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STATISTICAL ANALYSIS FOR THE MAIN FACTORS CAUSING CAR ACCIDENTS

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ABSTRACT

The main factors of car accidents were statistically investigated in Jordan. The car accidents were classified into three major categories, collisions, rollover and run over accidents. As the human errors were found to be the major reason for all kinds of accidents, they were classified into thirteen types of errors. The most serious errors of drivers causing accidents were failing to take correct measurements during driving, tailgating and incorrect lane taking. As the percentage of female drivers is less than 25%, they were found to make more collisions than male drivers, but male drivers make more run over and rollover accidents. Young male drivers were found to make more accidents than old ones. But young female drivers made less accidents than middle age and old female drivers. Statistical significance analysis showed that driver errors are the major factors of accidents in general, and collisions and turn over accidents in specific.

Keywords: car accidents, driver errors, collision accidents, run over accidents, factors of accidents, statistical analysis.

1. INTRODUCTION

The rapid development of modern means of transportation and the proliferation of highways and the increasing number of modes of transport associated with the increased number of road accidents that almost match the losses of human and material losses of war are traffic accidents and the resulting human and material losses of the major problems facing societies now.

Jordan has witnessed in recent decades developed in all aspects of social, economic and physical hitting area (89.342 km), where a network of internal roads extended to the area of 8700 km and road network for Foreign Affairs extended over an area of 5 thousand kilometers. Consequently, the size of the traffic became a risk source that require concerted efforts of stakeholders in traffic safety in Jordan to address incidents such as that to track a common and shared to reduce the depletion of human and economic resources. Whereas the use of vehicles and the consequent negative implications on human and material resources, it is essential to pay attention to this negative impact on traffic safety. As these incidents increase with the increase of population and expansion of infrastructure, it leads to further loss of lives and property. In Jordan, traffic accidents are the leading cause of death and injuries. It has become the level of traffic safety in Jordan less than the level of safety acceptable compared with the developed world traffic and the increase in the number of deaths is increasing where it has effects on both the social and economic aspects. The increase in traffic accidents lead to a decline in standard of living of families because of lower average per capita income for his family and thus the national income. Jordan as one of the countries of the Middle East that has a strategic location between other Arab countries and the importance of neighboring countries, where they use the international road network in Jordan.

The advanced countries and their mortality rates are common improving, while comparatively little is done in developing countries. This research is studying a good example of those developing countries with very high rate of accidents. The importance of this research is to identify the causes of traffic accidents and economic losses resulting there, and the main factors enhancing the traffic accidents, in order to make proposals and recommendations to address the problem of traffic accidents and minimize the effects of those factors and create more safety on roads of Jordan. As it is difficult to analyze the car accident reports in Jordan for the year of 2018, which are thousands of reports, Zarqa, the second biggest city in Jordan after the capital Amman was chosen to analyze the accidents there. Data for all accidents happened in 2018 in Zarqa, the second biggest city in Jordan, were collected from traffic police reports and analyzed. Zarqa has a strategic location in the Jordan in terms of location, as it is of a link between the capital Amman and the cities east and north of the Jordan, as it is the center of traffic where passing to most surrounding countries, like Iraq, Syria and Saudi Arabia) is made through this city, Zarqa. Besides having very high population intensity, Zarqa has many highways which passes through the city, and its population is a mix of males and females, old and young people, and so Zarqa represents a good example of the whole country Jordan.

2. LITERATURE REVIEW

A number of studies [1-30] have been conducted on accident characteristics, analyzing their driving abilities to reveal unique characteristics of senior drivers and to improve their safety. Some of these studies have discussed the accident causes related to the age of driver. According to the NHTSA (2003) [31], The National Highway Traffic Safety Administration report showed that in the last 32 years, the number of licensed drivers older than 65 years old has increased and age related diseases for those drivers. Bedard *et al.* (2002) [32] studied the independently the effect of the driver, the crash and the

vehicle characteristics on causing the accidents and the fatality of that accident. Most of the studies have focused on the rule of old drivers in causing accidents. Zhang *et al.* (2000) [33] have studied the factors affecting the severity of motor vehicle traffic crashes, where the drivers are old. They focused on analyzing accidents in Ontario and how to prevent them. McGwin and Brown (1999) [34] studied the characteristics of traffic crashes, and compared those accidents caused by young drivers with those caused by middle-aged drivers and with those caused by older drivers. Braver and Trempel (2004) [35] discussed whether older driver are at higher risk that young drivers. Keall and Frith (2004) [36] studied the older driver crash rates in relation to type and quantity of travel, which is very important point that should be considered. Evans (2000) [37] investigated the risks the older driver subject themselves to, and the threats they cause for others. Before that another study by Dulisse (1997) [38] discussed the risks road users are subject to, because of older drivers. Williams and Shabanova (2003) [39] investigated the responsibility of drivers for motor-vehicle accidents which resulted in deaths. They considered two main factors in their research, the age of the drivers and the gender of the drivers. Another study by Grabowski Morrisey (2001) [40] reviewed and analyzed the driver age effect on fatal accidents. Other factors causing vehicle accidents have been studied by other researchers, like the vehicle speed which was investigated by Spek *et al.* (2005) [41]. The effects or personality and gender on the risky driving behavior and involvement in accidents were studied by Oltedal and Rundmo (2005) [42]. Using the mobile phone was investigated as a reason for car accidents by Brusque and Alauzet (2007) [43]. Some researchers discussed how to reduce the car accidents resulting in death and injuries. O'Neill and Mohan (2002) [44] studied how to reduce motor vehicle crash deaths and injuries in newly motorizing countries. Bener and Crundall (2005) [45] compared the road car accidents in United Arab Emirates, as a Middle Eastern country, to Western countries. They found careless driving and the behavior of drivers is the major reason for accidents in United Arab Emirates. This research utilized from other research articles in the way they presented their work and analyzed the problem and producing the solution. According to road safety management studies, it is extremely important to focus on five factors to get road safety Engineering, Enforcement, Education, Experience and Emergency [46]. These elements must be arranged and collected to reach the goal of road safety. There are many factors which contribute to road traffic accidents and traffic damages, and these factors can be divided into three categories; infrastructure of roads, unsafe vehicles and human errors [47]. According to study in road traffic accidents in India by Singh *et al.* in 2016 [48], the types of elements that lead to the road traffic accident and resulting damages are connected to that reasoning disease. According to study in road fatalities in Nigeria done by Agbonkhese *et al.* in 2013 [49], road traffic accidents represent a huge healthcare problems in Nigeria, where they are a major cause of mortality and morbidity there. Road traffic accidents, damages, and fatalities in Nigeria are considered a major public health problem. Since deadly accidents mostly include young men, which cause loss to families and the nation. A study made in the United Arab Emirates by Hassan *et al.* in 2012 [50] identified the following awareness, infrastructure, driving behavior, training and vehicle as some main elements supporting to traffic safety in the country. Statistical analysis of this study showed that road traffic accidents and injuries were acceptable from the Ministry of Interior in Abu Dhabi between 2007 and 2010. The number of traffic accidents and injuries turned over this period showed that the 18-35 age groups had the greatest rate of traffic fatalities and the old people group had the smallest traffic injury rate. A study about the consequences of speeding in the United Arab Emirates, increasing speed limits has a damaging effect on road safety was done by Manner and Wünsch-Ziegler in 2013 [51]. It showed that United Arab Emirates had a record of the number of road traffic accidents progressing on the road where a particular software is needed to check these kinds of accidents and to specify the speed of a vehicle before a clash between two vehicles happens. Other research studies by Tester *et al.* (2004) [52] and Antić *et al.* (2013) [53] discussed the speed humps; as it had been used all over the world as common to decrease the traffic calming. A speed hump is planning to slow the vehicles and reduce the amount of accidents. It is also a very important part of a street, because it is changing driver's behavior and gives the driver the time to react in surprise circumstances. Speed humps have a major benefit, which minimizes the number of children being injured. According to a study by Donnell (2013) [54] about bends of roads, he found that curvatures on the road will support the driver to decrease the velocity of the vehicle. Therefore, it will reduce the number of an accident on the roads. To make the road safer, it is needed to put a sharp bends, and in industrial areas, bends need to be widened.

3. RESEARCH METHODLOGY

All accident reports and records were kept by the traffic police department in Zarqa, the second biggest city in Jordan after the capital Amman, and the most crowded city in the country. Each accident report explains how the accident happened, when it happened, cars involved in the accident, information about drivers and passengers, weather, driving, vehicles involved in the accident and road conditions, and the causes of the accident. As these information were descriptive, and sometimes graphical with no categorization or classification of types or causes of accidents, this research found it a very good chance to analyze those accidents and study the causes of accidents statistically by classifying the accidents into three major categories; collision accidents, run over accidents and rollover accidents. The numerical data used in this research were extracted from the accident reports obtained from the traffic police department in Zarqa for all kinds of accidents which happened in the year of 2014. Data obtained from those accident reports were classified and arranged and categorized so that useful results can be

obtained. Each of the following sections discussed the data about certain category and type of accidents, starting with the general factors causing accidents, then go for the factors causing each kind of accidents separately; collision accidents, run over accidents and rollover accidents. Then the human factor error as a major cause for accidents was studied for each type of accidents. The last factor that was studied is the effect of the gender and age category on causing accidents. All types of accidents were studied whether the driver is male or female and concerning the age of that male or that female driver and comparison between the two genders of drivers were made.

