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COST-BASED ANALYSIS FOR HIGH SEVERITY LOCATIONS OF TRAFFIC ACCIDENTS IN JORDAN

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ABSTRACT

Traffic accidents constitute a serious cause of death and injuries in the entire world. They are also considered as a major cause of financial and physical losses. This causes traffic accidents to have considerable threats and negative impacts on the entire society.

In the past few years, a large growth in the mobility of vehicles in Jordan has contributed to an increase in traffic congestion as well as in the number of traffic accidents. Although previous studies have indicated that risky behavioral characteristics of drivers is the main reason behind traffic accidents in Jordan, the number and severity of accidents can be mitigated and road safety can be improved through better design and engineering of road systems.

This study aims at investigating and analyzing traffic areas in the Governorate of Madaba in Jordan that can be considered as having low level of safety and so causing major negative impact on people's health and emotions. Data that shows severity, location and number of people and vehicles involved in each traffic accident in Madaba Governorate for the period from 2011 until 2013 was collected from the databases of the Pubic Security Department (PSD) in Jordan and analyzed.

Since the identification of accident location is a critical element in accidents' analysis, accidents were located on road maps. Sites with large number of accidents were precisely investigated and studied in terms of the severity of accidents, the expected economic loss and the problems causing the accidents in these sites.

This study will produce a number of practical solutions aim at improving the traffic safety and reducing the frequency and severity of traffic accidents and the associated economic and social costs in the governorate. This research will constitute a model for further studies that can be conducted in other areas in Jordan and in the world.

KEYWORDS: Traffic accidents, Traffic safety, Severity of accidents, Accident location, Economic cost

INTRODUCTION

Traffic accidents have an enormous effect on individuals and communities as well as on national economies. Large number of people is being killed every year on the world's roads. Although, many safety strategies are being widely and successfully applied every year in the world countries, results from the Global Status Report on Road Safety, prepared by the World Health Organization, shows that the overall number of people killed in the world due to traffic accidents is about 1.24 million every year, and this number was not reducing during the period between year 2007 and year 2010 (World Health Organization, 2013). The report also indicates that traffic injuries are the eighth leading cause of death globally, while they are the leading cause of death for young people aged 15 years to 29 years.

According to World Life Expectancy (2014), the number of traffic accidents' deaths in 2013 is 1,681 people that form 6.67 percent of the total deaths in Jordan. That makes road traffic accidents the fifth largest cause of death in Jordan after coronary heart disease, stroke, hypertension and diabetes mellitus. In addition to the large negative health and psychological impact on individuals and societies, traffic accidents in 2013 cost Jordan about 365

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million U.S. Dollars, causing about 1.086% loss in GDP (i.e. the financial value of all services and goods produced within the country for a year) calculated from the data provided by Jordan Traffic Institute (2013) and Central Bank of Jordan (2014a).

Traffic accidents are normally caused by factors related to the vehicle, the roadway and the driver. Malfunctions in the performance of vehicles, inadequate roadway design, deficient surrounding environment and risky behavioral characteristics of drivers are among the main reasons why accidents take place.

Records of traffic accidents reported by the Jordan Traffic Institute (2013) have showed that a percentage of traffic accidents have been caused by road defects, such as water puddings, holes, humps, defective or hidden traffic pillars, defective security barriers, defective road edges, lack of working on the road signs, road works debris, high and low manholes' covers and lack of traffic controls. The report by Jordan Traffic Institute (2013) shows that among road defects in Jordan, water puddings, holes and humps, seem to cause the largest number of road accidents compared to other types of defects. For the reasons recorded for traffic accidents in 2013, the road defects constitute only 0.09% of the total records, while 2.16% of the records indicate vehicle defects and 97.75% of the records indicate driver faulty and risky behaviors involved in traffic accidents.

Although, many studies tried to investigate causes of road accidents in Jordan (Abojaradeh, 2013; Al-Khateeb, 2010; Al-Masaeid, 2009; Al-Omari et al., 2013), finding the real cause of accidents can be a complex objective. An accident can be caused by a combination of several reasons, and the real reason behind the accident can be ambiguous. A good engineering design of roads and traffic systems can mitigate the effect of accidents' causes, and can cause a reduction in the number and severity of road accidents.

