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Statistical Analytical Study of Traffic Accidents and Violations in the State of Kuwait and Its Social and Economic Impact on the Kuwaiti Society

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Abstract Traffic accidents and their effects become one of the most important and dangerous challenges facing the community and individuals in their daily lives in the modern age, and because of the resulting deaths, reaching nearly one million and three hundred thousand cases a year and various dangerous injuries close to the fifty million cases taking into account their different consequences on the social and economic life, this is in addition to traffic violations and their impact on traffic and community public safety. Therefore, this research aims to analytical study of traffic accidents and traffic violations committed by the driver in the State of Kuwait through the study of the number of vehicles and accidents, injuries and deaths that result from these accidents in addition to the number of violations that are continuously growing and the amounts collected from committing such violations and study the relationship between them through its adaptation to some of the different statistical models and appropriate probability distributions for forecasting the coming years. The study also aims to identify the social and economic effects on the Kuwaiti society, as well as the role of government and institutions to reduce these repeated accidents and violations through the development of laws, policies and rehabilitation programs, which include some of the behavioral aspects and the process of rehabilitation and reduce the aggravation of these dangerous phenomena and costly burdens in the human life and stability in the community enjoying traffic public safety.

Keywords: *accidents, violations, statistical analysis, statistical and probabilistic models, predict or forecast*

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1. Introduction

Traffic accidents and the resulting deaths injuries form one of the most modern-day problems, Traffic Incidents today tops the list of causes of serious injuries and mortality in some countries of the world, particularly among countries of Middle East, which are suffering from the effects of the heavy losses, which include social and economic impacts and other related traffic and environmental problems. In addition to the failure of traffic accidents from social tragedies, they also represent the costs and burdens of economic terms, which cost the developing world between 2 to 4% of GDP annually. Add to that the human losses left by traffic accidents is inversely related to urban growth and the progress of societies, especially since the vast majority of victims of traffic accidents are young and productive elements in society. For example, according to statistics released by the US "Prevention Center for Disease Control", more than 2.5 million of Americans enter emergency rooms annually because of the doubling of injuries caused by road accidents which led to the doubling of the economic costs and medical care to more than 18 billion dollars a year. Saudi Arabia and the Arab Republic of Egypt have been ranked in first place in the world in the number of traffic accidents.

Many countries have realized the importance of traffic safety and mutual relationship between traffic safety and economic and social growth, and developed plans, procedures and precautions which aims to raise the level of traffic safety and reduce the economic and human losses as well as reduce their effects and harms. Where it is allocated separate budgets for plans and projects that include traffic safety studies and the implementation of the engineering improvements and treatment of hazardous accident and emergency sites and awareness education and others. Results interest of traffic safety issues has started to become clear in many countries, where a recent study, explained that resulting from road accidents deaths in Western Europe have fallen by 10% over the last ten years, and in return the proportion resulting from road accidents deaths in the Middle East region raised by 20% for the same period.

Gulf societies experiencing years ago a clear movements towards more openness, freedom and democracy, also, by increasing incomes and progressing the modern technology has increased the need for acquisition of vehicles of different types luxury ones and normal because of movement to and from any place, whether for business, entertainments or any other things

has become an urgent necessity in the era Modern vehicle use and acquisition where barely empty house of vehicle or more at least as well as public and private transport in all its forms. Consequently, Gulf cities and the world in general has become crowded vehicles and is growing rapidly from year to year, which led to increased traffic accidents, injuries and deaths caused by them to become one of the highest and most dangerous of the other non-traffic incidents and the resulting injuries and deaths, and also led to the increase of traffic violations and to the cost of this material irregularities, and therefore, the increase of traffic accidents and violations had a significant and profound impact in social life and the stability of families, as well as on the economic situation in particular and the national economy in general.

In the Kuwaiti society, in particular, Kuwaitis had more freedoms and openness to keep up with this massive and rapid development of modern technology as Gulf societies in the acquisition of vehicles of different types, and the State of Kuwait, like other countries are suffering from traffic problem which forms traffic accidents and congestion and then slow traffic and pollution of the environment. Also, in light of the statistics available, the size of the problem in the State of Kuwait is significant, it occupies a position between the countries that suffer from severe losses as a result of traffic accidents where it was found that the size of the losses from injuries and deaths as a result of traffic accidents in the year 1994 amounted to about 2309 with an average of 1357.6 injury and death per million of citizens and residents alike.

Perhaps what increases the seriousness of the situation that traffic accidents occupies the first place among the various causes of death, in young age (twenty) and thus maximizes the loss for the Kuwaiti rising young that looking to its youth as the hardware and future pillar home. In 1995, among a total of 24045 accidents reached, resulted in 2265 of injuries and deaths with lack of 44 cases with respect to 1994, with an average decrease of 1.9%. These incidents, despite their importance does not represent the only loss resulting from traffic accidents, there is also the economic impact of these losses as well as losses due to slow traffic in some areas or times of congestion and losses caused by environmental pollution resulting from the movement of vehicles and the use of public roads.

Therefore, it is necessary to study the traffic problem as analytical statistical study to determine the main causes of the problem in all its including aspects to reduce them so as to reflect the positive impact on society of social and economic aspects to reach the high levels of security and traffic safety.

This research will address an important issue of the traffic problem and the most serious one which is traffic accidents and their resulting mortality and injuries as well as traffic violations and amounts collected, taking into account the surprising increasing number of vehicles and study it as an analytical statistical study and work to provide statistical and probability models that aligned with the study data for the years between 2002 to 2013 in addition to predict the future data from 2014 to 2020 in order to identify the problem and to develop an appropriate suggestions and recommendations to reduce this serious problem, which has become alarming because of its social and economic implications affecting the safety of the citizen and the national economy in the State of Kuwait.

In addition, this research aims to identify the role of the government and various institutions to reduce these accidents and the repeated violations through the development of laws, policies and rehabilitation programs, which include some behavioral and practical aspects in order to process of rehabilitation and reduce the aggravation of these dangerous phenomena and costly burdens in human life and stability in the community enjoying public safety traffic.

2. Literature Review

Traffic accidents are considered of the most disturbing phenomena in all societies, whether in the industrial and technological developed countries of the world or those non- industrial and technological developed countries, but there is of course a difference in the quantity and quality of these accidents between those communities due disparities and differences in the type and number of traffic accidents in often to the driver himself in spite of the presence of many overlapping reasons leading to the accident. There is no doubt that the road type and different in terms of presentation and breadth and surrounded by rocks and trees and others are cause of accidents' causes in addition to the vehicle, which is considered a catalyst in a series of causal factors of accidents as well as the driver, who has the primary role in accidents and of cultural, educational and age driver characteristics and psychological characteristics all play a prominent role in the occurrence of traffic accidents. Now we will review some of the previous studies, which have one way or another related to the subject of the study.

