GBD-2010 overestimates deaths from road injuries in OECD countries: new methods perform poorly

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Abstract

Background: We assessed the quality of Global Burden of Disease-2010 (GBD-2010) estimates of road injury deaths by comparing with government statistics for Organisation for Economic Co-operation and Development (OECD) countries that report to the International Road Traffic Accident Database (IRTAD).

Methods: We obtained tabulated data for 25 OECD countries that report to IRTAD and also report vital registration (VR) data to WHO. We collated VR deaths corresponding to the GBD-2010 road injury definition and estimated ‘traffic’, ‘non-traffic’ and ‘unspecified whether traffic or non-traffic’ components. We estimated national road injury deaths by redistributing partially specified causes of death, as was done by GBD until this was replaced by more complex methods in GBD-2010.

Results: GBD-2010 estimates of road injury deaths exceeded IRTAD by 45% overall. IRTAD values fell below the GBD-2010 95% uncertainty interval in all but three countries. Mismatch of conceptual scope accounted for about 8% of this discrepancy, 5% was because GBD-2010 included cases other than road traffic and 3% because GBD-2010 (unlike IRTAD) includes deaths >30 days after injury. Pro rata distribution of partially specified causes in VR data gave estimates that were 18% higher than IRTAD but closer than GBD-2010 estimates for all but two countries. Cases in VR data specified as road injury gave estimates closer to IRTAD.

Conclusions: GBD-2010 road injury mortality estimates are substantially higher than the road death toll in OECD countries. The discrepancy is not explained by wider scope of the GBD road injury construct nor by undercounting by IRTAD. GBD-2010 likely attributed substantially more deaths with partially specified causes to road injuries than is appropriate.

Key words: Road traffic injuries, Global Burden of Disease, OECD countries
Introduction

In December 2012, the Global Burden of Disease (GBD-2010) study reported estimates of mortality for 291 diseases and injuries in 187 countries from 1990 to 2010. The study aimed to use all relevant published and unpublished epidemiological data on disease patterns, and new approaches for data synthesis and statistical estimation. Notably, these included new methods for handling deaths coded to poorly specified causes and ensemble techniques that combine diverse modelling strategies to improve predictive performance.

GBD-2010 will probably be influential in shaping health policy, funding and planning, as past revisions of GBD have been. In addition to global policy, the GBD-2010 explicitly aims to address the data needs of country-level policy makers. This includes high-income countries, as evidenced by the growing number of publications that present GBD-2010 results at national level.

Several studies have questioned the validity of aspects of GBD-2010 estimates. Most of the concerns are with concepts that are difficult to measure, such as disability weights of health states, or with diseases that primarily occur in information-poor settings, such as HIV/AIDS, tuberculosis and malaria, where statistical models must rely on relatively few primary data. In contrast, it is usually assumed that GBD-2010 estimates for well-studied diseases in high-income countries would line up well with existing knowledge.

Thus, it is puzzling that the GBD-2010 mortality estimates for road injuries in Organisation for Economic Co-operation and Development (OECD) countries are substantially and systematically different from official government statistics. Figure 1 compares GBD-2010 estimates for road injury mortality with official statistics for the 29 countries that report to the International Road Traffic Accident Database (IRTAD). IRTAD statistics are below the 95th uncertainty interval (UI) in the GBD-2010 results in all countries except the Czech Republic.

Road deaths in OECD countries represent a best-case scenario for GBD-2010 estimation methods. Deaths from road injuries are easily identified and relatively unlikely to be misdiagnosed or misclassified. In many countries, medico-legal processes, such as coroner review of unnatural deaths, substantial media attention and government road safety agencies provide extra scrutiny. Finally, most OECD countries have multiple data sources for road injuries, including death registers, hospital data systems, police reporting processes and forensic records, and researchers can combine sources to conduct completeness and validation studies. Road injury mortality statistics for OECD countries are likely to be among the more accurate of the inputs to GBD-2010.

