

Strategy to improve road safety in developing countries

Abdulbari Bener, PHD, MFPHM, Fikri M. Abu-Zidan, FRCS, DipApplStats, Abdel K. Bensiali, MSc, PhD, Ahmad A. Al-Mulla, MD, DrPH, Khair S. Jadaan, ITMA, MASCE.

ABSTRACT

Objective: To review the road safety situation in developed and developing countries compared with the Arabian Gulf countries and suggest a strategy to improve it. The role of road engineers in reducing accidents is highlighted.

Methods: This is a retrospective study of road traffic accidents (RTAs) for a period from 1988 to 1998 in Arabian Gulf Countries. The data was taken from the Directorate of Traffic and Ministry of Health records in Gulf Countries. Additional data was obtained from other sources including the World Health Organizations Statistics Annuals, International Road Federation, Transport Road Research Laboratory and accident facts publications. Overall fatality and injury rates of RTAs were calculated.

Results: The lack of reliable data is a serious problem in most of the developing countries. It is quite reasonable to assume that the incidence of accidents is much larger than

actually reported. A comparison of vehicle ownership levels and safety parameters in both developed and developing countries is presented to highlight the relative seriousness of the road safety situation in different countries. The fatality rates (per population and per vehicles) are selected for comparison purposes from developed and developing countries.

Conclusion: Road traffic accidents continue to be a major cause of mortality and morbidity in the Arabian Gulf Countries leading to substantial wastage of life and national resources. Further investigation is essential and will require close inter-sectoral collaboration between, traffic police, health, law, and transport authorities. Developing a research strategy for prevention will reduce casualties and death on the road.

Saudi Med J 2003; Vol. 24 (6): 603-608

Road traffic accidents (RTAs) are recognized as a growing public health problem in the Arabian Gulf and other developing countries.¹⁻⁴ The discovery of oil around the middle of the last century has changed many aspects of life in the Arabian Gulf Countries. The increased number of population and vehicles were accompanied by expanding road construction programs. Nevertheless, change in the behavior of drivers was slower.³ The result was a large number of traffic accidents that have high serious fatality. The magnitude of the road safety problem varied between different countries. Recent research has shown that many developing countries have a serious road accident

problem and that accident rates are higher than those of western industrial countries.⁵⁻⁶ Road traffic accidents are a significant but preventable, cause of death, disability and economic loss in developing countries.⁷⁻⁸ Motor vehicle injuries are the third most important cause of death in developing countries.⁹ This affects mainly the young males who are economically active. It is projected that RTAs will be the second cause of disability-adjusted life years in a developing countries.⁷ In United Arab Emirates RTAs are the second cause of death for all age groups.¹⁰⁻¹¹ Despite that, there is a low appreciation for its health and economical burden.¹² World Health Organization¹³ (WHO) has stressed the

From the Department of Medical Statistics & Epidemiology (Bener), Department of Public Health & Disease Control (Al-Mulla), Hamad Medical Corporation, Doha, Qatar, Department of General Practice and Remote Health Care Unit (Bener), Aberdeen University, United Kingdom, Department of Surgery (Abu-Zidan), Faculty of Medicine, United Arab Emirates University, Al-Ain, Red Crescent (Bensiali), Abu Dhabi, United Arab Emirates, and the Department of Civil Engineering (Jadaan), Faculty of Engineering, University of Jordan, Amman, Jordan.

Received 9th November 2002. Accepted for publication in final form 5th February 2003.

