Impact of Improving Vehicle Crashworthiness Design on the Burden of Injuries to Pedestrians in USA, Germany and India

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I. INTRODUCTION

Globally, 1.40 million people die in road traffic accidents every year. The overall burden from road traffic accidents is particularly high in Low and Middle Income Countries (LMICs). 'Burden' refers to the impact in terms of the resultant health problems and it is measured with regard to cost, mortality and morbidity. In total, 90% of the deaths from road traffic accidents occur in LMICs, with a disproportionately high share of pedestrian deaths (over 40% of all road deaths) [1].

United Nations test regulation 127 (UN 127) is concerned with mitigating the severity of head and lower limb injuries for pedestrians through vehicle design. The Euro New Car Assessment Program (Euro NCAP) performs pedestrian testing, but the majority of other NCAP programs around the world do not. While pedestrian impact testing has not been conducted on Indian cars to date, Global NCAP testing revealed that all five Indian cars that underwent frontal impact occupant crash testing failed to meet the minimum UN regulations, receiving 0 stars [2]. This suggests that the cars being sold in India may be substantially more hazardous for occupants than cars sold in many EU countries. Similarly, it is likely that cars in India would perform poorly in vehicle-pedestrian impact tests.

Data from Sweden and Germany comparing Euro NCAP pedestrian safety scores and real-world pedestrian outcomes have revealed that improving vehicle design can reduce deaths and the severity of injuries following collisions [3-4]. The aim of this study is to assess the impact of improved pedestrian-related vehicle safety standards on the burden of disease in three countries, representing three separate scenarios: one with mandated regulations for occupants and pedestrians (Germany); one with mandated regulations for occupants only (USA); and one without mandated regulations (India).

II. METHODS

The Global Burden of Disease (GBD) database was used to determine the number of pedestrian fatalities in 34 age-sex groups in each of the three countries in 2013 [1]. The deaths for Germany and the USA were rescaled to match national official pedestrian death toll reported by IRTAD (International Road Traffic and Accident Database) [5]. The total number of non-fatal pedestrian injuries was based on GBD-2010 estimates [6], which were disaggregated by age and sex using the distribution reported for the USA [7]. Vital registration data were used to estimate the proportion of pedestrian deaths caused by impact with passenger cars in the USA and Germany [8], whereas for India, the proportion was estimated using data collected by Johns Hopkins University in a province in India [9]. It was assumed that the proportion of pedestrian deaths where a passenger car was the impacting vehicle would not vary by age and sex. These data, along with population data for each of these countries in 2013, were used to calculate Disability-Adjusted Life Years (DALYs) lost from motor vehicle-related trauma using the tool Burden Calculator [10]. The model includes burden estimation parameters for various injuries, which were obtained from published literature. DALYs were calculated by summing years of life lost (YLLs) and years lost to disability (YLDs).

Burden of pedestrian injuries was estimated for the status quo (baseline), and then compared to estimates for what would happen to the annual pedestrian injury burden if all passenger cars in each of the three countries were required to have a rating of at least 3 stars (out of 4) in pedestrian tests according to Euro NCAP testing procedures [11]. In Germany, no cars were 3 stars in 1997 (pre Euro NCAP regulation), but this had evolved to 97% in 2013 in response to regulation [4]. The evolution of star ratings of cars in the USA and India is unknown. Therefore, we constructed three models with varying assumptions of how vehicle designs may have been influenced by regulation. Model A assumes that the current vehicle fleet in the USA is the same as Germany in 2013, i.e. the model assumes that vehicles in the USA continued to improve even without local regulation. Model B assumes that the current vehicle fleet in the USA is the same as Germany in 1997, i.e. the model assumes that in the absence of regulation, the US vehicle fleet has not improved at all. Model C (for India only) assumes that

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all cars have zero ratings. Within each model, there is a frequency distribution of star ratings that is assumed, and a probability of death and injury for each star rating was obtained from the literature [3-4]. A percent risk reduction was calculated by comparing the weighted probabilities of death and injury between the model scenario and the hypothetical scenario where all cars received at least 3 stars. This reduction was applied to the deaths and non-fatal injuries in each country across all ages and sexes. The Burden Calculator was then used to compare the DALYs lost for each scenario. Although buses and trucks are typically not included in pedestrian NCAP regulations, they are involved in a large proportion of pedestrian crashes in LMICs. Therefore, we studied the effect of regulating these vehicles by assuming that these design modifications would result in similar reductions in death and injury as observed with passenger cars. Table I shows change in burden due to pedestrian crashes with cars (A), and pedestrian crashes involving all vehicles (B).

TABLE I
THE IMPACT OF IMPROVING VEHICLE-PEDESTRIAN SAFETY RATINGS ON BURDEN OF PEDESTRIAN INJURIES IN EACH COUNTRY

Vehicle types	Scenario	Pedestrian Deaths/100,000			Pedestrian DALYs/100,000		
		Germany	USA	India	Germany	USA	India
(A) Passenger cars	Baseline	0.35	0.57	1.92	12.47	26.24	93.70
	Model A	0.34	0.56	-	12.29	25.84	-
	Model B	-	0.42	1.40	-	19.83	71.28
	Model C	-	-	1.04	-	-	55.13
(B) All Vehicles: Passenger cars & heavy vehicles	Baseline	0.45	0.64	5.52	15.86	29.31	269.18
	Model A	0.44	0.63	-	15.63	28.87	-
	Model B	-	0.47	4.03	-	22.15	204.76
	Model C	-	-	2.98	-	-	158.38

III. INITIAL FINDINGS

Our study found that the percentage of pedestrians killed by heavy vehicles out of all pedestrians killed was highest in India (41.0%), followed by Germany (12.8%) and USA (5.5%). In terms of the percentage of pedestrians killed by cars, Germany had the highest percentage (50.8%), followed by USA (38.3%) and India (21.9%). These results suggest that improving pedestrian regulations is likely to have a minimal impact on the burden of injuries in Germany, which has already substantially improved the safety of passenger cars. However, India would see reductions of 24–41% in the burden of pedestrian injuries by improving all vehicles, including buses and trucks.

IV. DISCUSSION

India could benefit substantially by regulating the pedestrian safety of all vehicles. While there are fewer vehicles per person in India, there are high rates of vehicle collisions with pedestrians. In the absence of regulations, there is also a high likelihood that many vehicles in India do not meet minimum pedestrian safety standards.

Given that the average pedestrian is poorer than the average person who drives a motor vehicle, governments have a duty of care to protect the poor by requiring that all vehicle manufacturers across the world meet the minimum standards set out by the UN regarding pedestrian safety (UN 127). Furthermore, expanding vehicle pedestrian safety regulations beyond passenger cars to cover trucks and buses could potentially result in even greater reductions in pedestrian injuries and deaths. Pedestrian infrastructure and pedestrian right-of-way are two further issues that can vary widely by country development and that can have an important impact on pedestrian injuries, although these issues are not addressed here.

V. REFERENCES

[1] IHME. GBD compare, 2013.
[2] Global NCAP. Democratising Car Safety, 2015.
[3] Pastor, C., ESV conference, 2013.
[4] Strandroth, J. *et al*., *Stapp Car Crash J*., 2014.
[5] IRTAD. International Transport Forum, 2016.
[6] World Bank. Transport for Health, 2010.
[7] Corso *et al*., *Injury Prevention,* 2006.
[8] WHO. WHO Mortality Database, 2015
[9] Bhalla, K. Final Project Report, 2015. .
[10] Bhalla, K. *et al*. Burden Calculator, 2015.
[11] Euro NCAP. Pedestrian Protection, 2015.