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Road traffic injuries in developing countries: a comprehensive review of epidemiological studies

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Summary Motor vehicle accidents are the leading cause of death in adolescents and young adults worldwide. Nearly three-quarters of road deaths occur in developing countries and men comprise a mean 80% of casualties. This review summarizes studies on the epidemiology of motor vehicle accidents in developing countries and examines the evidence for association with alcohol.

keywords developing countries, traffic injuries, fatalities

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Abbreviations AA, Automobile Association; AIS, Abbreviated injury scale; CFR, Case fatality rate; GNP, Gross national product; ICD, International classification of diseases; INRETS, (French)Institut National de Recherche sur les Transports et leur Securite; ISS, Injury severity score; MAAP, Microcomputer accident analysis package; RTAs, Road traffic accidents; TRL, Transport Research Laboratory

Definitions *Developing country*, a country with an annual per capita GNP less than US $ 7911 based on the 1991 figures from the World Bank (1993); (includes all countries of low-income and middle-income economies in Africa, Asia, Islands of Indian and Pacific Oceans, Middle-East, Central and South America, and the Caribbeans); *A motor vehicle crash*, an event occurring on a street, road or highway, in which at least one motor vehicle in motion is involved by collision or losing control, and which causes physical injury or damage to property; *Fatalities*, deaths that occur within 30 days as a result of a motor vehicle crash. This is the standard definition recommended by the Economic Commission for Europe and the World Health Organization (WHO 1979); *Injuries*, number of persons who sustain tissue damage, which may be slight or serious, in a motor vehicle crash. A serious injury is an injury for which a person is detained in hospital as an in-patient, whilst slight injury is an injury of a minor character such as sprain, bruise, a cut or laceration which is not judged to be severe and does not require in-patient treatment; *Casualties*, the total number of fatalities and injuries resulting from a motor vehicle crash.

Introduction

Motor vehicle crashes are the leading cause of death in adolescents and young adults (Taket 1986; Mohan & Romer 1991; Smith & Barss 1991; Feachem *et al.* 1992); and of the estimated 856 000 road deaths occurring annually worldwide, 74% are in developing countries (World Bank 1993). Dramatic increases in the proportion and absolute number of traffic fatalities have been witnessed in a number of developing countries, while they decreased by more than 20% in industrialized nations (Ross *et al.* 1991). In both Nigeria (Oluwasanmi 1993; Ezenwa 1986) and Kenya (NRSC 1992), for example, a fivefold increase in traffic-related fatalities was observed over the last

30 years. African and Asian countries, with relatively low vehicle densities, are experiencing substantially higher fatality rates per 10 000 vehicles than the industrialized European and North American states (Jacobs & Sayer 1983; WHO 1984). Traffic crashes also impact on the economy of developing countries at an estimated cost of 1–2% of a country's GNP per annum, as a result of morbidity, mortality and property-related costs (Fouracre & Jacobs 1976; Jacobs & Sayer 1983; WHO 1989; Jadaan 1989a & 1990; Downing *et al.* 1991). Causes of motor vehicle crashes are multifactorial and involve the interaction of a number of pre-crash factors that include people, vehicles and the road environment (Haddon 1980; AMA 1983; Stansfield *et al.* 1992; Robertson 1992). Human error is estimated to account for between 64 and 95% of all causes of traffic crashes in developing countries (TRL 1990). A high prevalence of old vehicles that often carry many more people than they are designed to carry, lack of safety belt and helmet use, poor road design and maintenance and the traffic mix on roads are other factors that contribute to the high rate of crashes in less developed countries.

In order to establish what is known in the developing world, prior to conducting further research or promoting particular public health policies on road safety, we examined the literature for available evidence concerning the epidemiology of traffic injuries, with the objective of identifying and summarizing available information about the epidemiology of motor vehicle crashes in developing countries, and examining evidence for an association with alcohol.

Materials and methods

Criteria for inclusion

Any publication, including government and institutional reports, or study providing quantitative data about motor vehicle crashes in developing countries was selected. Articles and case series from hospitals which described only clinical injury were excluded.

Search strategy

Published and unpublished reports on road traffic accidents in developing countries from 1966 to May 1994 were sought by: (1) electronic searches of MEDLINE (1966–1994), SCISEARCH (1980–1994) and LILAC (1982–1994) using a full text search of 'accidents or injuries or trauma'. Countries were identified by regions (Asia, Africa, Middle East, South America, Central America, Mexico, West Indies and Pacific Islands) which were then 'exploded' by Silver Platter Software into their constituent countries. All articles identified were then examined by scanning the title and abstract. Articles that did not meet the inclusion criteria were discarded. Full text copies of the remaining articles were obtained. We may have missed a small number of articles appearing in other databases that were not searched, such as the Transport Research Information System (TRIS) maintained by the United States Department of Transportation. (2) Relevant references cited in articles identified by (1) above were located. (3) References in existing reviews on traffic crashes in developing countries were scanned and selected if they met inclusion criteria. (4) Unpublished documents, official accident statistics reports and conference proceedings on RTAs were obtained from institutions and organizations such as the Transport Research Laboratories (UK), INRETS (France), Norwegian Centre for Transport Research, National Road Safety Councils (NRSC) (in Botswana and Kenya), Automobile Association of South Africa, Department of Transport and the Royal Papua New Guinea Constabulary.

