TRAFFIC ACCIDENTS AND ROAD SAFETY MANAGEMENT: A COMPARATIVE ANALYSIS AND EVALUATION IN NDUSTRIAL, DEVELOPING AND RICH-DEVELOPING COUNTRIES

GALAL A ALI

Professor and Consultant Engineer, Sudan University of Science and Technology
P O Box 12281, Khartoum 11111, Sudan Tel.: +249 912345507 Fax: +249 183 463614
E-mail: galalabdalla@sustech.edu ga03ali@yahoo.com

ABSTRACT

Road traffic accidents (RTAs) and casualties (injuries and fatalities) worldwide are contiuously increasing. Developing countries (DCs) where traffic accidents are among the major causes of death represent 2/3 of the world's RTA fatalities (about $0.75*10^6$) with an increase of 15 % in the past decade while the reduction in the industrialized world approached 20 %. Studies indicate that in DCs, fatality rates per 10,000 vehicles are among the highest in the world in spite of the low car ownerships (vehicles per 100 people). Nowadays, acquiring knowledge of the main causes of accidents and formulation of priorities for action plans are mandetory. This paper considers global and regional considerations with emphasis on accident characteristics and road safety management. Recent publications are overviewed covering developing, rich-developing and industrialized countries (DCs, RDCs and ICs). The issues discussed include casualty characterisitics particular to those countries, safety measures, techniques, implementation and new strategies. The paper also presents a comparative investigation of traffic accident characteristics and fatality rates in Sudan and Malawi (DCs), Sultanate of Oman (RDC) and New Zeeland (IC). Accident causes and involvement are classified and analyzed along with discussion of accident and casualty trends. Accident data are subjected to analysis to investigate the potential causes using records of 10-15 years for the purpose. Possible causes identified included driver behaviour, road characteristics, vehicle conditions and level of enforcement. The paper also includes the order of significance of the accident causes as well as detailed discussion and interpretation of the results. Major contributing factors were found to be conditions of the road network, vehicle fleet, speed limits and violations, seat belt usage, alcohol consumption and the lack of enforcement of regulations. Further, it is noted that fatality rates are much higher in DCs than in ICs. However, the rates at which the fatality rates are improving are greater in RDCs.

Keywords: ***accident characteristics and causes; comparative analysis; casualties; fatality rates; safety measures***

1. INTRODUCTION

Rapid growth in vehicle ownership in many developing countries, particularly the RDCs, resulted in an increase of traffic accidents, with high fatality rates. While Malawi (M) and Sudan (S) are considered in this paper as case studies of developing countries (DCs) for the purpose of comparative analysis, the Sultanate of Oman (SO) is typical of Gulf RDCs. New Zealand (NZ) represents developed or industrialized countires (ICs). Current casualty rates are about 6 to 15 times more in the first two categories compared to industrialized ones, although car ownership (persons per car) is about 6 to 100 times less. World

statistics also indicate that worldwide annual road traffic accidents (RTAs) fatalities exceed 0.75×10^6 with over 25 million each injuries and disabled [Petrucelli, 1991; Pattnaik and Sreedar, 1993; Ali and Shigidi, 2002]. Developing countries represent 67% of world RTA fatalities although they own only 11% of the vehicle fleet. Treatment of traffic accident injuries accounts for 5 to 10% of hospital costs, amounting to 90×10^9 US dollars in only 3 developed countries. According to the National Road Safety Council (NRSC) in Malawi, road traffic accidents annually cost about MK 3.5×10^9 (US$ 30×10^6) [NRSC-Malawi, 2005]. These and other alarming accident and casualty facts dictate development of improved techniques to approach the dilema of traffic accidents, provide better understanding of the problem and introduce new traffic regulations and safety measures. In general, there is need to focus on the four main elements in traffic stream operation, namely the road users, the vehicle, the roadway and traffic law enforcement. The various stakeholders concerned include traffic engineers, researchers, vehicle inspection and registration officials, driving license-issuing organizations, traffic regulation enforcing authorities, insurance companies, judiciary systems, the road user and the general public. Significant effort from everyone concerned is needed to improve the overall situation. The main objectives of this paper are to present an overview of the global and regional status of traffic accidents and safety management; and to carry out a comparative investigation of traffic accidents and casualties by considering two African developing countries (Sudan, Malawi), a rich Gulf developing country (Oman) and an industrialized country (New Zealand).

2. ACCIDENTS AND SAFETY IN MALAWI, NORTH AFRICA AND ASIA

An increase in road traffic accidents and lack of safety are apparent in Africa and Asia in terms of magnitude and severity of the problem. Similar situations prevail in most countries of the regions.

2.1. Accidents and safety in Malawi

The purpose of the Baseline Road Safety study conducted in Malawi at the NRSC and Road Traffic Directorate (RTD) was to reduce the high accident and fatality rates [NRSC-Malawi, 2005]. Current figures indicate a fatality rate of about 55 per 10^8 veh-km, with a traffic safety ratio (TSR) exceeding 70 fatalities per 10^4 vehicles compared to 2–5 and 15–25, respectively, in developed and many developing countries.