Address correspondence and reprint request to: Prof. Abdulbari Bener, Advisor WHO and Head of Department of Medical Statistics & Epidemiology, Hamad Medical Corporation, PO Box 3050, Doha, Qatar. Tel. +974 4391404/4391405. Fax. +974 4391284. E-mail: abener@hmc.org.qa or abaribener@hotmail.com

importance of adequate data on traffic injuries. Accurate epidemiological data from many developing countries are rare or difficult to find.²⁻¹⁴ Data on injury from developing and Arabian Gulf Countries are primarily based upon hospital logs²⁻¹⁰ or police records.^{1,3,10,11,14-17} A rapid rise in vehicle ownership occurred during the 1960s in Latin America, when accident rates also peaked and have remained at a high level since then. The annual increase in vehicle ownership in Asia is 12-18%, yet road networks and safety measures have not kept pace, resulting in a dramatic increase in the number and rate of accidents. In most African countries, vehicle ownership is limited and traffic is generally less crowded.¹ However, the dramatic growth of urban population caused a rapid rise in urban vehicle ownership and accidents. This study aims to review the road safety situation in developed and developing countries, compares this with the road safety in the Arabian Gulf Countries and suggests a strategy to improve it. The role of road engineers in reducing accidents is highlighted.

Methods. Data was obtained from the official statistical reports on road traffic accidents, injuries and fatalities and Ministry of Interior's Yearly Statistical Report and the Annual Reports of the Directorate of Traffic and Ministry of Health Annual Reports.¹⁸ Fatality is included, according to WHO criteria, if it occurs within 30 days from the accident. The annual statistical report contains information on the number of registered vehicles, number and nature of accidents, causes of road accidents, number of fatalities and casualties, age and gender of victims and causal factors. Additional data was obtained from various sources, including Ministry of Health, Health Statistics Annual Report for the period from 1988 and 1998,¹⁹ various edition of the WHO Statistics Annuals, International Road Federation, Transport Road Research Laboratory and Accident Facts publications.

Results. I. Accident rates, trends and costs. Many parameters have been used to describe the accident problem. These include the number of fatalities, fatality rates,²⁰ (fatality per 10,000 vehicles, per 100,000 persons or per million vehicles-km) and fatality index. Comparison of vehicle ownership levels and safety parameters between developed and developing countries may help to highlight the relative seriousness of the road safety situation in different countries. The fatality rates (per population and per vehicles) are selected for comparison purposes since information on vehicle usage is not yet available in many developing countries. The results are shown in **Table 1** and in **Figure 1**. The changing pattern in vehicle ownership levels and fatality rates over time was also investigated for selected developed and developing countries. The percentage changes in vehicles per person and in fatality rates over the 10-year-period (1988-1998) were calculated and the results are given in **Table 2**. However, such comparisons should be treated with caution due to its variations between countries in definition, degree of motorization

and accuracy of data. In addition misleading conclusions may be drawn if only one of the fatality rates is considered.²¹ Attempts have been made to relate vehicle ownership and fatality rates per vehicle for both developed and developing countries resulting in a number of predictive models. A summary of these models is shown in **Table 3**. This approach was subjected to criticism and different models were produced which incorporate more factors that are believed to contribute to traffic accidents. Such model was developed for rich developing countries.²² An attempt was made to test the relationship between fatality rate and other parameters that are believed to have some impact on fatalities in the United Arab Emirates.³ The parameters used were as follows: vehicle per-person; gross national product (GNP) per capita; population per physician; population per hospital bed; and percentage of the school age population attending schools. The reason for choosing parameters is that they are believed to reflect some social, economic, and health characteristics of Arabian Gulf Countries with sufficient variable data. Simple regression analysis was carried out to quantify separately the dependence of the fatality (per licensed vehicle) on those parameters. The logarithmic values of fatality rates per vehicle in Arabian Gulf Countries were related to the above parameters. The results of regression analysis obtained showed that the fatality rates were found: to decrease with increasing vehicle ownership; to decrease with increasing GNP per capita; decrease with increasing percentage of the school age population attending school; increase with population per physician; and increase with population per hospital bed.