In this study, we show that GBD-2010 estimates of road deaths substantially exceed official national statistics for OECD countries. We explore these differences by constructing new estimates using national vital registration data.

Methods

Ethics committee approval was not required for this study which involved secondary data analysis.

We obtained official national statistics on road traffic deaths that occurred in 2005 and 2010 in OECD countries that submit data to IRTAD, which is a permanent working group of the Joint Transport Research Centre of the OECD. The underlying data source for IRTAD road death statistics is usually police reports, which may be validated against other sources by police and government transport agencies. IRTAD defines as in-scope deaths from injuries sustained in road traffic crashes that occurred within 30 days of injury. Although the definition of a road traffic crash varies somewhat across countries, it generally refers to crashes that occur at least partly on a public roadway.
We also obtained estimates generated by GBD-2010 of road injury mortality in these countries in 2005 and 2010. Although GBD-2010 aspired to include all epidemiological information about road injuries, when high-quality death registration data were available other data sources were usually not used. Accordingly, tabulated data from national vital registration systems was the only data source underlying GBD-2010 estimates of road injury mortality in OECD countries. The GBD-2010 road injury estimates include deaths due to injury sustained in non-traffic (off-road) as well as traffic crashes. It also includes deaths coded to sequelae (late effects) of motor vehicle accidents. Hence, GBD-2010 road injury has wider scope than IRTAD road traffic injury.

Finally, we obtained cause of death tabulations from the WHO mortality database (WHOMDB, February 2014 update) which was our source for VR deaths data. The database includes age at death, sex and the underlying cause of the deaths registered by national vital registration (VR) systems. Underlying cause of death is coded using the rules of the International Statistical Classification of Disease and Related Health Problems (ICD). We acquired data for the OECD countries that are included in IRTAD, restricting attention to the 25 that also reported cause of death to the WHO using 4-digit ICD-10 codes, which allow the distinctions necessary to explore differences between IRTAD and GBD-2010 estimates. Where possible, we obtained data for deaths registered in 2010. Only older VR data were available in WHOMDB for three countries (Canada, Iceland and New Zealand), for which we obtained 2005 data and made comparisons with IRTAD data for 2005. The OECD had 34 member nations in 2010, of which 25 reported road traffic deaths data to IRTAD and supplied 4-digit ICD-10 VR data to WHOMDB.

Whereas we made no adjustments to the IRTAD and GBD-2010 data, we processed VR data as follows. First, we collated deaths that correspond to the GBD-2010 definition of road injury. Next, we collated the ‘traffic’, ‘non-traffic’ and ‘unknown whether traffic or non-traffic’ components of VR road deaths, according to whether the ICD-10 underlying cause of death code referred to injury in traffic or in non-traffic circumstances or did not specify the circumstances. We also computed the residual component, which corresponds to deaths specified to the VR road injury definition but not included in any of these three subgroups. The ICD-10 codes corresponding to each group are shown in Table 1.

Finally, we used the VR data to estimate national road injury deaths using the GBD-2010 case inclusion criterion (Table 1) and an algebraic process of redistribution of partially specified causes of death that is similar to that used by GBD until it was replaced in GBD-2010 by a new method which is more complex but less transparent. We have described the algebraic process of redistribution of deaths coded to partially specified causes previously.
Briefly, all deaths are reclassified into 48 categories that have well-specified causes and 22 categories that have partially specified causes. The extent of specificity varies among the partially specified categories, which can be treated as comprising a hierarchy of levels of information based on their specificity. Every death without a well-specified cause is assigned to the first applicable one of the following partially specified categories: unspecified transport injury, unspecified accident, unspecified injury, or death with unspecified cause (Table 1). Next, in a series of steps, the deaths in each of the partially specified categories are redistributed over the set of well-specified categories to which they could possibly belong, in proportion to the numbers of deaths in those categories before redistribution. This redistribution is done within age-sex groups.

