Analysis of Traffic Problems in Kuwait

MOHAMMED A. HAJEEH
Techno-Economics Division
Kuwait Institute for Scientific Research
P.O. Box 24885; Safat-13109
KUWAIT
mhajeeh@kisr.edu.kw http://www.kisr.edu.kw

Abstract: Road traffic accidents are ranked ninth as the leading cause of death worldwide, and are predicted to move to the third rank by 2020. The estimate cost of traffic crashes globally reaches 518 billion US dollars each year. Kuwait is one of the countries with the highest number of car accidents fatalities in the world; it is ranked first in the Middle East with 28 fatalities per 100,000 vehicles. The problem is very serious and immediate actions should be taken by the decision makers. This study attempts to examine the problem closely and presents some solutions. Due to the complexity of the problem with multiple objectives and constraints, the Analytic Hierarchy Process is used. Experts opinion are solicited in order to identify and rank the important targets and select and address the various relevant policies.

Key-Words: - Accidents fatalities, Vehicles, Policies, Targets.

1 Introduction

Road traffic accidents (RTAs) kill 1.2 million person per year (32876 per day), it accounts for injured and disabled between 20 to 50 million, RTAs rank 9th as a leading cause of death (2.1% of all deaths globally). More than 50% of RTAs occur among young adults between 15 and 44 years of age, and 73% of all fatalities are male. If no proper actions are taken, RTAs are predicted to increase globally by 67% by 2020 and rank third as a leading fatality cause. Estimate costs of traffic crashes globally are US$ 518 billion each year accounting 1-2% of the GNP of many countries. The global road mortality rate is 19.0 per 100,000 populations. Although road traffic injuries are a major health concern for all countries, the problem is particularly acute in low-and middle-income countries, which account for about 85% of deaths resulting from road traffic crashes globally [1]. The actual risks encountered in Japan and the United States were examined in [2]. Results identified the traffic risks in the two countries and confirm their potential for explaining cross-national difference in risk perceptions.

In [3], it was stated that about 90% of the disability adjusted life years lost worldwide due to road traffic injuries occurred in developing countries, it was found that the problem is increasing at a fast rate in these countries due to rapid motorization amongst other factors [4]. When comparing European countries, Belgium has one of the worst road safety records; 502 road traffic injures per 100,000 inhabitants and 14 fatalities (deaths within 30 days) per 100,000 populations. The second worst hit country in road traffic injures was Portugal with 462 road traffic injuries per 100,000 inhabitants. Portugal has however a higher number of fatalities than Belgium (16.8 per 100,000 inhabitants) [5].

Comparisons were made between the safety levels and trends in OECD countries from 1980-1994 using a statistical model [6]. It showed that the average annual fatalities due to car accidents decreased in all the selected countries except Japan (+12%), Greece (+56%), and ex-East Germany (+50%). The highest decrease was observed in ex-West Germany, Switzerland, Austria, and UK with -48%,-44%, -40%, -39%, respectively. The IRTAD (the OECD data) was used. The work in [7] examined road traffic accidents in Philippines, review of 35 years of data on injuries showed that one in 11 deaths in this country is due to traffic accidents. 42% of deaths are for people 15-44 years of age. The proportion of all deaths are attributed to intentional injuries has increased by 925% and that of motor vehicle crashes by 600% from 1960 to 1995. The study recommended that more research should be undertaken into the factors that contribute to RTAs and suggested appropriate measures for the prevention of these accidents.

An assessment of traffic safety conditions for rural roads in Egypt was provided in [8]. Egypt having a significantly high rate of deaths per 100 million vehicle km. Data was calculated in five rural roads in Egypt (1990-1999). Three ANOVA statistical tests were conducted to establish if there are any significant differences in the data used for models' calibrations as a result of differences among the five considered roads. The result showed that six causes contributed to around 83% of all accidents on the five roads, while drivers related causes contributed to around 59-73%. Vehicle related causes and pedestrian related accidents were around 23% and 4%, respectively. The economic costs of traffic accidents in Jordan during 1996 were estimated in [9]. Several indicators were used to estimate the unit cost of property damages such as the vehicle repair cost, detention period cost, and public and private costs. Results indicated that the total traffic costs in 1996 were 146.3 million. These costs attributed mainly to human losses, property damages with 40% and 43%, respectively.