This research hypothesis is based on studying the existence of different factors which cause accidents, and studying the relationship between those factors which affects having accident to take place. Those factors include the driver, the road condition, the car defects and the pedestrian mistakes. By studying the driver factor in more details, by relating the sex and age of the driver to having the accident takes place, then the main causes of accidents can be detected and described. That will lead into four major hypothesis; the accidents depend on the driver, the accidents depend the road condition, the accident depend on the car defects, and the accidents depend on pedestrian mistakes. Other hypothesis which should be tested as well are the accident dependence on the driver sex, male or female, and the accident dependence on the driver age. Hypothesis can be tested for car accidents in general and for each type of accidents as well.

3.1 Factors causing car accidents

In general, the car accidents were found to be caused by of the four major causes; driver error, road condition, car defects and pedestrian mistake. The driver error is expected to be unintentionally mistake made by the driver, which can be classified as human error, as human is subjected to make mistakes sometimes. The road condition is a factor when the road is not perfect to drive on. Like to be wet, icy, rough or has hard curves and jumps. The defects is a one of the main factors causing accidents. While that defect was there when the car started to run on the road, or whether the defect happened suddenly during running. Most car defects are related to tires, brakes and losing lights. The last main factor is the pedestrian mistakes which can be walking on the streets, cutting the street from places other than those specialized for pedestrians to cut the street at, and not following the regulatory signs. The number of accidents caused by each of these causes are shown in Figure-1, where the driver error represents the major cause with a total of 97981 accidents, followed by the car defect with 1455 accidents, then the pedestrian mistake caused 1322 accidents and the least cause was the road condition. The percentages of these causes are shown in Figure-2. Where the driver errors caused 96.8% of all accidents in the year of 2014 in that city. The accidents caused by car defects were around 1.4% of the total accidents. The pedestrian mistakes caused around 1.3% of the total mistakes that year and the road condition caused around 0.4% of the total accidents happened that year.

Based on percentages in Figure-2, the factors causing accidents can be formulated as follows:

Car Accidents = 96.8 Driver Errors + 0.5 Road Condition + 1.4 Car Defects + 1.3 Pedestrain Mistakes … (1)

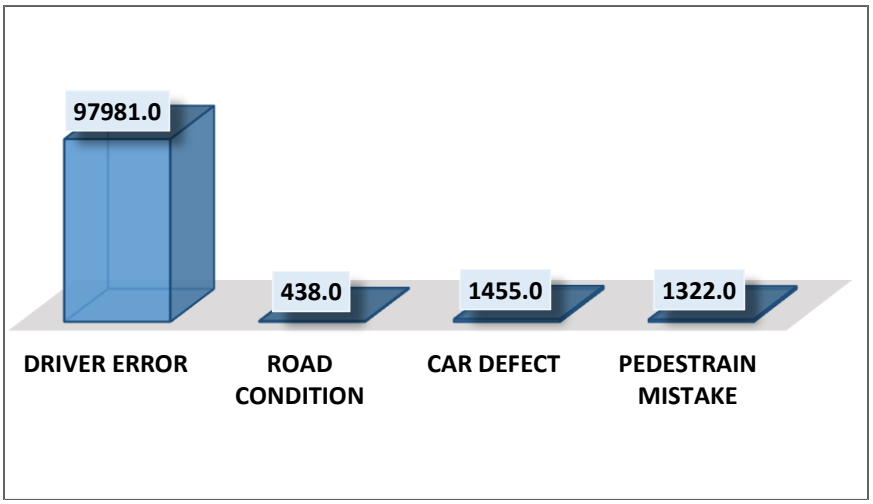

Figure-1. Main factors causing accidents.

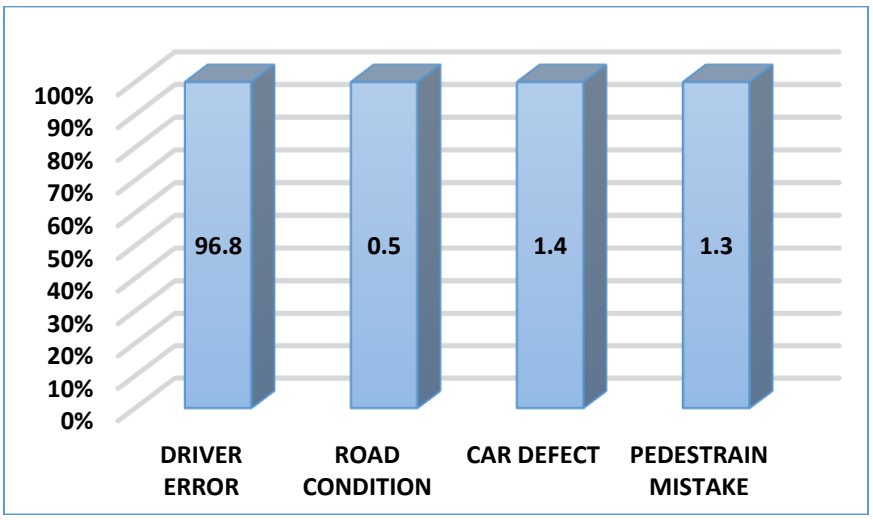

Figure-2. Percentage of factors causing accidents.

3.2 Factors causing car collisions

In this section only collision accidents were studied. The collision accidents were analyzed and the same four causes were considered to find that, as shown in Figure-3, 93940 collision accidents were caused by driver errors, 964 collision accidents were caused by the car defects and the remaining collision accidents of 411 were caused by the road conditions. As can be clearly seen in Figure-3, no collision accidents were caused by pedestrian mistakes.

Statistical wise, factors causing collisions can be expressed in the following equation:

Collisions = 98.55 Driver Errors + 0.43 Road Condition + 1.01 Car Defects …… (2)

It is noticed that most collisions are caused by driver errors, and collisions do not depend at all on pedestrian mistakes.

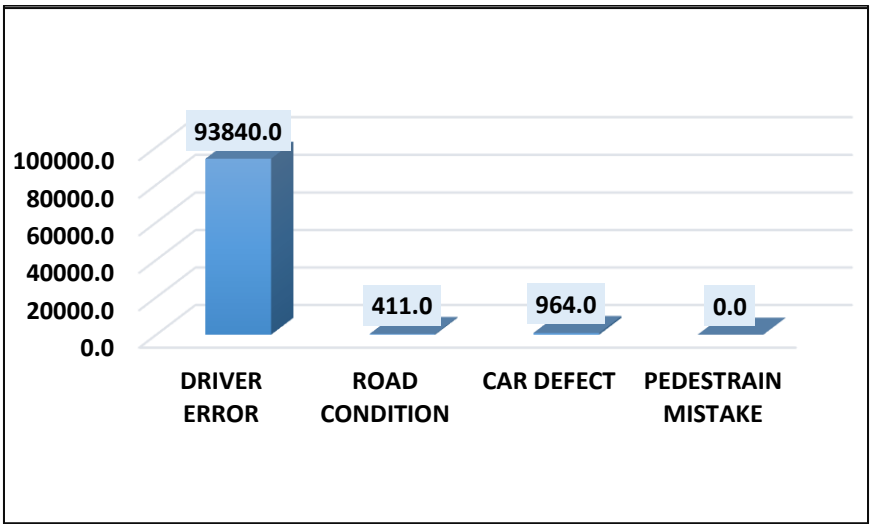

Figure-3. Main factors causing collision accidents.

3.3 Factors causing turn over accidents

In this section only turn over accidents were studied. The turn over accidents were analyzed and the same major four causes were considered to find that, as shown in Figure-4, 2452 turn over accidents were caused by driver errors, 1322 turn over accidents were caused by pedestrian, and mostly they are the ones involved in the accidents, 355 turn over accidents were caused by the car defects and the remaining turn over accidents of 17 were caused by the road conditions.

Statistical wise, factors causing turn over accidents can be expressed in the following equation:

Turn over = 59.14 Driver Errors + 0.41 Road Condition + 8.56 Car Defects + 31.89 Pedestrian Mistakes … (2)

It is noticed that most turn over accidents are caused by mainly by driver errors and pedestrian mistakes. Road conditions have almost same participation in turnover as it had it before in collisions.