Discussion. The above results, bearing in mind data limitations, shed some light on how social and economic parameters might affect the road safety situation in a particular country. The results also suggest that road accidents fatality rates could be reduced by improving medical services and education. The estimation of accident costs is difficult and particularly in developing countries. Nevertheless, correct costing is needed to accurately determine the cost effectiveness of traffic management schemes.^{13,16} Traffic accidents in developing countries are costing an enormous amount of money,^{2,23} (an estimated 1-2% of GNP) much of which must be paid in hard currency, since vehicles and medicines are usually imported. On the average, the total costs of road accidents, including an economic valuation of lost quality of life, were approximately 2.5% of the GNP.²⁴ Excluding the valuation of lost quality of life, road accidents cost an average 1.3% of the GNP. When valuation of lost quality of life is included, costs ranged from 0.5-5.7% of GNP. When valuation of lost quality of life is disregarded, costs ranged from 0.3-2.8% of GNP.²⁵ However the losses caused by traffic accidents are quite heavy in both developed and developing countries (as indicated in **Table 4**) and if they are to be reduced substantially, a comprehensive strategy for accident reduction and prevention is required.²⁵

II. Factors contributing to accidents. Most of the factors affecting accident occurrence and rates may be grouped and labeled as "economical" factors. The World Bank²⁶ relates much of the accident problem in developing countries to a shortage of funds, for both owners of vehicles and governments.

A study into the factors affecting traffic accidents in different countries may conveniently divide them into 2 groups: a) Direct factors - which contribute directly to the occurrence of individual accidents. These include: road user behavior, driver's ability and attitude, traffic engineering, roads and environment, and medical services. b) Indirect factors - that contribute to the total population and rates of accidents in the country. They include demographic (population structure and distribution), and vehicle population and characteristics (number, type, usage and occupancy). Many studies have shown that these factors contribute to higher accident risks or to more serious accidents. In developing countries the resource constraints, especially of hard currency may produce the following consequences. Moreover, road user behavior is reckless. Studies show that drivers routinely ignore traffic laws^{22,27} and pedestrians routinely walk in the middle of streets and cross without checking for traffic. Hobbs²⁸ has reported that in general, driver's errors, often accompanied by law violations, are in the chain of events leading to more than 90% of all highway accidents. However, the nature of behavior differs between countries. While alcohol, for example, is found to be the most common causes of accidents in many developed countries, it is negligible effect in Islamic countries where the law prohibits alcohol drinking.¹⁻³ Investigations into some aspects of driver behavior in some rich developing countries^{2,3,29,30} indicated that drivers acquire many dangerous and harmful driving habits and that driver observations of traffic regulations is poor. In recent years, many countries have launched integrated road safety programs which attempt to incorporate all the diverse elements related to accidents and casualties³¹ which is expected to increase the efficiency of road safety work and generate new solutions to the accident problem.

III. Strategies for better road safety. Comprehensive strategy for accident reduction and prevention is required to improve road safety in any country. World Health Organization¹³ has proposed such a strategy and produced guidelines that draw a clear distinction between accident reduction and accident prevention, with both is being necessary. Theoretically, reduction of accidents requires: (i) Reducing personal travel (and consequently road traffic). (ii) Reducing the risk, severity and consequences of road accidents. These approaches can be applied in a variety of ways and road safety improvement measures may be broadly classified into 2 groups: 1) "Technical" - which are direct measures intended mainly to improve safety. These include measures related to land use development, road and road user, vehicle design, traffic laws and their enforcement, medical services and insurance premiums. 2)

"Institutional" - which can improve road safety indirectly and are related to road safety organization, financing, research and development and staff education and training. An accident reduction program should entail the following stages: a) Identification of problem locations through the analysis of accident data. b) Diagnosis of the symptoms (namely factors involved in accident occurrence). c) Selection of the best treatment and program of work. d) Monitoring of the effects of the program.