For clarity when describing estimates of road deaths from these sources, we use the following short-hand terms: IRTAD for the road traffic death counts from that source; GBD-2010 Road for the mortality estimates published by that study under the heading ‘road injury’; and VR Road for the counts we obtained from the WHOMDB using the same inclusion criteria as GBD-2010 Road. Sub-sets of the VR Road data are named in a similar way (e.g. VR Traffic). The estimates produced by the redistribution process are referred to as VR Road (redistributed).

### Results

The IRTAD database reported a total of 69,330 road traffic deaths for the 25 countries over the years investigated here. In contrast, GBD-2010 estimated 100,243 road deaths for the same countries and years, an additional 45%. At the national level, GBD-2010 estimates exceeded IRTAD counts in all but one country, Iceland. GBD-2010 estimates exceeded IRTAD values by more than 30% in 22 of the 25 countries, and by more than 80% in 5: Denmark, Israel, The Netherlands, Sweden and the UK (Figure 2).

GBD-2010 estimates embody uncertainty (Figures 1 and 2) and the published 95th percentile UIs for road deaths at country level are quite wide, averaging 49% of the point estimates for these 25 countries and years. Nevertheless, for all countries but three (Canada, Czech

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**Table 1. ICD-10 definitions of road injury estimated in this study**

(a) Definitions of road injuries and their components

<table>
<thead>
<tr>
<th>Concept</th>
<th>ICD definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road injury</td>
<td>V01-V04, V06, V09, V10-V19, V20-V29, V30-V39, V40-V49, V50-V59, V60-V69, V70-V79, V80, V82, V87, V88, V89, Y85.0</td>
</tr>
<tr>
<td>‘Traffic’ component of road injury</td>
<td>V01-V04,[1], V06,[1], V09.2, V09.3, V10-V18,[4,5,9], V19,[4,5,6,9], V20-V28,[4,5,9], V29,[4,5,6,9], V30-V38,[5,6,7,9], V39,[4,5,6,9], V40-V48,[5,6,7,9], V49,[4,5,6,9], V50-V58,[5,6,7,9], V59,[4,5,6,9], V60-V68,[5,6,7,9], V69,[4,5,6,9], V70-V78,[5,6,7,9], V79,[4,5,6,9], V82.1, V82.9, V87, V89,[2,3]</td>
</tr>
<tr>
<td>‘Non-traffic’ component of road injury</td>
<td>V01-V04,[0], V06,[0], V09.0, V09.1, V10-V18,[0,1,2], V19,[0,1,2,3], V20-28,[0,1,2], V29,[0,1,2,3], V30-39,[0,1,2,3], V40-V49,[0,1,2,3], V50-V59,[0,1,2,3], V60-V69,[0,1,2,3], V70-V79,[0,1,2,3], V82.0, V88, V89,[0,1]</td>
</tr>
<tr>
<td>Unspecified whether traffic or non-traffic</td>
<td>V01-V04,[9], V06,[9], V09.9, V10-V18,[3], V20-28,[3], V30-V38,[4], V40-V48,[4], V50-V58,[4], V60-V68,[4], V70-V78,[4], V89,[9]</td>
</tr>
<tr>
<td>Residual</td>
<td>V19.8, V29.8, V39.8, V49.8, V59.8, V69.8, V79.8, V80, V82,[2,3,4,5,6,7,8], Y85.0</td>
</tr>
</tbody>
</table>

(b) Definitions of partially specified causes of death and how they were reattributed

<table>
<thead>
<tr>
<th>Partially specified category</th>
<th>ICD definition</th>
<th>Distributed proportionately over:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unspecified transport injury</td>
<td>V99, Y85.9</td>
<td>Road injury; and transport injuries that are not road injuries</td>
</tr>
<tr>
<td>Unspecified accident</td>
<td>X59</td>
<td>Road injury; and accidents that are not road injuries</td>
</tr>
<tr>
<td>Unspecified injury</td>
<td>Y34, Y87.2, Y89.9</td>
<td>Road injury; and injuries that are not road injuries</td>
</tr>
<tr>
<td>Unspecified cause of death</td>
<td>R95-R99</td>
<td>Road injury; and causes of death that are not road injuries</td>
</tr>
</tbody>
</table>

