Uncertainty in estimates of the burden of road transport

This web appendix illustrates uncertainty in some key aspects of the burden of motorized road transport reported in the 2014 *Transport for Health* report. It has one section each describing the uncertainty in estimates of the burden of road injury and the burden of vehicular pollution.

1.0 Uncertainty in estimates of the burden of road injuries

The methods used to estimate uncertainty in the Global Burden of Diseases, Injuries, and Risk Factors Study 2010 have been described by Lozano et al.[1] and Vos et al.[2] The uncertainty analysis attempts to capture uncertainty due to model parameter estimation, model specification, and fundamental uncertainty. For mortality estimates, GBD 2010 used an ensemble modeling strategy that generates more realistic uncertainty intervals (UIs) and more accurate predictions.[3]

1.1 Uncertainty in the cause ranking of the global road injury burden

GBD 2010 estimates that road injuries were the eighth-leading cause of death globally in 2010. Figure 1 compares uncertainty in road injury death toll with uncertainty in deaths from other causes to highlight the uncertainty in the cause of death ranking. The figure illustrates that, given the 95% uncertainty interval in the estimates for deaths due to road injuries and other causes, the rank of road injury deaths ranges from fifth to 11th. The uncertainty in the estimates of road injury deaths exceeds that of several diseases with comparable mortality, such as HIV/AIDS (ranked sixth), diarrheal disease (ranked seventh), diabetes (ranked ninth), and TB (ranked 10th). However, the magnitude of uncertainty in road injury estimates is similar to several other diseases, such as lung cancers (ranked fifth) and malaria (ranked 11th).

GBD 2010 estimates that road injuries were the 10th-leading cause of global health loss, measured in disability-adjusted life years (DALYs), in 2010. Figure 2 compares the uncertainty in road injury DALYs with the uncertainty in DALYs from other causes to highlight the uncertainty in the cause ranking of health loss. The figure illustrates that, given the 95% uncertainty interval in the estimates for DALYs due to road injuries and other causes, the rank of road injury DALYs ranges from fourth to 11th and overlaps with estimates for several other diseases.

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[1] Lozano. R, Naghavi M, Foreman K, Lim S, Shibuya K, Aboyans V, et al. Global and regional mortality from 235 causes of death for 20 age groups in 1990 and 2010: a systematic analysis for the Global Burden of Disease Study 2010. *The Lancet*. 2012;380(9859):2095–2128.

[2] Vos T, Flaxman AD, Naghavi M, Lozano R, Michaud C, Ezzati M, et al. Years lived with disability (YLDs) for 1,160 sequelae of 289 diseases and injuries 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. *The Lancet.* 2012;380(9859):2163–2196.

[3] Foreman KJ, Lozano R, Lopez AD, Murray CJL. Modeling causes of death: an integrated approach using CODEm. *Population Health Metrics.* 2012;10(1):1–1. doi:10.1186/1478-7954-10-1.

Figure 1: Global deaths (millions) with 95% uncertainty intervals versus rank by cause, 2010

