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doi:10.1136/ip.2008.018721

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Distribution of road traffic deaths by road user group: a global comparison

H Naci,¹ D Chisholm,² T D Baker¹

ABSTRACT

Background: Road traffic deaths are a major global health and development problem. An understanding of the existing burden of road traffic deaths in the population is necessary for developing effective interventions.

Objective: To outline systematically the global distribution of road traffic deaths by road user groups (pedestrians, bicyclists, motorcyclists, motorised four-wheeler occupants).

Methods: Comprehensive searches of PubMed, Google Scholar, TransportLink, grey literature and reference lists and communication with experts from international organisations and country-level institutions were conducted to identify eligible studies and data sources. All data sources that provided a breakdown of road traffic deaths by road user group at the national or sub-national level were eligible for inclusion. A breakdown of road traffic deaths by road user group was constructed for 14 epidemiologically defined World Health Organization (WHO) sub-regions in addition to World Bank income categories. In addition, the total number of road traffic fatalities by road user group in low-income, middle-income and high-income countries was estimated.

Results: The breakdown of road traffic deaths by road user group varies dramatically across epidemiological WHO sub-regions. The magnitude of pedestrian fatalities ranges from more than half in African sub-region Afra (55%) to 15% or less in AmrA or EurA. The distribution also varies across low-income, middle-income and high-income countries. 45% of road traffic fatalities in low-income countries are among pedestrians, whereas an estimated 29% in middle-income and 18% in high-income countries are among pedestrians. The burden of road traffic injuries on vulnerable road users differs substantially across income levels. An estimated total of 227,835 road traffic fatalities by road user group in low-income, middle-income and high-income countries was estimated.

Conclusions: Ameliorating road safety requires the implementation of context-specific solutions. This review of the road traffic injury literature provides strong evidence that the distribution of road traffic fatalities varies dramatically across different parts of the world. Therefore, context-appropriate and effective prevention strategies that protect the particular at-risk road user groups should be carefully investigated.

Road traffic injuries are a worldwide disaster. The World Health Organization (WHO) reported that an estimated 1.2 million die and 50 million are injured yearly as a result of road traffic injuries around the world and projects that road traffic injuries will become the third leading contributor to the global burden of disease and injury by 2020. In addition, an estimated 90% of the disability-adjusted life years lost worldwide as the result of road traffic injuries occurred in low-income and middle-income countries. High-income countries are expecting a 28% reduction in fatalities at the same time as increases of 92% in low-income and middle-income countries can be attributed to such factors as rapid urbanisation and motorisation, which results in increased exposure levels to risk factors of road traffic injuries.

The relationship between road traffic injury rates and economic development shows that the former generally increase with increasing per capita gross national product up to a threshold level and then decrease. Road crashes kill and maim the most productive segments of the population; globally, in 1998, 51% of fatalities and 59% of disabilities-adjusted life years lost as the result of road traffic injuries occurred in the most productive age groups. As a result, the economic costs of road crashes have been estimated to be as much as US$ 3.7 billion in Africa, US$ 24.5 billion in Asia, US$ 19 billion in Latin America and Caribbean, US$ 7.4 billion in the Middle East, and US$ 9.9 billion in Central and Eastern Europe. Such amounts for the economies of low-income and middle-income countries are estimated to exceed the total development assistance they receive annually.

Investments in research and interventions for road traffic injuries are grossly inadequate compared with the burden of injuries. National analyses have revealed that budgetary expenditure on road safety at all levels of government in low-income countries is extremely limited. Given the current low level of priority, investments in transport safety, if chosen with care, could be extremely beneficial in public health (as well as economic) terms. Under the current resource-constrained environment, it is vital to allocate investments effectively. The choice of interventions to be implemented depends on the main types of road traffic injuries in the population, together with their expected cost and impact. If a large proportion of road traffic deaths are among private car users, for example, the costs and effectiveness of interventions that focus on reducing the burden of injury and death in this road user group should be given particular attention (eg, establishing and enforcing speed limits, encouraging seat belt use). Therefore, a critical step in

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Accepted 30 September 2008
appropriately targeting efforts to address the road safety problem is determination of the underlying distribution of road traffic injuries in the population.

The distribution of road traffic injuries in fact varies dramatically across countries or world regions, not only in terms of age or sex groupings but also in terms of road user groups and risk factors (such as speeding, alcohol-impaired driving, and not wearing a seatbelt). Appropriately responding to disparities in types of road traffic injuries is necessary if this major global health problem is to be comprehensively addressed. To be effective, policies on road traffic safety in low-income and middle-income countries should be based on local evidence, and designed for the particular road traffic contexts that exist in these settings.

