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Temporal Analysis and Cause Investigation of Uae Traffic Crashes

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Abstract: Traffic accidents are a critical safety issue in the Gulf Cooperation Council (GCC), especially in the United Arab Emirates (UAE). The economic prosperity over the past few decades associated with excessive growth in population, major highway infrastructure development projects and high levels of car ownership have led to dramatic increase in traffic accidents. To address this issue, this article conducts a comprehensive study to investigate traffic accidents rates and causes in UAE to propose recommendations for reducing the traffic accidents hazard. Traffic accident data for the UAE for the period from 2000-2009 were collected from the Ministry of Interior (MOI). The collected data included detailed information mainly from the traffic accident reports stored in the database of the general administration of traffic coordination department. Using the obtained data, a comprehensive critical analysis was conducted. Different regression models for fatality, major and moderate accidents were established with different accidents types and their numbers. The analysis revealed aggregated causes and reasons behind the huge number of accidents, injuries and fatalities.

Key words: Traffic accidents, UAE, regression analysis, cause, effect analysis

INTRODUCTION

Road traffic accidents is a major public problem facing most developed and developing countries in the world resulting yearly in huge social, economical and environmental losses. It has a higher severity level in developing countries due to the poor transportation infrastructure system and low enforcement levels of traffic laws. Much of the existing literature has emphasized on the strong correlation between aggressive and faulty driving and traffic accidents occurrence (Bener *et al*., 2004). Based on a study carried out by Treat *et al*. (1977) human factor contribute solely to around 57% of total accidents and to >90% as a contributing factor while only 2.4 and 4.7% were the sole contribution of vehicle and environment factors, respectively. Most accidents are caused by human error such as over-speeding, not giving the right of way, sudden change of lanes, etc.

The Manchester Driver Behavior Questionnaire (DBQ), originally developed by Reason *et al*. (1990) is one of the tools that has been used extensively to study the relationship between human driving errors/violations and involvement in accidents. DBQ has been used by many researchers in different countries as in the research of Dobson *et al*. (1999), Kontogiannis *et al*. (2002) and Lajunen *et al*. (2004). Bener *et al*. (2008) used DBQ in a comparison study between Qatar and UAE.

Statistical approaches have been widely used by researchers in the literature to extract important patterns and relationships embedded in traffic accident data. Lord and Mannering (2010) provide an extensive review of the statistical methods being in used for decades to analyze traffic accidents data. Example of these methods include developing statistical models to highlight highway locations with traffic safety problems (Hauer, 1996; Stokes and Mutabazi, 1996; Tarko *et al*., 1996). Abdel-Aty and Radwan (2000) used negative binomial regression to model traffic accidents occurrence. Vistisen (2002) used different approaches to analyze hot spots locations with high accidents frequency. Other models tried to relate traffic flow characteristics such as in the work by Zhou and Sisiopiku (1997) where they use v/c ratio with accident rates.

This research conducts a comprehensive study to investigate traffic accidents rates and causes in UAE to propose recommendations for reducing the traffic accidents hazard. Traffic accident data for the UAE for the period from 2000-2009 were collected from the Ministry of Interior (MOI). The collected data included detailed information mainly from the traffic accident reports stored in the database of the general administration of traffic coordination department. Using the obtained data, a comprehensive critical analysis was conducted to establish a pattern of conditions and causes

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of traffic accidents with different accidents trends being extracted. The analysis revealed aggregated trends and correlations between accidents, injuries, fatalities, vehicle population and type, driver's age, gender and nationality.

MATERIALS AND METHODS

Traffic accidents in the united arab emirates: Traffic accidents in the UAE is a serious problem; the country suffers a lot due to accidents in loosing mostly young people at the same time paying cost of treatment, insurance and lifelong liability of injured persons. The objective of this section is to investigate the causative factors of traffic accidents in the UAE. A number of issues such as causes of accidents and characteristics of road users were considered in the study.

The traffic accidents data for the last 10 years (2000-2009) used in this report were collected from the Ministry of Interior, MOI (The General Administration of Traffic Coordination). The collected data included the traffic accident report data for the UAE as whole as well as, the same set of data for each of Abu Dhabi and Dubai emirates. The data were analyzed to investigate the predominant causes of accidents and the change of the rate of accidents in the last decade. In addition, the variation in the total number of traffic accidents in the UAE during the period (2000-2009) is shown in Fig. 1. As it can be noticed from Fig. 1, the total number of traffic accidents in the UAE dropped from about 10600-7900 over the last 10 years (a reduction of about 25.5%).