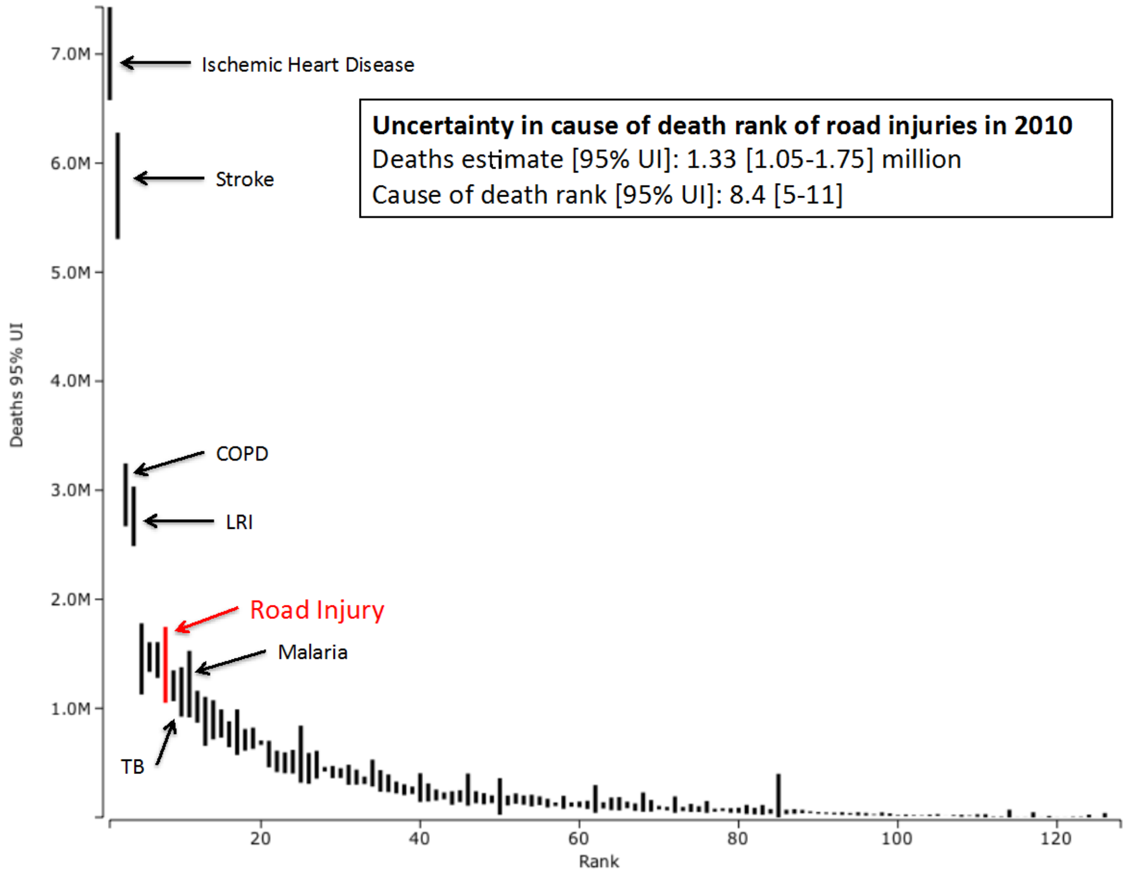
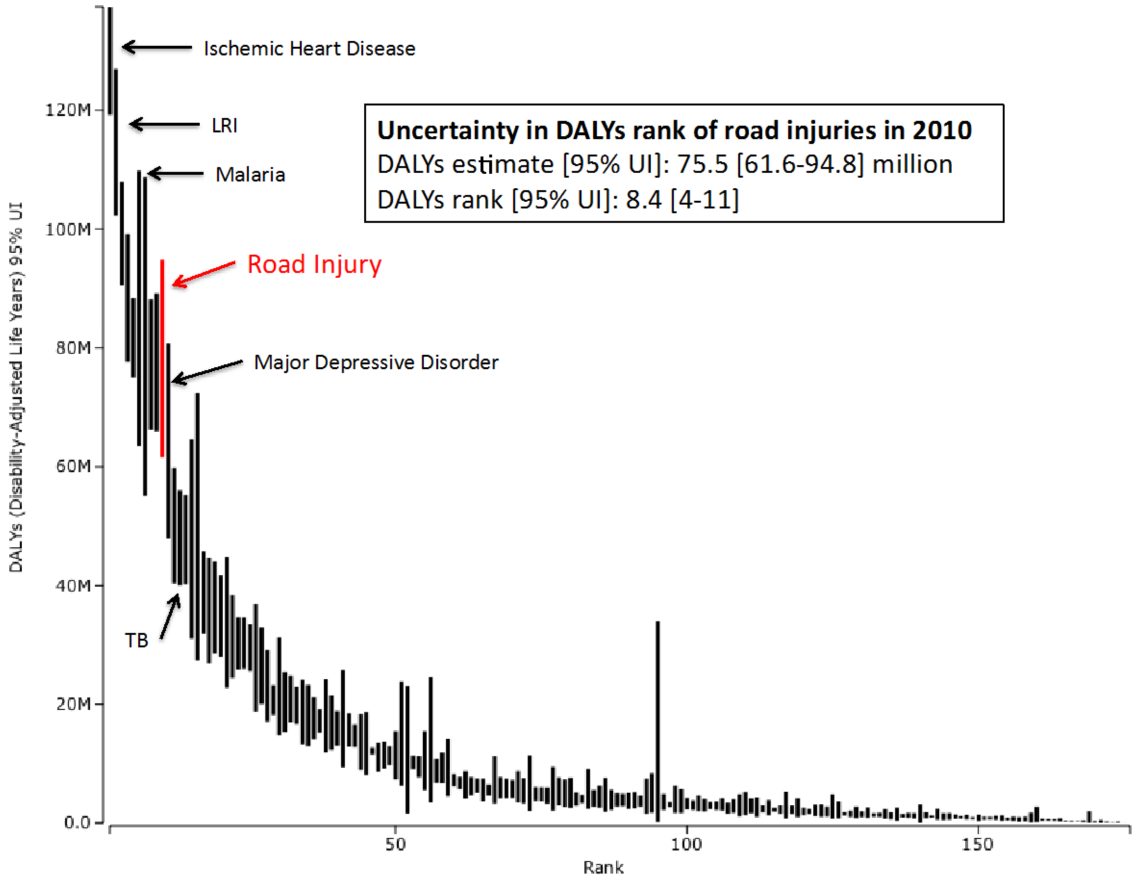