In this article, we provide an up-to-date overview of the distribution of road traffic injuries by road user group in different regions of the world, with a particular emphasis on low-income and middle-income countries (where most of the burden resides but for which the least information is available). A review conducted more than a decade ago by Odero et al examined the literature for available evidence concerning the epidemiology of road traffic injuries, with the objective of identifying and summarising available information about the distribution of motor vehicle crashes in developing countries. More recently, Paulozzi et al used disaggregated WHO mortality statistics to construct adjusted death rates for different road user groups in 43 (mainly high-income) countries in order to see whether this could better explain the non-linear relationship between development and road injury. Neither review held a truly global perspective.

## METHODS

### Search strategy

Acknowledging that the number of studies conducted on road traffic injuries in many parts of the world is very limited, we did not impose an a priori threshold for inclusion based on the conduct or quality of the studies. Accordingly, we included any publication—including peer-reviewed journal articles and governmental and institutional reports—that provided a breakdown of road traffic deaths by road user group at the national or sub-national level. Published and unpublished reports on country-specific road traffic injuries were sought for the time period 1991–2006 by:

- Conducting a standardised online keyword search to obtain country-specific information, using online search engines such as Google, Google Scholar, PubMed and TransportLink
- Incorporating relevant references cited in articles identified by the electronic search
- Obtaining unpublished documents and official crash statistics from international organisations and country-level institutions. These organisations included the International Road Federation, WHO, World Bank and others.

We identified 134 data sources (see supplemental information (Web document 1) for a list of included studies). Ninety-six were peer-reviewed journal articles. Nearly all of the peer-reviewed articles were descriptive, and in some cases made only passing reference to the distribution of injuries amidst other situational observations. Under-reporting and incomplete recording of road traffic deaths was widespread, meaning that estimates for different road user groups in some countries were taken from a number of studies. Sources of data were diverse, ranging from vital registration or national-level injury surveillance systems—which provide more representative estimates, see Discussion below—through to hospital databases and traffic police records. Outside of Europe and America, the number of national-level studies was limited; instead, the most data sources were urban, hospital-based studies. For a number of countries—about 20 (see Web document 1)—multiple data sources were found. In such cases, national-level studies/estimates were used where available (if more than one population-level study was available for a country, however, the most recent one was used); failing this, the most up-to-date
or representative study was taken. The complete or partial breakdown of road traffic injuries by road user group, together with an indication of the study type/data source, is provided for a total of 76 countries in Web document 2 (supplementary material).

Data synthesis
It was apparent that, even in the same country, different criteria had been applied in reporting motor vehicle crashes by road user category. For example, although some sources recorded bus and truck deaths as a separate category, most did not, leading us to group deaths incurred in buses and trucks in a “motorised four-wheeler occupants” category along with deaths occurring in private cars and taxis.

Deriving estimates by WHO sub-region
In order to complement estimates of the global burden of disease and injury and as an input into WHO cost-effectiveness analysis of road traffic injury prevention, a breakdown of road traffic deaths by road user group was constructed for 14 epidemiologically defined WHO sub-regions (each of the six WHO regions is split into two to three sub-regions; for definitions and a list of countries in each WHO sub-region, go to http://www.who.int/healthinfo/global_burden_disease/en/index.html). All available information from country-specific data sources within sub-regions was pooled in order to construct weighted averages. Total numbers of road traffic deaths required in order to construct these sub-regional weighted averages were also obtained from the Global Burden of Disease Study.

Deriving estimates by World Bank income categories
In order to generate an alternative regional breakdown—this time by income category (low, middle, high)—all available country information was likewise pooled, from which weighted averages were calculated. According to the World Bank classifications, countries with a gross national income per capita of US$905 or less are categorised as low-income, US$906–11 15 as middle-income, and US$11 116 or more as high-income. The complete list of countries by World Bank income category can be obtained at http://go.worldbank.org/K2CKM78CC0. Total numbers of road traffic deaths needed to construct the regional weighted averages were also obtained from the Global Burden of Disease Study.

RESULTS
Figure 1 shows the breakdown of these road traffic deaths by road user group in WHO sub-regions. We were not able to derive a sub-regional weighted average for the high-mortality sub-region of the Americas (AmrA) or the Eastern Mediterranean (EmrD) because of extremely limited information available on the distribution of road traffic fatalities in these two settings.