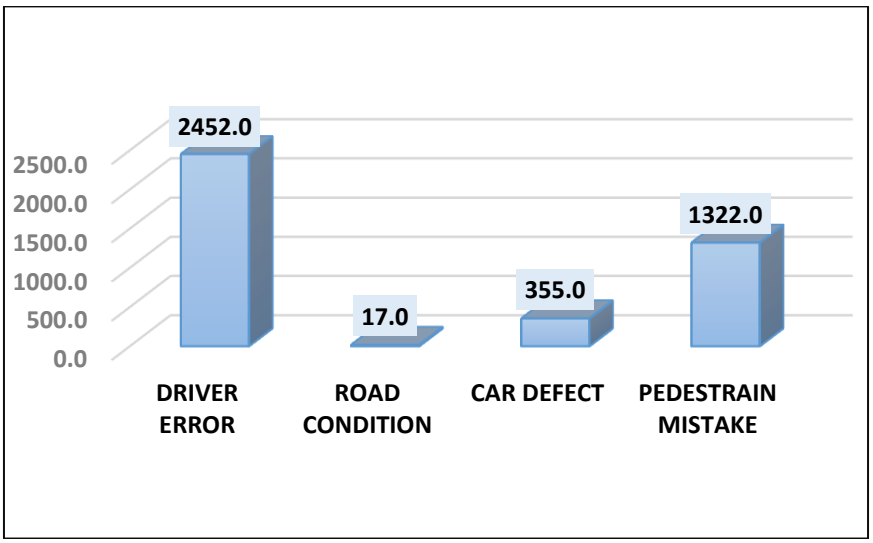

Figure-4. Main factors causing turn over accidents.

3.4 Factors causing rollover accidents

This section studied the factors causing rollover accidents. The rollover accidents were analyzed and the same four causes were considered to find that, as shown in Figure-4, 1689 rollover accidents were caused by driver errors, 136 rollover accidents were caused by car defects, 13 rollover accidents were resulted from road conditions and no rollover accidents were resulted from pedestrian mistakes.

Statistical wise, factors causing rollover accidents can be expressed in the following equation:

Rollover = 91.89 Driver Errors + 0.71 Road Condition + 7.40 Car Defects … (3)

As can be clearly seen that most rollover accidents are caused by driver errors. Again, pedestrian mistakes has no effect on rollover accidents.

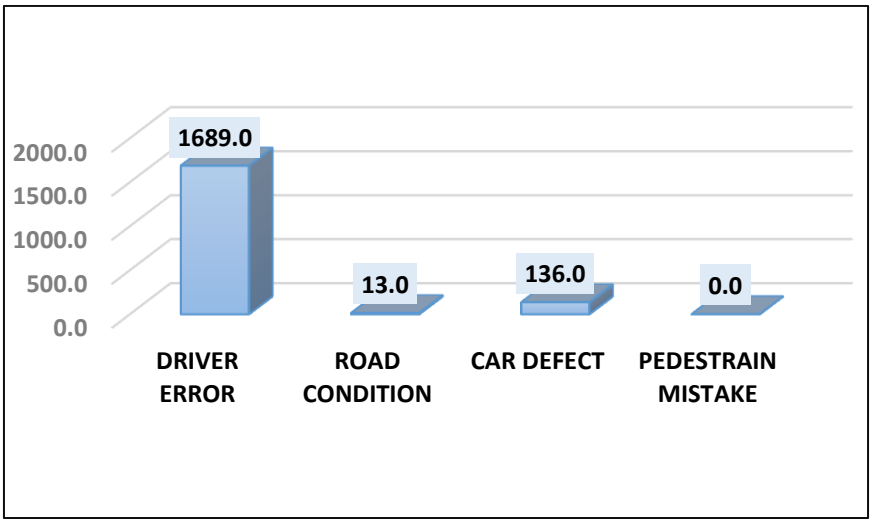

Figure-5. Main factors causing rollover accidents.

3.5 Driver errors causing accidents

As the driver error caused the highest percentages of all kinds of accidents, it has been studied in details in this section. Driver errors can be classified to thirteen types of errors according to Table-1.

Figure-6 shows a comparison between the thirteen types of driver errors which cause accidents. It can be seen that the most common error that causes accidents is E6, which is the tailgating. The least common driver error that causes accidents is E1, which is the driving opposite to traffic direction. All other driver errors causes accidents in the range between E1 and E6.

Table-1. The explanation of different types of drivers.

Error #	Drivers Error
E1	Driving Opposite to Traffic Direction
E2	Incorrect Overtaking
E3	Speed Limit Exceeding
E4	Incorrect Lane Using
E5	Incorrect Bending and Turning
E6	Tailgating
E7	Disregarding a Traffic Light Signal
E8	Disallowing Priority to Vehicle
E9	Disallowing Priority to Pedestrians
E10	Reversing Incorrect
E11	Failing to take correct Measurements during Driving
E12	Sudden Swerve
E13	Failing to Comply with Obligatory Signs

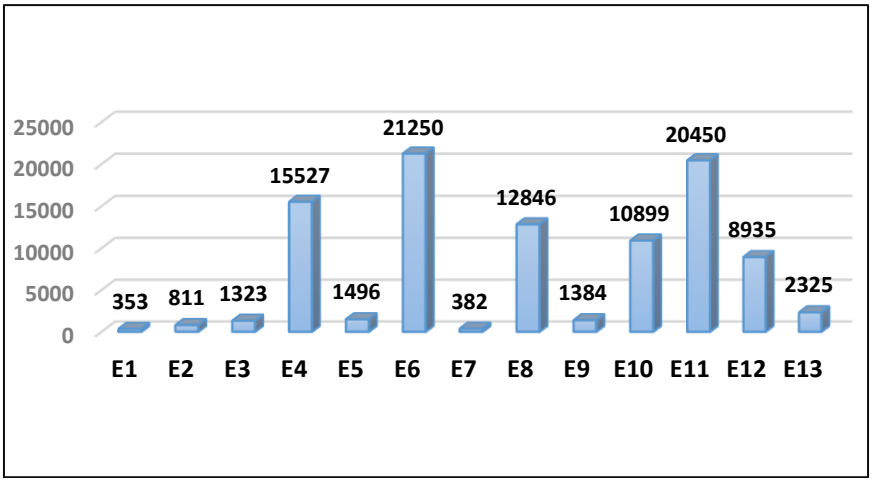

Figure-6. Comparison of driver errors causing accidents.

In analyzing collision accidents caused by driver errors, results are shown in Figure-7, where the most common driver error to cause more collision accidents is E6, which is the tailgating. The least common driver error that causes collision accidents is E1, which is the driving opposite to traffic direction.

Statistical wise, the accidents are caused by driver errors with different proportions as shown in the following equation:

$$\text{Accidents} = 0.36E1 + 0.83E2 + 1.35E3 + 15.85E4 + 1.53E5 + 21.69E6 + 0.39E7 + 13.11E8 + 1.41E9 + 11.12E10 + 20.87E11 + 9.12E12 + 2.37E13 \quad \ldots\ldots\ldots\ldots (4)$$

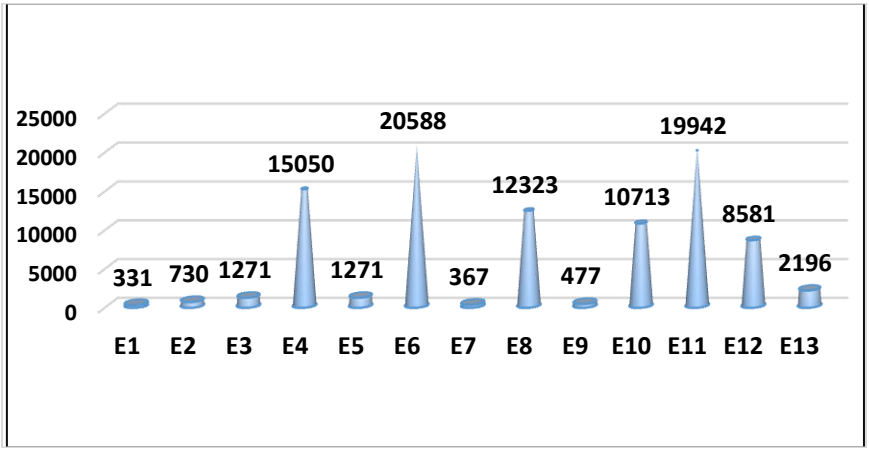

Figure-7. Comparison of driver errors causing collision accidents.

Analyses of run over accidents caused by driver errors, which are shown in Figure-8, shows that the most common driver error that causes more run over accidents is E9, which is disallowing priority to pedestrians. On the other hand, the least common driver error causing run over accidents is E7, which is disregarding a traffic light signal.

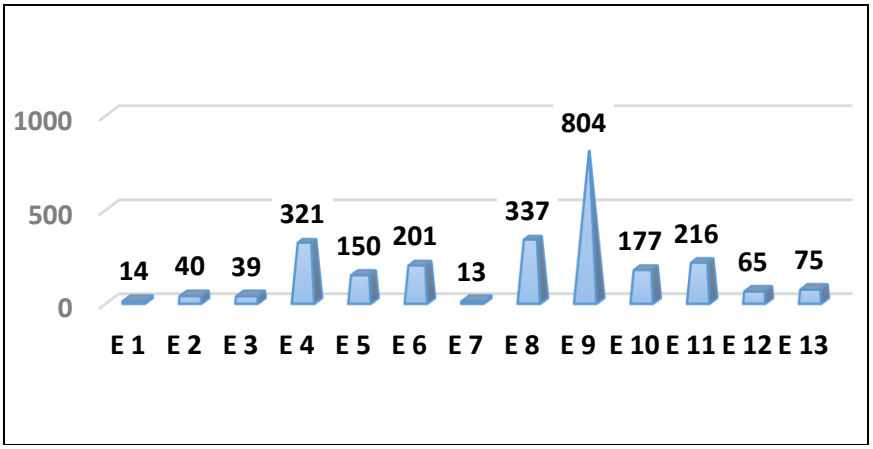

Figure-8. Comparison of driver errors causing run over accidents.