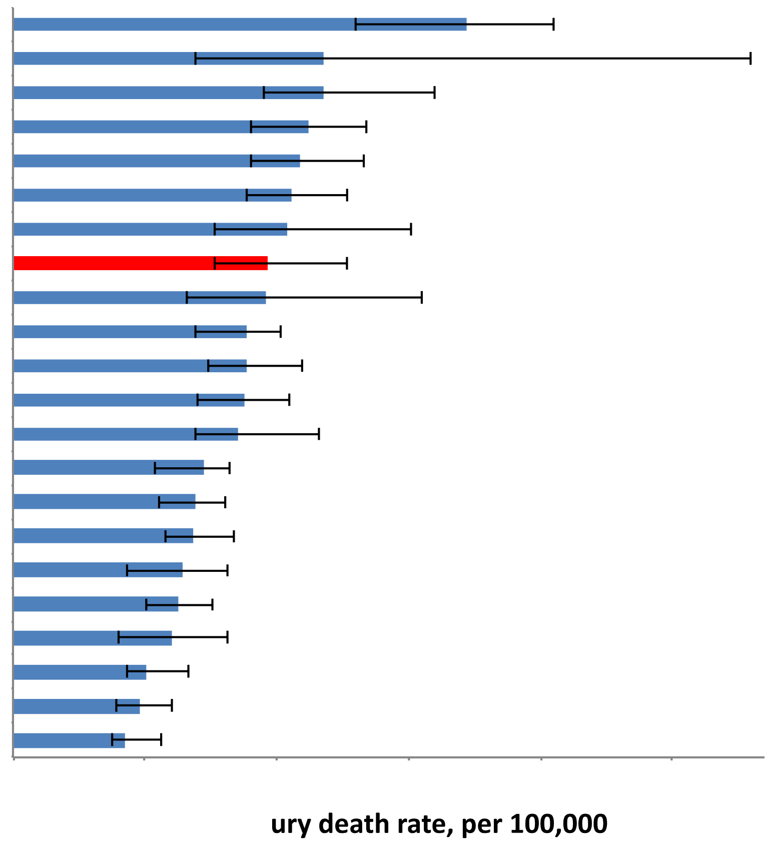
Figure 2: Global DALYs (millions) with 95% uncertainty intervals versus rank by cause, 2010