In order to forecast traffic fatalities by geographic region, the relationship between traffic fatality risk and per capita income was examined [10]. Data from 1963 to 1999 for 88 countries were collected. Linear and log linear models were used in order to project traffic fatalities. It was concluded that the death rate will increase in the future, and a decline in fatalities in high-income countries with an increase in China and India.

In this article [11], cross sectional data from the Gulf countries and time series data of road accidents were employed. Significant relationship was established between fatality rates and motorization levels. Fatality rates per vehicle were found to be inversely related to vehicle ownership levels. Fatality rates were also related to some social and environmental indicators such as population per physician, population per hospital bed, gross national product per capita

Recent data on road traffic accidents and road user behavior in the United Arab Emirates (UAE) were studied in [12]. Careless driving was identified as one of the major factors contributing to RTAs, accounting for more than 35% of all accidents. Excessive speed came in the second place accounting for 13.1% of total accidents, 19.5% of causalities, and 26.9% of fatalities. Tail gating was third with 6.4% of total accidents. The authors described the road pattern accidents in Qatar [13], this includes crashes, injuries, and fatalities for the period (1983-2000). It was found that although accidents have increased during this period, injuries had actually decreased by 285 and most accidents involved young drivers (10-19 years old).

The results of seven years of data from three air pollution monitoring stations in Kuwait was provided through several stations positioned in different locations such that the influence of traffic source on ambient air pollution contaminants could be detected [14]. The concentration of pollutants was measured during peak traffic hours. Analyses of the data showed a slight increase in the concentration of air pollution especially in districts located closer to the city.

In [15], the effect of seat belt use on motor vehicle accident fatalities in light of enacting Kuwait's belt law in 1994 was investigated. Data of more than 1200 accident victims were collected; statistical analysis showed that seat belt use has had a positive effect in reducing both road traffic fatalities and injuries.

Attempts were undertaken to identify the trend in seat belt use, smoking while driving, and road accidents of young drivers in Kuwait [16]. A survey questionnaire was used in a sample of 1467 randomly selected young drivers. It was found that females are usually safer drivers than their young male counterparts, those who smoked while driving used seat belt less, and had a higher rate of traffic accidents.

Traffic accidents in Kuwait are significantly high compared to many countries in world. This is attributed too many factors such as careless driving, not abiding by traffic rules and regulations among others. Figures 1 and 2 provide some statistics regarding traffic accidents and fatalities in Kuwait [17]. Table 1 provides a comparison between Kuwait and some other Middle East countries with regard to the number of traffic fatalities.

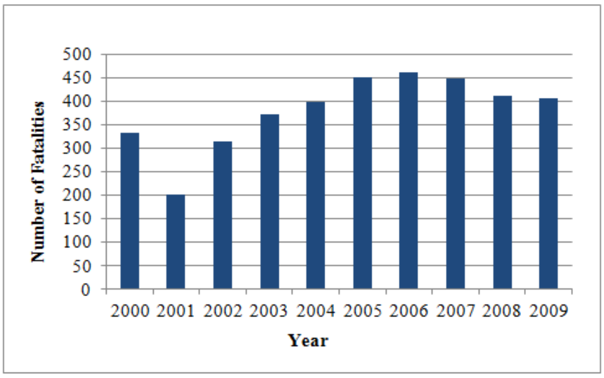

Figure 1. Number of car accidents fatalities in Kuwait during 2000-2009.

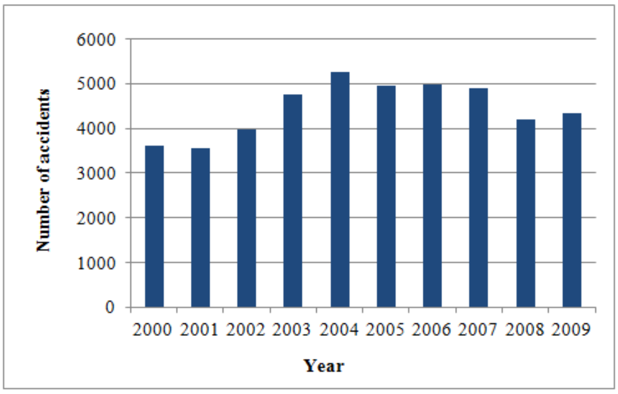

Figure 2. Number of car accidents per 100,000 vehicles in Kuwait during 2000-2009.