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1. This definition was chosen to match the GBD-2010 as closely as possible. GBD-2010 defined road injury as V01-V04, V06, V09, V10-V19, V20-V29, V30-V39, V40-V49, V50-V59, V60-V69, V70-V79, V80, V82, V87,[2,3], Y85.0. GBD-2010 documentation does not identify how deaths coded to V87,[0,1,4,5,6,7,8,9] were handled. We assigned these to road injury in our analysis because the ICD definition of V87, ‘Traffic accident of specified type but victim’s mode of transport unknown’, is within the conceptual scope of the GBD ‘road injury’ construct. Although the GBD-2010 definitions for road injury do not list V88 (‘Non traffic accident of specified type but victim’s mode of transport unknown’) or V89 (‘Motor- or non motor-vehicle accident, type of vehicle unspecified’), these were treated as dump codes in GBD-2010.1

2. Only those partially specified categories that affect road injury estimates are shown here. The detailed steps for distribution of all partially specified injury codes are described elsewhere.22
Republic and Iceland), IRTAD counts of road traffic deaths are below the 95th UI in the GBD-2010 results.

As noted above, the GBD-2010 ‘road injury’ construct has wider scope than IRTAD, the chief difference being that GBD-2010 does not include non-traffic cases. However, non-traffic deaths are a small proportion (3%) of VR Road deaths overall and below 10% for all but two of the 25 countries (Table 2). Only 2% of VR Road deaths, overall, were unspecified as traffic or non-traffic; fewer than 10% in all but four countries. Similarly, the residual group included only 2% of VR Road deaths overall, and 6% or less in all 25 countries. The residual group includes deaths attributed to sequelae (late effects; ICD-10 code Y85.0) of road injuries sustained on an earlier date; these accounted for 0.28% of the VR Road injury deaths.

Figure 2 illustrates by how much the redistribution of deaths coded to partially specified causes increased the raw VR Road injury death counts. The vertical bars show population-based crude rates based on raw VR Road injury deaths and the incremental effects of pro rata redistribution of deaths coded to unspecified transport accidents, unspecified accidents, unspecified injury and the broad unspecified causes of death category. These rates are compared with rates based on IRTAD road traffic fatality counts and with the GBD-2010 Road injury estimates.

The unadjusted VR Road injury death counts (black bars in Figure 2) are similar to IRTAD counts for most countries, the country level difference being less than 20% for all but three countries. Overall, the sequential redistribution of deaths coded to unspecified transport accidents, unspecified accidents, unspecified injury and unspecified cause of death added 1.0%, 7.7%, 0.9% and 2.1% to the estimates, respectively. Notably, redistribution of unspecified accident cases added substantially to the estimates for Italy (30%), Israel (27%), the UK (21%), France (21%) and Norway (20%).

We compared these VR-based estimates of road deaths with IRTAD data for the same countries and years (Figure 3). The box and whisker plots summarize the extent to which country-specific VR-based estimates differ from IRTAD counts for each of the five VR-based estimates, including GBD-2010, which are identified on the horizontal axis of the figure.

The VR-based counts of deaths restricted to well-specified cause codes (VR Traffic; VR Road excluding non-traffic; VR Road) correspond more closely with IRTAD values than does the VR-based estimate which also includes redistributed deaths with partially specified causes. The overall differences from IRTAD for these four estimates were −1.7%, +2.4%, +5.6% and +18.4%, respectively. However, all of these VR-based methods correspond much more closely with IRTAD values than do the GBD-2010 Road Injury estimates shown in Figure 2 and summarized in the last box and whisker plot in Figure 3 (overall difference 45%).
Discussion