2.2. Traffic congestion, accidents and pedestrian safety

The average annual RTA casualties in the Kingdom of Saudi Arabia (KSA) amounted to 4,000 fatalities and 31,000 injuries. The main cause in half of the 147,000 accidents were attributed to high speeds [A-Khaleej, 1996.]. Over three-quarters of involvements were in the age group of 18-40 years. A particular feature of RTAs in the United Arab Emirates (UAE) is young drivers, taxis and animals, with 90% of the 521 fatalities among the youth age group. In Bahrain, special traffic police was needed near schools due to severe congestion to reduce the number of children casualties in pedestrian accidents from 43% to 23% [Asharq Al-awsat, 1994]. Despite improved road network and advanced traffic control systems in Kuwait. RTA tolls were reported to be among the highest in the world. Poor driving and lack of awareness of traffic regulations by pedestrians led to about 20,000 accidents resulting in 290 fatalities and 2,020 injuries [Al-Damyan, 1995]. The 2009 traffic accidents fatalities and injuries in Sudan were 1,800 and 4,500, respectively [WB and WHO, 2004; Obeid, 2010].

2.3. Road Traffic Accidents Data and Analysis

Causes of traffic accidents are numerous and complex as safety is related to several factors. Successful traffic improvement programmes and safety enhancement require availability of sufficient and reliable data, followed by sound analysis incorporating related factors. Development of improvement schemes and effective safety management can then be implemented. Accident casualty analysis today relies largely on statistical methods and Artificial Neural Networks (ANNs). The former approach relates accidents and casualties either to registered vehicles per population [Al-Suleiman and Al-Masaeid, 1992] or traffic volume and time [Ali et al, 1994]. On the other hand, ANNs are relatively new in traffic analysis and prediction. They have only been sparsely demonstrated in a few areas [Al-Alawi, 1996].

3. ACCIDENTS AND CASULTY RATES IN MALAWI

3.1 Characteristics of Accidents and Fatalities Pertinent to Malawi

Traffic accident characteristics in Malawi were investigated in a comparable manner. The major causes of accidents were identified and means of reducing the number of accidents were explored. In Malawi, there is a heavy dependence on road transport with extended stretches of highway network among sparse-population centers across the country. The vehicles per 100 persons, also known as motorization level, increased in the past years by more than 50 % (from 0.63 to 0.97). Of the four major elements associated with road traffic accidents, the road users are the main cause of accidents, with speed violations, negligence and poor driving behaviour. Figure 1 indicates that the main causes of accidents were high speed (56%) and negligence (32%) both related to road users. The remaining 12 % of the accidents were attributed to vehicle, road and environment. Compared with reported global average value of 5 %, it is observed that the road and vehicle contribution of 12 and 15 % of the accidents to fatal accidents in Malawi and Sudan [Obeid, 2010], respectively, are rather high indicating that improvement of road and vehicle conditions could enhance safety. Figure 2 illustrates that as high as 58 % of the casualties are in the most productive age group of 18-44 years. As depicited in Figure 3, pedestrian fatalities in Malawi, including bicyclists and animal-drawn vehicles, amount to over 70%, one of the world's highest, compared to 18% in the USA and 32% in Oman.

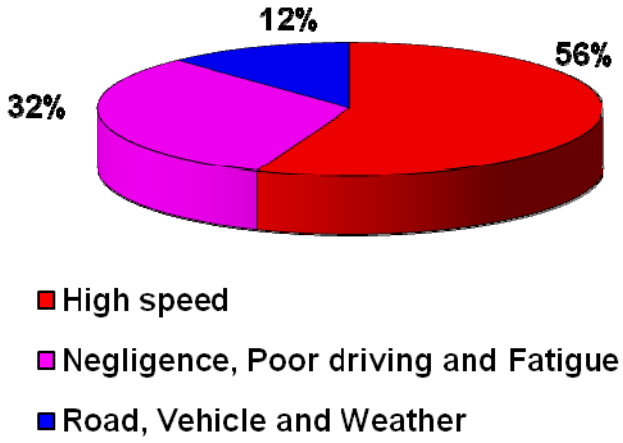

Figure 1 Causes of accidents in Malawi: 2005

This may be attributed to deficiency in road improvement and signing, the high involvement of minibuses and trucks in accidents and lack of strict enforcement of traffic regulations in addition to vehicle and driver control.

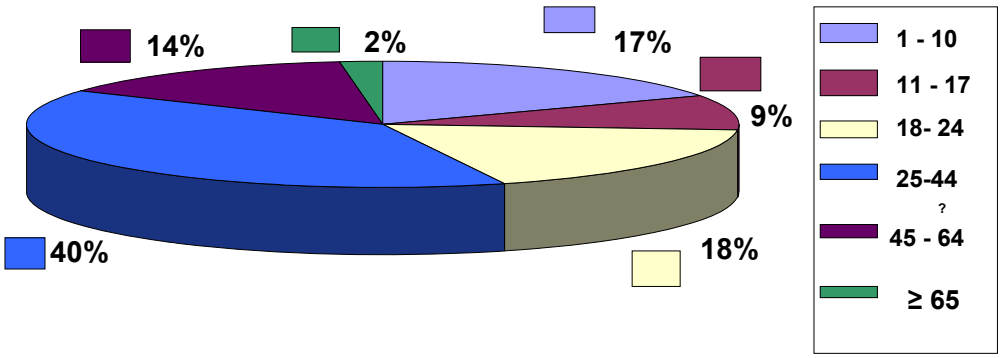

Figure 2. Accident fatalities by age group in Malawi: 2005

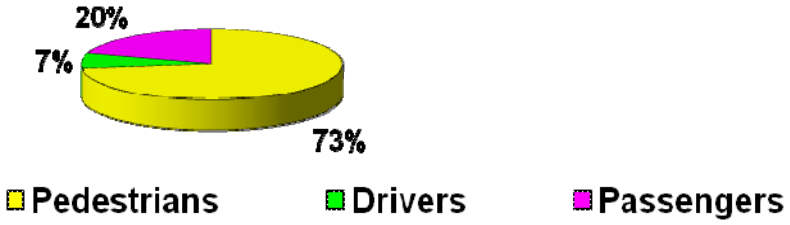

Figure 3. Accident fatalities by vehicle occupants and pedestrians in Malawi: 2005

.

