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Urban street structure and traffic safety

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A B S T R A C T

Introduction: This paper reports the influence of road type and junction density on road traffic fatality rates in US cities. *Method:* The Fatality Analysis Reporting System (FARS) files were used to obtain fatality rates for all cities for the years 2005–2010. A stratified random sample of sixteen USA cities was taken, and cities with high and low road traffic fatality rates were compared on their road layout details (TIGER maps were used). Statistical analysis was done to determine the effect of junction density and road type on road traffic fatality rates. *Results:* The analysis of road network and road traffic crash fatality rates in these randomly selected US cities shows that, (1) higher number of junctions per road length was significantly associated with a lower motor vehicle crash and pedestrian mortality rates, and, (2) increased number of kilometres of roads of any kind was associated with higher fatality rates, but an additional kilometre of main arterial road was associated with a significantly higher increase in total fatalities. When compared to non-arterial roads, the higher the ratio of highways and main arterial roads, there was an association with higher fatality rates. *Conclusions:* These results have important implications for road safety professionals. They suggest that once the road and street structure is put in place, that will influence whether a city has low or high traffic fatality rates. A city with higher proportion of wider roads and large city blocks will tend to have higher traffic fatality rates, and therefore in turn require much more efforts in police enforcement and other road safety measures. *Practical applications:* Urban planners need to know that smaller block size relatively less wide roads will result in lower traffic fatality rates and this needs to be incorporated at the planning stage.

1. Introduction

Most cities around the world are faced with serious problems of inadequate mobility and access, vehicular pollution, and road traffic crashes and crime on their streets. Increasing use of cars and motorized two-wheelers add to these problems, and this trend does not seem to be abating in most cities of the world. It is expected that improvements in public transport can help substantially in alleviating some of these problems. However, modern cities, especially in low- and middle-income countries (LMIC), have very mixed land use patterns, and very large proportions of all trips are walk or bicycle trips. Of the motorized trips, more than 50% are by public transport or shared para-transit modes (Mohan, 2008). Deaths and injuries due to road traffic crashes (RTC) are also a serious problem in these cities.

Walking and bicycling are the only clean modes of transport available. The use of these modes tends to diminish as incomes rise and cities become unfriendly to these modes when they are designed to prioritize motor vehicles. The high risk of injuries and fatalities in urban areas to pedestrians, bicyclists and commuters in access trips have been documented from all over the world (Boniface, Museru, Kiloloma, and Munthali, 2016; De Andrade et al., 2014; Harvey and Aultman-Hall, 2015; Kaplan and Prato, 2015; Lagarde, 2007; Mohan, Tiwari, and Bhalla, 2015; Naci, Chisholm, and Baker, 2009; Peden et al., 2004; Peltzer et al., 2015). Unless overall road traffic crash rates in urban areas are reduced, with particular emphasis on pedestrians' and bicyclists' safety, it will be difficult to promote these latter clean transport modes.

In the last five decades, the incidence of traffic crash fatalities and injuries has been reduced dramatically in the high-income countries (HIC), both on rural highways and urban areas. However, this is not true for most of the low- and middle-income countries (WHO, 2015). This has been possible in the HIC because of careful analysis and evaluation of the factors associated with crashes and implementation of interventions based on these analyses. On the other hand, in the last two decades, very few LMIC have been successful in reducing the number of lives lost and people injured due to road traffic crashes. Despite these overall trends, there is a great deal of variation in RTC

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fatality rates among countries with similar incomes, whether HIC or LMIC (Mohan and Bhalla, 2016). The reasons for these differences have not been investigated in detail.

A study on RTC fatality rates in different cities around the world also showed significant variations among cities with similar incomes, as shown in Fig. 1 (Mohan, 2008). These data show that there are wide variations across income levels and within similar income levels. The risk varies by a factor of about 20 between the best and the worst cities. Some characteristics are summarized below:

- Overall, the fatality risk in cities with very low per-capita incomes (less than USD 1000) and those with high incomes (greater than USD 10,000) seems to be similar.
- There is high variability in fatality risk among middle-income countries (USD 10,000–20,000)
- There is a great deal of variation in fatality risk even in those cities where the per capita income is greater than USD 20,000 per year.

These patterns appear to indicate that it is not sufficient to have the safest vehicle technology to ensure low road traffic fatality rates uniformly across cities in those locations. Even in low- and middle-income countries, the absence of funds and possibly unsafe roads and vehicles does not mean that all cities have high overall fatality rates. Provision of safely designed roads and modern safe vehicles may be a necessary condition for low road fatality rates in cities, but not a sufficient one. The fact that there are wide variations of overall fatality rates among high-income cities, where availability of funds, expertise and technologies are more similar, indicates that other factors like urban road infrastructure patterns, city design, and exposure (distance travelled per day, presence of pedestrians, etc.) may play an important role as well.