Table 1. Traffic fatalities per 100,000 vehicles for some countries in the Middle East.

Country	Population (Million)	Vehicles (000s)	Traffic Fatalities (per 100,000)
Algeria	32.1	2,730	12.8
Bahrain	0.7	205	10.9
Egypt	76.1	2,300	10.4
Jordan	5.6	361	12.8
Kuwait	2.3	754	28.8
Oman	2.9	492	23.6
S.Arabia	25.8	7,050	21.0

Source: United Nation Development Programme; World Health Organization 2005 [18]

2 Problem Descriptions

The main objective of this research work is to identify the most strategic policies to be used by the authorities in Kuwait in order to minimize the effects of car traffic problems both on human and property. In this regard, experts opinion were taken to identify the main targets and policies to be addressed; they are:

Targets

1. Reduce traffic accidents.
2. Reduce pollution.
3. Reduce carelessness.
4. Minimize congestion.

Strategic Policies

1. Strict application of traffic rules and regulation.
2. Awareness campaign.
3. Strict licensing rules.
4. Better car inspection tests.
5. Encouraging mass transport.
6. Improving infrastructure.
7. Efficient monitoring systems.

The analytic hierarchy process (AHP) was utilized to analyze the problem. Figure 3 presents the hierarchy of this problem in the AHP structure.

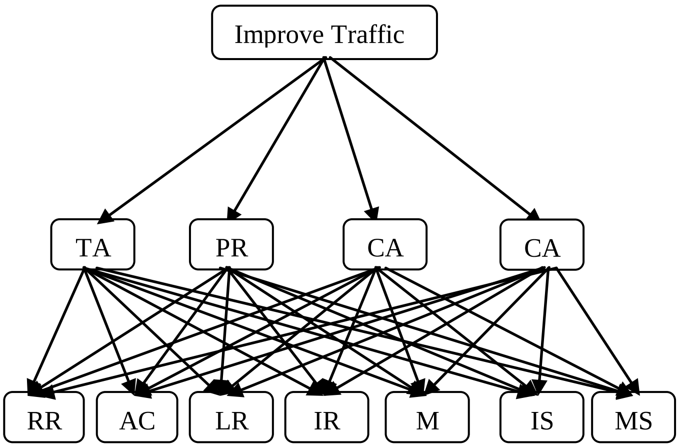

Figure 3. Hierarchy of the targets and policies for the traffic problem

3 The Analytic Hierarchy Process

The analytic hierarchy process (AHP) was developed by Thomas Saaty in 1970's. It is widely used for multi-criteria decision making and has been successfully applied to many practical decision making problems [19]. AHP was used as a decision support system for bid evaluation [20]. In [21] AHP was utilized in for the selection of a casting process, while in [22] it was used for the selection of the most suitable contractor in the pre-qualification of process of a project. Also AHP was employed to help in the selection of desalination plants in Kuwait [23].

In the AHP, the decision problem is structured hierarchically at different levels, each level consisting of finite number of elements. The relative importance of the decision elements (the weights of the criteria and the scores of the alternatives) is assessed directly from the comparison judgments. Pair-wise comparisons in AHP assume that the decision maker can compare any two elements E_i, E_j at the same level of the hierarchy and provide a numerical value a_{ij} for the ratio of their preference (importance), if E_i is preferred to E_j then $a_{ij} > 1$. Correspondingly, $a_{ji} = 1/a_{ij}$ and $a_{ii} = 1$ for $i,j = 1,2,\ldots,n$. Each set of comparisons for a level with