Table 1 summarizes 15-year Malawi data relevant for subsequent analysis and discussions. They include populaion, number of vehicles, total accidents, injuries and fatalities [NRSC-Malawi, 2005]. The table also shows the accident, injury and fatality rates computed as vehicle based rate (VBR) per 10^4 vehicles (Figure 4), and population-vehicle based rate (PVBR) per 10^{11} population-vehicles (Figure 5). Assuming data reliability, the normal trend is decreas in these rates depending on implemented safety measures and management. Both figures indicate Malawi accidents and casualties follow similar trends.

4. COMPARISON OF ACCIDENT AND CASULTY RATES AMONG CASE STUDIES

Raw data similar to those of Malawi on population, number of vehicles, accidents and casualties are provided in Tables 2 to 4 for Oman, New Zealand and Sudan, respectively [DGT-Oman, 1999; LTSA-NZ, 1999; DGT-Sudan, 2001]. The results of VBRs are presented for all four countries in Figures 6, 7 and 8 for accidents, injuries and fatalities, respectively. The increase in accidents and casualties in the case of Oman is pronounced in the latter years, indicating the effect of rise in speeding and other violations, requiring more strict enforcement of law and tougher penalties. The population based rates (PBRs) for accidents and casualties were not included in the paper as PBR does not reflect the true picture in terms of implementation of safety measures. For instance, the PBR for fatalities were computed during the same year to be about 2 and 20 in Sudan and New

Zealand, respectively. Comparing Sudan with NZ, although the order of magnitude of fatalities is the same, the number of vehicles in Sudan is about 10 times less while the population is about 10 times more. Compared to the popular vehicle-miles (or veh-km) rate per 10^8 veh-mi, the VBR plots of Figures 6-8 were found to reflect the true relative positions with respect to the four countries regarding accidents and casualties. Hence, It is recommended that vehicle-km or vehicle rates be used as they are better indicators than the population-vehicle based rate although it accounts for the joint effects of population and vehicles. Thus, the PVBR will be applied only to fatalities as a typical case (Figure 9).

Table 1. Traffic Accident and Casuality Data and Rates in Malawi: 1991-2005

Year	Popul-ation (1000)	Register-ed Vehicles	Number of Accid-ents	Number of Injuries	Number of Fatal-ities	Accid-ents per veh-rate	Injuries per veh-rate	Fatalities per veh-rate	Accidents per Pop-veh-rate	Injuries per Pop-veh-rate	Fatalities per Pop-veh-rate
1991	8400	34600	6800	3782	1027	1965	1093	297	2,339.7	1,301	353
1992	8620	36300	7600	4247	1120	2094	1170	309	2,428.8	1,357	358
1993	8840	38100	7500	4257	1140	1969	1117	299	2,226.8	1,264	338
1994	9060	40000	7200	4267	1011	1800	1067	253	1,986.8	1,177	279
1995	9286	56000	6800	4277	1140	1214	764	204	1,3077	822	219
1996	9518	60000	6400	4287	1090	1067	715	182	1,120.7	751	191
1997	9756	64000	6200	4297	784	969	671	123	992.98	688	126
1998	10000	68600	6450	4307	650	940	628	56	940.23	628	56
1999	10250	73400	6700	4317	665	913	588	55	890.54	574	54
2000	10510	78500	6900	4327	675	879	551	62	836.33	524	59
2001	10770	84040	7183	4339	686	855	516	82	793.60	479	76
2002	11040	90000	7219	4350	877	802	483	97	726.55	438	88
2003	11300	96000	7369	4485	987	768	467	103	679.30	413	91
2004	11600	110000	6718	3764	852	611	342	77	526.49	295	67
2005	11900	115000	6989	3724	1006	608	324	87	510.71	272	74