According to the traffic accident report format used by the UAE Traffic Department, the causes of accidents are divided into nine different types: disrespect of other road users, changing lanes frequently, not yielding, not leaving appropriate distance (tail getting), crossing red traffic light, speeding, negligent driving, tire bursting and other (which includes all other causes). Figure 2 shows a pie chart illustrating the share of the different factors in the total number of traffic accidents over the whole study period (2000-2009).

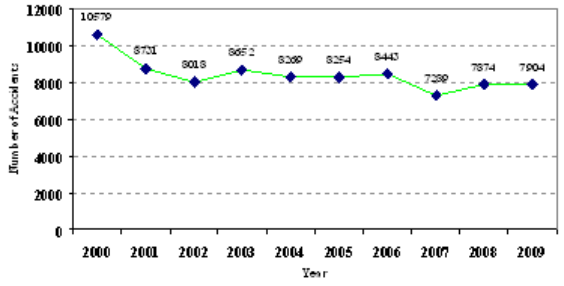

Fig. 1: The variation in the total number of traffic accidents in the UAE

Among many causes of accidents the main cause of accidents is the disrespect of other road users, according to Fig. 2, it account for almost 22%. The "other" category of the accident causes was found to account for nearly 29% of the causes as revealed from the data collected from the traffic accident reports. This very high percentage indicates that the accident report format needs some alternations to better categorize the traffic accident causes and make the judgment easier to traffic officers in the accident site. According to these data >90% of the accidents maybe associated with the driver faults. In addition, the most predominant cause of fatalities that accompany the accidents is speeding cause as concluded from the related data analysis (accounts for almost 47%). Furthermore, accidents data investigation shows that in terms of fines the speeding cause surpassed all other causes by 87% share of the total number of fines in the 2006-2009 period.

Uae road traffic accidents fatalities and injuries: Reducing the number of fatalities and injuries are the most important goals of any traffic study. Important aspects related to traffic accident fatalities and injuries are presented in this section. This part gives an overview on the fatalities and injuries due to traffic accidents for the last 10 years in the UAE. First the data available on the fatalities are discussed and correlations with key factors are made. Then the injuries data is discussed followed by studying some correlations between fatalities and injuries. This part is concluded by a brief discussion on the cost of traffic accidents.

Traffic accident fatalities: The relation between the number of traffic accidents fatalities for the period from 2000-2009 and different key factors are discussed in the following sections.

Emirate-based traffic accident fatalities: The overall numbers of fatalities in the UAE for the last 10 years are

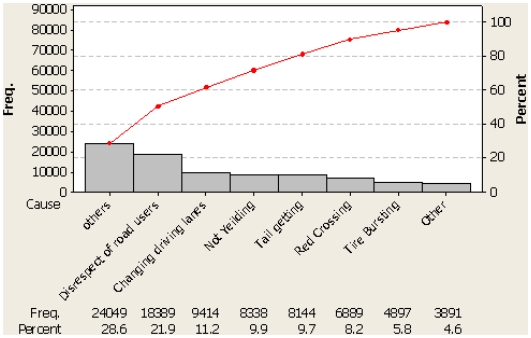

Fig. 2: Traffic accident causes in the whole UAE

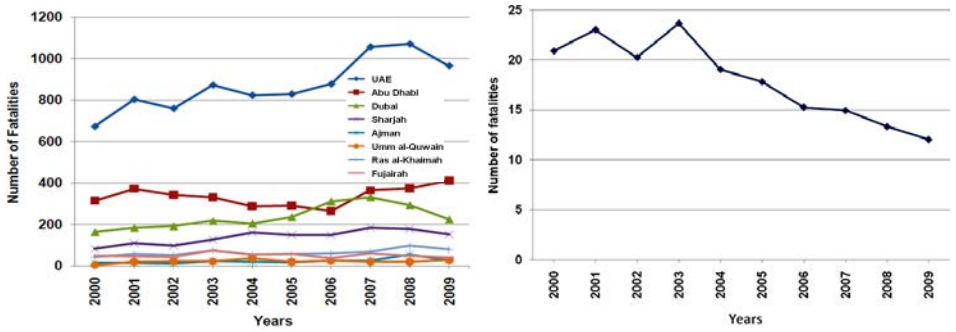

Fig. 3: Fatalities in the UAE (2000-2009): a) Overall numbers of and b) Number of fatalities per 100 thousands of population