Figure-9 shows the analyses of rollover accidents caused by driver errors. It can be clearly seen that the most common driver error causing rollover accidents is E6, the tailgating, and the least common driver error causing rollover accidents is E7, which is disregarding a traffic light signal.

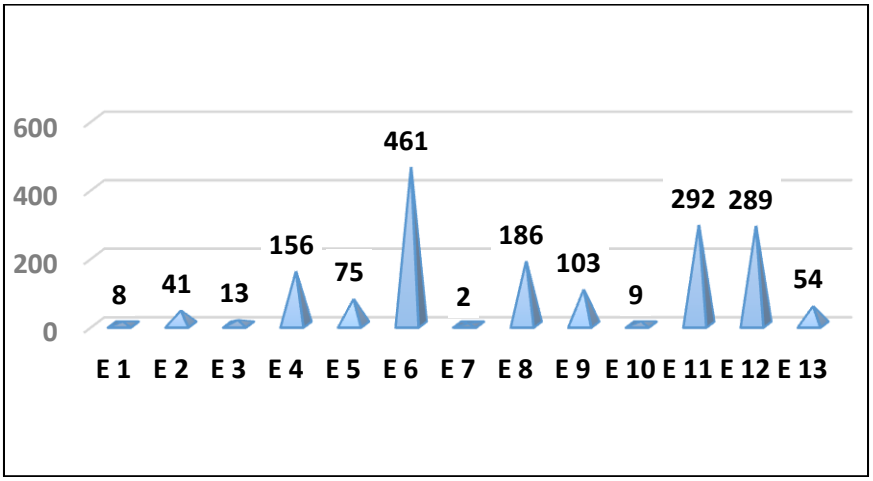

Figure-9. Comparison of driver errors causing rollover accidents.

Sometimes the driver errors cause fatality, sometimes they cause severe injury and sometimes they cause slight injury. Figure-10 shows a comparison between all kids of driver errors causing fatality. The most driver error causing fatality is E11, which is failing to take correct measurement during driving. On the other hand, it is found that in that year, E1, which is which is the driving opposite to traffic direction, did not cause any fatality. Figure-11 shows a comparison between all kids of driver errors and three possibility for each, fatality, severe injury and slight injury. All over summation of the three possibility, E11 has the highest, and E1 has the lowest summation.

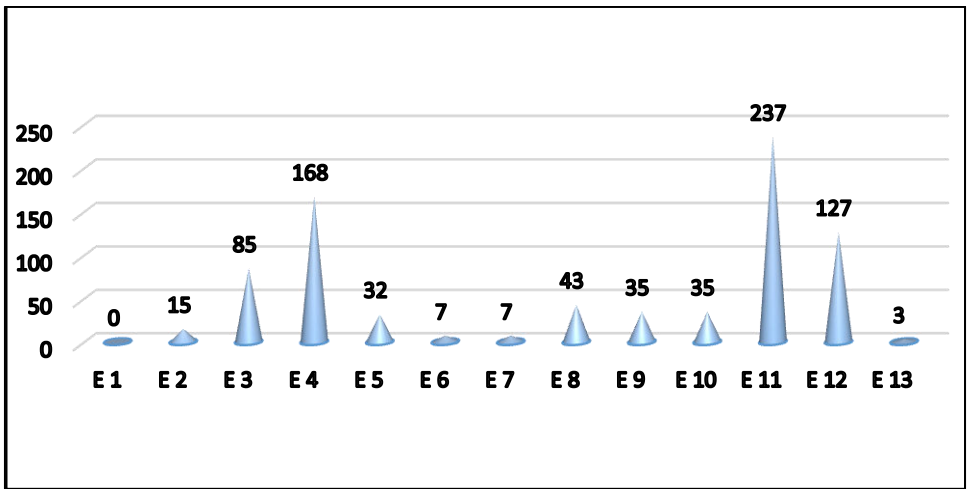

Figure-10. Comparison of driver errors causing fatality.

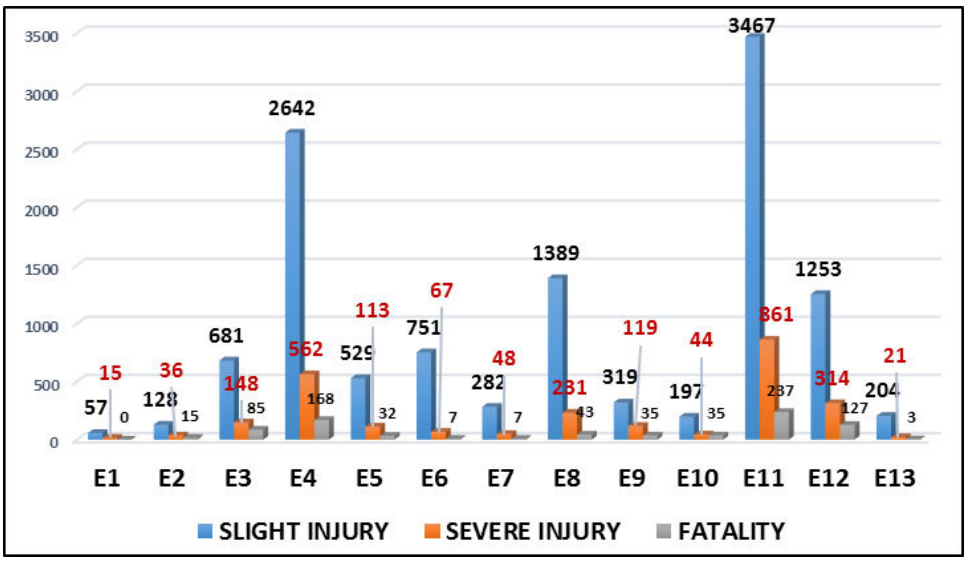

Figure-11. Comparison of driver errors causing injury and fatality

3.6 Comparison between males and females driver errors causing accidents

The analysis above was for driver errors, whether the driver is male or female. In this section the male driver accidents are counted separate from the female driver accidents. Again the analysis for female and male drivers are carried out for the three main kinds of accidents, collisions, run over and rollover accidents.

Equation (4) can be modified to Equation (5) to include the influence of males and females on each of the driver errors causing accidents.

Car Accidents = 0.36(0.73M+0.27F)E1 + 0.83(0.59M+0.41F)E2 + 1.35(0.76M+0.24F)E3 + 15.85(0.51M+0.49F)E4 + 1.53(0.52M+0.48F)E5 + 21.69(0.65M+0.35F)E6 + 0.39(0.78M+0.22F)E7 + 13.11(0.82M+0.18F)E8 + 1.41(0.32M+0.68F)E9 + 11.12(0.55M+0.45F)E10 + 20.87(0.50M+0.50F)E11 + 9.12(0.89M+0.11F)E12 + 2.37(0.82M+0.18F)E13 ….. (5)

Except E9, males cause more than 50% of each of all other errors. In case of E11, males and females share 50% each. E9 is the only error where females causes more accidents than females by this error. Even though, the

overall proportion of this error is only 1.35% of all accidents.

3.6.1 Comparison between males and females driver errors causing collision accidents

In this section the collisions accidents which made by male drivers are shown in Figure-12, based on the thirteen types of errors made by male drivers. For each type of error, the collision accidents are classified into three age categories. The first age category when the male driver is below 25 years old, the second category when the male driver is between 25 and 55 years old and the third category when the male driver is above 55 years old.

From Figure-12 it can be found that most of male driver collision accidents are resulted from E6, which is the tailgating. Male drivers below 25 years old made the highest number of collision accidents resulted from E8, which is disallowing priority to vehicle. The highest number of collision accidents made by the second age category, between 25 and 55 years old, and the third age category, above 55 years old, was a result of E6, the tailgating.

Comparing the three age categories of male drivers, it can be found that males below 25 years old made 25807 collision accidents that year. The second age category of male drivers, between 25 and 55 years old, made 19356 collision accidents, while the male drivers above 55 years old made 11533 collision accidents. That means more than 45% of collision accidents are caused by male drivers below 25 years old.