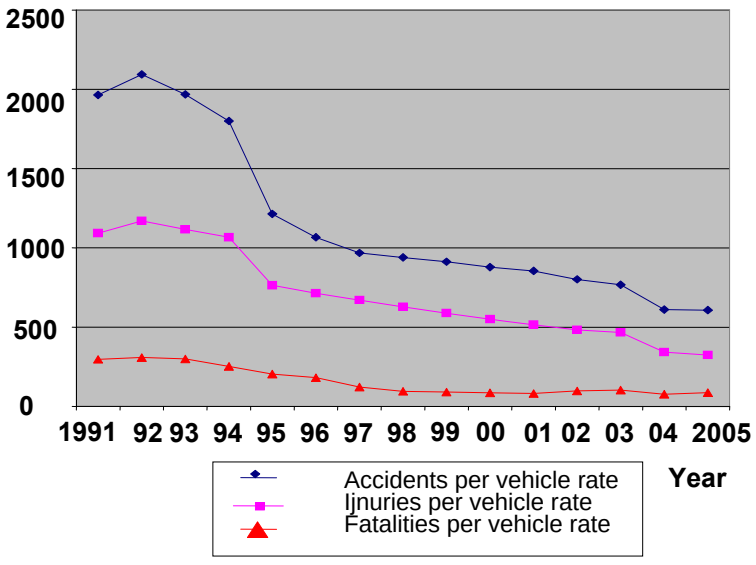

Figure 4. Accidents and casualties in Malawi per vehicle rate: 1991-2005

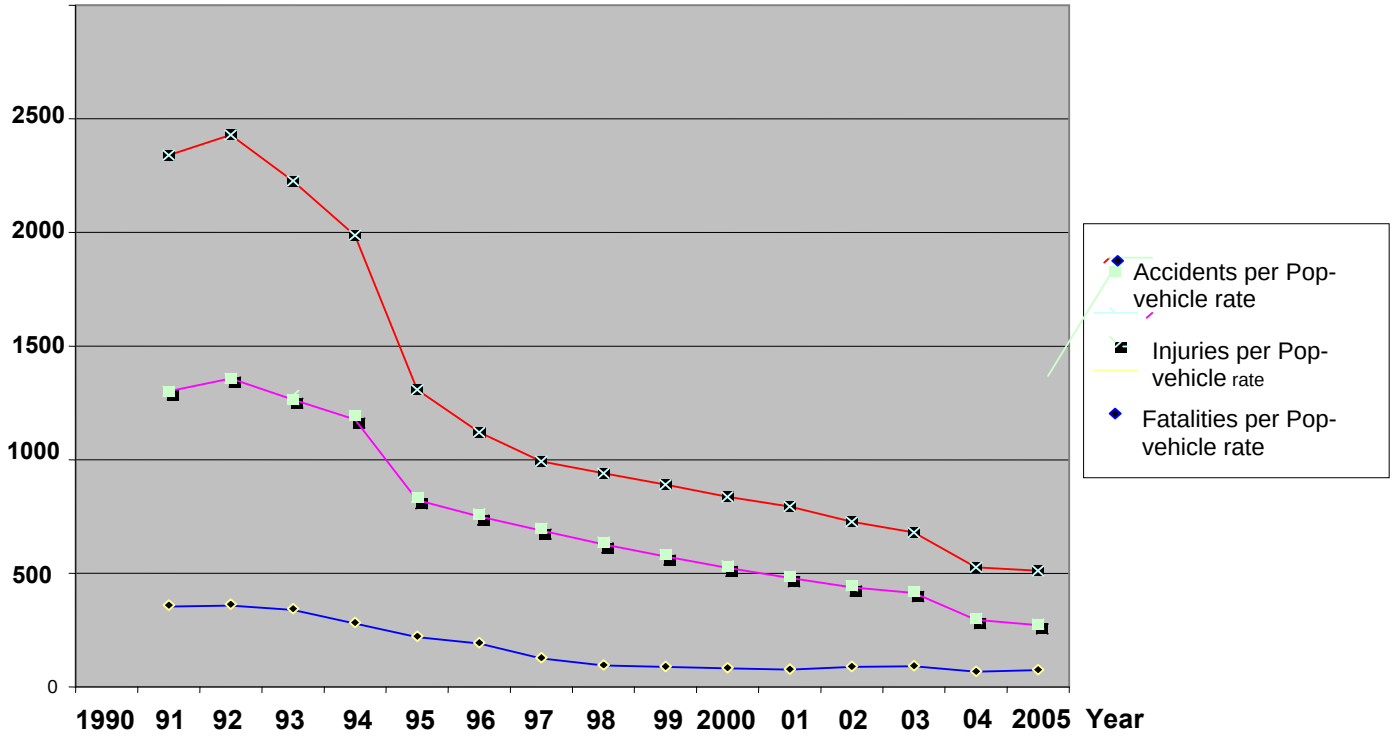

Figure 5. Accidents and casualties in Malawi per population-vehicle rate: 1991-2005

Table 2. Traffic accidents and casualities in Oman

Year	Population (Thousands)	Registered vehicles	Number of Accidents	Number of Injuries	Number of Fatalities
1991	24366	124720	10419	2912	395
1992	25040	151053	9600	4444	413
1993	25734	172933	8180	3543	404
1994	26445	163052	8398	3641	395
1995	27177	123389	9899	4532	580
1996	27489	164929	10934	5245	589
1997	28701	175722	11108	5452	608
1998	29495	182587	12056	5725	715
1999	30281	190000	15750	7113	864
2000	31088	198000	17991	8115	905
2001	31913	220000	23408	8820	952

Figures 6-8 also show that for Sudan there were no reductions in all rates indicating that safety measures are unsatisfactory compared with NZ, Oman and Malawi, compounded with a reduction in the number of registered vehicles in relation to the actual number on the road due to new vehicle registration controls. In Oman the VBR per 10^4 vehicles for fatalities reduced steadily to 15 although the reduction was not significant, while.in NZ it also steadily decreased from the low value of 3.6 to the lower figure of 2.1. Malwi experienced a significant drop in fatality rate from 00 to about 55 during the same period. Figures 10-a and 10-b present international comparisons of fatality rates per 10^4 vehicles and 10^{11} population-vehicles for NZ, Oman, Sudan and Malawi with those of several other industrialized countries. As expected, NZ refelects the lowest VBR and PVBR among the

Table 3. Traffic accidents and casualities in New Zealand

Year	Population (Thousands)	Registered Vehicles	Number of Accidents	Number of Injuries	Number of Fatalities
1989	3313	2108000	30428	16594	755
1990	3410	2197000	33047	17719	729
1991	3449	2220000	32412	16767	650
1992	3485	2227000	31198	15121	646
1993	3525	2228000	29192	15108	600
1994	3577	2289000	30313	16670	580
1995	3643	2554000	34526	16870	582
1996	3717	2379000	33564	14696	514
1997	3761	2393000	33454	13375	559
1998	3791	2318000	31673	12412	501
1999	3811	2426000	33162	11999	509

Table 4. Traffic accidents and casualities in Sudan

Year	Population (Thousands)	Registered vehicles	Number of Accidents	Number of Injuries	Number of Fatalities
1991	1757	233134	13176	5481	432
1992	1882	249787	13617	5876	468
1993	2000	261386	11754	6203	461
1994	2050	273244	11056	5954	497
1995	2131	300238	11025	6685	479
1996	2214	317428	9456	6654	512
1997	2255	357880	8444	7278	549
1998	2287	404375	8049	7913	614
1999	2353	447174	8947	8183	604
2000	2407	485813	13042	9323	492

countries under consideration. However, when the PVBR was used, the overall ranking of the countries were changed (Figure 10-b) due to population and low car ownership factors.