Excluded studies

Five studies published in non-English journals (2 Chinese and 3 Portuguese) were excluded as the full papers could not be found.

Included studies

Seventy-three studies were identified. Nearly all were descriptive, with the exception of one study (Nelson & Struber 1991), which used two exposed comparison groups to examine vehicle types as a risk factor of morbidity and fatality. Fifty-five of the studies were retrospective while 18 were prospective. Three studies (Gordon 1965; Choovoravech *et al.* 1980; Shepherd 1980) presented only hospital utilization data. Sources of data were diverse and included special surveys and hospital and traffic police records. Two studies used data from a population-based survey (Muhlrad 1987) and police records (Asogwa 1980). No intervention trials were identified.

Data synthesis

Methods of data collection were examined and a qualitative assessment of the data was made. Associations explored by the studies were summarized and tabulated. Where age groupings varied, data were regrouped in an attempt to produce comparable data between studies.

Data quality

Under-reporting and incomplete recording of crash details were common. Police-derived statistics were limited to motor vehicle crashes that were reported and in most cases lacked detailed demographic information of casualties. It is apparent that even in the same country, different jurisdictions apply different criteria in reporting motor vehicle crashes. Nevertheless, sufficient details, including a description of the vehicles involved, were provided.

Classification of casualties by category of the road-user was not uniform. For instance, in three studies (Eid 1980; Bayoumi 1981; Ofosu *et al.* 1988), casualties were classified as either vehicle occupants or unprotected road-users. Such aggregated groupings do not allow for accurate identification of road-users and assessment of the extent of involvement of a specific type of road-user.

Definitions were inconsistent and varied with respect to fatality, injury severity, and blood alcohol concentration (BAC) threshold. Of the 31 studies that showed fatality rates (Table 1), only one (Weddele & McDougall 1981) applied a definition recommended by the WHO (1979). Two studies (Siddique & Abengowe 1979; Jadaan 1989b) included all deaths occurring on the spot or any time after a crash.

In view of the variability of data sources, subject selection criteria and reporting thresholds of crashes, direct comparison of data sets from different studies would not be appropriate.

Results

Fatality rates

Fatality rates in relation to vehicle ownership and population of respective regions were indicated in 31 studies shown in Table 1. Based on the numbers of registered motor vehicles, the rates per 10 000 vehicles varied widely, from 3.0 in Saudi Arabia (Ofosu *et al.* 1988) to 301.9 in Haiti (Bangdiwala *et al.* 1987). As shown in Figure 1. There is an apparent correlation between an increase in vehicle ownership with low mortality rate per 10 000 vehicles. Studies that reported fatality rates per 100 000 persons per year, on the contrary, indicate that countries with low-income economies in Africa and Asia registered lower fatality rates than those in the middle-income per capita category in South-East Asia and the Middle East. The rates in relation to population density ranged from 4.0 per 100 000 in Tanzania (Vaaje 1985) to 65.0 in Qatar (Eid 1980). These variations can be explained by a number of factors, some of which are described below.

Associations

Associations of motor vehicle crashes were examined in relation to casualty characteristics, circumstances of occurrence, and extent of hospital utilization.

Casualty characteristics

Age

Age was presented in different groupings in 54 studies. In 8 studies (Patel & Bhagwatt 1977; Bayoumi 1981; Weddele & McDougall 1981; Sinha *et al.* 1981; Sinha & Sengupta 1989; Vaaje 1985; CAREC 1987; Wu *et al.* 1991; Bouramia 1993), those in the age group 15–44 years comprised between 48 and 78% (mean 69%) of all traffic casualties, a proportion greater than in the general population. In Papua New Guinea, for instance, it was 1.8 times higher than in the country's population. Other age groups were 15–39 years reported in 3 studies (Sayer & Hitchcock 1984; Dessie & Larson 1991; Jayasuriya 1991), 46–75% (mean 58%); 20–39 years reported in 7 studies (Oyemade 1973; Obembe & Fagbayi 1988; Salgado &