In this paper we have made an attempt to understand the role of urban street infrastructure on RTC fatality rates. In order to minimize the influence of national policies, laws and vehicle standards on RTC fatality rates, we have limited our study to cities in a single country. Due to the availability of data, we chose the USA.

2. Methods

2.1. Road traffic fatality data

To eliminate the issue of very large variations in income among cities, we examined the experience of cities within a single country, the USA. We expect that variations in enforcement, technology, funds and 'culture' would be less among USA cities than comparing cities across different nation states. While we recognize that cities within a country may be heterogeneous, they are more likely to be less heterogeneous than cities across countries.

To obtain RTC fatality data for USA cities, we used the Fatality Analysis Reporting System (FARS) (http://www-fars.nhtsa.dot.gov/Main/index.aspx) files to obtain the total number of fatalities for all cities for the years 2005–2010. The FARS dataset does have missing information just like all registries, primarily on blood alcohol concentration of drivers and other passenger characteristics; however, the variables we used – death counts and place and type of road where the crash occurred, are more completely reported. Other relevant variables obtained included: fatalities by road user type, location of fatalities by class of road, number of lanes at location of the crash, and whether the crash occurred at a junction or midblock. Population and city layout data for all cities were obtained from the US Census Bureau data files (www.census.gov). We used the average fatalities per year per unit population of the city to estimate risk of road users, which is an index of the probability of an individual dying due to RTC in each city. This study attempts to look at trends and the health risk of individuals over a life span. Therefore, other indices like deaths per 10,000 vehicles or deaths per passenger km have not been used, as these do not give an indication of road traffic injuries as a health problem (Mohan, Tiwari, Khayesi, and Nafukho, 2006). Since the number of trips taken in a city is proportional to its population, this index is also proportional to the risk of fatality per trip for that city (Knoflacher, 2007). This is the risk that individual road users must minimize if they have to maximize their life spans. The risk per trip is the experience that individuals approximate internally for decision-making regarding mode choice (Koornstra et al., 2002).

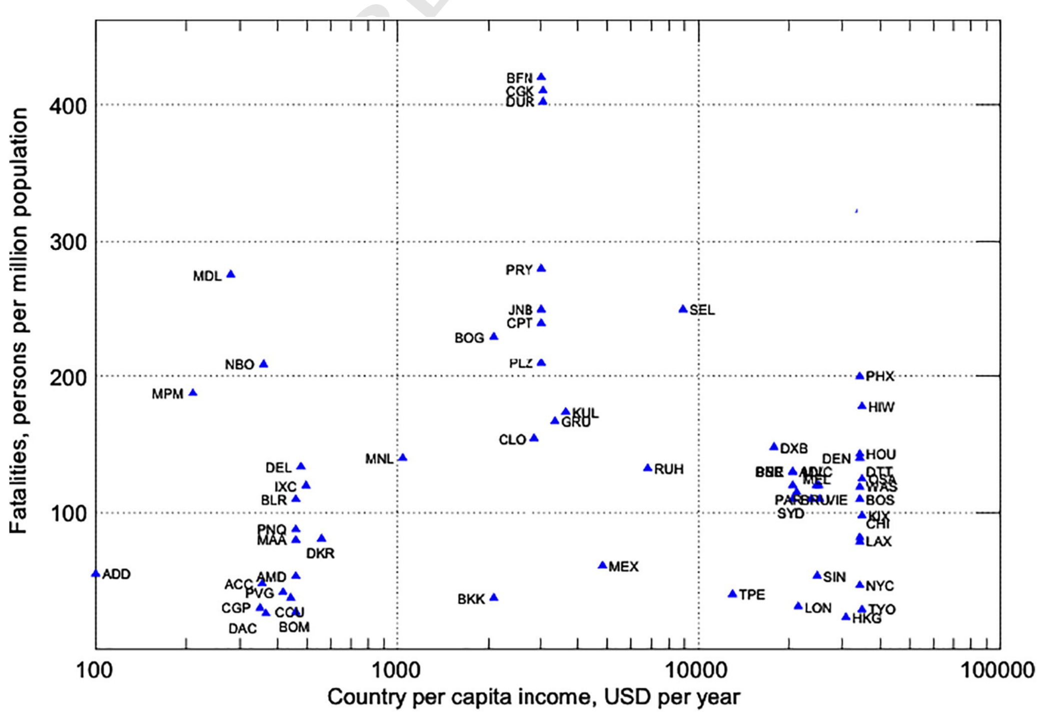

Fig. 1. Road traffic fatality risk in selected cities around the world. Cities are represented by their respective airport codes as given in Appendix A. (Source: Mohan, 2008).

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