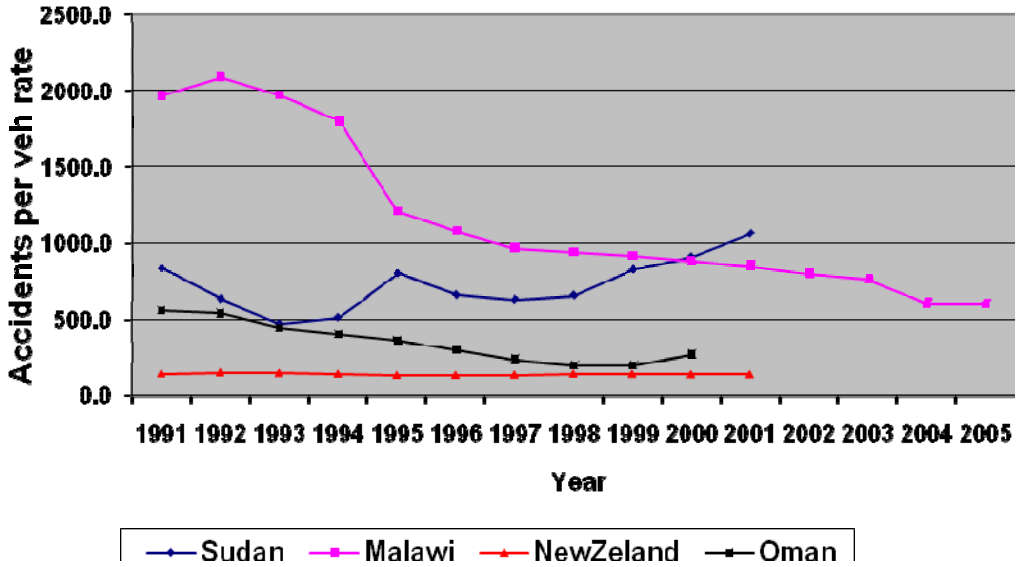

Figure 6. Accidents per vehicle rate: Four Countries

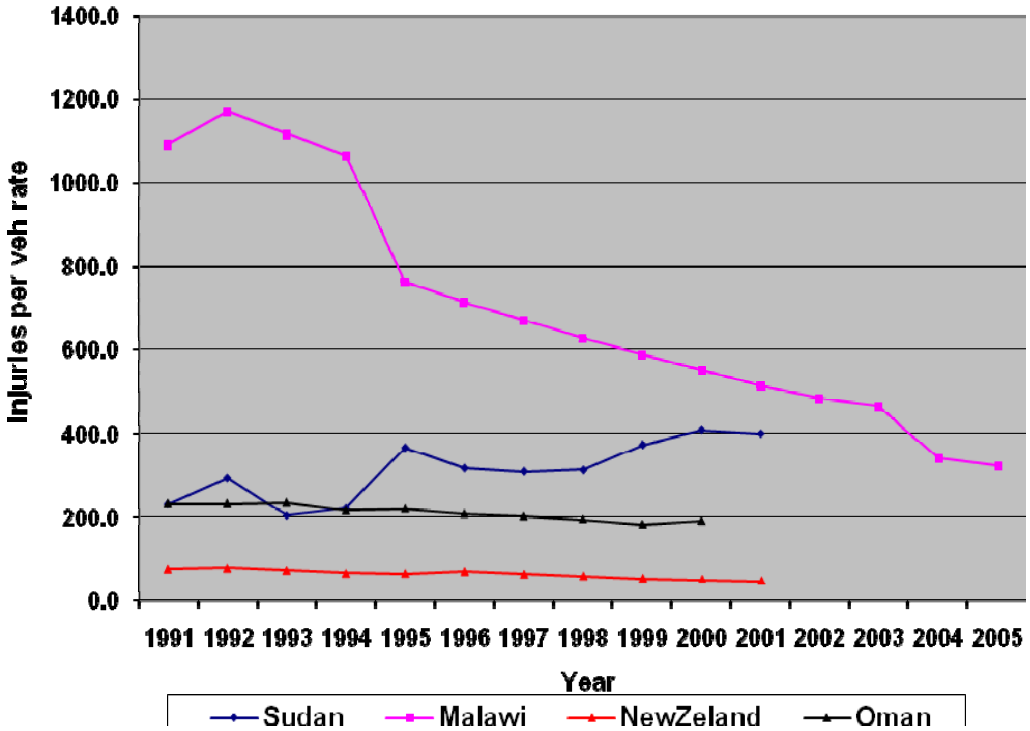

Figure 7. Injuries per vehicle rate: Four Countries

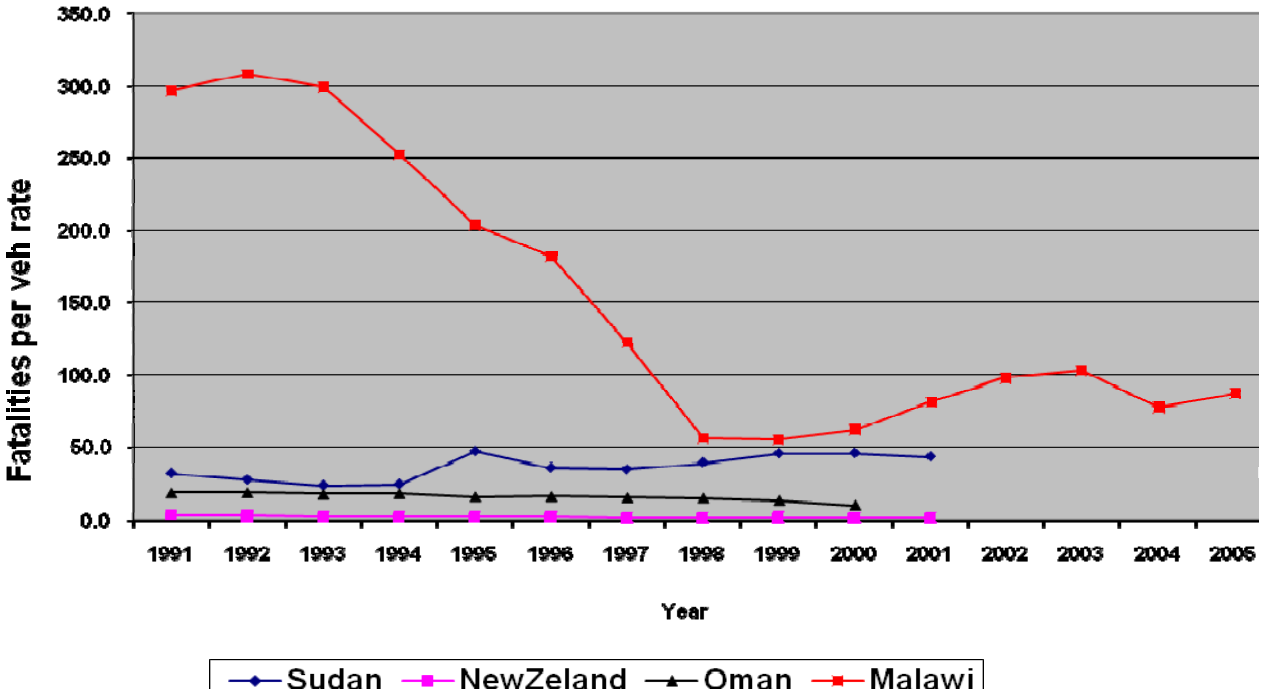

Figure 8 Fatalities per vehicle rate: Four Countries

5. SAFETY MEASURES

Often a neglected and frequently overlooked aspect of road safety is the role of education [Bakheit et al, 1998; Ali et al, 1987]. Formal traffic education for safe driving of drivers and road users in schools and specialized traing centers is crucial to reducing road accidents.