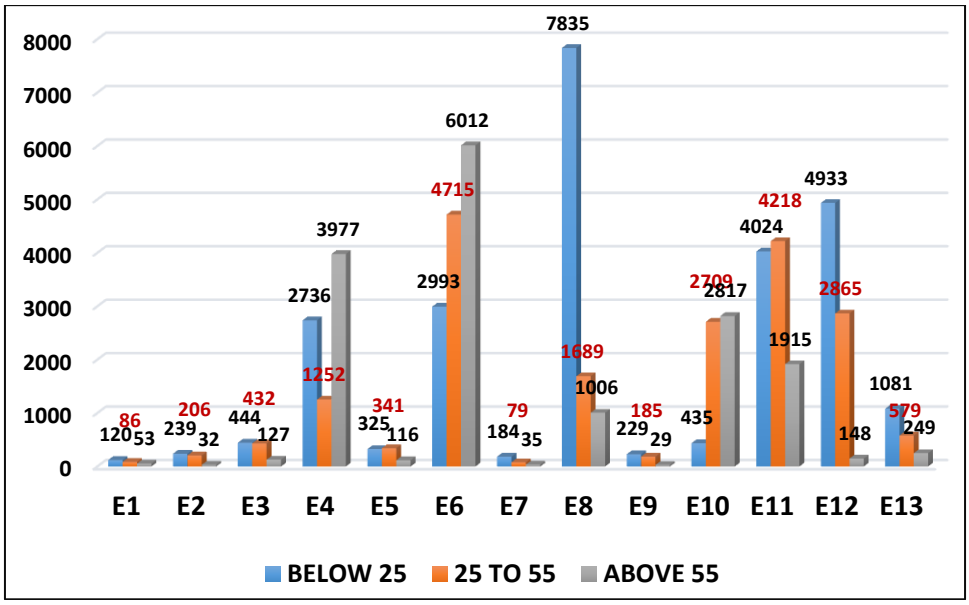

Figure-12. Collision accidents caused by males of 3-age categories.

Figure-13 shows the collision accidents made by female drivers of the same 3-age categories, below 25 years old, between 25 and 55 years old and the third category when female drivers are more than 55 years old. It can be easily found that most of female driver collision accidents are resulted from E6, which is the tailgating. Exactly as male drivers, which indicates it is not a matter of gender. The highest number of the collision accidents mad by female drivers in the youngest category was resulted from E8, disallowing priority to vehicles, which is again the same case for male drivers. The highest number of collision accidents made by the second age category, between 25 and 55 years old, and the third age category, above 55 years old, was a result of E6, the tailgating. Same results found for male drivers.

Comparing the three age categories of female drivers, it can be found that females below 25 years old made 9977 collision accidents that year. The second age category of female drivers, between 25 and 55 years old, made 12305 collision accidents, while the female drivers above 55 years old made 10108 collision accidents. That means the collision accidents made by female drivers are almost equal for the three age categories, with the highest percentage for the second category and the lowest for the first category, female drivers below 25 years old.

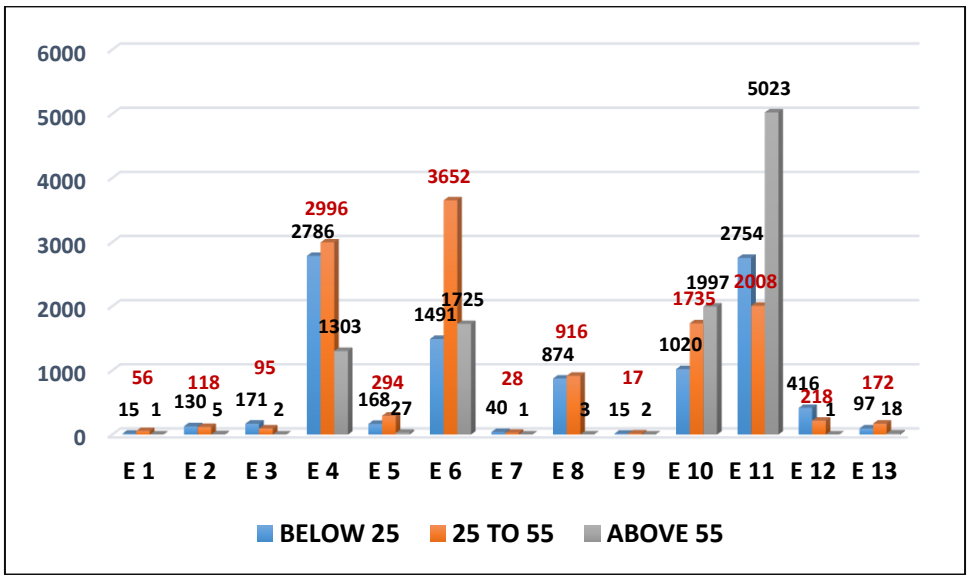

Figure-13. Collision accidents caused by females of 3-age categories.

Figure-14 shows a comparison between male and female drivers made collision accidents for each type of driver error. For all collision accidents, male drivers made 56696 collision accidents with a percentage of almost 63% and female drivers made 32390 collision accidents with a percentage of almost 37%. From Figure-14, it can be seen that for all types of error male drivers made more collision accidents than female drivers. The extreme case is E12, which is the sudden swerve, the male collision accidents were 7946 (93%) and by female drivers were 635 (7%) only. A close number of female and male drivers of collision accidents made is found for errors E4, which is incorrect lane using, and E11, which is failing to take correct measurement during driving.

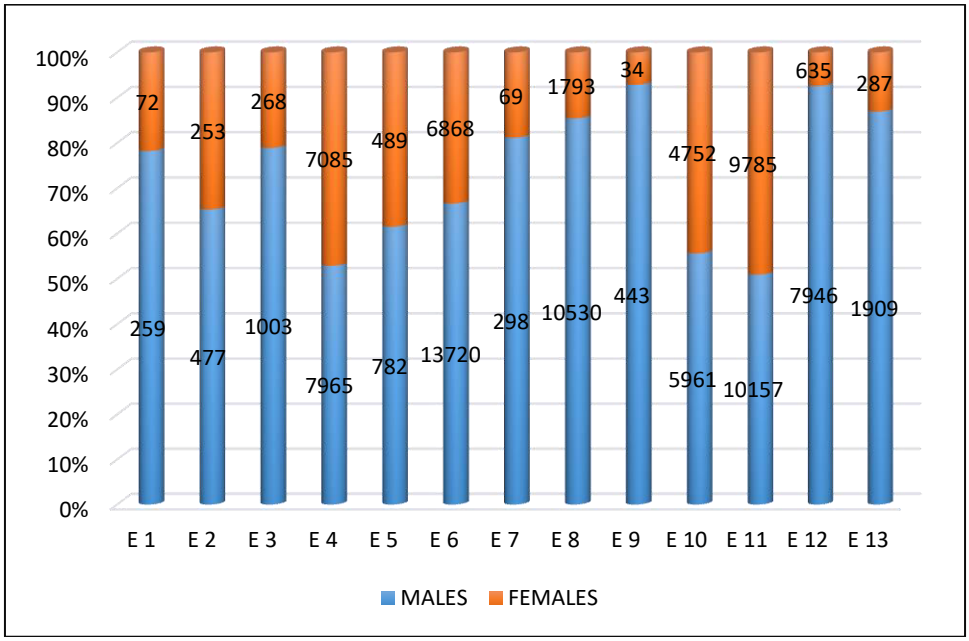

Figure-14. Comparison between males and females causing collision accidents.

3.6.2 Comparison between males and females driver errors causing run over accidents

In this section the run over accidents which made by male drivers are shown in Figure-15, based on the thirteen types of errors made by male drivers. For each type of error, the run over accidents are classified into three age categories mentioned before.

From Figure-15 it can be found that most of male driver run over accidents are resulted from E9, which is disallowing priority to pedestrians. Male drivers below 25 years old and in the second age category as well, made the highest number of run over accidents resulted from E9, which is disallowing priority to pedestrians. The highest number of run over accidents made by the third age

category, above 55 years old, was a result of E4, incorrect lane using.

Comparing the three age categories of male drivers, it can be found that males below 25 years old made 614 run over accidents that year. The second age category of male drivers, between 25 and 55 years old, made 848 run over accidents, while the male drivers above 55 years old made 457 run over accidents. That means more than 44% of collision accidents are caused by male drivers between 25 and 55 years old.

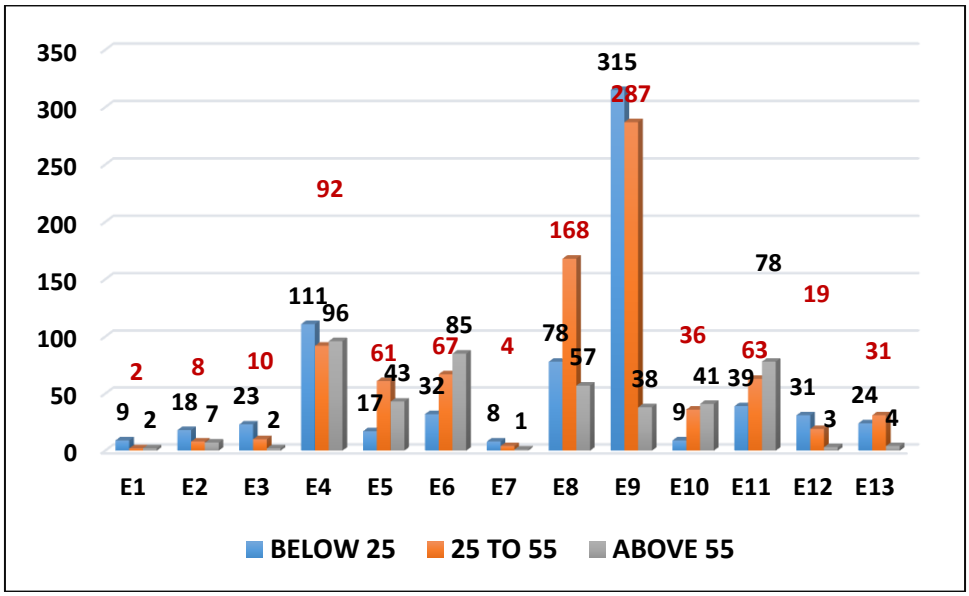

Figure-15. Run over accidents caused by males of 3-age categories.