Abdul Al-Aal [3] asserted that the presence of unexpectedly thoughtful intersections in the streets with those devoid of signage for drivers is of the causes of traffic accidents, this is in addition to that of the vehicle and maintenance of effect in the proportion of accidents in the community and this requires frequent maintenance and patrol vehicle for suitability for driving and thus to avoid the occurrence and avoid traffic accidents resulting from it.

Al-Saif [6] has indicated in his study that traffic accidents will be less between the categories of advanced educational level which lead to give experience and raise the efficiency and good disposition with developments in the road. The emotional factors and psychological negative trends toward some social situations in everyday life lead to the psychological state of a turbulent and unstable to be a strong factor in the commission of traffic accidents.

Also, Al-Saif et al. [7] pointed that it cannot be separated between the car and the driver personality, the vehicle safety and their validity, and the provide of all means of safety helps in reducing the traffic accidents by helping the driver to control the vehicle.

Al-Shawan [8] pointed out that there is a close relationship between the traffic accidents and the educational and cultural level of the drivers, and he believes that the people's commitment to the rules and public systems in the community without having to sergeant as drivers liability with traffic signals which is one of the indicators

that indicated the extent of drivers' respect for driving ethics.

According to another study for Lauer [20] pointed that the driver's behavior, which is derived from its culture and its close relationship with his vehicle driving pattern, as we also find that some of the studies confirm that the surrounding driver cultural environment affect his behavior and in his driving patterns positively and negatively, according to Zaidi [25], also Jinadu [19] found that the low level of education among drivers, which in turn affects the social and cultural awareness among individuals of the most important reasons behind traffic accidents. As also Bemch and Maiaefitte (1996) indicated in their study that the lack of serious thought and full awareness, particularly among adolescents is the reason for the high accident rate among that class of society.

Also, Jalel [18] revealed in his study that the educational level of the driver has a significant impact on the abundance or lack of accidents in the community where it was found that the educated Saudi less involved in accidents than the illiterate ones as the educated driver has more knowledge of traffic rules and regulations than others.

But, Abdo [2] pointed out that among the reasons that led to accidents in Jordan is a low traffic culture among motorists and incompetence, also found that the non-observance of road traffic from exceeding the speed and failure to comply with the priorities of the wrong turn and wrong stop as well as some drivers driving their vehicles in an inappropriate health and psychological conditions resulted accidents and these reasons closely linked to the culture of the driver, consciousness and the sense of the seriousness of the violation of traffic.

Also, Al-Meqbell [5] confirms in his study that the human qualities like habits and the educational level play a major role in gaining experience and raising the efficiency and good manners but the indifference is the one lead to driving at high speed and to overcome the signals and intersections as well as lack of commitment to specific tracks.

And, Yousef [24] mentioned that failure to comply with traffic rules and traffic safety behavior spontaneously comes from the weakness of rehabilitation and integration into the civilized system through rehabilitation and socialization carried out by the formal and informal social institutions in the community.

Regarding traffic violations, Abu Al-Rub [1] has pointed in a report on traffic violations in Palestine from the beginning of 2014 until the middle of May of the same year amounted to 46569 traffic violation, increased by nearly 20% compared with the same time period in 2013 where there was editing 38872 traffic violation and the proper Law deterrent which was applied during the beginning of 2014 and the imposition of necessary fines gave a positive tangible results in the number of deaths for the same period of time where decreased during 2014 to 24 deaths compared to 2013 for the same period, which amounted to 47 deaths as a result of traffic accidents. Despite the editing of the vast amount of irregularities, but it does not represent a strong deterrent to reduce irregularities because of the weakness of the collection of amounts of the irregularities and that they became accumulated from many years due to the economic conditions of citizens and delayed of the competent authorities to issue penalties for violations. And he mentioned that the traffic law should be modified in a better deterrent way.

Farghali [12] also pointed out in an article, according to the latest statistics to the Ministry of Interior of the United Arab Emirates from 2006 to 2009 that traffic accidents for four years amounted to about 37108 accidents, leaving 3971 deaths, including 889 civilians as well as 45522 injured, including 11281 citizens. While the number of traffic violations for four years amounted to about 19541177 traffic violation where acquired extra speed on the proportion of 67.64% of them, pointing out that the causes of traffic accidents where not to leave the distance was enough in the first place, followed by all of miscalculation of road users and enter the street before making sure that it is free and non-compliance with their lanes, respectively, and other reasons. The report said that the promotion of traffic culture and education, has contributed significantly to reducing the mortality rate of 1072 deaths in 2007 to 720 deaths in 2011.

In addition, Hamed, et al. [15] have considered road accidents from other aspects of where they developed a mathematical model to study the number of accidents in Jordan from 1988 to 1992 to study the impact of the Gulf War in 1990 on the number of traffic accidents as a result of the return of people to Jordan because of the war. They developed a random model to adapt it, and using appropriate estimates and its study show that the Gulf War did not significantly affect the increase of traffic accidents in Jordan.

Rock [22] studied the effect of using a seat belt law in Illinois on the dangers arising from traffic accidents. He used two statistical models in his study, the first model is due to study before and after the using while the second model use the time series analysis through ARIMA model, and unlike the model before and after the activation of the law, the results showed that the activation of the seat belt law did not affect the increase in the number of traffic accidents. These results are contrary to what reached by Ashe et al. [9]. As well as all of Evans and Graham [11] and Jarbaz (1991) and (1992) who used the method of analysis before and after use, where the correlation coefficient is present and therefore affect the use of regression analysis used in the analysis.

Another study in the literature focused on speed 55 miles per hour and its impact on traffic accidents, where the law of download speed to 55 miles per hour were applied as a result of the energy crisis in 1973 in the United States, and then studies on the use of the law of download speed were increased and its impact on traffic accidents (TRB 1984). Where, Hilvinstein (1990) studied the effect of download speed on traffic accidents. The study dealt with the time factor found that the download speed reduced traffic accidents.

There are many researchers took various topics in the field of traffic accidents from various and different aspects such as Nasser [21], Al-Ghamdi [4], Hareb [16], and other researchers.

3. Study Problem and Its Significance

The importance of this research in that it aims to study the traffic problem as an analytical statistical study to find out the main causes of the problem in all its aspects to

reduce them so as to reflect positive impact on the Kuwaiti society of social and economic aspects to reach the high levels of traffic safety and security, which is reflected thus on the safety of the citizen and the preservation of the national economy in the State of Kuwait.

This research aims to study traffic accidents and the resulting mortality and injuries in addition to the traffic fines and the amounts collected from them taking into account the increasing number of vehicles as statistical and analytical study so as to provide statistical and probability models adapted with study data for the years between 2002 to 2013 in addition to the prediction of future data from 2014 to 2020 in order to identify the problem and to develop appropriate suggestions and recommendations to curb this serious problem. In addition to identifying the role of government and various institutions to reduce these accidents and the repeated violations through the development of laws, policies and qualifying programs for rehabilitation and reduce the aggravation of these dangerous phenomena and costly burden in human life.