The economic cost of accidents is relatively significant (Al-Masaeid et al., 1999; Jadaan et al., 2013). Therefore, many infrastructure upgrades in roadway network can be justified by cost benefit analyses. Traffic accidents can be classified in terms of severity as fatality, personal injury and property damage accidents. Fatal accidents are those involving loss of life. Personal injury accidents are those involving injuries to drivers and passengers of involved vehicles. While property damage accidents are those involving damages to vehicles, roadway infrastructure, utilities and traffic control devices.

A study by Al-Masaeid et al. (1999) has aimed to estimate the economic costs of traffic accidents in Jordan during the year of 1996. According to the research, the costs of traffic accidents were estimated and calculated by collecting traffic accident records from traffic police departments, insurance companies and hospitals. The results estimated the cost of fatal, injury and property damage accidents. These results take account of costs such as, vehicles and properties repair cost, detention period cost, hospital and medical treatment cost, police activities' cost, insurance administration costs, loss of output, loss of quality of life and community and family losses.

OBJECTIVES OF RESEARCH

This study aims at investigating traffic accidents in the Governorate of Madaba in Jordan. Available records about accidents in the Governorate of Madaba were collected from the database of the Public Security Department (PSD) in Jordan. Records about time, severity, location coordinates and number of people and vehicles involved in traffic accidents are available for each traffic accident occurred in Madaba Governorate for the period from 2011 to 2013.

Although, some research papers have investigated the reasons of traffic accidents, there is a lack of relating these accidents to the characteristic of the location and the surrounding environment. Therefore, this research aims at locating traffic accidents on maps to study the accidents in terms of location and surrounding environment.

Areas of high number and severity of traffic accidents will be located and investigated. Accident severity index and cost of accidents of locations will be calculated to help in highlighting areas of high risk.

METHODOLOGY OF RESEARCH

Calculations of accidents Severity Index will depend on the method adopted by Jordan Traffic Department (2000). In this method, the number of accidents that caused fatality, injury or property damages should be counted in road intersections and in road sections with 1 kilometer length, within a time period of 3 years. Therefore, only the latest available data of the years 2013, 2012 and 2011 will be used in this study. Then, Equation (1) should be used to calculate the required severity index. Traffic Black Spots have been defined by the ministry of housing

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and public works in Jordan to refer to the areas where the severity index is greater than 10 units in the capital or 5 units elsewhere. In future research it is recommended to enhance the equation to take into consideration four severity levels of traffic accidents (Fatal, Sever Injury, Slight Injury and Property Damage Accidents) provided in the data from the PSD of Jordan.

Severity Index = (Number of Fatal Accidents × 3) +
(Number of Injury Accidents × 1)+
(Number of Property Damage Accidents / 3) ……Equation (1)

Depending on the study of Al-Masaeid et al. (1999), economic cost of accidents for the year 1996 will be estimated in U.S. Dollars as (89,931), (5,852), and (1,972) for fatal, injury and property damage accidents respectively. It is recommended in future research that the cost should be recalculated for the four severity levels of accidents described previously. In this study, the severity and cost of slight injury accidents will be regarded or estimated as equivalent to property damage accidents. The following paragraphs in this section describe the procedure adopted to estimate the cost of accidents for the years 2011, 2012 and 2013 included in this research.

The U.S. Federal Highway Administration (2005) has recommended an adjustment procedure to modify cost of accidents for specific years. This adjustment procedure uses a ratio of the Consumer Price Index (CPI), shown in Equation (2), to estimate the economic cost of traffic accidents in a specific year from a known cost in a different year. CPI is a measure that expresses changes on the prices of a list of goods and services in a year, to show the effect of inflation on purchasing power (BusinessDictionary.com, 2014).