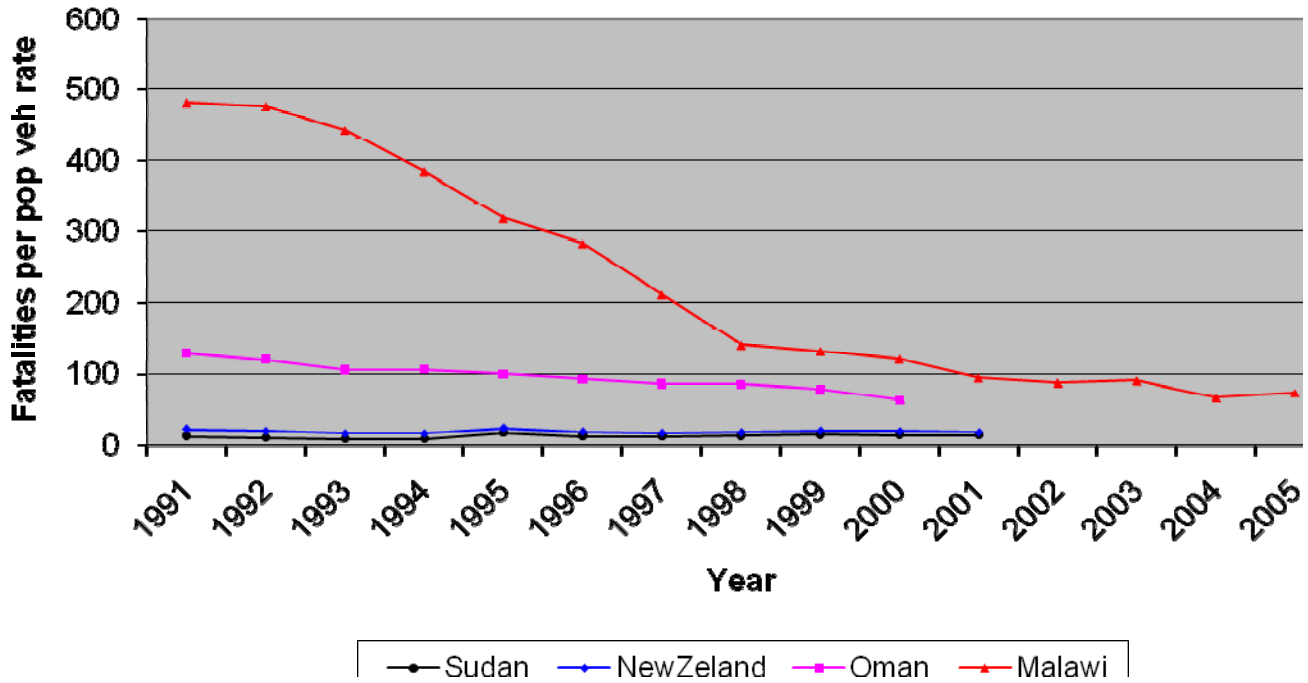

Figure 9. Fatalities per vehicle-population rate: Four Countries

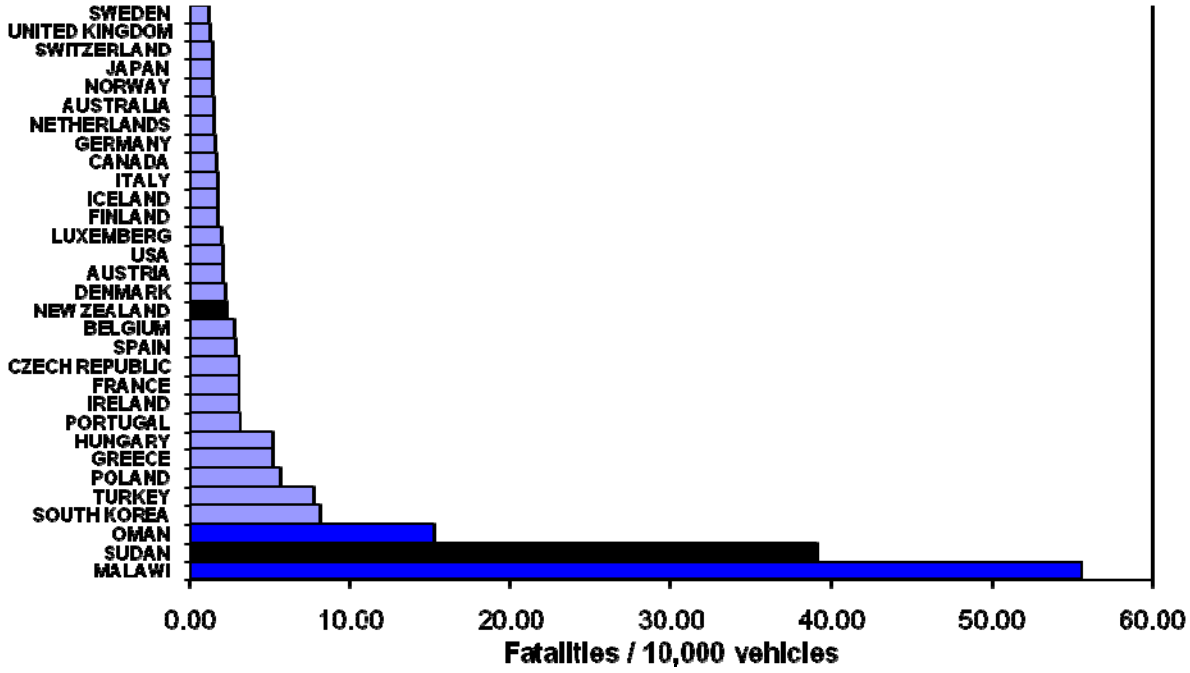

Figure 10-a. International comparison of fatalities per vehicle rate: VBR

Messages on accidents and safety might be communicated to the public through various media. Driver training, law enforcement, adherence to design standards, and use of safety oriented road signs should be emphasized. The use of mobile phone is not allowed while driving except