shown in Fig. 3a. This Fig. 3a shows that the years 2007 and 2008 witnessed a noticed increase in the number of fatalities compared to the previous years. Whereas, the year 2009 showed a decrease in the number of fatalities. For most of this period Abu Dhabi had the highest rate of fatalities followed by Dubai and then Sharjah. The rest of the Emirates had comparable numbers of fatalities. The Fig. 3b shows also that Dubai had a major reduction in the last two years (2008 and 2009) which may be attributed to the implementation of the new traffic laws. Fig. 3b showed that the fatality per 100 thousands had the highest rate of 24 at 2003, the rates have been decreasing since then and it reached a rate of 12 in 2009. This shows that there is a reduction of 50% in the number of fatalities per 100 thousands of population from the peak value at 2003. The ratio of the number of road traffic violations to the number of fatalities due to road accidents is reviewed for each Emirate. Ajman has the largest ratio among all emirates. Comparing these ratios to the average ratios for all emirates over the 10 years period showed that up to the year 2004 only Ajman had ratios higher than the average. In 2009 Ajman had the highest ratio followed by Dubai, then. Umm Al Quwain.

Regression analysis: Fatality versus No. of Accid.
The regression equation is:

$$\text{Fatality} = 1.15 + 0.127 \text{ No. of Accid.}$$

The Table 1 and 2 output demonstrates the ANOVA analysis for fatality and the number of accidents model, noting that variables included in models are significant since the p-value associated with each parameter is too close to 0.00. The value of $R^2 = 0.71$ is obtained thus the model accounts for about 71% of the variability in the response. In order to verify the simple linear regression model, its adequacy and performance should be

Table 1: Regression analysis: fatality versus no. of accid

Predictor	Coef SE	Coef	t-value	p-value	S	R^2	R^2 (adj)
Constant	1.146	9.599	0.12	0.906	7.81754	71.0%	69.9%
No. of Acced.	0.12661	0.01557	8.13	0.000			

Table 2: Analysis of variance

Source	df	SS	MS	F-value	p-value
Regression	1	4042.1	4042.1	66.14	0.000
Residual error	27	1650.1	61.1		
Total	28	5692.2			

checked. Some of the model assumptions can be evaluated by calculating the residuals and plotting or otherwise analyzing them. The following plots can be constructed to test the validity of the assumptions:

- Residuals against the explanatory variables in the model as illustrated above. The residuals should have no relation to these variables (look for possible non-linear relations) and the spread of the residuals should be the same over the whole range
- Residuals against explanatory variables not in the model. Any relation of the residuals to these variables would suggest considering these variables for inclusion in the model
- Residuals against the fitted values
- A normal probability plot of the residuals to test normality. The points should lie along a straight line

Normal Probability plot being used to see how the points are fitted along the plot as shown; none of the points are far from the line, therefore, the model is accurate and can represent the data (Fig. 4).

Traffic accident fatalities according to age-group, gender and citizenship: The ages of traffic accident fatalities can be divided into 5 groups as shown in Fig. 5 The distribution of the total number of fatalities for the last

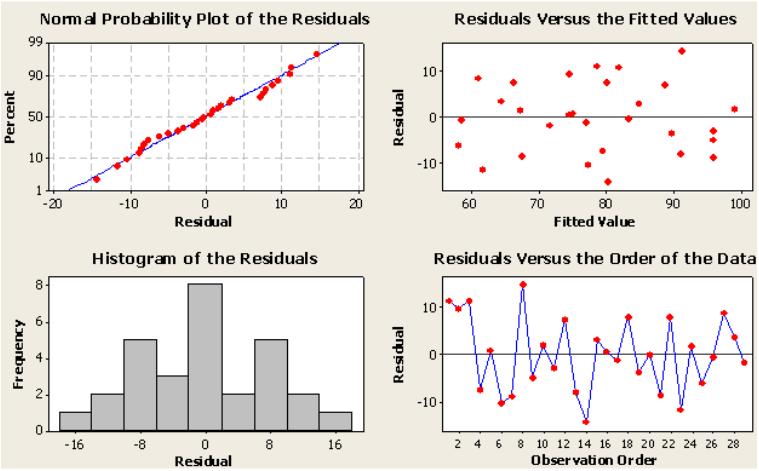

Fig. 4: Residual plots for fatility

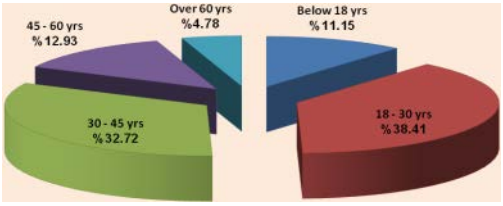

Fig. 5: Distribution of fatalities percentages according to the age-group for the 2000-2009 period