Table 1 Fatality rates and vehicle ownership index by county and source

1st Author, year, country	Rates/10^4 vehicles (*N*)	Rate/10^5 pop. (mln)	Motor index[1]
Africa			
National RSC 1984, Botswana	37.7 (34 479)	13.8 (0 941)	63.6
Muhlrad 1987, Cote d'Ivoire	43.0 –	8.2 (8.5)	–
Dessie 1991, Ethiopia	59.5 (60 000)	17.9 (1.6)[2]	3.4
Jacobs 1976, Kenya	83.7 (159 000)	11.0 (12.2)	13.0
NRSC 1992, Kenya	68.0 (390 000)	11.4 (23.5)	16.4
Jinadu 1984, Nigeria	–	7.4	–
Obembe 1988, Nigeria	–	10.0 (7.6)[2]	–
Vaaje 1985, Swaziland	41.0 (40 800)	28.0 (0.605)	67.4
Dept. Health 1989, S. Africa	20.5 –	35.8 (34.5)	–
Vaaje 1985, Tanzania	59.0 (140 000)	4.0 (20.6)	6.8
Schram 1968, Uganda	113.6 (44 000)	6.4 (8.0)	5.5
Vaaje 1985, Zambia	118.0 (60 000)	11.3 (6.2)	9.7
Zwi 1993, Zimbabwe	28.8 (386 943)	11.1 (10.0)	38.7
Asia			
Bhandari 1969, India	37.0 –	12.6	–
Mohan 1985, India	12.4 (535 129)	11.6 (5.7)[2]	93.9
Gururaj 1993, India	8.6 (700 000)	13.6 (4.4)[2]	159
Jayasuria 1991, Papua NG	67.4 (51 498)	9.9 (3.5)	14.7
Krishnan 1992, Malaysia	8.4 (4.5 mln)	2.22 (17)	264
Sayer 1984, Sri Lanka	39.0 (314 626)	–	–
Selgado 1988, Sri Lanka	23.3 (523 723)	–	–
Middle East			
Jadaan 1989, Jordan	23.5 (221 700)	–	–
Bayoumi 1981, Kuwait	8.4 (454 463)	32.0 (1.2)	379
Eid 1980, Qatar	16.1 (88 688)	65.0 (0.22)	403
Mufti 1983, S. Arabia	3.0 –	41.3	–
Bener 1985, S. Arabia	3.0 (981 811)	40.7 (0.73)[2]	1335
Weddele 1981, UAE	–	25.0 (0.93)[2]	–
Latin America and Caribbeans			
Olivares 1968, Mexico	40.0 (438 744)	–	–
Bangdiwala 1987, Haiti	301.9 (53 000)	31.7 (5 053)	10.5
Kaye 1971, Puerto Rico	9.0 (500 000)	16.1 (2.8)	178.6
Kaye 1973, Puerto Rico	7.0 (793 883)	19.5 (2.83)	280
CAREC 1987, Suriname	9.9 (71 860)	19.7 (0.36)	199.6

[1] Motorization index = vehicles/1000 persons.
[2] Hospital data for city or region.

Colombage 1988; Wu & Malison 1990; Robles & Vargas-Marinez 1991; Balogun & Abereoje 1992; Bener & Jadaan 1992), 45–59% (mean 51%); 20–40 years, shown in 10 studies (Olivares-Ubina 1965; Nair & Khare 1977; Siddique & Abengowe 1979; Eid 1980; Mbaruku 1980; Mufti 1983; Jinadu 1984; Jadaan 1989b; Sathiyesekaran 1991; Shanks & Al-Kalai 1994) ranged from 37 to 67% (mean 50%). Although the groupings overlap, these results clearly indicate the excess representation of adolescents and young adults. However, no data were available on the age distribution of those actually exposed to the risk of being involved in traffic accidents.

Sex

Forty-six studies that described casualties by sex showed consistent predominance of males over females, with males comprising between 67 and

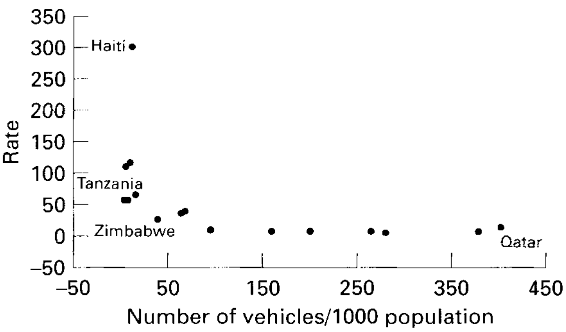

Figure 1 Fatality rate/10 000 vehicles in relation to vehicle ownership in selected countries (data from Table 1).

99.5% (mean 80%). The male to female ratio was >2 in all studies, but >3 in 83% of the studies. Even when examined by type of road-user, males were still over-represented in every category, especially amongst drivers, where they comprised between 87 and 100%. This can be explained by the greater exposure of men to traffic or their increased risk due to other factors, given similar exposure levels.

Road-users

Thirty-eight studies described casualties by the category of road-user, but only 24 provided fatality data (Table 2). Pedestrian fatalities were highest in 75% of the studies accounting for between 41 and 75%, followed by passengers (38–51%) in 62% of the studies. Drivers were third in 55% of the studies, and never ranked first in any country. Pedal and motorcyclists killed ranked first in India (Mohan & Bawa 1985; Sidhu *et al.* 1993) and Surinam (CAREC 1987). Passengers ranked first amongst the non-fatal casualties reported in 14 studies. Pedestrians were second, with the exception of one hospital-based study by Dessie and Larson (1991) in Addis Ababa that reported a very high proportion of pedestrians, accounting for 91% of all traffic casualties. Driver injuries were greater in Saudi Arabia (Bener & El-Sayyad 1985; Ofosu *et al.* 1988), while motorcyclists were the most involved in Taiwan (Wu & Malison 1990). A relatively high proportion of cyclist injuries in South-East Asian countries, ranging from 39 to 63%, reflects the effects of traffic mix on the roads in the region.