1.2 Uncertainty in regional estimates of road injury deaths

Figure 3 illustrates that uncertainty in estimates of road injuries varies substantially across global regions. In general, regions of sub-Saharan Africa, especially the central region, have considerably higher uncertainty (i.e., 95% wider UIs) than the global average. South Asia and East Asia also have relatively high uncertainty. It is noteworthy that these are all regions with weak vital registration systems, which were a key source of data in GBD 2010. In contrast, uncertainty in road injury estimates is relatively low in high-income regions.

Figure 3: Regional road injury death rates (per 100,000 population) with 95% uncertainty intervals, 2010



2.0 Uncertainty in estimating traffic-related air pollution burden

This web appendix illustrates some key issues associated with the GBD 2010 estimates of the burden of air pollution that can be attributed to motorized road traffic. This appendix does not discuss the uncertainty in GBD 2010 estimates for air pollution.[4]

2.1 Comparison of methods estimating the burden associated with traffic-related fine particulate matter exposure

We examined three methods to estimate burden (deaths and DALYs) associated with fine particulate matter ($PM_{2.5}$) exposure from traffic sources. The data structure used for these estimates included the population-weighted country-level $PM_{2.5}$ concentration z_j and the proportion of that concentration attributable to traffic sources p_j, with $\Delta_j = p_j z_j$ being the concentration of $PM_{2.5}$ attributable to traffic.

Exposure is related to risk by the model:

$$RR_{IER}(z) = \begin{cases} 1, \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots, z < z_{cf} \\ 1 + \alpha(1 - e^{-\gamma(z - z_{cf})^{\delta}}), \ldots., z \geq z_{cf} \end{cases}$$

In the above model, *z* is the exposure to $PM_{2.5}$ in µg/m^3 and z_{cf} is the counterfactual concentration below which we assume there is no additional risk. We term this model the integrated exposure-response (IER) model because its development requires the integration of exposures to $PM_{2.5}$ from different combustion types.[5]

Relative risks are predicted for each country from the IER model, converted to population attributable fractions (PAF), and combined with country-level mortality rates to determine burden estimates. To estimate the burden associated with exposure to $PM_{2.5}$ specifically from traffic sources, we considered three approaches:

- ***Method 1 (direct proportion of burden)***: In this approach, we multiply the estimated number of deaths and DALYs associated with $PM_{2.5}$ by p_j.
- ***Method 2 (top of curve)***: In this approach, we assume that the exposure will be reduced from z_j to $z_j - \Delta_j$. The relative risk of such a change is given by $RR_{IER}(z_j) / RR_{IER}(z_j - \Delta_j)$. This method is most appropriate when one is predicting the future change in risk if traffic sources were eliminated.

[4] A detailed discussion of the methods, associated publications, and estimates of the overall burden of air pollution are available on the GBD 2010 website at: http://www.healthmetricsandevaluation.org/gbd.

[5] Lim S, Vos T, Flaxman A, Danaei G, Shibuya K, Adair-Rohani H, et al. A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990–2010: a systematic analysis for the global burden of disease study 2010. *The Lancet*. 2012; 380(9859):2224–2260.

