road network is needed to be able to handle this type of transportation with acceptable level of safety. The population study of Baghdad city presented in this research revealed that the people are concentrated on the east part of the city. Accordingly, the following recommendations are proposed to develop the road network:

- The improvement should be started on the most populated zones on the east part (Al-Sadr city, Baghdad Al-Jadida, Al-Adhamiya and Palestine).
- Adding a lane for motorcyclists is required on the multi-lane roadway that pass through or connected between the zones mentioned above.
- The assessment of this development should be made to expand the benefits and avoid the negative points related with the using of this modification.
- Improve the whole city road network based on the experience got from applied the improvement on the zones mentioned above.
- The users of motorcycles should be enforced to obey the traffic rules and pay a fine when they break these rules.

Declaration of competing interest

The authors declare that they have no known financial or non-financial competing interests in any material discussed in this paper.

Acknowledgments

Authors would like to acknowledge the Iraqi Ministry of Higher Education and Scientific Research and Mustansiriyah University. The authors would like to thank Mustansiriyah University, College of Engineering, Civil Engineering Department and Highway and Transportation Department for their support and help to accomplish the work contained in this study. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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