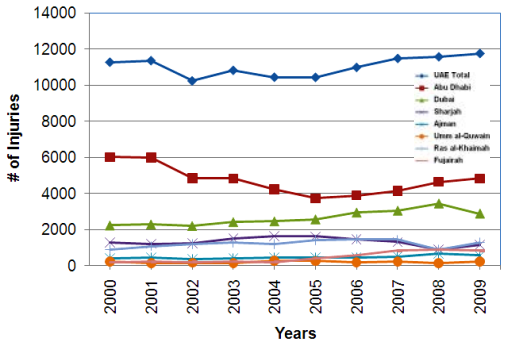

Fig. 6: Overall numbers of traffic accidents' injuries in UAE for the last 10 years

10 years among these 5 age groups showed that about 39% of the fatalities lied in the age group (from 18 to <30 years old) and about 33% in the age group (from 30 to <45 years old). Only about 28% of the fatalities lied in the age groups younger or older than these two age groups. These results show that the people ageing from 18 to<45 years are more prone to being a traffic accident fatality. The same conclusion can be withdrawn from the distribution of the fatalities in different age groups for each year in the last 10 years.

In terms of gender, the percentage traffic accident fatalities of males and females shows that males form from 85-93% of the fatalities whereas females form from 7-15%. This may be attributed to the fact that the number of male licensed drivers is higher than that for females. A review of the accidents data based on the citizenship category reveals that expats form from 6-79.5% of the fatalities whereas UAE citizens form from 20.5-32%. These percentages indicate that expats' fatalities from traffic accidents are more than twice that of UAE citizens.

Traffic accidents injuries: The relations between number of injuries from traffic accidents and different key factors are discussed in the following sections.

Emirate-based traffic accidents injuries: The overall numbers of injuries due to traffic accidents in the UAE for the last 10 years are shown in Fig. 6. This figure shows that the overall injuries rates are slightly increasing over the last years. For this period Abu Dhabi had the highest rate of injuries followed by Dubai and then Sharjah and Ras Al Khaimah. The rest of the Emirates had comparable numbers of injuries. Figure 7 shows also that Dubai had a slight reduction in the last year (2009). The injuries per 100 thousands had a decreasing trend among the last 10 years with the rate of 147 in year 2009. This shows that there is a reduction of 58% in the number of injuries per 100 thousands among the last 10 years. Studying the average number of injures per accident in each emirate for the last 10 years shows that it ranged from 0.75-1.66. Among all emirates Dubai had the largest followed by Abu Dhabi and Ajman. On the other hand, Umm Al Quwain had the smallest number of injuries per accident (Table 3 and 4).