The distribution of road traffic deaths by road user group varies dramatically across these sub-regions. In the very low-mortality sub-regions of the Americas and Europe, most road traffic deaths occur among motorised four-wheeler occupants (AmrA, 78%; EurA, 62%). In the South-East Asian region, by contrast, motorcyclists contribute the most by far to road traffic fatalities (SearB, 50%; SearD, 43%), with motorised four-wheeler occupants constituting less than 20% of total fatalities (SearB, 17%; SearD, 19%). The magnitude of pedestrian fatalities also varies considerably, from more than half in African sub-region AfrE (55%) to 15% or less in AmrA or EurA. Elsewhere, and this includes some relatively high-income regions such as WprA and EurB, pedestrian fatalities account for an estimated 25–40% of road traffic deaths.

The distribution of road traffic deaths by road user group also varies across low-income, middle-income and high-income countries (fig 2). Forty-five percent of road traffic fatalities in low-income countries are among pedestrians, compared with 29% in middle-income countries and 18% in high-income countries. Road traffic fatalities among motorised-four wheelers are estimated to be 63% of fatalities in high-income countries, 40% in middle-income countries and 54% in low-income countries. An estimated 21% of road traffic deaths in middle-income countries are among motorcyclists. According to the updated estimates of the Global Burden of Disease estimates for the year 2002, there were 496 174 road traffic deaths in low-income countries, 556 900 in middle-income countries and 118 750 in high-income countries.12 From these values, we estimate that each year: a total of 227 835 pedestrians die in low-income countries, 161 501 in middle-income countries and 40 200 in high-income countries; a total of 172 142 motorised four-wheeler occupants die each year in low-income countries, 161 501 in middle-income countries and 22 500 in high-income countries; a total of 172 142 motorised four-wheeler occupants die each year in low-income countries as opposed to 222 760 in middle-income countries and 75 000 in high-income countries. Motorcyclist deaths in middle-income countries amount to 116 949. Figure 3 shows the differential burden of road traffic deaths by vulnerable road user groups and income category.

DISCUSSION
This study aimed to allocate the global distribution of road traffic deaths by road user group. Although our review of the road traffic injury literature reveals a general paucity of good-quality data sources, it nevertheless provides persuasive evidence that the distribution of road traffic fatalities varies dramatically across different parts of the world. The percentage of road traffic deaths among pedestrians, for example, is estimated to range from 11% in the very low-mortality sub-region of the Americas (AmrA) to 55% in the high-mortality African sub-region AfrE. Motorised four-wheeler occupants account, by contrast, for 40% in middle-income countries and 34% in low-income countries (AmrA, 78%; EurA, 62%). In the South-East Asian region, by contrast, motorcyclists contribute the most by far to road traffic fatalities (SearB, 50%; SearD, 43%), with motorised four-wheeler occupants constituting less than 20% of total fatalities (SearB, 17%; SearD, 19%). The magnitude of pedestrian fatalities also varies considerably, from more than half in African sub-region AfrE (55%) to 15% or less in AmrA or EurA. Elsewhere, and this includes some relatively high-income regions such as WprA and EurB, pedestrian fatalities account for an estimated 25–40% of road traffic deaths.
fatalities ranges from a low of 3% in EurB to the extremely high level of 50% in SearB.

When the breakdown of road traffic fatalities is compared according to income level, a very clear trend is observed in motorised four-wheeler occupant deaths. Deaths among motorised four-wheeler occupants constitute 60% of road traffic deaths in high-income countries compared with 40% in middle-income and 34% in low-income countries. Road traffic deaths among motorised four-wheeler occupants in low-income and middle-income countries are mainly due to fatalities that occur in public buses and trucks. An estimated 26% of road traffic deaths in Russia, for example, are among bus and truck occupants. Approximately 32% of road traffic deaths in Ghana are among bus and truck occupants, and 23% in Mozambique and Tanzania. In Pakistan, the growth in the number of commercial vehicles has not been able to keep up with the increase in demand for transport resulting from rapid population growth. Hence, along with the profit motive of overloading these vehicles, additional factors such as poor maintenance, poor driver training and driver fatigue have led to increased numbers of fatalities of bus and truck occupants.

The burden of road traffic injuries on vulnerable road users differs substantially across income levels. Pedestrian deaths constitute 45% of road traffic deaths in low-income countries compared with 29% in middle-income and 18% in high-income countries. An alarmingly high proportion of road traffic deaths in AfrE (55%) are among pedestrians. Pedestrian fatalities are at an extremely high level in both Ethiopia, where 54% of road traffic deaths occur in pedestrians, and Cote d’Ivoire, where 75% of road traffic deaths occur in pedestrians. Deaths among another vulnerable road user group, motorcyclists, constitute 50% of road traffic deaths in SearB and 45% in SearD sub-regions. WprB, which includes China, stands out as the sub-region with the highest percentage of bicyclist deaths (15%). The predominance of vulnerable road user casualties in South-East Asian and African countries can be attributed to the unique traffic mix on the roads, characterised by the abundance of motorised and non-motorised vehicles, as well as lack of segregated facilities for them in the road network.