Cost Adjustment Ratio of Traffic Accidents in Year n =
$CPI_{\text{in year } n} / CPI_{\text{in year 1996}}$ ……Equation (2)

Central Bank of Jordan (2014b) has described the methodology used to estimate the CPI values for different years in Jordan. CPI values were estimated by the Jordanian Department of Statistics to measure the general price level of a fixed basket of 851 commodities and services consumed by the Jordanian family, while assuming that CPI in the year 2006 equals 100.

CPI values have been collected from the statistical database of the Central Bank of Jordan (2014c) for the years from 1976 to 2013. In this research, the CPI values that will be used are for the year 1996 with known cost of accidents according to Al-Masaeid et al. (1999), and for the years 2011, 2012 and 2013 that will be analyzed in this study. Table 1 shows CPI values, calculated adjustment ratios, and estimated cost of traffic accidents in Jordan for the years 2011, 2012 and 2013.

Table 1: Adjusted Cost of Traffic Accidents

Year	CPI	$Adjustment\ Ratio = CPI_N/CPI_{1996}$	Cost of Traffic Accident in U.S. Dollar		
			Fatal	Injury	Property Damage
1996	77.675	1.000	89931	5852	1972
2011	129.967	1.673	150474	9792	3300
2012	136.150	1.753	157633	10257	3457
2013	143.617	1.849	166277	10820	3646

Site investigations for the areas with considerable number and high severity of accidents were conducted, and possible causes of accidents, especially related to road defects, were investigated. This study, with the records of accidents, helps to identify causes of traffic accidents and may initiate a number of subsequent studies to further determine possible implementations of strategies to reduce the frequency and severity of traffic accidents and the associated economic cost.

In this study, the researchers incorporate environmental impacts of traffic accidents. This will produce a number of practical implementations aimed at improving the traffic safety in the governorate. Furthermore, this study will constitute a model for further studies to be conducted in other areas of the kingdom.

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ANALYSIS OF TRAFFIC ACCIDENTS

Madaba governorate is located in central Jordan in the south-west of the capital Amman. It is well known nationally and internationally of its heritage and religious places. It is one of the most important places for tourism in Jordan. This encouraged the Jordanian government to provide more attention to the safety of traffic and roads in Madaba.

From year 2004 to year 2010, traffic accidents caused killing of about 5,585 people and severely injuring of about 17,919 people in Jordan. In Madaba governorate, about 136 people were killed and about 515 people had severe injuries for the same time period. This constitutes about 2.4 and 2.9 percent of the whole number of dead and severe injured people of the traffic accidents in Jordan, respectively.

Reports produced by the Jordan Traffic Institute record the total number and casualties of traffic accidents in in Jordan. Figure 1 and 2 provide presentation for the records in the reports from year 2004 to year 2013.

