Accident Analysis and Prevention 112 (2018) 105–115

Contents lists available at ScienceDirect

Accident Analysis and Prevention

journal homepage: www.elsevier.com/locate/aap

Modelling of road traffic fatalities in India

Rahul Goel

MRC Epidemiology Unit, University of Cambridge, UK

ARTICLE INFO

Keywords:
India
Traffic fatalities
Distance-decay functions
Accident prediction model
Ecological model

ABSTRACT

Passenger modes in India include walking, cycling, buses, trains, intermediate public transport modes (IPT) such as three-wheeled auto rickshaws or tuk-tuks, motorised two-wheelers (2W) as well as cars. However, epidemiological studies of traffic crashes in India have been limited in their approach to account for the exposure of these road users. In 2011, for the first time, census in India reported travel distance and mode of travel for workers. A Poisson-lognormal mixture regression model is developed at the state level to explore the relationship of road deaths of all the road users with commute travel distance by different on-road modes. The model controlled for diesel consumption (proxy for freight traffic), length of national highways, proportion of population in urban areas, and built-up population density. The results show that walking, cycling and, interestingly, IPT are associated with lower risk of road deaths, while 2W, car and bus are associated with higher risk. Promotion of IPT has twofold benefits of increasing safety as well as providing a sustainable mode of transport. The mode shift scenarios show that, for similar mode shift across the states, the resulting trends in road deaths are highly dependent on the baseline mode shares. The most worrying trend is the steep growth of death burden resulting from mode shift of walking and cycling to 2W. While the paper illustrates a limited set of mode shift scenarios involving two modes at a time, the model can be applied to assess safety impacts resulting from a more complex set of scenarios.

1. Introduction

India has one of the highest shares of road traffic fatalities in the world. A large proportion of these fatalities are pedestrians, cyclists, and riders of motorised two-wheelers (2W) (Hsiao et al., 2013; Mohan et al., 2015). This is because a large share of daily trips is contributed by the three modes. According to Census 2011 in India (Census-India, 2017a), the three modes contribute up to 70% of work trips. India lacks government-led efforts for transport-related data in terms of travel surveys or traffic counts. As a result, road traffic injury models been limited in their approach to account for exposure of multiple road user groups. At most, models have used vehicle registration numbers of 2W and cars which highly overestimate actual in-use fleet (Goel et al., 2015; 2016). Moreover, registration data does not account for walking, cycling and use of public transport (PT) and is therefore limited in its application.

Current levels of vehicle ownership in India are far lower than most high-income countries. In 2011, only 6% of all the households in India owned a car, compared to more than 75% households in many high-income countries (Census-India, 2017b; Statista, 2017). As a result, a large proportion of population continues to walk, cycle, or use PT. At the same time private vehicle ownership witnesses an inevitable growth. From 1990 to 2015, the average year-on-year growth rate of 2W and cars was 9–10%, implying that private motorised fleet is doubling every 7–8 years. This rate is many times higher than the growth rate of population and, therefore, indicates a dramatic mode shift from walking, cycling and PT to private vehicle use.

Motorisation in India is also different from many of the high-income countries in two main aspects. Firstly, motorised traffic in India is dominated by 2W. For every car in India, there are more than five times as many 2W (MoRTH, 2013). In case of a crash, ceteris paribus, a 2W rider is many times more vulnerable to an injury than a car driver. Thus, a motorisation based on 2W makes its road users more risk-prone. A car-based motorisation, on the other hand, ensures higher safety of vehicle occupants. Secondly, PT modes in India include not only buses and trains but also a range of other intermediate modes such as auto rickshaws and tuk-tuks, common in many south-Asian settings. They serve the purpose of PT and, at the same time, have a smaller engine capacity than a bus or even a car. Thus, an impact of these modes on safety is important from the perspective of transport policies.

In summary, travel patterns in India present a complex and a unique mix of traffic modes and are going through rapid changes. All these changes are occurring in the context of poor enforcement of traffic laws, as well as a lack of safe infrastructure for walking and cycling. Given this background, travel patterns are likely to be a strong predictor of the number of road injuries. This is the first time Census in India has

E-mail addresses: rg574@medschl.cam.ac.uk, rahulatiitd@gmail.com.

https://doi.org/10.1016/j.aap.2017.12.019
Received 29 October 2017; Received in revised form 25 December 2017; Accepted 27 December 2017
0001-4575/ © 2018 The Author. Published by Elsevier Ltd. This is an open access article under the CC BY license (http://creativecommons.org/licenses/BY/4.0/).

included travel-related information. The information includes the mode of travel and the travel distance for workers. This gives an opportunity to explore how the travel patterns are related to road deaths to assess and design travel demand and traffic safety policies in India.

2. Objectives

The main objective of this study is to develop an ecological model of road traffic fatalities, with states of India as areal units. The model aims to establish a relationship between total annual road fatalities and commute travel distance by different modes, while controlling for state-specific confounders. I aim to develop a model with a form often used in injury modelling and shown in Eq. (1):

$$n = M1^{e1}M2^{e2}M3^{e3}e^{\sum \beta_i x_i} \quad (1)$$

where, M1, M2, and M3 represent travel distance (or volume) of the three road user categories, e1, e2, and e3 represent their respective exponents, x_i represents a set of predictor variables which control for factors other than volume, and β_i their corresponding coefficients. The values of exponents and coefficients are obtained using regression modelling.