ISBN: 978-1-61804-071-8

n elements requires *n* (*n*-1)/2 judgments, which are further used to construct positive reciprocal matrix of pair-wise comparisons $A = [a_{ij}]$. The priority vector $w = (w_1, w_2,.., w_n)^T$ may be obtained from the comparison matrix by applying some prioritization method. AHP has three underlying concepts: structuring the complex decision problem as a hierarchy of goal, criteria, and alternatives, pair-wise comparisons of elements at each level of the hierarchy with respect to each criterion on the preceding level, and finally vertically synthesizing the judgments over the different levels hierarchy. The AHP consists of the following steps

1. State the overall objective of the problem and identify the criteria that influence the overall objective.
2. Structure the problem as a hierarchy of goal, criteria, sub-criteria, and alternatives.
3. Start by the second level of the hierarchy:
   - Do pair-wise comparison of all elements in the second level and enter the judgments in an $n \times n$ matrix using Table 2.
   - Calculate priorities by normalizing the vector in each column of the matrix of judgments and averaging over the rows of the resulting matrix and you have the priority vector.
   - Compute the consistency ratio of the matrix of judgments to make sure that the judgments are consistent.
4. Repeat step 3 for all elements in a succeeding level but with respect to each criterion in the preceding level.
5. Synthesize the local priorities over the hierarchy to get an overall priority for each alternative.

Table 2. AHP scale of preferences in the pair-wise comparison process

Numerical Ratings	Preferences between alternatives *i* and *j*
1	*i is equally preferred to j*
3	*i is slightly more preferred than j*
5	*i is strongly more preferred than j*
7	*i is very strongly more preferred than j*
9	*i is extremely more preferred than j*
2,4,6,8	*Intermediate value*

In AHP, the consistency index (*CI*) is defined as:

$$CI = (\lambda_{max}-n)/(n-1) \tag{1}$$

For each size of matrix *n*, random matrices were generated and their mean and consistency index (*CI*) values are calculated. The consistency ratio (*CR*) for each matrix is found using equation (2), were the value for the random index (*RI*) is tabulated in Table 3.

Table 3. Random index values sample size

n	3	4	5	6	7	8
RI	0.58	0.9	1.12	1.24	1.32	1.41

$$CR = CI/RI \tag{2}$$

The consistency ratio *CR* is a measure of how a given matrix compares to a purely random matrix in terms of their consistency indices. A value of the consistency ratio of less or equal to 0.10 is considered acceptable. Larger values of *CR* require the decision maker to revise his judgments.

4 Results and Analysis

In order to analyze the traffic problem in Kuwait, opinions were collected for the various targets and policies. Pair-wise comparisons were made between the targets in order to rank them according to their importance, results are as shown Table 4.

Table 4. Pair-wise comparison between the different targets and their geometric mean (GM)

	TA	PN	CA	MC	GM
TA	1.00	2.00	2.50	1.50	**0.39**
PR	0.50	1.00	1.25	0.80	**0.20**
CA	0.40	0.80	1.00	0.50	**0.15**
MC	0.67	1.25	2.00	1.00	**0.27**

$\lambda_{max} = 4.006$, CI = 0.002, CR = 0.002

Next step in the AHP is to compare the various polices with respect to each target. The pair-wise comparisons are as shown in Tables 5, 6, 7, and 8 along with the geometric mean (GM).

Table 5. Pair-wise comparison between the polices with respect to reducing traffic accidents

	RR	AC	LR	IR	MT	IF	MS	GM
RR	1.00	2.50	1.50	6.00	4.00	5.00	0.50	**0.23**
AC	0.40	1.00	0.75	4.00	3.50	4.50	0.30	**0.14**
LR	0.67	1.33	1.00	5.00	3.00	3.50	0.45	**0.17**
IR	0.17	0.25	0.20	1.00	0.70	0.80	0.15	**0.04**
MT	0.25	0.29	0.33	1.43	1.00	2.00	0.25	**0.06**
IF	0.20	0.22	0.29	1.25	0.50	1.00	0.20	**0.04**
MS	2.00	3.33	2.22	6.67	4.00	5.00	1.00	**0.32**

$\lambda_{max} = 7.18$, CI = 0.030, CR = 0.001

Table 6. Pair-wise comparison between the polices with respect to reducing pollution.