The large discrepancy between GBD-2010 estimates of road injury deaths and official government statistics for OECD countries is surprising because these are information-rich countries and the outcome in question is a distinct and clearly defined cause of death. Whereas underreporting of road deaths in official government statistics is rampant in emerging economies, most OECD countries have multiple independent data systems (usually including police registers and vital registration) that are available for public scrutiny, making widespread underreporting unlikely. For this reason, the research frontier in injury metrics in these countries lies in improving estimates of the incidence and public health burden of non-fatal injuries. This is reflected in studies and conferences on the matter, particularly in the past decade.13–17

The two main candidate explanations for the discrepancy are: (i) the wider conceptual scope of the construct estimated by GBD-2010 than that of IRTAD; and (ii) the altered method, introduced for GBD-2010, for dealing with deaths with poorly specified causes.

Conceptual scope

IRTAD estimates road traffic deaths due to injury, a commonly used construct in the road safety sector of OECD countries. Although it also used the title ‘road injury’, GBD-2010 estimates a wider construct than IRTAD, also including deaths due to injuries sustained in non-traffic circumstances plus certain other deaths, such as injuries to animal riders in transport accidents (ICD-10 code V80). There are also conceptual differences in the time domain: IRTAD restricts attention to deaths within 30 days of road traffic injury; GBD-2010 does not apply an equivalent restriction.

We used VR data from the WHO Mortality Database (the same source underlying the GBD-2010 road injury death estimates) to estimate the extent to which the wider
The conceptual scope can explain the higher values estimated by GBD-2010. We conclude that restriction of the scope of IRTAD to traffic cases can account for a difference of about 5% overall in the countries assessed, 3% due to the inclusion of non-traffic cases and 2% due to the other (‘residual’) causes included by GBD-2010.

We could assess only part of the time aspect of the difference in concepts directly. The sequelae (late effects) cases included by GBD-2010 can be considered to be part of this difference. However, in our analysis they account for only 0.28% of the total road injury deaths in these OECD countries. The WHO Mortality Database does not provide information on duration between date of injury and date of deaths attributed to injury. However, published data from other studies indicate that only about 3% of deaths occur more than 30 days after crash.24 Therefore, we conclude that conceptual factors may account for a difference of up to about 8% between GBD-2010 and IRTAD values, about 5% due to the inclusion in GBD-2010 of non-traffic deaths and 3% due to inclusion of deaths that occurred after 30 days of injury. Conceptual differences thus account for less than one-fifth of the observed difference between IRTAD and GBD-2010 Road injury.

**Changed GBD method**

The bulk of the discrepancy appears to be due to the new method introduced in GBD-2010 to handle deaths with poorly specified causes. VR coding assigns causes of death which vary in specificity. Even in OECD countries, the causes of many injury deaths are not fully specified; in half of all Western European countries, over 20% of unintentional injury deaths are coded to unspecified accidents (ICD-10 code X59), which provides little information on cause.22 GBD redistributes such deaths to more specific causes, including road injury. Our analysis shows that the redistribution of deaths with poorly specified cause can substantially inflate the raw counts for road deaths but that the method used for GBD-2010 does so much more than the method used for earlier GBD projects.

When deaths in VR data with partially specified causes are redistributed pro rata (within age–sex-groups) over specified external causes of injury, the resulting estimates of road deaths are closer to IRTAD values than are the GBD-2010 results (Figure 3). This is consistent with results of earlier GBD projects, which used pro rata redistribution. For instance, GBD-200425 estimated 45,611 road traffic deaths in the USA in 2004, which is only 6% more than the US IRTAD count for 2004. In comparison, the GBD-2010 estimate of road deaths in the USA is 34% larger than the US IRTAD count for 2010. Similarly, GBD-2004 estimates for the UK and Australia were 11% and 1% above IRTAD values in 2004, whereas GBD-2010 estimates for these countries were 95% and 49% above IRTAD values for 2010, respectively.
GBD-2010 methods for handling poorly specified causes add substantially more deaths to raw VR Road death counts than previous GBD studies. However, even the older GBD method probably overestimates road deaths in OECD countries. Pro rata distribution assumes that the set of unspecified deaths is not biased towards any particular causes—i.e. within each age- and sex-specific stratum, the pattern of true causes of deaths with partially specified causes is similar to the distribution of cases in the well-specified cause categories over which they are redistributed. However, causes such as road injuries, which are scrutinized by medicolegal processes, may be less likely than other causes to be classified to dump categories. This may explain why even the estimates based on simple pro rata redistribution of poorly specified cases are about 18% higher than IRTAD counts and above VR Road death counts to a similar extent.