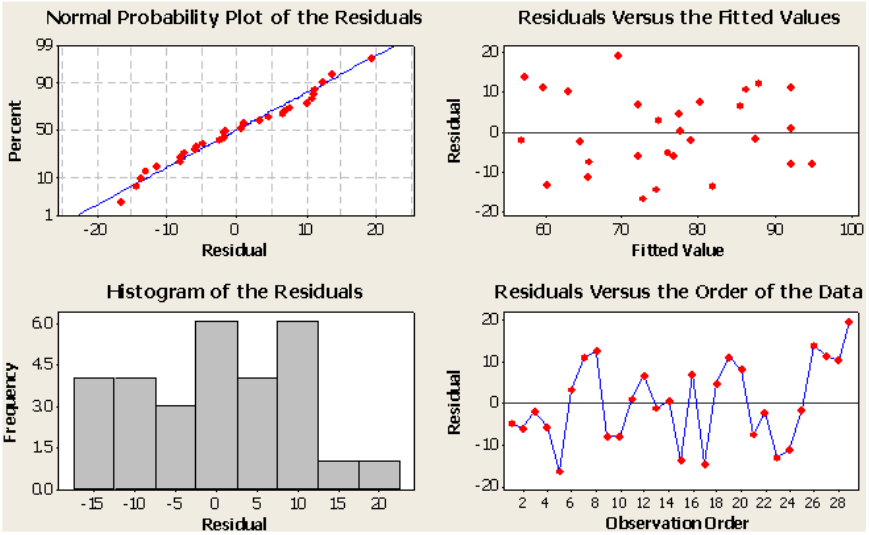

Fig. 7: Residual plots for serios Inj

Table 3: Predictor constant

Predictor	Coef SE	Coef.	t-value	p-value	S	R^2	R^2 (adj)
Constant	3.94	12.18	0.32	0.749	9.92064	56.8%	55.2%
No. of Acced.	0.11779	0.01976	5.96	0.000			

Table 4: Analysis of variance

Source	DF	SS	MS	F-value	p-value
Regression	1	3498.5	3498.5	35.55	0.000
Residual Error	27	2657.3	98.4		
Total	28	6155.8			

Regression analysis: Seriois Inj versus No. of Acced. The regression equation is:

$$\text{Seriois Inj} = 3.9+0.118 \text{ No. of acced}$$

Figure 7 shows the normal probability of the residuals and as it can be seen that a straight line can be fitted through these points which mean that there's no severe deviations from normality are exists (Table 5-7).

Regression analysis: Moder. Inj versus No. of Acced. The regression equation is:

$$\text{Moder. Inj} = 25.4+0.514 \text{ No. of acced}$$

RESULTS AND DISCUSSON

Traffic accident cost estimation: Based on the information provided by the Ministry of Interior, the cost of each traffic accident fatality in million dirhams is estimated to be 6.49 and the cost of injuries is about 0.9 millions (based on the distribution shown in Table 3). The trend of the costs due to fatalities and injuries from traffic accidents followed the same trend as that for the accidents as expected (Fig. 8). The average cost per year of fatalities for the last 10 years was ADE 5672 millions and the average cost per year of injuries was ADE 9873 millions. The cost of fatalities and injuries for each emirate shows that it was the highest for Abu Dhabi then Dubai (Table 8 and Fig. 9).

Table 5: Coefficient of predictor

Predictor	Coef SE	Coef.	t-value	p-value	S	R^2	R^2 (adj)
Constant	25.43	29.87	0.85	0.402	24.3300	80.7%	79.9%
No. of Acced.	0.51418	0.04845	10.61	0.000			

Table 6: Analysis of variance

Source	df	SS	MS	F-value	p-value
Regression	1	66662	66662	112.61	0.000
Residual Error	27	15983	592		
Total	28	82645			

Table 7: Cell contents: pearson correlation

	Values							
Parameters	1	2	3	4	5	6	7	8
Tadahwor	0.798	0.000						
Dahs	0.713	0.399	0.000	0.032				
Fatility	0.824	0.559	0.731	0.000	0.002	0.000		
Seriois Inj	0.760	0.697	0.496	0.682	0.000	0.000	0.006	0.000
Moder. Inj	0.907	0.791	0.627	0.728	0.749	0.000		
p-value	0.000	0.000	0.000	0.000				

Table 8: Cost estimation of a traffic accident injury

Injury type	Injury (%)	Cost ($)	Estimated cost
Very severe	1.8000	1980000	3564000
Severe	7.1000	630000	4473000
Moderate	22.1900	342000	7588450
Simple	68.9000	126000	8680851
Total ($)	243063.0100		
Cost (Million $)	0.2431		
Cost (Million AED)	0.8945		