	RR	AC	LR	IR	MT	IF	MS	GM
RR	1.00	1.50	3.00	0.30	0.50	2.00	0.75	**0.11**
AC	0.67	1.00	2.00	0.20	0.30	1.50	0.70	**0.08**
LR	0.33	0.50	1.00	0.10	0.20	0.75	0.30	**0.04**
IR	3.33	5.00	10.00	1.00	1.50	7.00	2.00	**0.35**
MT	2.00	3.33	5.00	0.67	1.00	4.00	1.25	**0.22**
IF	0.50	0.67	1.33	0.14	0.25	1.00	0.20	**0.05**
MS	1.33	1.43	3.33	0.50	0.80	5.00	1.00	**0.16**

λ_{max} = 7.07, CI = 0.012, CR = 0.0004

Table 7. Pair-wise comparison between the polices with respect to minimizing drivers carelessness

	RR	AC	LR	IR	MT	IF	MS	GM
RR	1.00	2.00	3.00	5.00	4.00	7.00	1.50	**0.32**
AC	0.50	1.00	2.00	2.50	2.50	4.00	0.70	**0.17**
LR	0.33	0.50	1.00	2.00	2.00	3.00	0.40	**0.11**
IR	0.20	0.40	0.50	1.00	0.75	1.50	0.30	**0.06**
MT	0.25	0.40	0.50	1.33	1.00	3.50	0.35	**0.08**
IF	0.14	0.25	0.33	0.67	0.29	1.00	0.20	**0.04**
MS	0.67	1.43	2.50	3.33	2.86	5.00	1.00	**0.22**

λ_{max} = 7.095, CI = 0.016, CR = 0.0005

Table 8. Pair-wise comparison between the polices with respect to minimizing congestion

	RR	AC	LR	IR	MT	IF	MS	GM
RR	1.00	0.75	0.60	1.25	0.15	0.25	0.30	**0.06**
AC	1.33	1.00	0.75	1.50	0.35	0.50	0.60	**0.09**
LR	1.67	1.33	1.00	2.00	0.40	0.70	0.75	**0.11**
IR	0.80	0.67	0.50	1.00	0.10	0.15	0.25	**0.04**
MT	6.67	2.86	2.50	10.00	1.00	1.50	2.00	**0.33**
IF	4.00	2.00	1.43	6.67	0.67	1.00	1.20	**0.21**
MS	3.33	1.67	1.33	4.00	0.50	0.83	1.00	**0.17**

λ_{max} = 7.090, CI = 0.0158, CR = 0.00048

The data in Table 4 and in Tables 5, 6, 7, and 8 are synthesized and the composite geometric weights of the different policies are calculated. Details are given in Table 9.

Table 9. The Composite weight (CW) of the different polices in reducing traffic problem

	TA	PR	CA	CG	
	0.39	**0.20**	**0.15**	**0.27**	**CW**
RR	0.23	0.11	0.32	0.06	**0.18**
AC	0.14	0.08	0.17	0.09	**0.12**
LR	0.17	0.04	0.11	0.11	**0.11**
IR	0.04	0.35	0.06	0.04	**0.11**
MT	0.06	0.22	0.08	0.33	**0.17**
IF	0.04	0.05	0.04	0.21	**0.09**
MS	0.32	0.16	0.22	0.17	**0.23**

It can be observed from the results in Table 4, that the most important targets to be addressed by the authorities in order to reduce traffic problem are minimizing accidents and solving the congestion problem. With regard to the most preferred polices, improving monitoring systems comes first with a score of 23%, followed by strict application of traffic rules and regulation 18%, followed by encouraging mass transport (17%). Details are shown in Table 9.

5 Conclusions

The traffic problems in Kuwait are very serious and have become more severe and complicated over the years. The study recommends that decision makers in Kuwait take serious and immediate actions to resolve the traffic problem and the risk associated with it before it becomes acute and irreversible. It was found that many factors contribute to this problem, examples are drivers not abiding by traffic rules and regulations, carelessness driving, old vehicles that contribute to polluting the atmosphere, relaxed licensing procedures. In this study, opinions were taken to identify the most urgent policies to be enforced. Results showed that improving monitoring system and enforcing rules and regulations will undoubtedly contribute to minimizing the traffic problem, especially in reducing fatalities and injuries.