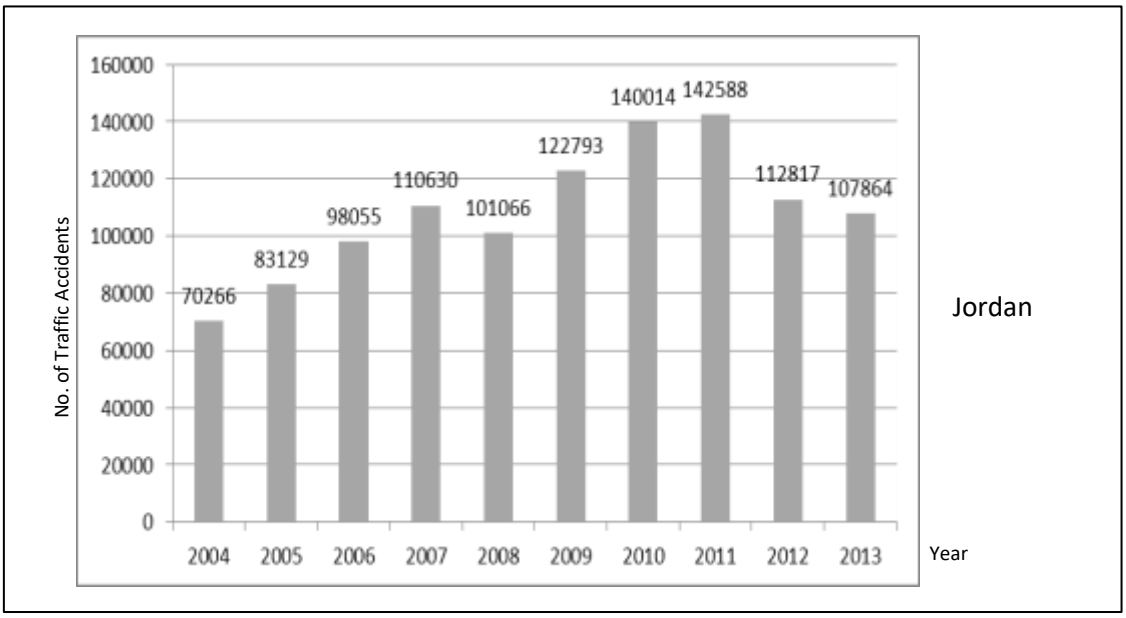

Figure 1: Number of Traffic Accidents in Madaba Governorate and in Jordan (Source: Jordan Traffic Institute (2004 to 2013))

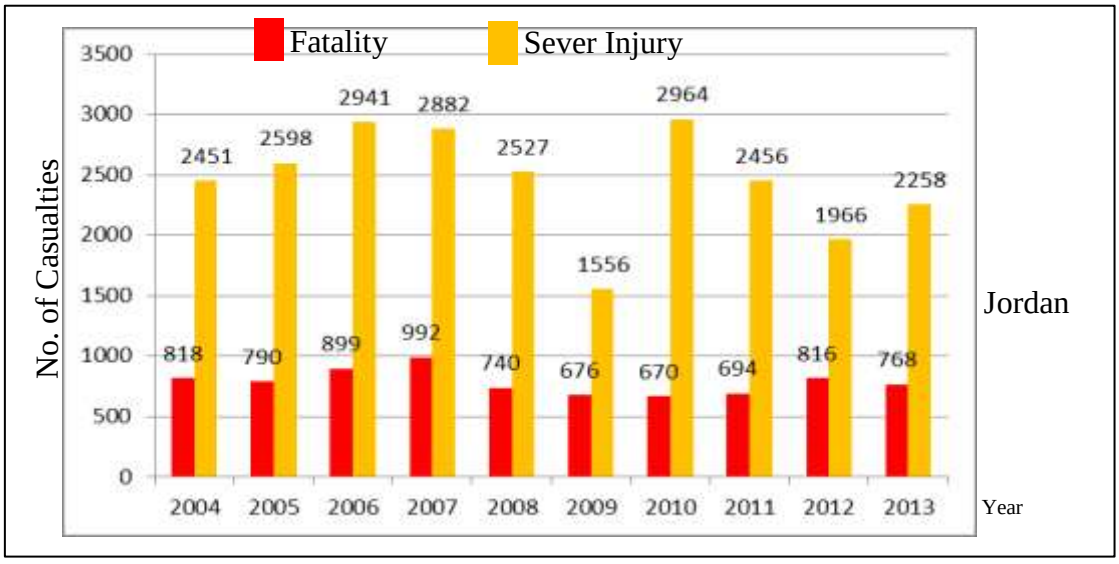

Figure 2: Number and Severity of People Casualties in Madaba Governorate and Jordan (Source: Jordan Traffic Institute (2004 to 2013))

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An increase in the number of accidents during the period from year 2004 to year 2007 (shown in Figure 1) was linked to the increase of the number of registered vehicles in Jordan. The records in Figure 1 and 2 show that a reduction in the number of accidents and casualties in Jordan was occurred in the year 2008. This reduction was caused by the temporary adoption of stiffer policy by the Jordanian government due to the increase in the number and severity of traffic accidents and after a horrific accident in Jordan with large number of casualties (Al-Masaeid, 2009). Although the data in Figure 1 shows a decrease in the number of accidents in Jordan in the years 2012 and 2013, it cannot be concluded from Figure 2 that there is a reduction in the number of casualties.