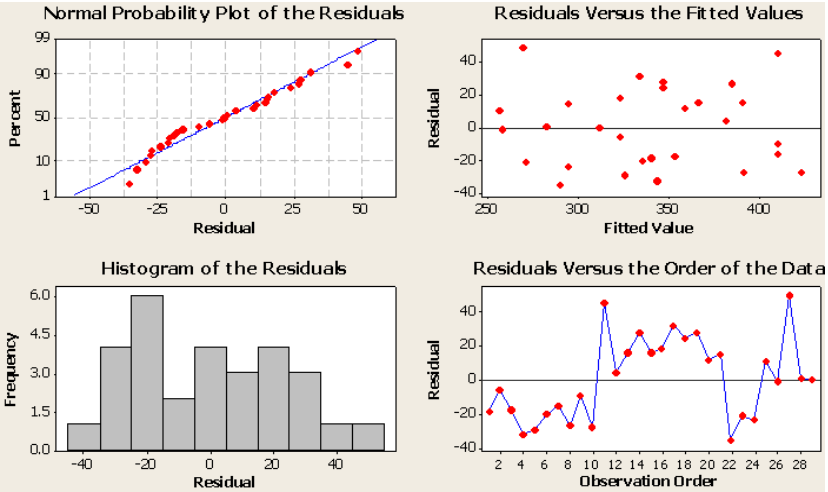

Fig. 8: Residual plots for Moder. Inj

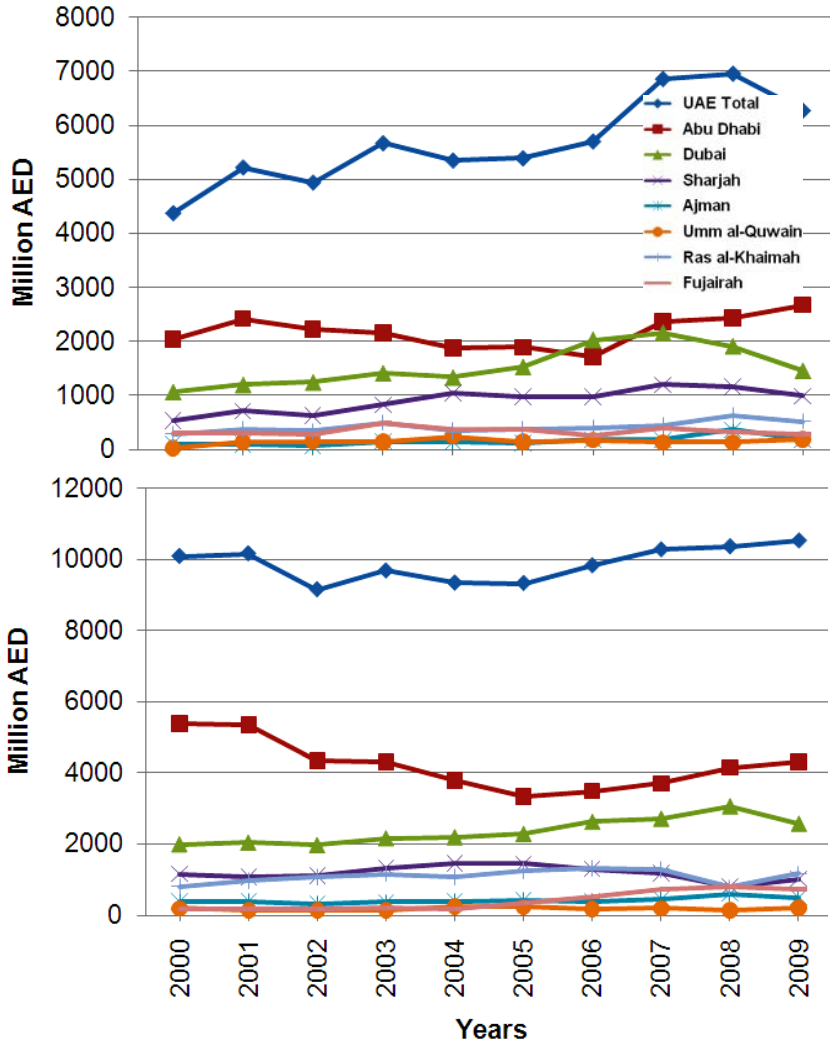

Fig. 9: Fatalities a) and injuries and b) costs in million AED for the period 2000-2009

Comparison of road traffic accident statistics with other countries: To compare the road accident fatalities statistics for the UAE with those for the Gulf countries, Arabic countries and worldwide, the latest statistics provided by the World Health Organization (WHO) was used. The latest WHO (2009) report provided statistics for road accidents facilities for the year 2007 for most counties and that for 2006 or 2005 when not available for latter years. The UAE shows the 2nd highest number of accident fatalities and injuries among the Gulf countries after Saudi Arabia. If you sort the Gulf countries once based on the number of road accidents fatalities and another time based on the population you will almost get the same order in both cases. The number of accidents per 100 thousand of population is used to eliminate the effect of the difference in population. Oman had the highest number of fatalities per 100 thousand of population followed by Saudi Arabia and then UAE and Qatar. Bahrain had the lowest number of fatalities per 100 thousand. On the other hand, Bahrain had the largest number of road injuries followed by Oman then Kuwait then UAE. The Saudi Arabia had fewer injuries per 100 thousand of population than UAE. The percentage of each gender (males and females) from the total number of road accident fatalities shows that in all Gulf countries the percentage of female fatalities is way smaller than that for male fatalities. This may be attributed to the fact that more males have licenses than females in these countries.