with head set. Even this has been ruled out by medical specialists as a person cannot concetrate on two things at a time without jeopardizing safety. The number of mobile-use violations while driving is increasing worldwide in proportion to increase in mobile users. In 1998, the number of drivers using mobile phones in Oman increased by more than 120% in 4 years.

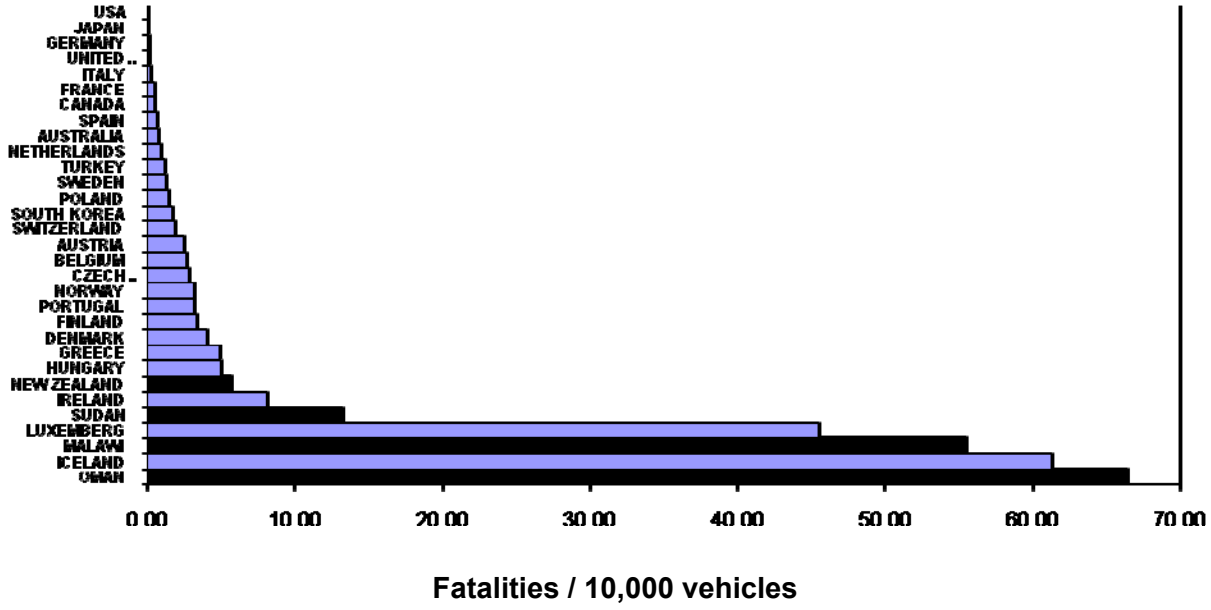

Figure 10-b. International comparison of fatalities per population-vehicle rate: PVBR