Crash incidence

Time

Fifteen of the 26 studies that provided figures showed that between 60 and 80% of casualties were injured during the day. Approximately one-third of traffic injuries occurred during the night with the highest incidence being between 1800 and 2400h. Only 6 studies (Kaye 1971; 1973; Ferguson 1974; Fosseus 1983; Obembe & Fagbayi 1988; Holder 1989) indicated proportions greater than 50% for night-time crashes (range 51–69%). Although there is less traffic at night, the risk and probability of injury is likely to be much higher than during the day. Data on whether different road users are more or less likely to be involved, depending on time, were not available.

Day of the week

There was a greater incidence of traffic injury during weekends, between 0600h on Friday and Monday 0600h, compared to mid-week days, in 79% of the 19 studies that provided data. Of the total weekly figure, an average of 52% occurred during weekends (range 36–74%), which is significantly higher than the expected proportion of 43% over a 3-day period, had the frequency been evenly distributed throughout the week. This high incidence, in excess of the expected average, suggests the effect of variations in traffic density and the influence of additional exposure risk factors, including alcohol and possibly other intoxicating agents. Relatively low proportions of weekend casualties of 36 and 38% were reported in only 2 studies (Mbaruku 1980; Aganga *et al.* 1983), while there was no evidence of across-the-week variations in 2 studies reported by Olivares-Urbina (1965) and Ofosu *et al.* (1988). It would be useful to have available data on traffic flows over the week in order to correct for this potentially important variable.

Alcohol

Thirty-three studies mentioned alcohol, but only 26 actually provided prevalence data. As shown in Table 3, a number of studies did not test all subjects in the study. Although fatality studies showed the highest alcohol prevalence, it is likely that a greater proportion of blood samples was obtained from

Table 2 Percentage of traffic fatalities by source, country and class of road-user

Author, year, country	Class of road-user: Pedestrian	Passenger	Driver	Cyclist
Africa				
Muhlrad 1987, Cote d'Ivoire[1]	75.0	17.0	–	–
Jacobs 1976, Kenya	45.0	32.5	8.0	11.8
NRSC 1992, Kenya	*41.2*	*39.7*	*12.3*	7.0
Siddique 1979, Nigeria	45.5	6.8	15.9	32.0
Vaaje 1987, Swaziland	43.0	30.0	20.0	7.0
Ferguson 1974, S. Africa	65.0	–	35.0[2]	–
Auto Assoc 1991, S. Africa	45.0	28.1	22.3	7.9
Vaaje 1985, Tanzania	39.0	44.0	11.0	6.0
Schram 1968, Uganda	45.0	26.0	9.0	20.0
Patel 1977, Zambia	50.2	28.1	15.2	6.4
Vaaje 1985, Zambia	46.0	33.0	14.0	8.0
Asia and Oceania				
Mohan 1985, India	33.0	15.0	3.0	39.0
Sidhu 1993, India	16.0	58.0[2]	–	25.8
Wyatt 1980, Papua NG	41.0	38.0	10.0	5.0
Sinha 1981, Papua NG	34.5	45.6	14.6	3.5
Sinha 1989, Papua NG	34.4	45.0	18.2	3.0
Dept Transp. 1991, Papua NG	33.8	51.3	13.4	1.6
Salgado 1988, Sri Lanka	51.4	11.2	2.4	34.5
Middle East				
Bayoumi 1981, Kuwait	55.0	–	40.8[2]	4.0
Eid 1980, Qatar	50.0[3]	–	50.0[2]	–
Latin America and Caribbeans				
Kaye 1971, Puerto Rico	54.0	16.0	23.0	4.7
Kaye 1973, Puerto Rico	47.0	19.0	23.0	2.2
CAREC 1987, Suriname	15.0	15.0	9.0	58.0
Holder 1989, Trin. & Tobago	45.7	21.7	21.7	10.9

[1] Data for Abidjan.
[2] Vehicle occupants.
[3] Pedestrians and cyclists.

victims suspected to have been drinking; and blood alcohol concentration (BAC) thresholds were different. Alcohol prevalence in drivers ranged between 30 and 53% in 5 studies undertaken in South Africa (Myers *et al.* 1977), Zambia (Patel and Bhagwatt 1977) and Papua New Guinea (Wyatt 1980; Lourie and Sinha 1983; Sinha and Sengupta 1989) where a cut-off point of 80 mg/100 ml was applied, while it ranged from 48 to 69% in 3 studies in Puerto Rico (Kaye 1971; 1973; 1974) that applied a lower cut-off of 20 mg/100 ml. Two hospital-based surveys (Holder 1989; Wu *et al.* 1991) evaluated intoxication status by breath test measurements but with different BAC cut-off criteria. Much greater variations were evident in 14 reports that assessed the presence of alcohol by subjective methods, such as smell of alcohol in breath and interviewing; the percentage ranged from 0.1 in the Zaria region of Nigeria (Aganga *et al.* 1983) to 45 in Jamaica (Golding 1974). These values certainly underestimate the true alcohol prevalence, given the problems associated with obtaining timely breath and blood alcohol tests, subject selection and the insensitivity of subjective assessments. The variations also