4. Statistical Analysis

This research have adopted on the official statistics of traffic accidents, injuries and deaths caused by them and the number of vehicles as well as the number of violations and the amounts collected from them as released in the statistical report of traffic department of State of Kuwait from 2002 to 2013. The statistical package SPSS has been used in statistical analysis to calculate the appropriate statistics to the study data from, which represented as follows:

1. Some descriptive statistical measures and calculation of confidence intervals for the variables of the study, as well as some probability models such as the binomial distribution to make some necessary future expectations and predictions for the variables of the study.
2. Some regression analysis models for modeling the variables and their relationships to each other and testing the goodness of fit of these models to know the validity of these models before applying them in an appropriate future projections and forecasts.
3. We may use some other statistical measures if needed during the study process.

5. Study Results and Discussion

This item addresses a display to official statistics of traffic accidents, injuries and deaths caused by them as well as the number of vehicles and the number of traffic violations besides the collected amounts from them in Kuwaiti Dinars according to the statistical bulletin for traffic department in the State of Kuwait from 2002 to 2013 as shown in Table 1 below. And therefore it will be statistically analyzed using appropriate statistical methods and then to find a statistical and probability models to study the relationships among them and to make future forecasts of these variables for the years from 2014 to 2020.

Table 1. Traffic statistics of the State of Kuwait from 2002 to 2013

Year	Total number of Vehicles	Total number of accidents	Total number of incidents	Total number of deaths	Total number of violations	Total collected amounts in KWD from violations
2002	947382	37650	2249	315	1740527	18609535
2003	954978	45376	1332	372	2384397	18952560
2004	1042617	54878	824	400	3043451	22782050
2005	1134042	56235	863	451	3045265	31006090
2006	1215745	60410	853	460	2757485	25421360
2007	1293308	63323	1014	447	2877848	30610630
2008	1353390	56660	1095	410	2624738	30119680
2009	1414925	61298	670	407	3289904	30162440
2010	1477769	65861	786	374	3995451	44753797
2011	1554737	75194	971	493	3531791	40220585
2012	1644314	86542	9959	454	3716039	40930805
2013	1748424	89527	8977	445	3448815	43247930

Table 1 shows the original traffic data of the State of Kuwait for the years from 2002 to 2013. It is noted that there is a troubled increase in the total number of vehicles, an increase of 801042 vehicles during the twelve years, as well as there are troubled increase in the total number of accidents, an increase of 51877 incidents resulted in the increase in the number of injuries where the increase amounted to about 6728 injury and an increase in the number of deaths for the same period, reaching 130 cases of traffic deaths.

As for the total number of violations, the data in Table 1 above shows that there is a troubled increase in the number of violations during the preceding twelve years, an increase of one million and 708 thousand and 288 violations in 2013 compared to the beginning of the period in 2002. The total collected amounts resulted in Kuwaiti Dinars reached for these violations in 2013 about 43247930 Kuwaiti dinars, an increase of 24 million and 638 thousand and 395 dinars compared to the year 2002.

And considering also the total number of injuries resulting from traffic accidents, we note that it reached its peak in the years 2012 and 2013 which reached 9959 and 8977 injury respectively from a year preceded by 2011 which accounted for 971 injured, an increase of 8988 injury in 2012 and an increase of 8006 injury for the year 2013 from the year 2011.

5.1. Traffic Statistics Rates Per 1000 Units

Traffic statistics rates are calculated per 1000 units in the state of Kuwait from 2002 to 2013. The following Table 2 shows it.

Table 2. Traffic Statistics Rates per 1000 units of the State of Kuwait from 2002 to 2013

Year	Average number of accidents per 1000 vehicle	Average number of incidents per 1000 accidents	Average number of deaths per 1000 accidents	Average number of violations per 1000 vehicle	Average collected amounts in KWD per 1000 violations
2002	39.74	59.73	8.37	1837.20	10691.90
2003	47.52	29.35	8.20	2496.81	7948.58
2004	52.63	15.02	7.29	2919.05	7485.60
2005	49.59	15.35	8.02	2685.32	10181.74
2006	49.69	14.12	7.61	2268.14	9219.04
2007	48.96	16.01	7.06	2225.18	10636.64
2008	41.87	19.33	7.24	1939.38	11475.31
2009	43.32	10.93	6.64	2325.14	9168.18
2010	44.57	11.93	5.68	2703.70	11201.19
2011	48.36	12.91	6.56	2271.63	11388.16
2012	52.63	115.08	5.25	2259.93	11014.63
2013	51.20	100.27	4.97	1972.53	12539.94

Looking to Table 2, we note that the average number of accidents per 1000 vehicles ranging from 39.74 to 51.2 traffic accident during the years of study with an annual increase of some little of one to two accident per 1000 vehicles. While the average number of injuries per 1000 accident has decreased from 59.73 injury in 2002 to 12.91 injury in 2011, and this shows the strict security measures during this period even though the casualty rate is clearly rose to 115.08 injury in 2012 and to 100.27 injury in 2013 per 1,000 Traffic accident. This shows that there is something wrong in these two years occurred in 2012 and 2013 led to this remarkable rise. And it is noticeable during those two years and after the financial crisis and the large number of circumvention of manpower having a large number of cars without licenses in addition to the driving licenses expired and not renewed the old cars where it became fraud and non-compliance with laws and regulations due to economic conditions during that period led to a significant rise in the number of casualties, Then the Ministry of Interior and the Department of Traffic started to launch campaigns on drivers, laws and is confiscated a large number of cars because they are invalid and deport a large number of residents for not having a driver's licenses and the lack of commitment to the laws and regulations governing traffic safety, which in turn reflected on the safety of the citizen and the overall national economy.

Regarding the average number of deaths per 1000 traffic accidents has decreased during the years of study from 8.37 death cases in 2002 to 4.97 death cases in 2013. This shows that the accident was in total because of the lack of validity of vehicles and lack of attention and the collisions is severe and run over accidents and others.

Also, regarding the average number of violations per 1000 vehicle was volatile a bit up and down occasionally at other times during the study period where ranged between 1837.2 to 2919.05 traffic violations. But the average amounts collected from violations in Kuwaiti Dinars, the rates have shown an increase at the rate of 1848.04 dinars per 1000 traffic violations.

5.2. Statistical Measures and Confidence Intervals

In this item some statistical measures are calculated to the variables of the study such as the minimum and the maximum value as well as sample mean and standard deviation value, in addition to the 95% confidence intervals to the traffic data are calculated too as shown in the following Table 3.