III.1 Strategy for developing countries. The model derived by Jacobs and Cutting²⁷ using 1980 data from 20 developing countries and that derived by Smeed³² using 1938 data from 20 developed countries (**Table 3**) suggest that the situation in developed countries in 1938 is similar to that in developing countries in 1980. In terms of vehicle ownership and general approaches to the safety problem, this may well be the case. However, the suggestion of similarity is not true in many other aspects affecting road safety such as roads, user behavior and law enforcement. Wider social and behavioral differences between developed and developing countries must be considered when assessing the potential for road accident reduction in developing countries.^{2-4,10} A multi-directional approach should be considered for the overall reduction of traffic accidents in developing countries. A traffic safety management system as shown in **Figure 2** could be adopted and the activities coordinated and applied collectively. Based on findings of the World Bank report,³³ this stresses the importance of improving systems for data collection and analysis; establishment of official, national coordinating committees and a small team working full time on road safety; and training traffic engineers to analyze accidents, conduct limited safety studies to identify the most important problems, convince officials to take action and design and evaluate corrective measures. Finally, the complexity of factors influencing road safety and the wide variety of available counter measures call for a systemic approach of road safety activities. Carlsson and Hedman³⁴ suggested simplified framework for such an approach as follows: setting of goals, data collection and analysis, identification of safety measures, setting of priorities, and activities related to the selected safety programs which include design, financing, implementation, monitoring, and evaluation.

III.2 Strategy for developed countries. Well-planned and timed strategy should be launched against RTAs. These accidents cause high mortality and inflict heavy economical losses. This strategy should be comprehensive and not incremental. In developed countries, where there is a better appreciation of the problem, the remedy requires commitment from both the officials and the public and should take the form of a positive strategy from a coordinated group of decision makers. The study should outline the policy and strategy, the means and the resources needed to face this serious problem and set targets to achieve during set periods of time.³⁵ It produced a policy that called for road safety management on national and local levels.

Table 1 - Motorization levels and fatality rates for various countries during the period of 1988-1998.

Countries	Vehs/10,000 persons	Fats/10,000 vehicles	Fats/10,000 persons
Developing countries			
Brazil	1000.7	4.22	0.42
Chile	748.6	12.79	0.96
Ethiopia	8.9	292.06	0.26
Jordan	770.9	17.73	1.37
Korea (South)	391.5	44.72	1.75
Malaysia	1111.0	21.88	2.43
Morocco*	341.0	31.08	1.06
Niger	50.1	46.68	0.23
Pakistan	40.4	121.44	0.49
Thailand	277.6	12.98	0.36
Tunisia	573.0	21.24	1.22
Arabian Gulf countries			
Bahrain	2458.9	6.57	1.62
Kuwait	3014.1	4.84	1.46
Oman	1395.5	16.37	2.28
Kingdom of Saudi Arabia	4193.2	6.36	2.66
United Arab Emirates	1892.3	11.29	2.10
Qatar	2186.6	7.34	1.58
Eastern European countries			
Bulgaria	1452.1	8.85	1.28
Hungary	1756.1	8.45	1.48
Yugoslavia	1329.2	12.75	1.78
Developed countries (Western)			
Denmark	3666.5	3.71	1.36
Finland	2219.2	3.05	1.18
France†	4698.3	3.76	1.77
Germany (W)	4854.7	2.68	1.30
Great Britain	4545.5	2.13	0.97
Japan*	4078.4	1.87	0.76
New Zealand	5950.3	4.03	2.40
Spain	3111.7	4.85	1.51
United States of America	77403.2	2.30	1.80
Data source: International Road Federation. World Road Statistics. Various Editions (1988-1998) *death within 24 hours, †death within 6 days Vehs - vehicles, Fats - fatalities			

Table 2 - Percentage change in vehicle ownership and fatality rates in selected countries during the period of 1988-1998.