Table 3 Alcohol prevalence, in percentages, by country and category of road-user

Author, year, country	Casualty type	Sample Size: Total	Sample Size: % tested	Class of road-user (n): Driver	Pedestrian	Passenger	Cyclist	All	Test method and cut-off BAC
									Blood analysis (mg %)
Myers 1977, S. Africa	N/F	165	70	47.0 (34)	28.6 (21)	37.5 (24)	27.7 (36)	35.6	80
Patel 1977, Zambia	fatal	217	100	30.3 (33)	32.1 (109)	14.7 (61)	33.3 (12)	26.7	80
Wyatt 1980, Papua NG	fatal	121	70[1]	3.33 (15)	69.0	—	—	76.0	80
Lourie 1981, Papua NG	fatal	171	23	52.6 (19)	90.0 (20)	—	—	71.8	80
Sinha 1989, Papua NG	fatal	363	17	48.5 (33)	66.7 (30)	—	—	57.1	80
Kaye 1971, Puerto Rico	fatal	451	75	63.0 (57)	61.0 (106)	26.0 (67)	—	58.9	20
Kaye 1973, Puerto Rico	fatal	552	73	69.2 (65)	64.8 (105)	48.8 (29)	—	63.2	20
Kaye 1974, Puerto Rico	fatal	577	85	48.0	34.0	—	—	—	20
Fosseus 1983, S. Africa	fatal[3]	48	83	—	—	—	61.3	—	10
Aguwa 1982, Nigeria	N/F	32	100	56.0 (32)	—	—	—	—	10
									Breath test (mg %)
Wu 1991, Taiwan	N/F[3]	489	92	—	—	—	8.5	—	50
CAREC 1987, Surinam	N/F[2]	289	87	15.4 (26)	18.2 (44)	13.6 (44)	22.1 (140)	20.6	1
									Subjective
NatRS 1984, Botswana	N/F, fatal	1614	—	—	—	—	—	7.5	blood/smell
Bouramia 1992, Benin	N/F	796	—	—	—	—	—	1.0	judgement/smell
Aganga 1983, Nigeria	N/F	2669	—	0.16	—	—	—	—	judgement/smell
Obembe 1988, Nigeria	N/F	209	100	14.0 (50)	17.6 (159)	—	—	16.7	judgement/smell
Vaaje 1985, Swaziland	N/F	915	—	1.6	—	—	—	—	judgement/smell
Mbaruku 1977, Tanzania	N/F	239	100	—	—	—	—	13.0	judgement/smell
Vaaje 1985, Zambia	N/F	4213	—	0.7	—	—	—	—	judgement/smell
Zwi 1993, Zimbabwe	N/F	11463	—	3.2	—	—	—	—	judgement/smell
Bener 1985, S. Arabia	N/F	20339	—	1.1	—	—	—	-	judgement/smell
Ofosu 1988, S. Arabia	N/F	—	—	0.9	—	—	—	—	judgement/smell
Asogwa 1980, Nigeria	N/F	1296	43	7.7	—	—	—	—	Self-report
Gururaj 1993, India	N/F	1784	—	16.0	16.0	—	21.0	16.0	Self-report
Wong 1990, Singapore	N/F[3]	198	100	—	—	—	—	10.0	Self-report
Golding 1974, Jamaica	N/F	—	—	—	—	—	45.0	—	Self-report

N/F, Non-fatal.
[1] Age tested<10 years.
[2] Age tested>14 years.
[3] Motorcyclists.

reflect actual differences in the extent of alcohol use, drinking behaviour and cultural practices across different countries.

Traffic violations

Evidence of high driving speed and driver negligence was examined in 20 and 16 studies, respectively. Fifteen of the studies mentioned excessive speed as the main cause of crashes on the basis of traffic police reports. Similar findings were obtained from injured drivers presenting to hospitals in Singapore (Wong *et al.* 1990b) and Taiwan (Wu *et al.* 1991). As expected, proportions of crashes attributed to high driving speed varied enormously between countries; for instance, 67% in Saudi Arabia (Mufti 1983; Bener & El-Sayyad 1985), 60% in Cote d'Ivoire (Muhlrad 1987), 10% in Jordan (Jadaan 1989b) and 8.5% in Kenya (NRSC 1992). In 14 studies, driver negligence, which encompasses reckless driving, improper overtaking, and disregarding traffic lights, was judged by the police as the main causal factor. Such causes may have alcohol as the underlying but often unidentified contributing factor.