Figure-16 shows the run over accidents made by female drivers of the same 3-age categories. It can be easily found that most of female driver collision accidents are resulted from E9, which is disallowing priority to pedestrians. Exactly as male drivers, which indicates again, it is not a matter of gender. The highest number of the run over accidents mad by female drivers in the youngest category, and the second age category was resulted from E9, disallowing priority to pedestrians, which is again the same case for male drivers. The highest number of run over accidents made by the third age category, above 55 years old, was a result of E10, reversing incorrect.

Comparing the three age categories of female drivers, it can be found that females below 25 years old made 165 run over accidents that year. The second age category of female drivers, between 25 and 55 years old, made 206 run over accidents, while the female drivers above 55 years old made 63 run over accidents. That means the run over accidents made by female drivers are mostly made the first two age categories, but female drivers above 55 years old made only 14% of the run over accidents made by females.

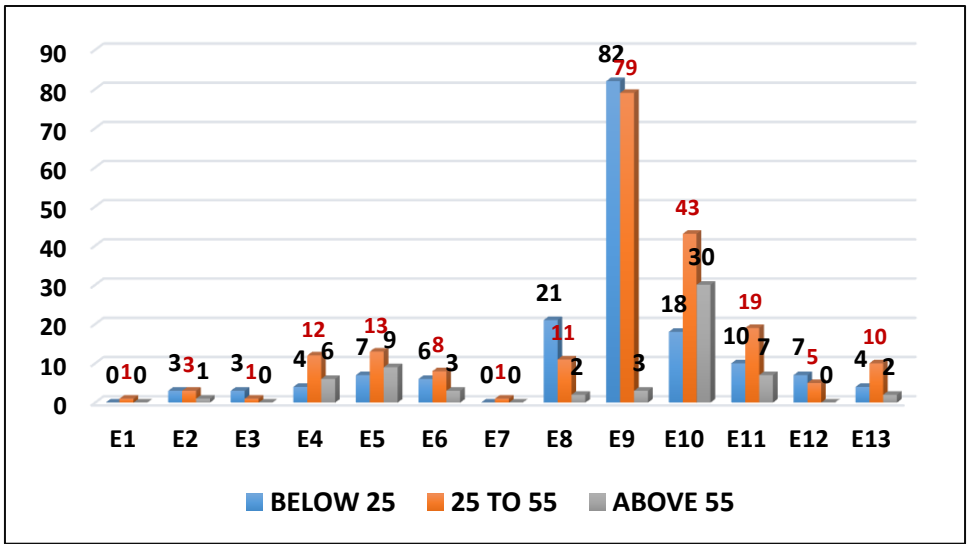

Figure-16. Run over accidents caused by females of 3-age categories.

Figure-17 shows a comparison between male and female drivers made run over accidents for each type of driver error. For all run over accidents, male drivers made 2018 run over accidents with a percentage of almost 82% and female drivers made 434 run over accidents with a percentage of almost 18%. From Figure-17, it can be seen that for all types of error male drivers made much more run over accidents than female drivers, except for E10, reversing incorrect, where female drivers made more run over accidents than female drivers, 51% vs 49%.

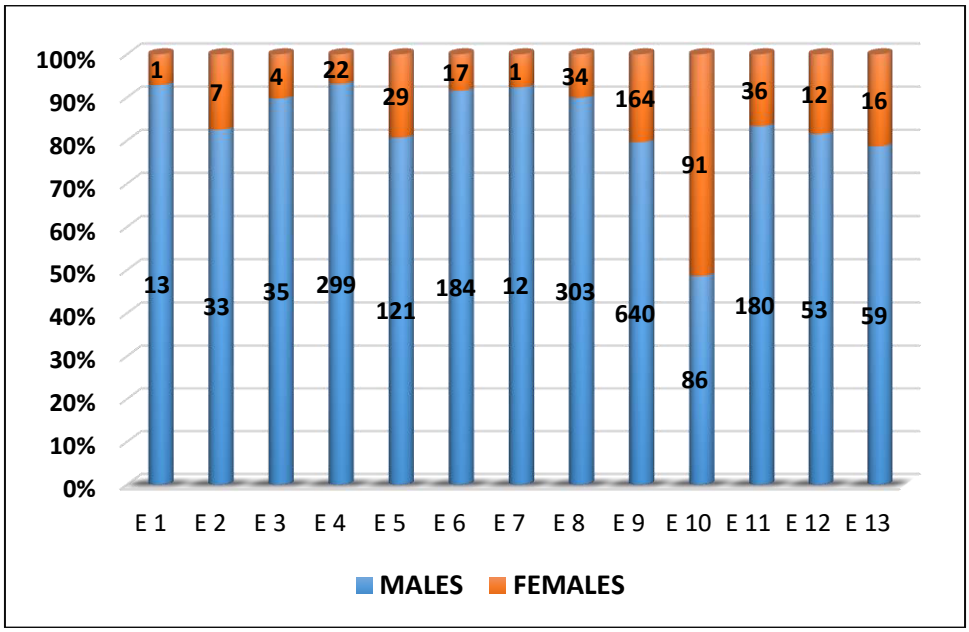

Figure-17. Comparison between males and females causing run over accidents.

3.6.3 Comparison between males and females driver errors causing rollover accidents

In this section the rollover accidents which made by male drivers are shown in Figure 18, based on the thirteen types of errors made by male drivers. For each type of error, the rollover accidents are classified into the three age categories mentioned earlier.

From Figure-18 it can be found that most of male driver rollover accidents are resulted from E6, which is tailgating. Male drivers above 55 years old, made the highest number of rollover accidents resulted from E6. The highest number of rollover accidents made by the first age category, below 25 years old, was a result of E12, sudden swerve, while the highest number of run over accidents made by the second age category, between 25 and 55 years old, resulted from E6.

Comparing the three age categories of male drivers, it can be found that males below 25 years old made 524 rollover accidents that year. The second age category of male drivers, between 25 and 55 years old, made 449 rollover accidents, while the male drivers above 55 years old made 454 rollover accidents. That means the distribution of rollover accidents on male driver age categories was almost equal.

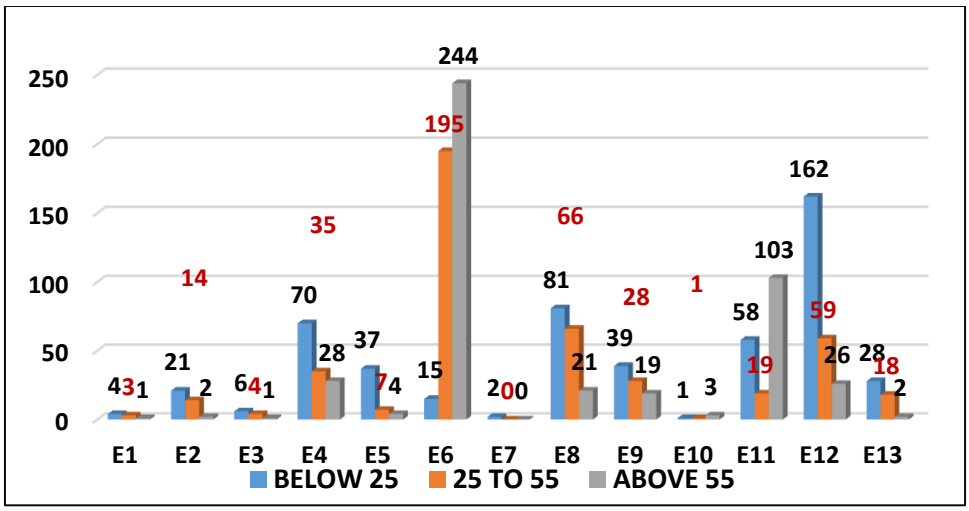

Figure-18. Rollover accidents caused by males of 3-age categories.

Figure-19 shows the rollover accidents made by female drivers of the same 3-age categories. It can be easily found that most of female driver rollover accidents are resulted from E11, which is failing to take correct measurements during driving. The highest number of the rollover accidents mad by female drivers above 55 years old and were resulted from E11.

Comparing the three age categories of female drivers, it can be found that females below 25 years old made 106 rollover accidents that year. The second age category of female drivers, between 25 and 55 years old, made 86 rollover accidents, while the female drivers above 55 years old made 70 run over accidents. That means the rollover accidents made more by young female drivers.