Countries	Vehs/10,000 persons	Fats/10,000 vehicles	Fats/10,000 persons
Developing countries			
Brazil	48.9*	5.7†	40.2*
Chile	467.5	51.5†	18.7†
Ethiopia	43.6†	40.6*	20.4†
Jordan	124.0*	63.4†	18.1†
Korea (South)	417.8*	69.9†	55.8*
Malaysia	83.1*	43.8†	2.9*
Morocco*	16.0*	37.0†	26.9†
Niger	7.3*	24.9†	19.3†
Pakistan	86.2*	43.2†	6.1*
Thailand	74.5*	64.1†	37.4†
Tunisia	78.8*	28.2†	28.8*
Arabian Gulf countries			
Bahrain	39.7*	60.0†	44.8†
Kuwait	-9.5†	53.4†	55.9†
Oman	567.3*	45.2†	305.1*
Kingdom of Saudi Arabia	192.0*	65.0†	3.8
United Arab Emirates	68.4*	25.3†	15.4†
Qatar	77.2*	49.5†	9.1†
Eastern European countries			
Bulgaria	89.4*	42.3†	9.3*
Hungary	113.0*	58.8†	12.2†
Yugoslavia	50.5*	52.8†	25.6†
Developed countries (Western)			
Denmark	13.6*	26.3†	16.3†
Finland	14.5†	47.2†	21.3†
France†	29.2*	44.5†	28.3†
Germany (W)	35.8*	60.8†	46.8†
Great Britain	26.3*	39.8†	23.9†
Japan*	45.6*	32.9†	2.3†
New Zealand	30.5*	17.4†	7.8*
Spain	60.3*	28.7†	14.2*
United States of America	10.2*	23.5†	15.8†
Data source: International Road Federation. World Road Statistics. Various Editions (1988-1998) *increasing, †decreasing Vehs - vehicles, Fats - fatalities			

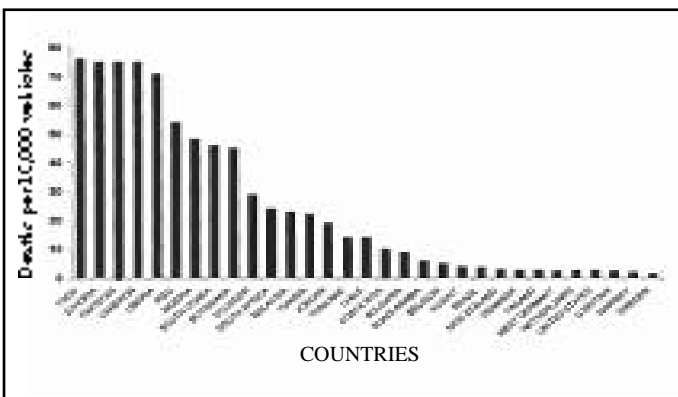


Figure 1 - Road accident fatalities (deaths per 10,000 vehicles) in selected countries, 1988-1998.

Table 3 - A summary of models relating vehicle ownership and fatality rate.

Year of data	Type of countries	N of countries	Model
1938	Developed	20	*F/ V = 0.0003 (V/P) -0.66
1980	Developing	20	†F/ V = 0.00036 (V/P) -0.65
1978-1980	Developing	35	†F/ V = 0.00039 (V/P) -0.64
1980	Developed	20	†F/ V = 0.00021 (V/P) -0.72
1982	Gulf and Middle Eastern	11	‡F/ V = 0.00052 (V/P) -0.60
*Smeed, ³² †Jacobs and Cutting, ²⁷ ‡Jadaan ²³ F - fatalities from road accidents, V - number of vehicles, P - population			

Table 4

Countries	Year	Currency	Cost (USD) millions	Ref. no.
Developing countries				
Ethiopia	1981	GBP	10.6	5
India	1983	IRs	2,3676	26
Jordan	1985	JD	41.4 (62.7)	24
Rich developing countries				
Kuwait	1982	KD	115 (396.6)	6
Libya	1978	USD	160	30
Kingdom of Saudi Arabia	1985	SR	7,366 (1,959)	2
Developed countries				
Australia	1978	AUD	1,591	26
New Zealand	1983	NZD	510	26
United Kingdom	1981	GBP	2,182	26
United States of America	1980	USD	57,199	26

GBP - Great Britain Pound, IRs - Indian Rupees, JD - Jordanian Dollar, KD - Kuwait Dinar, USD - US Dollar, SR - Saudi Riyals, AUD - Australian Dollar, NZD - New Zealand Dollar

Table 4 - Indicative cost of traffic accidents in selected countries.