Hospital utilization

Traffic-related injury accounted for between 30 and 86% of all trauma admissions. Eleven of the 15 studies that provided hospital utilization data examined the length of stay. The overall mean length of stay was 20 days, ranging from 3.8 in Jordan (Jadaan 1989b) to 44.6 days in Sharjah, United Arab Emirates (Weddele & McDougall 1981). Patients who sustained spinal injury, head injury or compound fractures had the longest duration of hospitalization. For example, in one study (Balogun & Abereoje1992), 25% of the admissions were hospitalized for more than 60 days. Other indicators of hospital use showed that traffic-involved patients represented between 13 and 31% of all injury-related attendances (Balogun & Abereoje 1992; Sathiyesekaran 1991), 48% of bed occupancy in surgical wards (Tamimi *et al.*1980), and were the most frequent users of operating theatres and intensive care units (Shepherd 1980; Shanks & Al-Kalai 1994). In addition, the increased workload in X-rays departments (Jadaan 1989b; Weddele & McDougall 1981) as well as the demand for physiotherapy and rehabilitation services (Wu *et al.* 1991; Balogun & Abereoje 1992) were to a large extent attributed to traffic injuries. Despite the fact that only a small sample of studies presented hospital data regarding post-injury care, it is evident that traffic-related trauma exerts a considerable burden on the already constrained health care resources in developing countries. Unfortunately no data were available on the associated long-term morbidity and disability.

Discussion

This review adds to existing summaries of the burden of RTAs in developing countries by examining fatality rates, risk groups and associations; and highlights problems with data collection and definitions used.

Varying definitions, measurement methods and data completeness meant direct comparison of fatality rates between countries and the relation with level of motorization was problematic. However, these data were illustrative of general associations, and consistency between studies was apparent. Nevertheless, caution in direct comparisons between studies is warranted.

Implications for policy and interventions

The analysed data show that men are more at risk than women of being injured in crashes. The preponderance of males may be attributed to their greater exposure to traffic and other associated factors. Similar evidence is well documented in several studies in industrialized countries (Warren & Simpson 1980; Galloway & Jacobs 1981; Forster *et al.* 1988). While most motor-vehicle drivers are men, a high proportion of males involved as pedestrians, passengers or cyclists, suggests the co-existence of other social and behavioural factors contributing to their vulnerability. However, no study in this review attempted to investigate specific potential factors that would explain the observed gender differences. Such a study is desirable and would need to assess and correct for levels of exposure by gender.

The findings that adolescents and young adults are at high risk of traffic injury is well documented in many reviews on the subject. This has important economic impacts as these are people in their most economically productive years. It also has implications for the design and implementation of more targeted interventions.

There are wide variations in the characteristics of motor vehicle crashes between countries and regions of the developing world. Pedestrians are most vulnerable to injury and death. This may be due to a number of factors, including lack of pedestrian facilities in road design, poor knowledge and practice of road safety measures by the general population, uncourteous behaviour of motorists, high speed driving, and low levels of vehicle ownership. The high proportions of passenger fatalities appear to be associated with extensive use of public transport, types and condition of such vehicles, and the driving skill of their operators. In Papua New Guinea, for example, a significant number of deaths occur amongst passengers riding on open-back utility vehicles (Lourie & Sinha 1983; Jayasuria 1991; Nelson & Struber 1991). The predominance of cyclist casualties in South-East Asian countries and Surinam can be attributed to the common traffic mix on the roads, characterized by the abundance of motorized and non-motorized two and three-wheeler vehicles, as well as lack of segregated facilities for them in the road network (Downing 1991). However, segregating different forms of road use may not necessarily be the solution, since, in the absence of a varied mix of road users, the available motor vehicles would be greatly overloaded and the speeds travelled by motorized vehicles would increase resulting in higher risks of traffic crashes.

While the existence of regional variations in relation to road-user injury and fatality has been well established, it is likely there are also within-country differences. Detailed data indicating characteristics of road-users at greatest risk are therefore needed for each region of a country. It also implies that road safety measures transferred from one country to another need to be adapted and targeted to the identified concerns of a given country.

There is sufficient evidence in support of a high incidence of day-time casualties. This can be explained by greater traffic volume during the day resulting in greater risk of accident involvement as people travel to work, children go to school, and commercial enterprises are open for business. The relative decline in traffic casualties at night may be explained by less night-time activity and travel. There are, however, indications from both developing and industrialized countries that the case fatality rate is higher for night-time crashes than for those occurring during the day (Muhlrad 1987; Obembe & Fagbayi 1988; McCarrol & Haddon 1962; Borkenstein *et al.* 1964; Holt *et al.* 1980; Walsh and Macleod 1983). Perhaps if correction were made for the density of traffic, the fatality rate for night-time crashes would be much higher; unfortunately, diurnal traffic volumes were not estimated in these studies. Darkness and decreased visibility have been suggested as contributing factors at night, but do not fully explain the high incidence of more severe injuries occurring between 1800 and 2400h, which progressively decline as the night advances. Simple interventions, such as painting bicycles yellow instead of black or wearing reflector bands may be cost-effective and decrease traffic injuries. Such interventions need to be tested. Excess night-time crashes in industrialized countries are associated with alcohol intoxication. No study in this review attempted to examine this relationship, although several authors hinted that the dusk-to-night peak could be attributed to alcohol consumption (Kaye 1974; Muhlrad 1987; Nelson & Struber 1991; Bouramia 1993). The high case fatality rates for night-time crashes may also be explained by delays in reporting injuries and less efficient medical emergency services at night due to lower staffing levels within emergency units, although these aspects were not examined in the studies. Prompt evacuation of casualties and improved trauma care can significantly reduce traffic-related fatality rates.