Table 3. Some Descriptive Statistical Measures and Confidence Intervals for Traffic data

Subject	Num. of Data	Min. Value	Max. Value	Mean	St. Dev.	95% Confidence Interval	
						Lower	Upper
Vehicles	12	947382	1748424	1315100	265219	1146600	1483600
Accidents	12	37650	89527	62746.17	15162.39	53112.45	72379.89
Incidents	12	670	9959	2466.083	3303.025	367.441	4564.726
Deaths	12	315	493	419	49.084	387.813	450.187
Violations	12	1740527	3995451	3038000	620728	2643600	3432400
Amount Collected (KWD)	12	18609535	44753797	31401000	9144460	25591000	37212000

Table 3 above showed that the minimum number of vehicles was 947382 vehicles and the maximum number of vehicles was 1748424 vehicles with a mean of 1.3151 million vehicles with standard deviation of 265219 vehicles. Also note that the 95% confidence interval for the number of vehicles was from 1.1466 million to 1.4836 million vehicles during the years of the study from 2002 to 2013.

Regarding the number of accidents, the minimum number of accidents reached 37650 accidents while the maximum number of accidents reached 89527 accidents with a mean of 62746.167 accidents and a standard deviation of 15162.388 accidents, but the 95% confidence interval for the number of accidents has ranged between 53112.445 to 72379.888 traffic accidents.

As for the number of incidents, the minimum number of injuries reached 670 injuries and the maximum number

reached 9959 injuries with a mean of 2466.083 injuries and a standard deviation of 3303.023 injuries. While the 95% confidence intervals for the number of incidents was ranged between 367.441 and 4564.726 injuries resulting from traffic accidents.

The table also shows that the minimum number of deaths was 315 death cases, and the maximum number of deaths was 493 death cases with a mean of 419 death cases and standard deviation of 49.084 death cases resulting from traffic accidents, While the 95% confidence interval for the annual number of deaths has ranged between 387.813 and 450.187 death cases.

And looking to the number of violations, Table 3 were showed that the minimum number of violations during the study period was 1740527 traffic violations and that the maximum number of violations recorded during the same period was 3995451 traffic violations with a mean annual rate of 3.038 million and a standard deviation of 620728 traffic violations, while the 95% confidence interval for the annual number of violations ranged between 2643600 and 3432400 traffic violations.

As for the total annual amounts collected from traffic violations in Kuwaiti dinars, Table 3 above showed that these amounts ranged between 18609535 KWD to 44,753,797 KWD as their minimum and maximum amounts respectively with a mean of 31.401 million Kuwaiti dinars and a standard deviation of 9.14446 million Kuwaiti dinars. The 95% confidence interval for the total annual amount collected for the same period from 2002 to 2013 has ranged between 25.591 million and 37.212 million Kuwaiti dinars.

5.3. Statistical and Probabilistic Models for Traffic Data

This item deals with the study of the relationships between the variables of the study with each other from vehicles, number of accidents, number of incidents, number of resulting deaths, number of traffic violations and amounts collected from them in Kuwaiti Dinars for the period from 2002 to 2013. Simple linear regression model, cubic regression model and logistic regression model have been used to the variables of the study as follows:

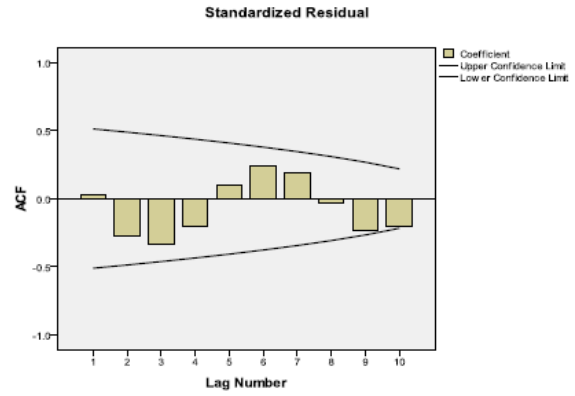
(1) Modeling the total number of vehicles by years of study:

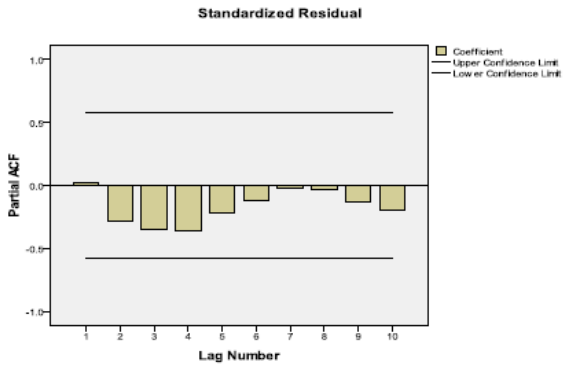
Simple linear regression is used for modeling the annual number of total vehicles with the years of the study from 2002 to 2013. Assuming the independent variable X represents years of study and the dependent variable Y represents the number of total annual vehicles, we note that the estimated model $\hat{Y}$ is given by the following relationship:

$$\hat{Y} = -1.459x10^{8} + 73344.696X$$

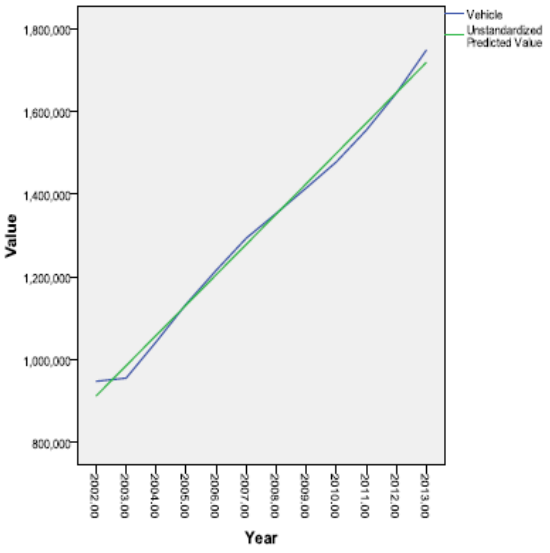
Note that the value of the correlation coefficient of this model is high, reaching about 0.997 and the coefficient of determination is equal to 0.994, which shows that the above model with a high validity and can be used to estimate future data.

Also residual analysis is used to check the efficiency of this model were the autocorrelation function (ACF) and partial autocorrelation function (PACF) are used and all achieved the Goodness of Fit Test which supports the use of the model to estimate future data. These figures are as follows:





And the following figure represents the original and the estimated values using the above suggested model;



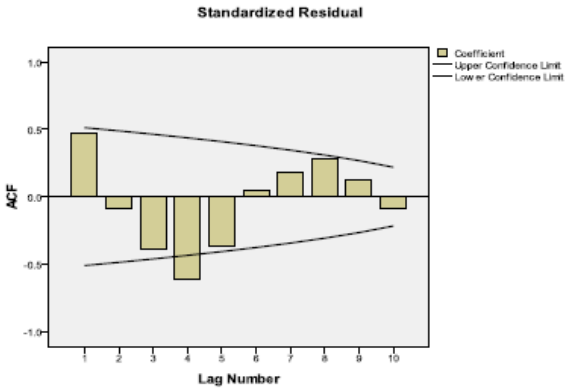
(2) Modeling the total number of traffic accidents by the annual number of total vehicles:

Simple linear regression is used for modeling the annual number of total traffic accidents with the annual number of total vehicles. Assuming the independent variable X represents the annual number of total vehicles and the dependent variable Y represents the number of total annual traffic accidents, we note that the estimated model $\hat{Y}$ is given by the following relationship:

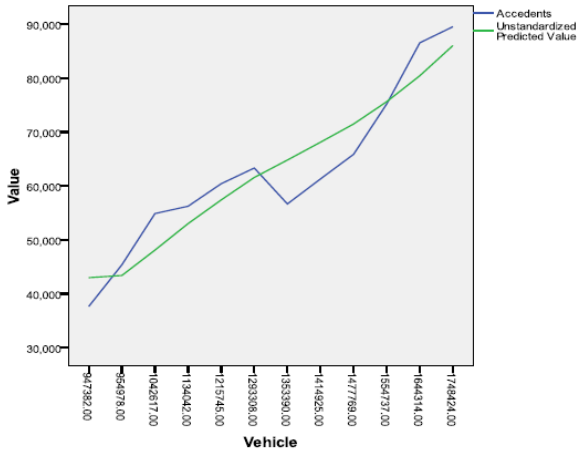
$$\hat{Y} = -7921.624 + 0.054X$$

Note that the value of the correlation coefficient of this model is high, reaching about 0.940 and the coefficient of determination is equal to 0.883, which shows that the above model with a high validity and can be used to estimate future data.

Also residual analysis is used to check the efficiency of this model were the autocorrelation function (ACF) and partial autocorrelation function (PACF) are used and all achieved the Goodness of Fit Test which supports the use of the model to estimate future data. These figures are as follows:



And the following figure represents the original and the estimated values using the above suggested model;



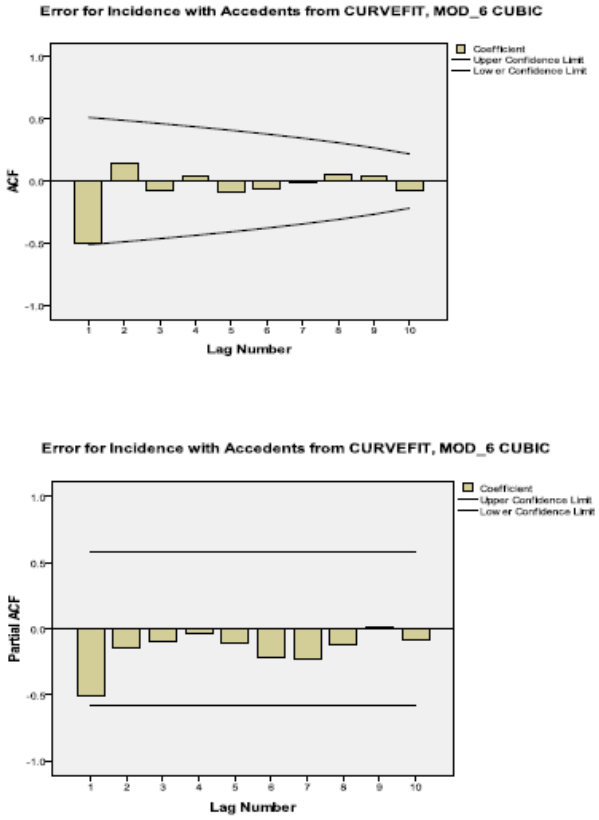
(3) Modeling the total annual number of incidents by the number of traffic accidents:

Cubic regression model is used for modeling the annual number of total incidents with the annual number of total traffic accidents. Assuming the independent variable X represents the annual number of total traffic accidents and the dependent variable Y represents the number of total annual incidents, we note that the estimated model $\hat{Y}$ is given by the following relationship:

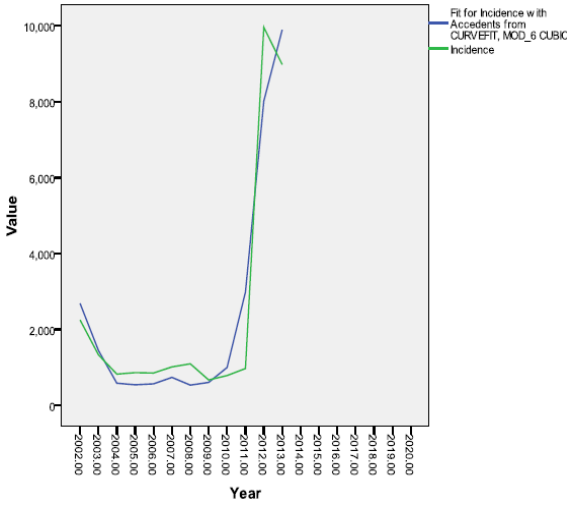
$$\hat{Y} = 8200.61 - 6.868x10^{-6} X^2 + 7.908x10^{-11} X^3$$

Note that the value of the correlation coefficient of this model is high, reaching about 0.959 and the coefficient of determination is equal to 0.920, which shows that the above model with a high validity and can be used to estimate future data.

Also residual analysis is used to check the efficiency of this model were the autocorrelation function (ACF) and partial autocorrelation function (PACF) are used and all achieved the Goodness of Fit Test which supports the use of the model to estimate future data. These figures are as follows:



And the following figure represents the original and the estimated values using the above suggested model;



(4) Modeling the annual number of total deaths by the number of traffic accidents:

This model is different to some extent from the previous models, where the proportion of deaths is computed as follows:

Let $n(D)$ be the number of total deaths and $n(A)$ be the number of total accidents then:

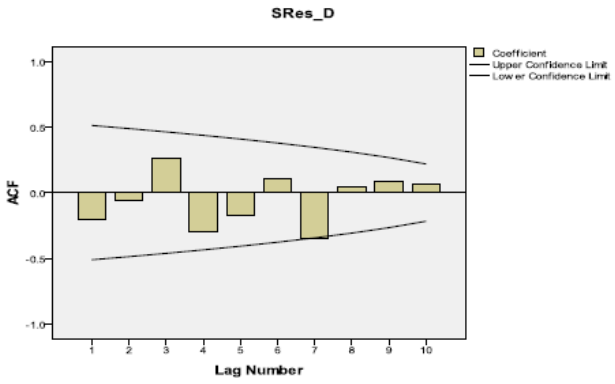
$$p = \frac{n(D)}{n(A)}$$

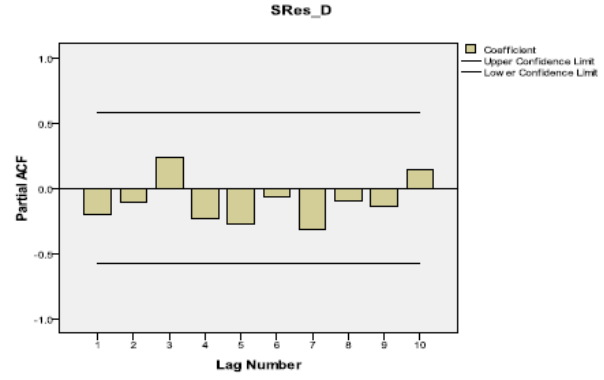
Logistic regression model is used for modeling the annual number of total deaths with the years of the study from 2002 to 2013. Assuming the independent variable t represents the years of the study and the dependent variable p represents the proportion of deaths, we note that the estimated model $\hat{p}$ is given by the following relationship:

$$\hat{p} = \exp\left(-5.729x10^{-37} + 1.045t\right)$$

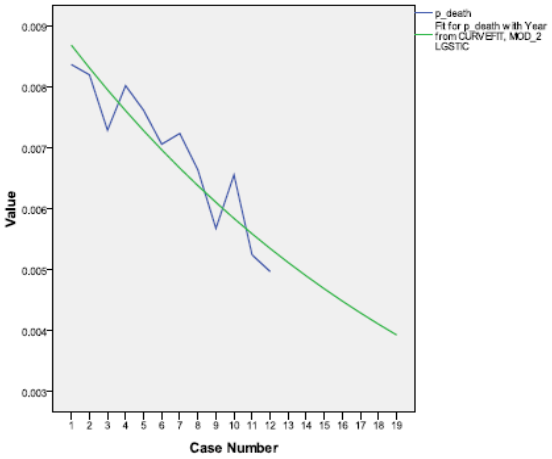
Note that the value of the correlation coefficient of this model is high, reaching about 0.920 and the coefficient of determination is equal to 0.846, which shows that the above model with a high validity and can be used to estimate future data of proportion of deaths.

Also residual analysis is used to check the efficiency of this model were the autocorrelation function (ACF) and partial autocorrelation function (PACF) are used and all achieved the Goodness of Fit Test which supports the use of the model to estimate future data. These figures are as follows:





And the following figure represents the original and the estimated values of proportion of deaths using the above suggested model;



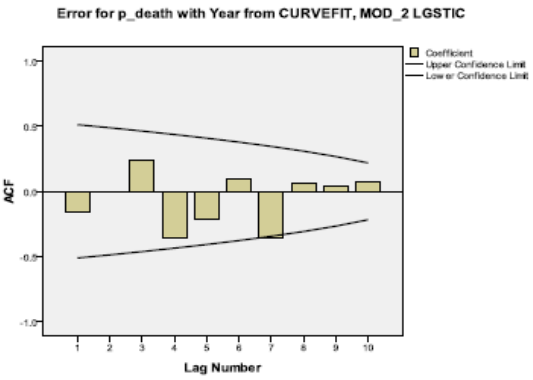
Now, and after the validity of the above model is proved, thus we can estimate the annual number of total deaths according to the annual number of total accidents as follows:

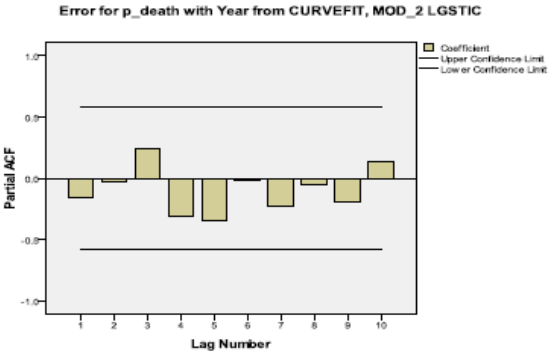
Assuming the independent variable X represents the annual number of total traffic accidents and the dependent variable Y represents the annual number of total deaths, we note that the estimated model $\hat{Y}$ is given by the following relationship:

$$\hat{Y} = X \cdot \exp\left(-5.729x10^{-37} + 1.045t\right)$$

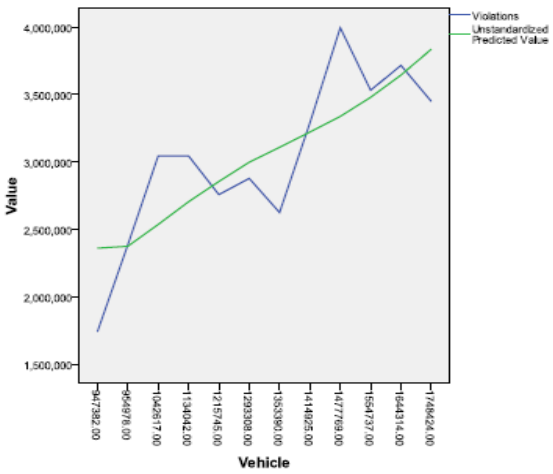
where t represent the year.

Also residual analysis is used to check the efficiency of this model were the autocorrelation function (ACF) and partial autocorrelation function (PACF) are used and all achieved the Goodness of Fit Test which supports the use of the model to estimate future data to the total number of deaths according to number of accidents and its corresponding year were the accidents occurred. These figures are as follows:





And the following figure represents the original and the estimated values using the above suggested model;



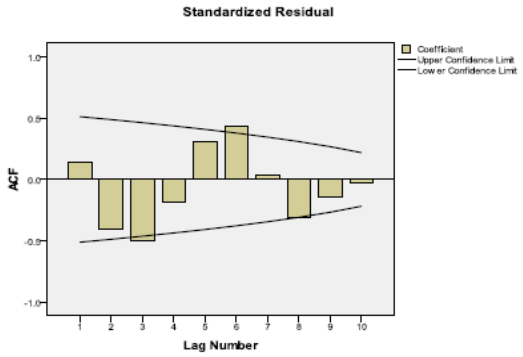
(5) Modeling the total number of traffic violations by the annual number of total vehicles:

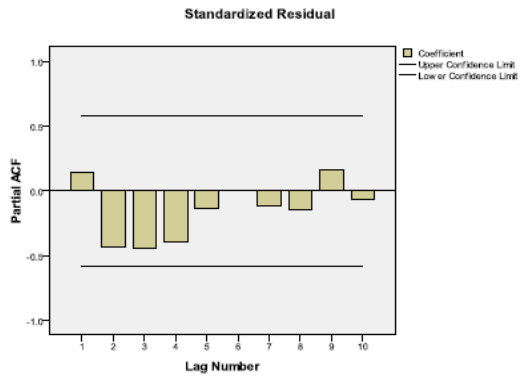
Simple linear regression is used for modeling the annual number of total traffic violations with the annual number of total vehicles. Assuming the independent variable X represents the annual number of total vehicles and the dependent variable Y represents the number of total annual traffic violations, we note that the estimated model $\hat{Y}$ is given by the following relationship:

$$\hat{Y} = 614.899 + 1.843X$$

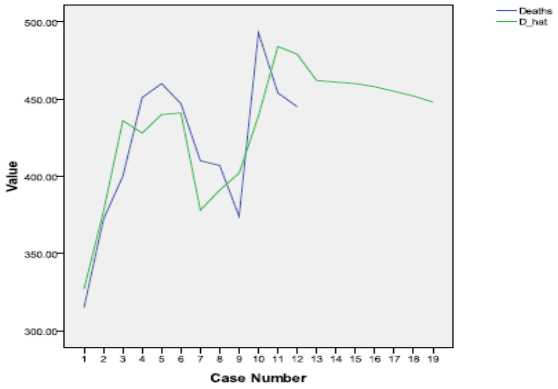
Note that the value of the correlation coefficient of this model is high to some extent, reaching about 0.787 and the coefficient of determination is equal to 0.620, which shows that the above model with a high validity and can be used to estimate future data.