Figure 2 - Traffic safety management system for developing countries.

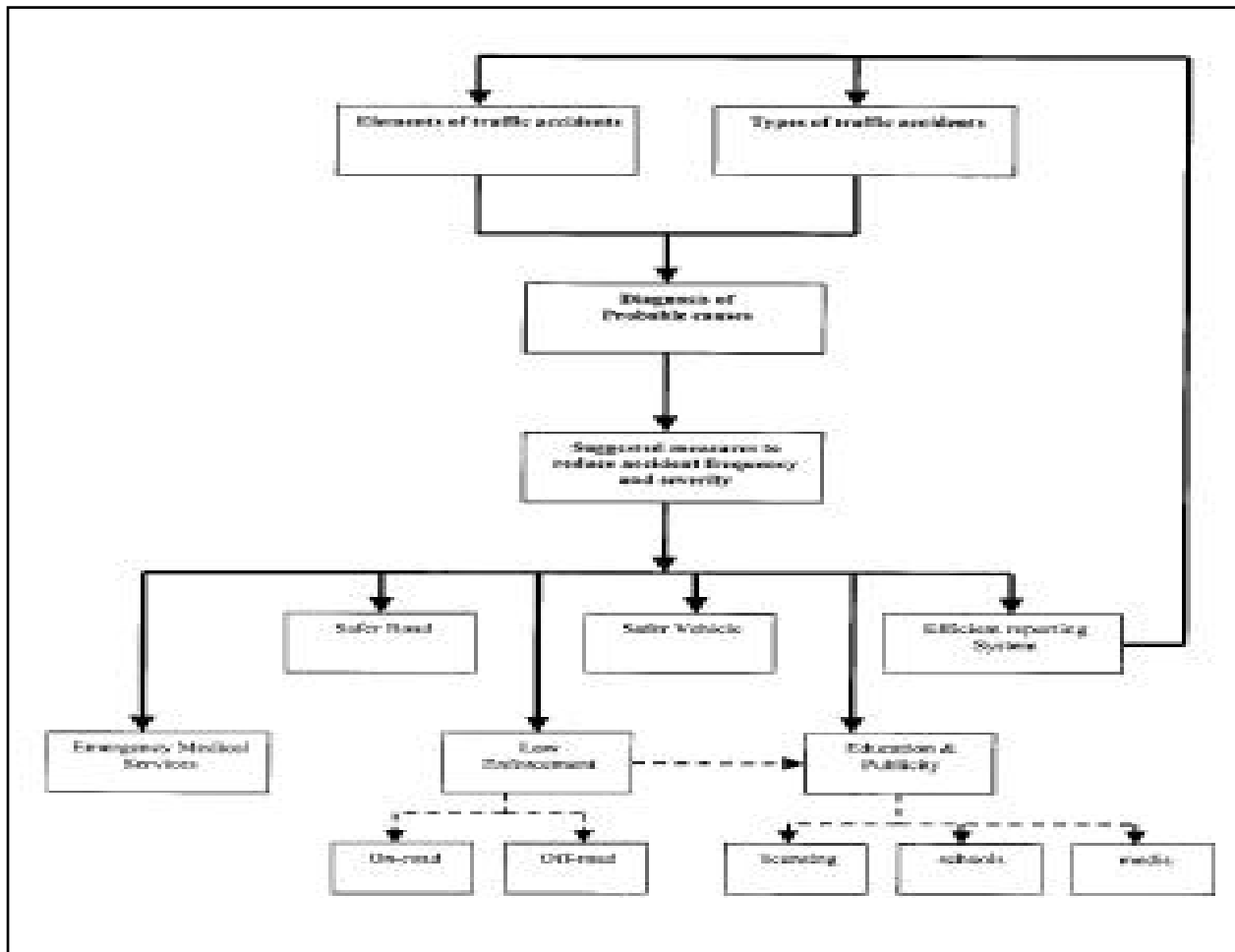


Figure 2

IV. Role of engineers. Road accidents are considered a "public health" problem, which confronts society generally. Engineers must, therefore, work closely with experts in other scientific disciplines such as educators, health and enforcement agencies to effectively tackle the problem. Engineering improvements to road safety can be conveniently subdivided into 3 categories:³⁶ improvements to the road and its environment; improvements to road vehicles; and improvements aimed at assisting other scientific disciplines. Road and vehicle engineering measures have been well proven effective in reducing accidents. Road safety is more appreciated in developed countries and their accident rates are generally improving. In comparison, the problem may appear of little concern in developing countries and their accident and casualty rates are higher than developed countries. It is unlikely that much progress can be made in substantially reducing accident cost unless a comprehensive strategy is adopted. A multi-directional approach should be considered in developing countries and a safety management system is proposed. Road traffic accidents continue to be a major cause of mortality and morbidity in the Gulf Countries leading to substantial wastage of life and national resources. Further investigation is essential and will require close intersectorial collaboration between, traffic police, health, law, and transport authorities. Developing a research strategy for prevention will reduce casualties and deaths on the road.

Acknowledgment. We would like to thank Prof. Leonard Evans (United States of America), Mr. David Lynam (Transport Research Laboratory, United Kingdom), and Ms. Sarah Groombridge (Transport Research Laboratory, United Kingdom) for their valuable information for the preparation of this paper.