The effective solution to this is strict enforcement of the law and severe penalties. Police patrol for driver and high speed control, implementation of periodic vehicle inspection, and improving road conditions and signing would enhance safety. An efficint and safe operation of public (bus) transport syatem should draw attention of safety authorities. Development, implementation, continuous monitoring and promotion of Emergency Medical Services (EMSs) for victims of road traffic accidents should be considered as an inseprable entity of road safety programmes. Better and faster communication system, efficient and well-equipped ambulance services, and satisfactorily in-reach distribution of medical and health facilities are crucial components of an acceptable EMS. All of the above safety measured can be well managed and implemenrted by establishing National Road Safety Councils (NRSCs). In fact, such a proposal has just been approved in Sudan after a series of work shops and a meeting of stakeholders that included ministries of Interior, Health, Education, Finance, Transport and Roads, Information and Communication, Infrastructure, Red Cresent, Universities and Research Institutions, and related private sectors [WB and WHO, 2004; Obeid, 2010].

6. CONCLUSIONS AND RECOMMENDATIONS

Within the scope of this investigation and accounting for data accuracy and completeness, the following conclusions and recommendations may be drawn from this research study:

Fatality rates per 10^4 vehicles in developing countries (DCs) such as Malawi (77 in 2004) and Sudan (50 in 2002) are among the highest in the world despite their low car ownership (106 persons / vehicle in Malawi). On the other hand, developed countries have the lowest VBRs for fatality (2-4). More safety measures need to be adopted in DCs to attain comparable rates. Itnwas aslo found that drivers' negligence, poor driving and speeding are the main causes of accidents and the resulting casualties, with road users being responsible for about 85-90 %. Thus, certain factors need to be carefully considered to bring accidents and casualties down in DCs. These factors include speed control, mandatory use of safety belts, training of drivers and rigorous licesing, driver behavior and pedestrian crossing, special attention to adherance of buses and trucks to safety regulations, and improved and signed/marked road and intersection design. Furthermore, for road safety enhancement, it is crucial to establish National Road Safety Councils as in Oman, Malawi and Kingdom of Saudi Arabia. Sudan is currently taking action in this direction. Traffic accidents delima is drawing global concern, and particularly DCs as

witnessed by increasingly held international conferences to sddress these iossues. Priority should also be given to implementation of Emergency Medical Services.

7. ACKNOWLEDGEMENTS

The author would like to thank all those assisted in providing the data and valuable documents: the National Road Safety Council in Malawi, MTPW; Oman Directorate General of Traffic (DGT); Sudan DGT; and the Land Transport Safety Authority in New Zealand. The. financial support provided by Sudan Univrsity of Science and Technology to attend the conference is gratefully appreciated.

8. REFERENCES

Al-Alawi, S, Ali, GA and Bakheit, CS, 1996. A novel approach for traffic accident analysis and prediction using artificial neural network, J RTR, ARRB, Vol 5, No. 2 p. 118

Al-Damyan, A,1995. Traffic accidents in Kuwait, Asharq Al-Awsat newspaper, No. 5906

Ali, GA, Bakheit CS, and.Sivakugan, N, 1994. Traffic accidents in Oman: comparative analysis of fatality rates, World Safety J, VIII/1-94, p 15

Ali, G A, Koushki, PA and Mufti, MH, 1987. Transport and Communication for Road Traffic Injuries, Proc, Symp towards road traffic accident prevention, Amman, Jordan

Ali, GA and Shigidi, AMT, 2002. A comparative analysis of traffic accidents and road safety management, SORIC' 02, Manama, Bahrain

Al-Khaleej daily newspaper, 1996. Cost of traffic accidents in the KSA No. 6102

Al-Suleiman, TI and Al-Masaeid, HR, 1992. Descriptive model for fatality rates of traffic accidents in Jordan, ITE, 62(4) p. 37

Asharq Al-Awsat newspaper, 1994. Traffic accidents and their victims, Nos. 5827-5833

Bakheit, CS, Ali, GA and Al-Ismaili, A, 1998. Effects of mandatory use of seatbelts on traffic accident fatalities in Oman, SORTIC'98, Manama, Bahrain, p. 409

Directorate General of Traffic, 1975-1999. General traffic statistics, Muscat, Oman

Directorate General of Traffic, 1991-2001 Traffic reports, Khartoum, Sudan

Land Transport Safety Authority, 1999. Motor Accidents in New Zealand, Research and Statistics, Strategy Division, New Zealand

National Road Safety Council of Malawi, 2003-2005. Baseline survey and establishment of a road safety database, MTPW, Lilongwe, Malawi

Obeid, T, 2010. Strategy foundation for road traffic safety in Sudan, Directorate General of Traffic, Ministry of Interior, Khartoum, Sudan

Pattnaik, SB and Sreedar, MA, 1993. Accident analysis with an expert system for remedial measures, ITE, 74 (I) p. 122

Petrucelli, E, 1991. Traffic injuries: A public health concern worldwide. ITE, 61(7) p. 15

World Bank (WB) and World Health Organization (WHO), 2004. International Country Reports on Protection from RTAs casualties, WB, Washington, DC, USA