Data of location, severity and number of vehicles and casualties involved in traffic accidents for the time period from 2011 to 2013 was collected from the database of the Public Security Department (PSD). In this study, Google Earth maps was used to locate the traffic accidents of the three year time period to calculate cost of accidents and severity index for chosen sever areas.

The number and characteristics of recorded accidents in Madaba Governorate that is analyzed in this study is show in Table 2. Only small number of these records contain errors and so cannot be processed.

Table 2: Number of Records Processed in this Study

Year	Number of Accidents	Vehicles Involved	Fatal Accidents	Sever Injury Accidents	Slight Injury Accidents	Property Damage Accidents
2011	1499	2903	11	30	183	1275
2012	1517	2948	9	54	125	1329
2013	1857	3581	11	50	164	1632
Total	4873	9432	31	134	472	4236

The data of traffic accidents was processed by using Geographic Information System (GIS) and Google Earth (GE) maps. The resulting map is shown in Figure 3.

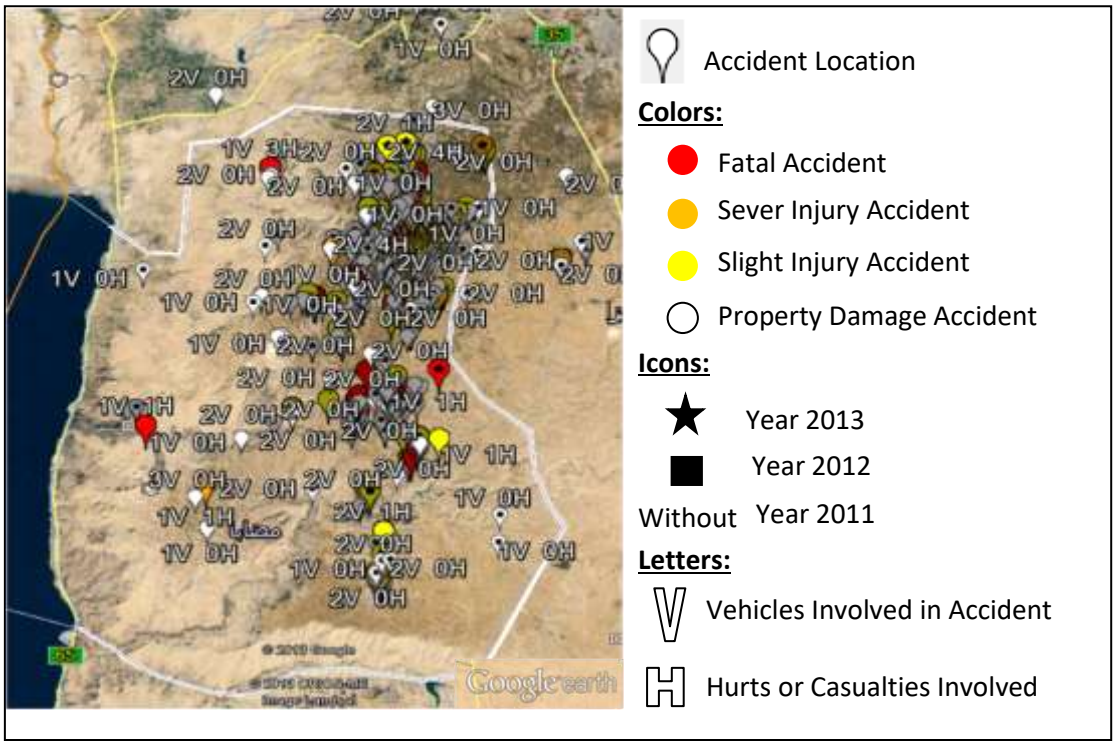

Figure 3: Traffic Accidents in Madaba Governorate

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In this paper, five of the most dangerous areas in Madaba Governorate, shown in Figure 4, have been chosen and analyzed in term of location, severity, and number of involved casualties and vehicles for the traffic accidents occurred in years 2011, 2012 and 2013.