References

- Ofosu JB, Abouammoh AM, Bener A. A study of road traffic accidents in Saudi Arabia. *Accid Anal Prev* 1988; 20: 95-101.
- Bener A, Jadaan KS. A perspective on road fatalities in Saudi Arabia. *Accid Anal Prev* 1992; 24: 143-148.
- Bener A, Breger E, Al-Falasi AS. Risk-taking behaviour in Road Traffic Accidents. *Journal of Traffic Medicine* 1994; 23: 65-70.
- Aljanahi AA, Rhodes AH, Metclafe AV. Speed, speed limits and road traffic accidents under free flow conditions. *Accid Anal Prev* 1999; 31: 161-168.
- Jacobs GD, Sayer IA, Downing AJ. A preliminary study of road user behaviour in developing countries. TRRL Report SR 646. Crowthorne (UK); Transport Research Laboratory; 1981.
- Jadaan KS. Kuwait accident patterns and cost evaluation. *Aust Road Res* 1986; 16: 241-249.
- Murray CJL, Lopez AD. Alternative projections of mortality and disability by cause 1990-2020: Global Burden of Disease Study. *Lancet* 1997; 349: 1498-1504.
- Viano DC. Cause and control of automotive trauma. *Bull N Y Acad Med* 1988; 64: 376-421.
- Soderlund N, Zwi AB. Traffic related mortality in industrialized and less developed countries. *Bull World Health Organ* 1995; 73: 175-182.
- Bener A, Achan NV, Sankaran-Kutty M, Ware J, Cheema MY, Al-Shamsi MA. Casualty risk reduction from safety seat belts in a desert country. *J Roy Soc Health* 1994; 114: 297-299.
- Bener A, Alwash R. A perspective on Motor vehicle Crash Injuries and Speeding in the United Arab Emirates. *Traffic Injury Prevention* 2002; 3: 61-64.
- Zwi AB, Forjough S, Murugusamphillay S. Injuries in developing countries: policy response needed now. *Trans Roy Soc Trop Med Hyg* 1996; 90: 593-595.
- Norton R, Hyder A, Peden M. The Epidemiology of Road traffic Injuries: What exist, gaps, the role of public health. Consultation to develop a WHO strategy on road traffic injury prevention, Geneva: WHO; 2001.
- Mohan D. An analysis of road traffic fatalities in Delhi India. *Accid Anal Prev* 1985; 17: 33-45.
- Bangdiwala SI, Anzola-Perez E. Traffic Accidents as a serious Public Health problem in selected developing countries of the Americas. *Bull Pan Am Health Organ* 1972; 1: 38-47.
- Razzak JA, Luby SP. Estimating death and injuries due to road traffic accidents in Karachi, Pakistan, through the capture-recapture method. *Int J Epidemiol* 1998; 27: 866-870.
- Hyder A, Ghaffar A, Masood TI. Motor vehicle crashes in Pakistan: the emerging epidemic. *Injury Prevention* 2000; 6: 199-202.