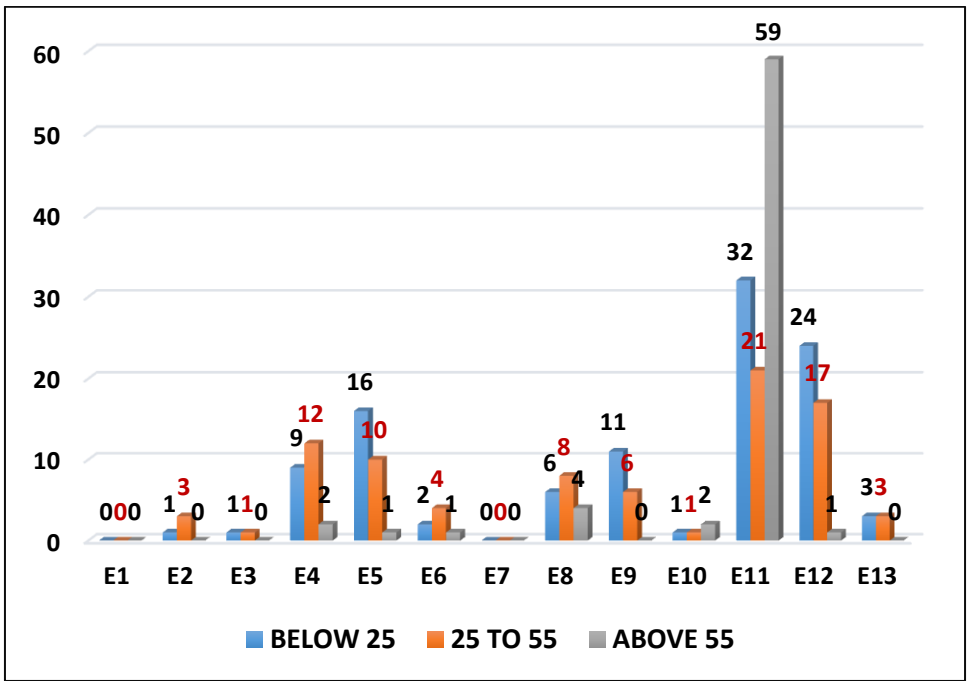

Figure-19. Rollover accidents caused by females of 3-age categories.

Figure-20 shows a comparison between male and female drivers made rollover accidents for each type of driver error. For all rollover accidents, male drivers made 1427 rollover accidents with a percentage of almost 84.5% and female drivers made 262 rollover accidents with a percentage of almost 15.5%. From Figure-20, it can be seen that for all types of error male drivers made much more rollover accidents than female drivers, except for E10, reversing incorrect, where percentage of rollover accidents by males and females is very close.

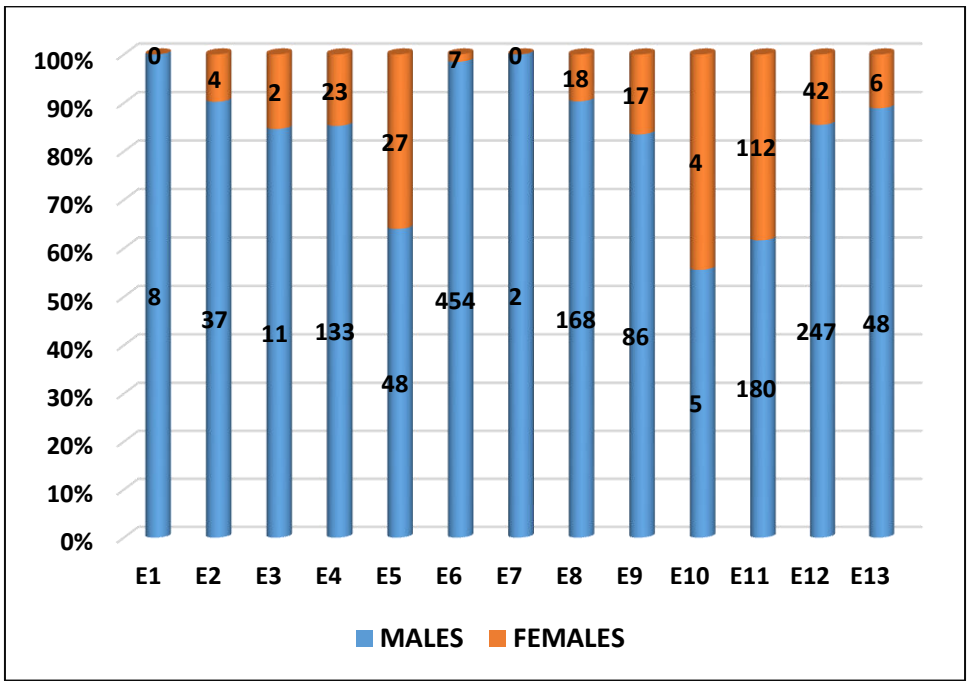

Figure-20. Comparison between males and females causing rollover accidents.

4. TEST OF HYPOTHESIS AND SIGNIFICANCE OF RESULTS

To investigate the statistically significance of the results, a one tailed test of hypothesis was used with a significance level (α) of 0.05. In each case we need to test the significance of the effect of a certain factor on accidents, as represented Tables 2, 3, 4 and 5 below, the null hypothesis H_0 is defined considering one of the factors to be tested, and the mean accidents caused by that tested factor is compared to the mean of total number of accidents caused by all factors. And so, in the test of hypothesis, the null hypothesis is assumed to be true.

4.1 Test of hypothesis for main causes of accidents

For the first tested cause (driver error), the test of hypothesis will be as follows:

$H_{0:}$ Mean of accidents caused by (driver error) = Mean of total accidents

$H_{A:}$ Mean of accidents caused by (driver error) < Mean of total accidents

The hypothesis can be explained as, if the sample of accidents caused by that factor of study is statistically with 0.05 one sided error, equals to the total accidents mean, then that factor is statistically significant to be a major cause of accidents.

For this hypothesis testing, the normal distribution is assumed as the number of accidents is too large, and as the standard deviation of each tested sample is known. The critical value can be calculated and compared to the one tail of the corresponding value to α of 0.05, which is -1.645. Based on that, as the calculated *z* test statistic value is less than -1.645, then we reject H_0 and we can accept H_A. If the z statistic value is between -1.645 and zero, then we cannot reject H_0, which means we can accept H_0. Accepting the null hypothesis means that cause of study is statistically is considered a major cause of accidents. The one sided tail is used because we never expect the mean of the tested sample to be higher than the mean of the total population of accidents.

In calculating the z-test statistic, the following formula was used:

$$z=(x-\mu)/(s/\sqrt{n}) \quad (1)$$

Where:

x is the mean of the sample of accidents caused by that cause of study

μ is the mean of the population of accidents

s is the sample standard deviation

n is the sample size

Another measure to have the results are statistically significant, we need to have P less than 0.05, the significance level, so that H_0 will be rejected. If P value is more than 0.05, then we fail to reject H_0, which means we accept H_0. Accepting H_0 means the average of accidents caused by that category equals statistically to the mean of all accidents caused by all categories, which means that category can be statistically significantly considered as a major cause of accidents.

The hypothesis above is tested for other factors of the same category as well; the road condition, the car defect and the pedestrian mistake. The corresponding *z* test statistic values are summarized in Table-2. Only *z* test statistic values above -1.645 are given special attention.

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Table-2. The *z* test statistic values for car accident factors.

Factor	Accidents	Collision	Rollover	Turn over
Driver Error	**-0.920**	**-0.312**	<-1.645	**-0.313**
Road Condition	<-1.645	<-1.645	<-1.645	<-1.645
Car Defect	<-1.645	<-1.645	<-1.645	<-1.645
Pedestrian Mistake	<-1.645	<-1.645	<-1.645	<-1.645

As Table-2 shows, sixteen hypothesis were tested, and thirteen of them showed that H_0 is rejected, which means driver error is not a major factor of rollover accidents, road condition is not a major factor of accidents, collisions, rollover or turn over accidents, car defect is not a major factor for any type of accidents and so the pedestrian mistakes. Only three hypothesis with a z test values greater than -1.645 showed that H_0 is accepted, and concluded that the driver error is a major factor for accidents in general and for collision accidents and for turnover accidents as well. May be the responsibility of rollover is shared between drivers and pedestrian, that is why neither this nor that formed a major factor for this type of accidents.

4.2 Test of hypothesis for errors of driver

To investigate which of the driver errors can be statistically significant factor for accidents, the following hypothesis was tested each time for each of the thirteen driver errors:

$H_{0:}$ Mean of accidents caused by (Ei) = Mean of total accidents caused by driver error

$H_{A:}$ Mean of accidents caused by (Ei) < Mean of total accidents caused by driver error

Where I goes from 1 to 13. Results for the *z* test statistic values for different accident types are shown in Table-3.

Table-3. The *z* test statistic values for driver errors.