Figure 4: Five Dangerous Areas in Madaba (General View)

Severity indices and cost of accidents in the five locations were calculated and presented in Table 3 using the procedures described in the methodology of research (Section 3). The calculations in Table 3 will regard slight injury accidents as equivalent to property damage accidents. The results show that the five chosen areas can be regarded as severe areas or Black Spots because the value of Severity indices are larger than 10. The results show that it is important and urgent to enhance these areas and provide traffic solutions.

Table 3: Severity Index and Cost of Accidents for the Five Areas in Madaba

Area Number		1	2	3	4	5
Number of Accidents 2011	Fatal	0	1	0	0	0
	Sever Injury	3	0	0	0	0
	Slight Injury	13	5	3	5	1
	Property Damage	36	17	6	35	9
Cost of Accidents 2011 (U.S. Dollar)		191,054	223,064	29,696	131,983	32,996
Number of Accidents 2012	Fatal	0	0	0	0	0
	Sever Injury	2	1	0	1	0
	Slight Injury	4	10	0	4	1
	Property Damage	33	50	13	44	23
Cost of Accidents 2012 (U.S. Dollar)		148,407	217,651	44,935	176,172	82,957
Number of Accidents 2013	Fatal	1	0	0	0	0
	Sever Injury	0	1	0	0	0
	Slight Injury	2	1	3	0	1
	Property Damage	13	32	25	5	14
Cost of Accidents 2013 (U.S. Dollar)		220,969	131,142	102,091	18,231	54,692
Severity Index		41.67	43.33	16.67	32.00	16.33
Cost of Accidents During 2011, 2012 and 2013 (U.S. Dollar)		560,430	571,857	176,723	326,386	170,645

DISCUSSION AND CONCLUSION

Site investigations for a number of areas with high calculated cost of accidents and accident severity index were conducted. Problems that may have negative impacts on traffic, such as increasing the number, severity, vehicles involved or casualties of traffic accidents are listed for each site location. Main problems which are common in the studied areas can be summarized as follows:

[1] The existence of a number of U-Turn intersections in high speed highways with no warning signs. Some of these U-Turn intersections are with no special lane for turning or humps for speed reduction.

[2] Most of the roundabouts have no warning signs, no signs for giving the priority to vehicles in the roundabout, and no signs for preventing vehicles from parking near the roundabout.

[3] Many of the road intersections have no stop signs, warning signs, giving priority signs or speed reduction humps. Also, there is a lack of mechanism to prevent vehicles from parking near roads intersections.
[4] There is a lack of police enforcement in areas with traffic problems.
[5] There is a need to improve the paint marking for all roads in Madaba Governorate.
[6] There is a need to improve roads sidewalks and pedestrians crossing areas.
[7] There is a lack of police enforcement or traffic cameras in high speed highways, cross sections, roundabouts, and cross sections with traffic signals.
[8] There is a lack of warning signs and speed humps in highways passing near residential areas.

RECOMMENDATIONS FOR FUTURE RESEARCH

This research study is conducted to provide a useful model to encourage researchers to study traffic problems and provide possible solution for other areas in Jordan. This study provides a platform that should be transformed into an action plan for the enhancement of traffic system in Madaba Governorate to improve safety and reduce number and severity of traffic accidents. Also, more efforts will be needed in the future to evaluate the implemented improvements in traffic systems and their effect on traffic safety.

More studies should be conducted to recalculate the recent expected cost of traffic accidents according to four severity levels of fatal, sever injury, slight injury and property damage accidents. More efforts are also required to improve the equation used to calculate severity index of traffic areas to take into consideration the four severity levels of accidents.

In this research, it is recommended to encourage police officers, and enhance their awareness about the importance to precisely record the detailed information about each traffic accident. Information should include characteristics of traffic accidents such as location and coordinates, accident reason and shape, road shape, road defects, road condition and environment, number of involved casualties and vehicles, speed limit, light and weather condition, and severity level of accident. This will help researchers in Jordan to conduct studies with enhanced quality, and help to provide better results and solutions for traffic problems. This will encourage improved implementation and application of traffic solutions for safer traffic in Jordan.

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