Also residual analysis is used to check the efficiency of this model were the autocorrelation function (ACF) and partial autocorrelation function (PACF) are used and all achieved the Goodness of Fit Test which supports the use of the model to estimate future data. These figures are as follows:





And the following figure represents the original and the estimated values using the above suggested model;



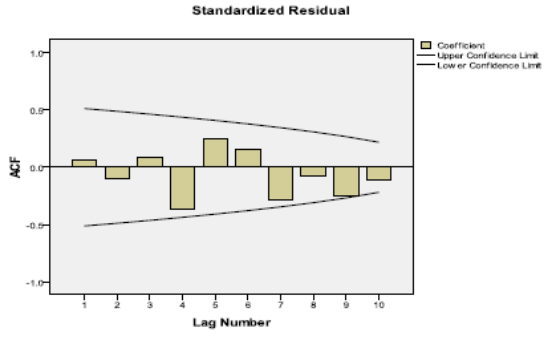
(6) Modeling the annual of the total collected amounts by the number of traffic violations:

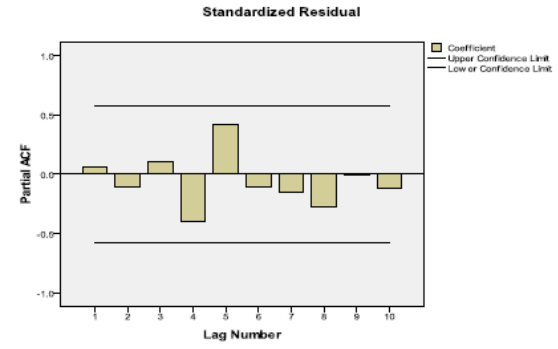
Simple linear regression is used for modeling the annual number of total collected amounts with the annual number of total traffic violations. Assuming the independent variable X represents the annual number of total traffic violations and the dependent variable Y represents the annual of the total collected amounts, we note that the estimated model $\hat{Y}$ is given by the following relationship:

$$\hat{Y} = -8145460.964 + 13.018X$$

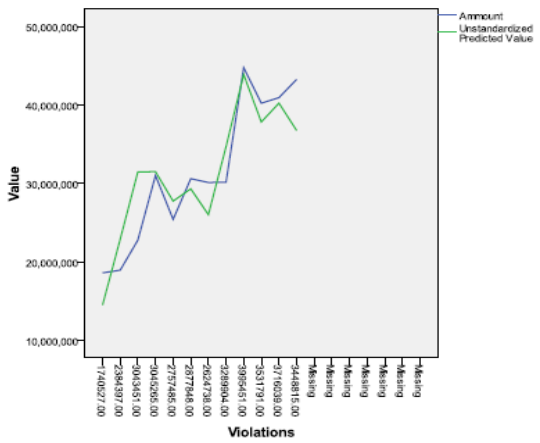
Note that the value of the correlation coefficient of this model is high, reaching about 0.884 and the coefficient of determination is equal to 0.781, which shows that the above model with a high validity and can be used to estimate future data.

Also residual analysis is used to check the efficiency of this model were the autocorrelation function (ACF) and partial autocorrelation function (PACF) are used and all achieved the Goodness of Fit Test which supports the use of the model to estimate future data. These figures are as follows:





And the following figure represents the original and the estimated values using the above suggested model;



5.4. The Estimated Statistics for Future Traffic Data

This item concentrated on the computation of estimated statistics for future traffic data according to the previous mentioned statistical and probabilistic models for the years from 2014 to 2020 after the application of the goodness of fit tests for those models and its validity to estimate the future traffic data.

Using the suggested sixth models in the previous item, the estimated traffic statistics as shown in the following Table 4:

Table 4. The expected traffic data of the State of Kuwait for the years from 2002 to 2013 and the estimated ones for the years 2014 to 2020

Year	Total number of Vehicles	Total number of accidents	Total number of incidents	Total number of deaths	Total number of violations	Total collected amounts in KWD from violations
2002	911740	42985	2685	327	2360788	14512720
2003	985085	43393	1447	377	2374787	22894619
2004	1058429	48103	585	436	2536306	31474184
2005	1131774	53015	543	428	2704802	31497799
2006	1205119	57405	568	440	2855381	27751479
2007	1278464	61573	738	441	2998330	29318364
2008	1351808	64802	534	378	3109061	26023378
2009	1425153	68108	606	391	3222470	34682509
2010	1498498	71485	998	402	3338291	43867320
2011	1571842	75621	2985	439	3480143	37831394
2012	1645187	80434	8013	484	3645234	40229935
2013	1718532	86029	9892	479	3837108	36751213
2014	1816218	90154	10325	462	3962052	43432535
2015	1889562	94115	13290	461	4097226	45192233
2016	1962907	98075	16740	460	4232401	46951932
2017	2036252	102036	20705	458	4367575	48711631
2018	2109597	105997	25213	455	4502749	50471329
2019	2182941	109957	30295	452	4637924	52231028
2020	2256286	113918	35980	448	4773098	53990727

Comparing the official statistics for the traffic data through the figures mentioned in the previous item which represented by the original and the estimated data, we note how much close the original and the estimated data for traffic statistics, and then these suggested models may use to study the future traffic data and their impact on the traffic safety which then reflect on the safety of citizens and on the security of the national economy for the state of Kuwait.

Also, comparing the rates of estimated traffic statistics for the year 2020 with the original traffic statistics for the year 2013 per 1000 unit as shown in the following Table 5:

Table 5. Comparing the rates of traffic statistics for the year 2020 with the year 2013 per 1000 units

Subject	Year 2013	Year 2020	Increasing Rate
Average number of accidents per 1000 vehicles	51.20	50.49	-0.71
Average number of incidents per 1000 accidents	100.27	31.93	-68.34
Average number of deaths per 1000 accidents	4.97	3.93	-1.04
Average number of violations per 1000 vehicles	1972.53	2115.47	142.94
Average collected amounts in KWD per 1000 violations	12539.94	11311.46	-1228.48

Table 5 above shows that the expected number of accidents per 1000 vehicles will decrease with amount of 0.71 per 1000 vehicles in the year 2020 in comparison with the year 2013, and the expected number of incidents per 1000 accidents will decrease with amount of 68.34 injury cases in the year 2020 in comparison with the year 2013, also the expected number of deaths per 1000 accidents will decrease with amount of 1.04 death cases in the year 2020 in comparison with the year 2013.