A review of the data showing which Gulf countries has seatbelt laws, the level of enforcement of these laws and the seatbelt wearing rate had been done. All the Gulf countries had seatbelt laws for front seat passengers and only Saudi Arabia had laws for all passengers. The level of enforcement of these laws was equal to or <61% for all Gulf countries except Oman that had a 95% level of enforcement. There was no correlation found between the rate of wearing the seatbelt for the front passenger and the number of accident fatalities or injuries per 100 thousand of population.

The road accident fatalities and injuries for six selected Arabic countries (Libya, Egypt, Jordan, Lebanon, Yemen and Iraq) were reviewed. Egypt had the highest number of fatalities (12,295) and injuries (154,000) among the selected Arabic countries, whereas the UAE had the fifth highest number of fatalities and the fourth highest number of injuries. Based on the number of fatalities per 100 thousand of population the UAE (24) had the second largest number among the selected Arabic countries after Libya (35). It also had the second largest number of injuries per 100 thousand of population after Jordan (303).

Among the selected Arabic countries the percentage of female fatalities is way smaller than that for male fatalities. This may be attributed to the fact that more males have licenses than females in these countries.

Furthermore, the number of fatalities and accidents in the UAE is compared to some selected worldwide countries of interest: USA, Canada, England, Switzerland, Sweden, Japan and South Africa. The UAE shows the second highest number of accident fatalities per 100 thousand of population among the selected worldwide countries after South Africa. On the other hand, it has the lowest number of road accident injuries per 100 thousand of population. The percentage of each gender (males and females) from the total number of road accident fatalities is reviewed. In the selected countries the percentage of female fatalities is way smaller than that for male fatalities. The difference between the percentage of male and female accident fatalities is smaller in these selected worldwide countries than those for the Gulf countries or the selected Arabic countries.

Summary: This study came to investigate and analyze traffic accidents rate and causes and to find recommendations to reduce the traffic accidents hazard. Data on traffic accidents in the UAE were collected from the General Administration of traffic coordination department at the Ministry of Interior (MOI). The collected data covered the period from 2000-2009.

Through investigating the causative factors of traffic accidents in the UAE, a number of issues such as causes of accidents and characteristics of road users were considered in the study. Based on the performed critical analysis, the total number of traffic accidents in the UAE per 100 thousand of population dropped by about 70% over the last 10 years (2009 in comparison with 2000). Abu Dhabi witnessed 38% of the traffic accidents; the highest number among the seven emirates, followed by Sharjah (20%), then Dubai (19%). Among many causes of accidents, the main cause of accidents is the disrespect of other road users, it accounted for almost 22%. The "other" category of the accident causes was found to account for nearly 29% of the causes as revealed from the data collected from the traffic accident reports. This very high percentage indicates that the accident report format needs some alternations to better categorize the traffic accident causes and make the judgment easier to traffic officers in the accident site. The >90% of the accidents maybe associated with the driver faults/behavior. The most predominant cause of fatalities that accompany the accidents is the speeding cause (accounts for about 47%).

The study also provided an overview of the fatalities and injuries due to traffic accidents for the last 10 years in the UAE. In addition, the economic impact of traffic accidents was discussed. The overall numbers of fatalities

in the UAE for the last 10 years witnessed a noticeable increase in year 2007 and 2008 compared to the previous years. Whereas, the year 2009 showed a decrease in the number of fatalities. The number of fatalities per 100 thousand of population dropped from 21 in 2000 to 12 in 2009 which reflects a major improvement in reducing the severity of traffic accidents. For most of this 10 years period Abu Dhabi had the highest rate of fatalities followed by Dubai and then Sharjah. The distribution of the total number of fatalities for the last 10 years among different age groups showed that the people ageing from 18 to <45 years are more prone to being a traffic accident fatality. The 39% of the fatalities lied in the age group (from 18 to <30 years old) and about 33% in the age group (from 30 to <45 years old). The same conclusion can be extended to the traffic accident injuries for the period from 2007-2009.