The proportion of road deaths among cases coded to these ‘dump’ categories may differ between countries, reflecting differences in coding and medicolegal practice. GBD-2010 does not incorporate such nuances and relies primarily on algorithms that are applied across all countries, periods and age-sex strata. Analyses of road deaths using country-level data are likely to be more accurate than country estimates derived only from a global model, such as the GBD-2010 estimates for the US26 and UK.8

The particular aspects of the GBD-2010 method that account for the observed high estimates for road injury deaths are difficult to pinpoint. Naghavi et al. provide a description of how ‘garbage’ codes were identified in GBD-2010 and how they were assigned.3 The assignment method was intended to allow for certification practice and pathophysiology, and was implemented by proportionate redistribution, statistical models and algorithms based on expert opinion. Its complexity is such that it is difficult to estimate, from the material in the paper, the net effect of the process. Moreover, it is logically possible that some component of the discrepancy could be due to aspects of data processing not explicitly described by Naghavi et al.

Understanding the broader implications of the discrepancy in GBD-2010 will require analysis that is not possible with publicly available information provided in Naghavi et al.3 Since GBD-2010 ensures that the sum of all cause-specific death estimates equals national all-cause mortality, overestimation of road injury deaths in a country will necessarily lead to an underestimation of deaths from other causes, particularly other external causes. Assessing which causes are underestimated requires detailed knowledge of the magnitude of ‘garbage codes’, where these are assigned and in what proportion.

It is likely that the global road injury death toll is overestimated by GBD-2010. However, the extent of overestimation is difficult to estimate without access to the complex statistical models that are used to model road injury deaths in GBD. The GBD project is now being continuously updated. We recommend that updates revert to previous methods of handling injury deaths coded to incompletely specified causes until newer methods have been corrected and validated. Consideration should be given to relying on IRTAD estimates of road traffic deaths for OECD countries.

We conclude that GBD-2010 Road injury mortality estimates are substantially higher than the true road death toll in OECD countries. The error appears to be due mainly to inappropriate reassignment of deaths with incompletely specified causes to road injury. The method used for GBD-2010 is more complex than the redistribution method used for earlier GBD studies and is incompletely documented in published literature. The findings reported here suggest that the method used for GBD-2010 performs more poorly than the older method for road deaths in OECD countries.

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Conflict of interest: We declare that we have no conflicts of interest.

References

Commentary: Estimating the undeniable, not denying the immeasurable

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There can be no dispute that road traffic deaths are a major public health threat, nor that it is currently impossible to precisely measure them. In many areas of the world, complete vital registration data and accurate cause of death data remain unavailable. As such, the estimates produced by the Global Burden of Disease (GBD) are often relied upon to provide the global perspective and context.

However, the analysis by Bhalla and Harrison clearly indicates that the latest edition of the GBD substantially overestimated road traffic injury deaths in OECD (Organization of Economic Cooperation and Development) countries. This is shown to have been largely due to a new and somewhat opaque method for attributing poorly classified injury deaths to road traffic injuries. Bhalla and Harrison make compelling arguments against the continued use of the new attribution method for OECD countries, which have strong vital registration systems, and for the consideration of the short-term reintroduction of the previous, transparent, attribution system.

Recommendation 2 of the World Report on Road Traffic Injury Prevention urged governments to establish systems to collect standardized and reliable road traffic death and injury data. It therefore seems illogical for road traffic injury data from countries with high quality data to be relied upon to provide the global perspective and context.

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