The differential distribution of vulnerable road user deaths by world region and income level carries important equity implications. The population groups exposed to highest risks of injury and fatality from traffic crashes in low-income and middle-income countries—pedestrians, passengers of buses and trucks, motorcyclists and bicyclists—are from lower socio-economic groups within these countries. These population groups are exposed to higher levels of the risk factors for road traffic injuries because the modes of transport affordable to these segments of the population expose them to higher risks than private cars. Accordingly, there is a need to design and implement social policies focused on the vulnerable populations that bear the brunt of road traffic injuries. The increasing burden of road traffic injuries among vulnerable road users in low-income and middle-income countries and the emerging public health community mobilising around road safety provides an opportunity to operationalise equity in the context of health sector reform.

In terms of the limitations of this review, it is important to note that the accuracy of the regional and income-level weighted average estimates depends on the representativeness of the data sources from which they are constructed. Most of the data sources used in this analysis for regions outside Europe and America were urban, hospital-based studies (as opposed to national-level statistics, which are more representative of the underlying road traffic death rate in the entire population). As the road user mix may vary dramatically between different sections of a country (rural versus urban), urban hospital-based studies may not be representative of the distribution of road traffic injuries by road user category for an entire country. However, owing to lack of available population-level data sources, we relied on these studies in order to derive a baseline set of sub-regional estimates against which refinement may be made as more and better information becomes available. The substantial differences in data quality among high-income,
middle-income and low-income countries, along with the lack of national-level data sources, highlight the urgent need in low-income and middle-income countries to develop information systems for the systematic collection of data on road traffic injuries.

Our review was not able to compare the risk of road traffic injury and death between WHO sub-regions and World Bank income categories. The ideal way of comparing the risk of road traffic injuries and deaths between different settings is to compare the number of deaths/injuries per kilometre travelled. However, this is extremely difficult to determine even in high-income countries, let alone low-income and middle-income countries. Information systems that collect systematic information on exposure to different modes of road traffic are urgently needed in high-income, middle-income and low-income countries. This could be a useful direction for future research in road traffic injury prevention.

Establishing and improving an information system is a critical initial step to confirm the important public health impact of road traffic injuries in low-income and middle-income countries. Road traffic injuries occur as a result of the interaction of a number of factors; the driver, the vehicle and the environment all play critical roles in the occurrence and outcome of road traffic injuries.21 Defining the problem and its contributing factors is a vital step in establishing preventive measures to ameliorate road traffic safety problems. This would advance our understanding of the behavioural, road-related and vehicle-related factors that affect the number and severity of casualties in motor vehicle crashes, which would facilitate informed identification of interventions. Accurate data obtained through systematic reporting is vital in decision-making on effective road safety planning. An information system in place will provide specific insight into the scale of the problem, as well as its social and economic costs, which are often downplayed in the political arena.22 22 Furthermore, establishing road safety agencies to oversee data collection, evaluating policy and conducting research is much needed in low-income and middle-income settings.23

Acknowledgements: The views expressed in this article are those of the authors and not necessarily those of the World Health Organization. We thank Susan P Baker of the Johns Hopkins Bloomberg School of Public Health, and Margie Peden and Melecikdzedek Khayesi of the World Health Organization, Switzerland, for their editorial assistance. We are very grateful to Dr Adnan A Hyder, Dr Nhan Tran and other members of the Road Traffic Injury Research Network (RTRIN), Dr Salim Mahmud Chowdhury (Centre for Injury Prevention and Research, Bangladesh), Ms Sann Socheata (Handicap International, Belgium), Simone Assis (CLAVES/FIOCRUZ, Brazil), Dr Kim Mundie (Health Statistics, Nova Scotia, Canada), Dr Andres Villaveces (Cisalva Institute, University of El Valle, Colombia), Dr Karun Abdella (WHO, Ethiopia), Dr Francis Abantang (Komfo Anokye Teaching Hospital, Ghana), Dr Jamal Mujahid (Road Safety Youth Fund, Jordan), Dr Antonio Zacarias (Maputo Central Hospital, Mozambique), Dr Junaid Razzaq (Agha Khan University, Pakistan), Dr Margie Peden (WHO, Switzerland), Dr Annette Poiss-Ustun (WHO, Switzerland), Dr Paibul Suryawongsaisai (Community Medicine Center, Thailand), Dr Pham Viet Cung (Center for Injury Policy and Prevention Research, Vietnam) and Andrew Downing (Transport Research Laboratory, UK) for their valuable data contributions and recommendations.

Competing interests: None.

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