Future work should study the cost associated with traffic accidents both to human and property. Another research area is identifying the contribution of driver's behavior in causing accidents and congestion.

References

[1] H. Alyson, B.S., and John E. Ehiri, Road Traffic Injuries: Hidden Epidemic in less developed countries, *Journal of the National Medical Association,* V. 98, No.1, January 2006, pp.73-82.

[2] H. Hayakawa, P.S. Fishchbeck, and B. Fischhoff, Traffic accident statistics and risk perceptions in Japan and the United States, *Accident Analysis and Prevention*, V. 32, 2002, pp.827-835.

[3] E. Krug, *Injury: a leading cause of global burden of disease*. Geneva: WHO. 1999.

[4] G. Jacobs, A. Aaron-Thomas, and A. Astrop, Estimating global road fatalities. London: Transport Research Laboratory, TRL Report 445, 2000.

[5] http//www.mdcr.cz/text/rocemla_01/yearbook/html/e651.htm .2003.

[6] A statistical model to compare road mortality in OCED countries, Yves Page, *Accident Analysis and Prevention*, V. 33, 2001, pp. 371-385.

[7] R. J. Consunji, and A. A. Hyder, The burden of injuries in the Philippines: implications for national research policy, *Accident Analysis and Prevention*, V. 36, 2004, pp. 1111-1117

[8] K.A. Abbes, Traffic safety assessment and development of predictive models for accidents on rural roads in Egypt, *Accident Analysis and Prevention*, V. 36, 2004, pp. 149-163.

[9] R. Hashem, A. Al-Masaeid, A. Al-Mashajbeth, A. M. Qudah, Economic costs of traffic accidents in Jordan, *Accident Analysis and Prevention*, V. 31, 1999, pp. 347-357.

[10] E. Kopits and M. Cropper, Traffic fatalities and economic growth, *Accident Analysis and Prevention*, V.37, 2005, pp.169-178.

[11] Jadaan, K.S, Traffic Safety in the Gulf countries with special reference to Kuwait, *Transport Reviews*, V. 8, No. 3, 1988, pp. 249-265.

[12] A. Bener, and D. Crundall, Road traffic accidents in the United Arab Emirates compared to Western countries. *Advance in Transportation Studies an International Journal*, Section A6, 2005, 5-12.

[13] A. Bender, and D. Crundall, Risk Taking behavior in Road Traffic Accidents and Fatalities, *3rd international conference on traffic & transport psychology*, 5-9 September, 2004

[14] N. Al-Mutairi, and P. Koushki, Potential contribution of traffic to air pollution in the state of Kuwait, *American Journal of Environmental Sciences*, V.5, No. 3, 2009 pp.218-222.

[15] P.A. Koushki, M.A. Bustan, and N. Kartam, Impact of safety belt use on road accident injury and injury type in Kuwait, *Accident Analysis and Prevention* V. 35, 2003, 237-241.

[16] P.A. Koushki, and M. Bustan, Smoking, belt use, and road accidents of youth in Kuwait, *Safety Sciences* V. 44, 2006, pp. 733-746.

[17] Traffic Statistics, Ministry of Interior, State of Kuwait, 2010.

[18] World Health Organization, The world Report on Road Traffic Injury Prevention, 2004

[19] T.L. Saaty, *The Analytical Hierarchy Process*, McGraw Hill, New York, USA. 1980.

[20] M.A Mustafa, and T.C. Rayan, Decision Support for Bid Evaluation, *Project Management*, 8, No. 4, 1990, pp.230-235.

[21] M.K. Tiwari, M.K., and R. Banerjee, A Decision Support System for the Selection of a Casting Process Using Analytic Hierarchy Process” *Production Planning and Control*, V.12, No.7, 2001, pp. 689-694.

[22] A.A. Kamal, Application of the AHP in Project Management, *International Journal of Project Management*, V.19, 2001, pp. 19-27.

[23] M. Hajeeh, and A. Al-Othman, Application of the Analytic hierarchy process in the selection of desalination plants, *Desalination* V. 174, No. 1, 2005, pp. 97-108.