The three road user categories have been used only for illustration. This form of the model is achieved by anti-logging a log-linear relationship between injury counts (n) and the volume or distance variables (M1, M2, M3). It is a usual practice to include these variables in their logged form. This also results in multiplicative risk factors as shown in Eq. (1). Such models are often referred to as accident prediction models. This name, however, is an oxymoron, since accidents by nature are not predictable, and therefore a more scientific term should be injury prediction models.

The models have been developed at a range of level of aggregation. These includes traffic junctions, roundabouts, crossings, or road sections among the 'micro 'or 'meso-level' models to city wards, traffic zones, and municipalities among the 'macro-level' or ecological models (Elvik and Bjørnskau, 2017). For this paper, I will only discuss models at areal or macro levels. The outcome variable in these models also vary based on the objective of the study. Most models include number of injuries or crashes of a specific road user as outcome. In such models, the exposure variables include the volume of that road user (injuries of which are outcome variable) along with the volume of conflicting road user. For instance, models with pedestrian injuries as outcome and pedestrian and car volume as explanatory variables. No model in the literature has accounted for more than two road users, except Elvik (2016) who modelled pedestrian injuries using volume of cars, cyclists and pedestrians.

The model presented in this paper differs from the previous literature in two main aspects. First, the dependent variable in the model is the number of road deaths of all road users and not specific to a single road user. Second, the model accounts for multiple modes as explanatory variables, and not just two modes, thus reflecting the heterogeneity of traffic on Indian roads. Thus, the model in this paper aims to establish a relationship between overall road death burden and a mix of travel modes. This also implies that a comparison of the results presented in this paper with the literature needs to be done cautiously.

My aim to develop this model is twofold—analytical and for prediction. The former will be achieved my assessing the magnitude and signs of exponents of different road users. The latter will be achieved by simulating future travel patterns to assess their impact on road deaths. I will explain these using an example. Suppose that there are three road users in the model specified in Eq. (1), and from the regression modelling it is estimated that the two of them (say, M1 and M2) have positive exponents (e1 and e2) and one (say, M3) has a negative exponent (e3).

From an analytical perspective, this implies that an increase in M1 and M2 will increase injury burden, while an increase in M3 will reduce it. Among M1 and M2, the comparison between the magnitudes of their exponents will also illustrate which of the two modes will result in higher injury burden if both are increased by the same amount. From a prediction perspective, one can model what-if scenarios of mode shift and understand the trajectories of road death burden. For instance, mode shift from M3 (mode associated with less risk) to M1 or M2 (modes associated with higher risk) will result in much higher death burden than mode shift within M1 and M2.

The literature on accident prediction models is also divided among those where the exposure of different road users (such as M1, M2, and M3 in the example above) are in the form of counts (or volumes) and those where it is in the form of distance (Elvik and Bjørnskau, 2017; Schepers and Heinen, 2013). When the units of analysis are point locations or of a consistent size, the counts can be justified as an exposure variable. For instance, counts of motor vehicles, pedestrians, or cyclists at traffic junctions, road sections, or traffic analysis zones in a city. If the units of analyses differ in their size, the counts may be an incomplete measure. The models with only counts also eliminate the possibility to predict changes in injuries if population travelled using the same modes however the distance of travel changed. Therefore, a model with distance is more robust in its application to predict changes in injuries resulting from changing travel patterns.

3. Data

The model explained in the previous section needs three main data types—a) annual number of road deaths for each state as dependent variable, b) mode-specific commute travel distance, and c) other explanatory variables. In 2011, India had 28 states and 7 Union Territories (UTs). The average population of the UTs is 2.9 million while that of the states is 41 million. Two of the UTs are islands, Andaman and Nicobar Island in the east and Lakshadweep in the west, and contribute 0.04% of the total population of the country. These were excluded from the analysis. The remaining 28 states and 5 UTs will be referred to as 33 states henceforth. Note that Delhi, the capital city of India, is a city-state and is therefore included as one of the units in this analysis. The states cover a large range of population from 0.24 million to 200 million. Table 1 presents the descriptive statistics.

National Crime Records Bureau of India publishes annual number of road accidents, number of people injured, and number of deaths for each state and UT in India. Number of injury crashes are highly underestimated in India (Mohan et al., 2015), and as a result only number of deaths have been used for the analysis. Corresponding to census year, I used average number of fatalities for the three years (2010 through 2012) for stable estimates (NCRB, 2011; 2012; 2013).

In almost all the states, year-to-year variation of number of road deaths was minimal across the three years (see Appendix: Table A1). There are, however, two exceptions—Punjab, where number of road deaths corresponding to three years are 2133 (2010), 4897 (2011) and 4795 (2012), and Nagaland, with 71 (2010), 106 (2011), and 44 (2012) deaths. In both the states, highest number of deaths is more than 2 times higher than the lowest number. Average fatality rate across the states is 11.6 per 100,000 persons and vary from 2.3 to 22.4. Fig. 1 presents fatality rates for all the 33 states and overall India in a descending order.

In this analysis, I have excluded deaths occurring at railway crossings, which is an area where on-road modes and trains interact. Over the three years, total number of road deaths at railway crossing are 3344 (2010), 2366 (2011), and 1808 (2012). In contrast, total number of road deaths for the three years are 133938, 136834 and 139091 respectively (NCRB, 2011; 2012; 2013), thus, deaths on railway crossing is 1–3% of the on-road deaths.

In 2011, Census of India introduced two questions regarding the commute of workers (Census-India, 2017a). These questions were asked from a subset of all workers—the category called 'other workers'. This category excludes those involved in agricultural or household-based activities. The category of 'other workers' represent 42% of all the

Download English Version:

https://daneshyari.com/en/article/6965238

Download Persian Version:

https://daneshyari.com/article/6965238

Daneshyari.com