The overall numbers of injuries due to traffic accidents in the UAE showed that the overall injuries numbers are slightly increasing over the last years. On the other hand, the number of injuries per 100 thousand of population showed a 58% reduction in the number of injuries per 100 thousands among the last 10 years. For this 10 years period Abu Dhabi had the highest numbers of injuries followed by Dubai and then Sharjah. Based on the information provided by the Ministry of Interior, the average cost per year of fatalities for the last 10 yours was found to be AED 5672 millions and the average cost per year of injuries ADE 9873 millions. Abu Dhabi had the highest cost of fatalities and injuries followed by Dubai.

Driver has a very important role in traffic accidents and most of the time he/she holds the major responsibility (>90%) as he/she has the highest control level on the road. There has been an excessive increase in the number of new driver's licenses issued over the past 10 years where they almost doubled in number in 2009 as compared to that in 2000 (496138 in 2009 while it was 262045 in 2000). Most of these licenses are newly issued licenses (in 2009, 325523 new licenses and 170616 renewed licenses). The lack of experience that usually associates new drivers can play a major role in traffic accident occurrence.

For fatality associated accidents, results indicate that the average number of licenses associated with each fatality is decreasing over years which indicate that there is an increase in the accident severity (fatality) over time with more cars being involved in these accidents upon their occurrence.

CONCULSION

A significant increase in the number of fines issued per license can be seen clearly which rises on average from 5 fines/license in 2000 to 13 fines/license in 2009. The major increase happened after year 2008 after the implementation of the unified law which reflects that a stronger traffic enforcement law took place which played a major role in traffic accidents reduction. Regarding the citizenship of the drivers who are involved in traffic accidents, results indicated that for all types of vehicles emirates nationals drivers represent the citizenship with the highest involvement rate in traffic accidents followed by Pakistanis then comes the Indians drivers.

RECOMMENDATIONS

Based on the statistical analysis performed in this study and our field work, it was clearly noticed that the traffic accident report needs to be modified to include more details about the traffic accident such as traffic accident exact location using a GPS system to record the traffic accidents location coordinates by traffic police at the time of accident. Accident locations can be then identified on digital GIS maps to highlight the High Accidents Locations (HALs) for further remedy of such sites. Accident reasons need to be revised and to be made easier to measure. For example, disrespect of other road users is hard to measure by the traffic policeman and other reasons that can be related to the traffic accident such as not yielding, not slowing down at pedestrian crossing areas, etc., can be used. It is better to include the geometric details of the highway at the accident location in the accident report such as the highway width, median geometry, etc., to better understand the relationship between road geometry and traffic accidents. This can also include information about traffic control devices used at the intersection/highway to measure the commitment level of drivers. Details related to passengers such as whether they were wearing the seatbelt or not can be added to the report. Sections about injuries, fatalities can be also added to the traffic accident form.

As speed is considered a crucial factor in fatality related accidents, a review of the speed limit over highway sections that are exposed to high accidents rates is necessary. According to prevalent traffic, road and accidents condition, speed limit might need to be revised to enhance traffic safety levels. It's also recommended to check other geometric highway details such as highway stopping sight distance, intersections' sight distances, etc., to check their compatibility with the current road conditions. Traffic lights performance need to be checked to ensure a better traffic circulation system especially in terms of signals coordination, dilemma zones eliminations, etc. It's important to perform traffic volumes counts for highway sections with high accidents rates to check if the

road is working at or near capacity and how can this be related to traffic accidents records. Vehicle registration (especially for insurance) can be related to driver history of fines and traffic accidents. Higher insurance can be assigned to drivers with large fines and accidents record. Development of special programs for training, assessment and monitoring for the highest involved citizenships in traffic accidents is needed. These can be done in different languages to ensure their effectiveness.

Finally, several traffic safety issues are still in need of further analysis and discussion. For example, the causes reported by the police are only specific to each case. These causes are not the same as overall (system-wide) causes for traffic accidents. In other words, while these data might show that 90% accidents are caused by driver error, how do we know that diver error is not caused by say, "improper licensing" or "overworked taxi drivers" or "faulty highway design" or any other reason. Further, we do not know what the police means by "disrespect of other road users", we also do not know why many of the other causes (e.g., "tail-gating") do not fall within the "disrespect" category. There is a need to clarify what causes are contained within the "disrespect" category.

The research has to also study many of the potential causes of accidents including but not limited to highway design, licensing procedures, management of taxis, policing issues, etc. With the available data it is difficult to make any real recommendations and as it turns out the recommendations made is simply a request for more data.

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