The data set examined here shows that more than 50% of the weekly traffic injuries occur on Friday, Saturday and Sunday, with a high peak on Saturdays. In the Papua New Guinea studies, nearly 60% of the weekly traffic injuries are reported to occur during this period and it is likely that a greater proportion is alcohol-related. Weekend crashes have long been associated with drink-driving in the industrialized countries (Warren & Simpson 1980; Holt *et al.* 1980; Walsh & Macleod 1983; Forster *et al.* 1988). The increased night-time and weekend crashes place high demands on emergency staff at times when staffing in hospitals is often at its lowest level, and has implications for the efficient organization and provision of emergency medical services. Determination of the local distribution patterns of crashes is crucial for the development of appropriate and more focused road safety interventions.

A comparison of alcohol prevalence in studies that applied similar measurement methods, such as those reported by Patel and Bhagwatt (1977), Wyatt (1980), Sinha *et al.* (1981) and Sinha and Sengupta (1989), shows a high proportion of intoxication. Although such data suggest that alcohol is likely to be an important contributing factor in fatal motor vehicle crashes, the equivalent information was not obtained from survivors. It is therefore not possible to conclude whether intoxication was more prevalent amongst those fatally injured than in non-fatal casualties. The relative risk of alcohol in motor vehicle crashes can be estimated from case-control studies specially designed to compare alcohol prevalence in two groups of drivers, such as fatal and non-fatal casualties, or accident-involved drivers and the driving population. It is clear that none of the studies reviewed was designed for this purpose. The extent of the contribution of alcohol, amongst other factors, still needs further research in developing countries, with the aim of formulating policies and executing interventions that will reduce alcohol-related crashes.

Driving speed is an important pre-event factor in the generation of traffic crashes. Consequently, most countries have set maximum speed limits permissible for specific types of vehicles, and on specified roads and locations. Experience in a number of countries demonstrates that strict enforcement of speed regulation measures can be effective in preventing serious injury and fatality from motor vehicle crashes (Wilkinson 1974; Meiring 1974; Engel and Thompson 1992; Lave and Elias 1994). However, with the current trend in the production of high performance vehicles, coupled with the ever increasing demand for mobility, the potential danger of increased speed, if not closely and effectively monitored, may surpass other efforts of road safety management, especially in developing countries where road safety initiatives are still weak.

In the past 15 years there have been major advances in the design of vehicles and in their ability to protect occupants in a crash. The introduction of airbags, side-impact protection, crumble zones and other engineering advances, to both vehicle and road design, presents opportunities for further improvement if widely adopted. Of concern is the fact that such developments are not automatically available in low and middle income countries.

Limitations and implications for research

This review reaffirms that most accident statistics are obtained from routine data collected by traffic police and hospitals. A number of methodological problems, however, limit their use both for research and for making international comparisons. These limitations can be summarized under the following categories:

Lack of uniformity in definitions

There are differences in defining deaths that do not occur immediately. Traffic police often report deaths occurring within a few days, while hospital statistics include those who die, from injury complications, any time after their injury even up to 1 year. Such definitions do not conform with the internationally recognized interval of 30 days recommended by the WHO (1979). The variable definitions in effect imply that direct inter-country comparison of fatality rates would not be appropriate.

No objective systematic criteria for classifying injury severity were applied by the police or medical staff. While there is no agreed measure of injury morbidity, classification of severity based on the Abbreviated Injury Scale, Injury Severity Score (AMA 1971; Baker *et al.* 1974) or any other appropriate indicator, such as length of hospital stay, would be more objective if consistently used.

Lack of denominator data

Under reporting of non-fatal injuries, especially those that are less severe amongst children and non-motorized road-users, and those not attending hospitals for treatment, is common. Such evidence has been well documented by Reichenheim and Harpham (1989) in a community-based survey in Brazil, where 85% of children injured were not reported, while in Sri Lanka, Sayer and Hitchcock (1984), found the equivalent figure to be 77% in a hospital-based study. Vaaje (1985) also showed that police records contained only 50% of casualties from motor vehicle crashes that occurred in a number of southern African states. The actual numbers of motor vehicle crash victims therefore remain unknown. Under-reporting presents a more serious problem than deaths in respect of non-fatal casualties as it has the effect of reducing the size of the denominator applied in the calculation of fatality rates. This results in the exaggeration of case-fatality rates and may also overshadow the recognition of any achievements made in road safety work in developing countries.