Regarding the average number of traffic violations, Table 5 shows increasing in the average number of the expected violations in the year 2020 with an amount of

142.94 violations per 1000 vehicles, and decreasing on the expected collected amounts from these violations with an amount of 1228.48 Kuwaiti dinars per 1000 violations in the year 2020 in comparison with the year 2013.

The total increase of the estimated traffic statistics for the year from 2013 to 2020 as shown in the following Table 6:

Table 6. The amount of increasing in estimated traffic statistics and their percentages from the year 2013 to 2020

Subject	Year 2013	Year 2020	Increasing Rate	Percentage of increase
Number of vehicles	1748424	2256286	507862	29.05%
Number of accidents	89527	113018	24391	27.24%
Number of incidents	8977	35980	27003	300.8%
Number of deaths	445	448	3	0.67%
Number of violations	3448815	4773098	1324283	38.4%
Collected amounts in KWD	43247950	53990727	10742777	24.84%

Table 6 above shows that the percentage of increase in the number of vehicles in the year 2020 amounted 29.05%, the percentage of increase in the number of accidents amounted 27.24%, the percentage of increase in the number of violations amounted 38.4%, the percentage of increase in the collected amount in Kuwaiti dinars resulted from violations amounted 24.84%. But for the number of incidents, the percentage of increase in the year 2020 was very high and amounted 300.8% and this high percentage causes big problem to the traffic safety for both citizens and residents and then affects the national economy in spite of the cost for hospitals is very high which forms big problem to the state. Whereas, the percentage of increase in the number of deaths was very low to some extent and amounted 0.67% which is a good indicator shows the importance of nice application to the laws and systems of traffic department, but it should work in reducing this percentage to be decreasing because the safety of citizens is a major theme and should concentrating on it in the traffic safety.

Finally, a comparison was done between the percentages of increase in the estimated traffic statistics for the year from 2014 to 2020 and the previous seven years from 2007 to 2013 as shown in the following Table 7:

Table 7. Comparison between the percentages of increase in the traffic statistics for the years 2007-2013 and the years 2014-2020

Subject	Percentage of increase past seven years 2007-2013	Percentage of increase estimated seven years 2014-2020	Amount of increase in percentage
Number of vehicles	35.19%	29.05%	-6.14%
Number of accidents	41.38%	27.24%	-14.14%
Number of incidents	785.31%	300.8%	-484.51%
Number of deaths	-0.45%	0.67%	1.12%
Number of violations	19.84%	38.4%	18.56%
Collected amounts in KWD	41.28%	24.84%	-16.44%

Looking to Table 7 above, we note that the percentage of increase in the number of vehicles decreases with percentage of 6.14% and decreases in the number of accidents with percentage of 14.14% and highly decrease in the number of incidents with percentage of 484.51%. Whereas, the table shows high increase to some extent in the percentage of increase in the number of deaths resulting from the traffic accidents in the state of Kuwait with percentage of 1.12%. But for the number of violations, the table shows high percentage in the estimated percentage of increase with percentage of 18.56%, and decreases with percentage of 16.44% in the amount that will be collected in Kuwaiti dinars from the estimated traffic violations.

6. Suggestions and Recommendations

Based on the above results of the study and discussion, I outlined some important suggestions and recommendations, which thus works to reduce the aggravation of the problem of traffic and public safety on the citizen and the security of the national economy. The most important of these suggestions and recommendations include:

1. Apply all the rules and the terms of the traffic law very seriously and without discrimination as well as activate the deactivated items such as the withdrawal of driving licenses, as well as fines and work on its suitability with income levels to become a strong deterrent to curb violations and accidents and thus work to reduce injuries and deaths resulting from traffic accidents.

2. Adopting direct violation system to adjust the traffic violations and speeding the judging in the indirect cases of violations and speed up the implementation of verdicts right.

3. Working on the support of the General Traffic Department with manpower and material resources to achieve universal deployment of traffic forces in all parts of Kuwait in order to impose full control and fine control over the traffic movement and that consequently lead to the imposition of security and traffic safety throughout the State of Kuwait.

4. Work on the provision of sophisticated information network able to apply all the provisions of the Traffic Low to find out necessary information about the vehicles and drivers and to link this network with police department networks and insurance companies to contribute to everyone in controlling traffic movements and control them to achieve discipline and traffic safety.

5. Work to support traffic awareness programs and public safety with all modern means and coordination with the Ministry of Education and universities to enter a

course in the traffic awareness in order to broadcast traffic awareness culture and public safety among young people and their impact on community safety and on the national economy.

6. Activating the role of public benefit associations such as safety association for the prevention of road accidents, as well as the role of clubs, syndicates and unions in the State of Kuwait in order to play its role in the broadcast the culture of traffic safety in the Kuwaiti society through seminars, lectures and festivals that help in traffic awareness to curb Traffic accidents of all kinds and that lead to the reduction of injuries and deaths and raise the national economy and the safety of the community.

7. work to increase interest in verification of public and private standards for drivers of health fitness, medical examination, age and other criteria when the issuance of driving licenses, as well as follow-up driving schools to comply with basic standards when they are approved by the Traffic Department in order to obtain drivers bear the moral responsibility and trained excellent training to reduce traffic accidents.

8. Work on the follow-up the behavior of road users and drivers by activating the adjustment of the actual observation of the roads through putting cameras and other advanced technology to adjust violations to constitute a means of deterrence for drivers to maintain traffic safety. As well as monitoring the behavior of pedestrians on these roads so that some of the studies should be activated in order to increase public awareness for traffic safety to preserve the public morals of the traffic.

9. Activating the engineering role for the development of special engineering materials for monitoring road conditions and the use of modern and advanced technology in order to regulate the traffic and remove the obstacles on the roads and look at intersections, bridges, entrances and exits in the roads to be suitable with the traffic density on it so as to prevent traffic movements.

10. Activate the comprehensive observation role for vehicles condition in terms of the comprehensive inspection, periodic examination and commitment to public standards that be defined by the Traffic Department and intensify sudden inspection campaigns to follow the readiness of vehicles and providence of the general conditions of the safety in them.

11. Work on the development of compulsory insurance systems for the vehicle to match the driver behavior by looking at the driver file to see the number of violations committed and the quality of these violations and their impact on community safety in order to identify segments of private insurance, according to the driver file.

12. Work to encourage mass transportation system so that the traffic department with schools, universities and various ministries cooperate to activate the mass transportation systems to reduce traffic congestion, which in turn leads to traffic accidents and that are harmful to the safety of the citizen and the state as well as the social and economic security.

13. Conduct a comprehensive study for the possibility to work by system of non-unified working categories for employees of different ministries in the public sector as well as the private sector in terms of identifying different starting time for the working hours to reduce congestion on the roads and thus knowing their impact on the traffic movement and public safety.

Fund

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