Error	Accidents	Collision	Rollover	Turn over
E1	<-1.645	<-1.645	<-1.645	<-1.645
E2	<-1.645	<-1.645	<-1.645	<-1.645
E3	<-1.645	<-1.645	<-1.645	<-1.645
E4	<-1.645	<-1.645	<-1.645	<-1.645
E5	<-1.645	<-1.645	<-1.645	<-1.645
E6	<-1.645	<-1.645	<-1.645	<-1.645
E7	<-1.645	<-1.645	<-1.645	<-1.645
E8	<-1.645	<-1.645	<-1.645	<-1.645
E9	<-1.645	<-1.645	<-1.645	<-1.645
E10	<-1.645	<-1.645	<-1.645	<-1.645
E11	<-1.645	<-1.645	<-1.645	<-1.645
E12	<-1.645	<-1.645	<-1.645	<-1.645
E13	<-1.645	<-1.645	<-1.645	<-1.645

As all *z* test statistic values for driver errors shown in Table-3 are less than -1.645, then in all the fifty two tests performed, the H_0 is rejected, which means none of the thirteen driver errors forms a major factor for accidents in general or to any specific type of accidents.

4.3 Test of hypothesis for the driver gender

To investigate if the driver gender, male or female can be considered statistically significant factor for accidents, the following hypothesis was tested for accidents in general and for each type of accidents:

$H_{0:}$ Mean of accidents caused by (Male) = Mean of total accidents

$H_{A:}$ Mean of accidents caused by (Male) < Mean of total accidents

Then males are replaced by females and the hypothesis is tested again. Results for the *z* test statistic values for male and female drivers are shown in Table-4.

Although males were found to cause 64895 (66%) of total accidents resulted from driver error, and females caused 33086 (34%), but significance wise, as the z test value were found to be less than -1.64, it cannot be

approved that males or females are major factor of accidents.

In the same direction, males caused around 61450 of collision accidents (65%), and females caused 32390 of collision accidents (35%), but significance wise, it could not be proved that males are one of the major factors of accidents as the z test statistic value is outside the confidence interval. Same for females, significance wise, they are not a major factor of collision accidents.

In case of rollover accidents, the z statistic test was found to be -0.86, which means we accept $H_{0.}$ That means, males are statistical wise form a major factor of rollover accidents. Same results were found for turn over accidents, were the z statistic test value was found to -0.62, which implies we accept $H_{0.}$ That means statistical wise; males are considered a major factor of turn over accidents. On the other hand, as the z test statistic vales for females in both rollover and turn over accidents are less than -1.645, then H_0 is rejected in both cases and females are not considered as a major factor in rollover or turn over accidents.

Table-4. The *z* test statistic values for males and females.

Driver Gender	Accidents	Collision	Rollover	Turn over
Male Driver	<-1.645	<-1.645	**-0.86**	**-0.62**
Female Driver	<-1.645	<-1.645	<-1.645	<-1.645

4.4 Test of hypothesis for different age categories

To investigate if the driver age category can be statistically significant factor for accidents in general or in any type of accidents, the following hypothesis was tested each time for each of the thirteen errors:

$H_{0:}$ Mean of accidents caused by (Below 25) = Mean of total accidents

$H_{A:}$ Mean of accidents caused by (Below 25) < Mean of total accidents

Same hypothesis was tested for the other two age categories, between 25 and 55 and above 55 years category. Results for the *z* test statistic values for different accident types are shown in Table-5. All results summarized in Table 5 show that all z test statistic values are found to be less than -1.645, which means in all twelve tested hypothesizes, the H_0 is rejected. That implies no age category can be significantly form a major factor of accidents in general, or to any specific type of accidents.

Table-5. The *z* test statistic values for different age categories.

Age Category	Accidents	Collision	Rollover	Turn over
Below 25	<-1.645	<-1.645	<-1.645	<-1.645
25 to 55	<-1.645	<-1.645	<-1.645	<-1.645
Above 55	<-1.645	<-1.645	<-1.645	<-1.645

5. DISCUSSION OF THE RESULTS

Investigating the factors of car accidents showed that 96.8% of accidents resulted from drivers' errors, 1.4% to car defects, 1.3% to pedestrian mistakes and 0.4% to road conditions. The car accidents were classified into three main types; car collision accidents, run over accidents and rollover accidents. Out of 95215 collision accidents happened that year, 98.5% of them were caused by drivers' errors. 59% of run over accidents were caused by drivers' errors, 32% by pedestrian mistakes, less than 1% caused by car defects and very few caused by road condition. For rollover accidents, around 92% of them were caused by drivers' errors, the rest by car defects, very few by road condition and none caused by pedestrians. Based on that, the drivers' errors were studied and classified into 13 types of errors. E6, tailgating, was found to cause the maximum number of accidents, followed by E11, failing to take correct measurements during driving. E1, which is the driving opposite to traffic direction, was a factor for the least number of accidents. Tailgating is a result mainly of crowded streets, and drivers learn to keep a distance, accidents will be significantly reduced. Also some education for driving to take correct measurements during driving will help to reduce car accidents. From E1 results it is clear that drivers are aware of risk of driving opposite to traffic direction.

E6 was the factor of highest number of collision accidents and the rollover accidents, E9, which is Disallowing Priority to Pedestrians, was found to be the factor of the highest number of run over accidents. The error that caused the maximum number of fatalities was E11, failing to take correct measurements during driving.

Comparing accidents caused female with male drivers' errors, it was found that for collision accidents, male drivers made 56696 collision accidents with a percentage of almost 63% and female drivers made 32390 collision accidents with a percentage of almost 37%. It is high percentage for females if it is realized that the percentage of female drivers is less than 25%. For all run over accidents, male drivers made 2018 run over accidents with a percentage of almost 82% and female drivers made 434 run over accidents with a percentage of almost 18%. That clearly shows that males causing more run over accidents than females. For all rollover accidents, male

drivers made 1427 rollover accidents with a percentage of almost 84.5% and female drivers made 262 rollover accidents with a percentage of almost 15.5%. Here also male drivers causing more rollover accidents than females.

For each male and female driver, they were categorized into three age categories; below 25 years old, between 25 and 55 years old, and above 55 years old. It was found that the most of male and female driver collision accidents are resulted from E6. But in case of males, males below 25 years old caused the highest number of collision accidents with E8. On the other hand, females with ages above 55 years old caused the highest number of collision accidents with E11. Less curiosity was the reason in case of males, and lower ability to focus in driving was the reason in case of females. In all types of errors, males are causing more collision accidents than females.

For run over accidents, the most of male and female driver run over accidents are resulted from E9. For both male and female drivers, the highest number of run over accidents was caused by E9 and by the age category below 25 years old. That was a result of driving faster with less driving experience by that age category. In all types of errors, males are causing more run over accidents than females except for E10, where females have problem in reversing compared to male drivers.

For rollover accidents, the most of male and female driver rollover accidents are resulted from E6 and E11, respectively. For both male and female drivers, the highest number of run over accidents was caused by the age category above 55 years old, by E6 in case of males and E11 in case of females. In both cases, males and females, all age categories caused close number of rollover accidents, which indicates that causes of rollover is common between all drivers. For all error types, males caused more rollover accidents than females. E10 has close results for males and females and no rollover accidents caused by females by E1.

In summary, most of the car accidents are caused by drivers' errors (96.8%), then by car defects (1.4%) and pedestrian mistakes (1.3%) and very few by road condition (0.4%). Collision accidents were caused by drivers' errors (98.5%), car defects (1%) and road condition (0.5%). Run over accidents were caused by drivers' errors (59%), pedestrian mistakes (32%), car defects (8.5%) and road condition (0.5%). Rollover accidents were caused by drivers' errors (92%), car defects (7.4%) and road condition (0.6%). Based on that, human factors and driving qualifications need to be improved to reduce accidents.

Thirteen types of driver errors were found to cause car accidents. The most two serious causes of accidents were failing to take correct measurements during driving and tailgating. These two causes are directly related crowded streets and exceeding the roads capacity. The third major driver error causing accidents is incorrect lane taking. That is mainly related to missing street marking paints. Failing to take correct Measurements during Driving and incorrect lane using are the two major fatal causes of accidents.

It was found male young drivers are causing more accidents than old drivers. It is not the case for female drivers, where young females caused less accident than old females and the middle age females who made the highest number of accidents. As formal statistics indicated that 25% of the drivers are females, it was found that 37% of collision accidents caused by females. Based on female drivers percentage of 25%, that means female drivers caused more collision accidents than male drivers. Run over accidents caused by females were 18% only. That means males caused more run over accidents than females. Female drivers caused around 15.5% only of rollover accidents, which means males caused more rollover accidents than female drivers as well.

6. CONCLUSIONS

To minimize the human and economic losses resulting from car accidents in Jordan, as an example of Middle Eastern and third world countries, the factors of car accidents were studied for the year of 2014. Based on the statistical analysis of the 2014 accidents, the following conclusions can be drawn:

- Statistical analysis showed that only driver errors can be a major factor for accidents in general and for collision and turn over accident types in specific. Rollover accident responsibility can be shared by driver errors and pedestrian errors, but statistical wise none of them can be the major factor for this type of accidents.

- Thirteen types of driver errors were found to factor car accidents. Whereas the most two serious factors of accidents were failing to take correct measurements during driving and tailgating, no statistical significance could be found to say these two errors are the major factors of accidents in general or to any specific type of accidents.

- No statistical significance could be found for the effect of gender or age category on being a major factor of accidents.

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