- Ministry of Interior, Directorate of Traffic, United Arab Emirates. Road Traffic Accident, Statistics Annual Report 1977-1998. Abu Dhabi (UAE): Ministry of Interior, Directorate of Traffic; 1998.
- Ministry of Health, Preventive Medicine Department, Annual Statistical Reports, United Arab Emirates (UAE), Health Statistics Annual Report 1988-1998, Abu Dhabi (UAE): Ministry of Health; 1998.
- Haight FA. Traffic safety in developing countries. *J Safety Res* 1980; 12: 50-58.
- Jadaan KS, Bener A, Al-Zahrani A. Some aspects of Road user behaviour in selected Gulf Countries. *Journal of Traffic Medicine* 1993; 20: 143-148.
- Jadaan KS. Traffic safety in Gulf countries with special reference in Kuwait. *Tranp Reviews* 1988; 8: 249-265.
- Jadaan KS. Road accident costs on Jordan. *J Royal Soc Health* 1989; 109: 144-146.
- Elvik R. How much do road accidents cost the national economy? *Accident Analysis Prev* 2000; 32: 849-851.
- Nicholson AJ, Jadaan KS. A review of recent developments and current issues in road safety. *Journal of Traffic Medicine* 1989; 17: 13-22.
- Ross A, Nwiraria M. Road safety a lethal problem in Third World Urban Edge. Issue 14. Washington (DC): Urban Edge; 1990.
- Jacobs GD, Cutting CA. Further research on accident rates in developing countries. *Accid Anal Prev* 1986; 18: 119-127.
- Hobbs FD. Traffic Planning and Engineering: Institution of Highways and Transportation, Accident Reduction and Prevention. 2nd ed. United Kingdom: Pergamon Press; 1987.
- Mekky A. Road traffic accidents in rich developing countries: The case of Libya. *Accid Anal Prev* 1984; 16: 263-277.
- Murray CJL, Lopez AD. Mortality by cause for eight regions of the World: Global burden of disease Study. *Lancet* 1997; 349: 1269-1276.
- Organization for Economic Cooperation and Development (OECD). Integrated Road Safety Programmes, Paris (FR): OECD; 1984.
- Smeed RJ. Some statistical aspects of road safety research. *J Royal Stat Society* 1949; 12: 1-34.
- Ross A, Nwiraria M. Road safety-review of World Bank experience: Need for action. A general operational review paper for the World Bank. Issue 14. Washington (DC): Urban Edge; 1990.
- Carlsson G, Hedman K. A Systematic Approach to Road Safety in Developing Countries. Technical Paper, Report INU63, the World Bank, Infrastructure and Development Department, January 1990.
- Bluet J, Fleury D. National and local road safety policies in France. *Journal of International Association of Traffic Safety Sciences (IATSS) Research* 1990; 14: 16-24.
- Searles B. Engineering greater road safety. *Engineers Australia* 1987; 3: 42-46.