Vehicle ownership is often used in some national statistics as a proxy measure of wealth, and mortality rate per 10 000 registered vehicles as an indicator of road safety. The rates are substantially higher and vary widely in developing countries, while they are much lower and more homogeneous in the industrialized countries. A report (WHO 1984) clearly illustrates the relation between road accident fatality rates, vehicle density and population size. Nevertheless, caution is warranted in direct interpretation of such rates since they are affected by the methods of collection of vehicle statistics, policy regarding registration, the official definition of a vehicle, and the accuracy of annual vehicle registers in each country. For instance, non-motorized two-wheeler and three-wheeler vehicles, prevalent in South-East Asian countries (WHO 1989), may not be included in the official vehicle statistics in other countries. The statistics of vehicles actually in use in some countries are lower than the official figures since the numbers registered are often not adjusted when vehicles are scrapped or written-off. This implies that denominator data used in the calculation of death rates are inaccurate, not uniform, and have the effect of either under-estimating or over-estimating fatality rates in relation to vehicle ownership, consequently rendering international comparisons inappropriate. The universal adoption of a standard policy and system for collecting vehicle statistics would improve the quality of traffic-related mortality rates.

Fatality rate per 100 000 population is frequently used as an indicator of population risk of death or injury. Such rates would be applicable to the general population only if the denominator figure, obtained from census data or estimated by projections, corresponds to the year for which accident statistics are presented. It would also be deceptive to attempt to estimate fatality rates for the general population based on hospital-based casualty data, where the actual size of the catchment population cannot be precisely defined. Analysis of motor vehicle fatalities in relation to per capita GNP of a country has shown a strong direct correlation, especially in low-income developing countries (Wintemute 1985; Söderlund and Zwi 1995). A systematic comparison of per capita GNP and motor vehicle mortality in different developing nations might be useful in estimating population risks of injury or fatality from crashes. Transportation use surveys which allow calculation of fatality rates per mile travelled, by transportation mode, would be informative where resources exist for their adoption.

Inconsistency in classification

Age, sex and class of road-user injured or killed were indicated in only a proportion of the routine accident statistics. In the absence of complete information on all casualties, the data reported may not be representative of the total country population. Besides, the different age groupings presented render comparative age-specific analysis problematic. Classification of age groups into at least 5 standard categories, such as 0–14, 15–24, 25–34, 35–44 and 45+ years, and the separation of data by sex, would allow for epidemiological analysis by specific age brackets and gender.

Errors in classifying severity of injury by the police, in the absence of clinical information, are common. Police officers are likely to subjectively assess injury as slight, while the subsequent outcome may be serious or fatal. Corroborative clinical evaluation of casualties, using standard criteria, is therefore desirable. Systematic collection of detailed injury data in hospital attenders using a standardized recording system, such as the E-codes and N-codes of the International Classification of Diseases (WHO 1993), would yield a more complete data set that include distribution of injuries by mechanism, location and nature, as well as facilitate linkage with police records.

Reporting bias

Routine data are known to be biased with regard to subject selection and completeness. Deaths and severe injuries are more likely to be reported than minor injuries; drivers and passengers also have a greater likelihood of being recorded by traffic police than pedestrians, cyclists and other non-motorized road users. Hospital-based data usually exclude casualties attending, health centres and those receiving self-treatment, and are recognized sources of reporting bias. There is also evidence that injuries occurring in the under-served urban communities and amongst children are less likely to be reported. Traffic-related morbidity and mortality statistics based on routinely collected data therefore represent an unknown proportion of the true values. The design and establishment of a population-based traffic injury surveillance system would complement police and hospital-derived crash and collision events.

The assessment of the cause of a motor vehicle crash by the police is subjective and likely to be inconsistent and, among other factors, depends on training of the police force and their investigative skills and integrity, which vary from country to country. Moreover, traffic crash investigations often emphasize the identification of who is at fault, while paying less attention to environmental factors, such as the state of roads or weather conditions. An in-depth investigation of a sample of motor vehicle crashes (fatal crashes, bus or multiple-vehicle accidents) by a multidisciplinary team composed of experts such as road engineers, traffic police, motor-vehicle mechanics, sociologists and doctors, would yield more information than reports based entirely on police judgement. This would not only minimize cause assignment biases, but also promote intersectoral involvement in the development and implementation of specific road safety interventions. In-depth crash studies using a similar approach, though requiring additional resources and experts to execute, have enabled investigators in Cote d'voire (Muhlrad 1987) to reconstruct each crash event, identify causative factors and advise on appropriate safety measures. However, the cost and practical issues involved might be prohibitive for the sustainability of such a system in developing countries.

Despite these limitations, crash statistics, if collected by a consistent system, are useful for monitoring trends and effectiveness of interventions within a given country. However, the use of internationally accepted standard definitions, accurate estimation of denominators, careful and complete recording of relevant event characteristics and casualty information can significantly improve the epidemiological value of the data. A system that links hospital data with traffic police reports would be most appropriate. For instance, the Microcomputer Accident Analysis Package (MAAP) developed by the Transport Research Laboratory in the UK, has been shown to be an effective tool for recording and analysing accident data collected by traffic police in several developing countries (Hills and Baguley 1993). Establishment of a practical data collection system with a minimum set of variables is an important yet unresolved issue that needs further research and attention of all countries concerned, and collaboration with international organizations such as the World Health Organization, the Transport Research Laboratory, INRETS and other institutions. A common system that is adaptable to each country has the potential of yielding country-specific statistics that are comparable across nations.

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