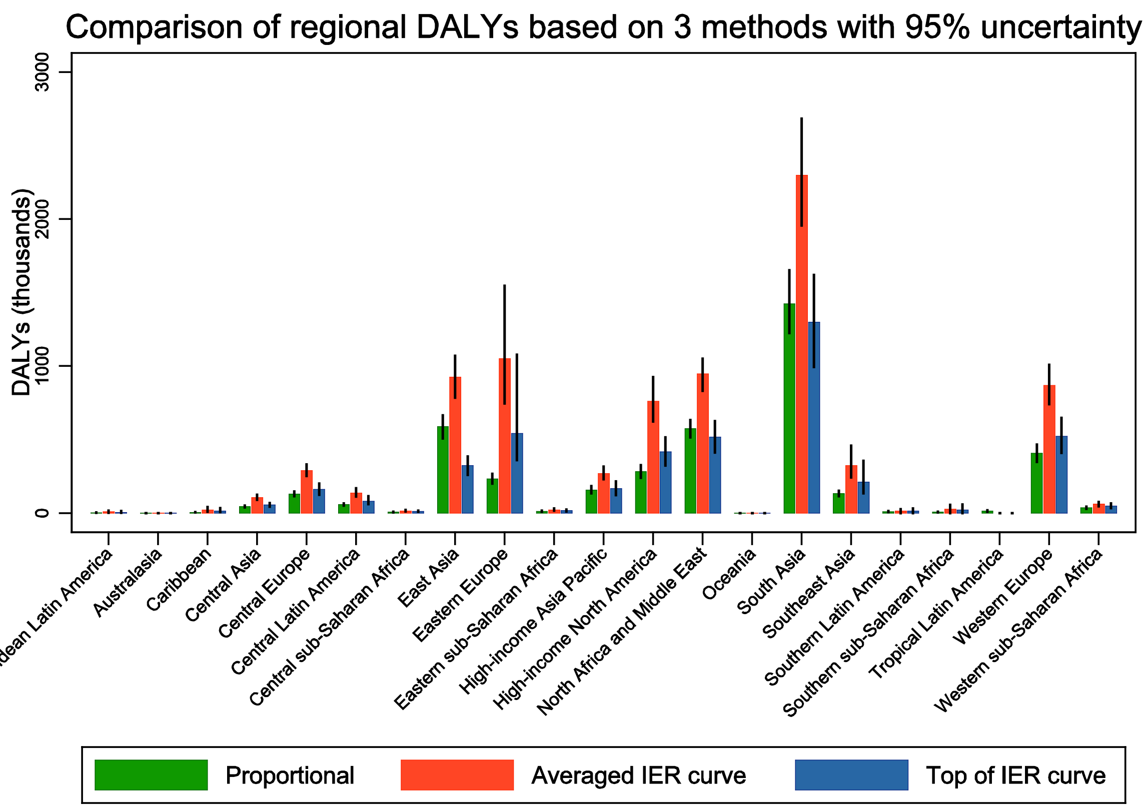
- ***Method 3 (average risk)***: The IER model is non-linear, with larger changes in risk for lower concentrations. Change in risk associated with a change in exposure depends on the concentration against which the change is evaluated. Lower values of this concentration will yield larger relative risk estimates. For any given country, it is not known where on the IER curve to attribute the change in exposure associated with traffic sources. We thus calculate the average relative risk of a change in concentration associated with traffic sources at small increments of $PM_{2.5}$ values. This calculation is written mathematically as:

$$AveIER(z_j) = \frac{1}{\varepsilon(z_j - \Delta_j) + 1} \sum_{i=0}^{\varepsilon(z_j - \Delta_j)} \frac{IER(\frac{i}{\varepsilon} + \Delta_j)}{IER(\frac{i}{\varepsilon})}$$

  $1/\varepsilon$ is the increment at which concentrations of $PM_{2.5}$ are to be evaluated. In this case, we set ε =10 for which the IER is evaluated at each 0.1 $\mu g / m^3$.

The number of deaths associated with traffic-related $PM_{2.5}$ by region is presented in Figure 4. The top of curve method yielded lower estimates compared to the average method, as expected, due the non-linear nature of the IER model. The average method yielded larger estimated number of deaths for each region compared to the direct proportion of burden method, but there was no consistent relationship with the other two approaches.

Figure 4: Comparison of regional deaths from traffic-related air pollution based on three methods



A similar comparison is noted for DALYs (Figure 5).

Figure 5: Comparison of regional DALYs from traffic-related air pollution based on three methods