# RAPID DESK-BASED STUDY:

## The economic impact of road traffic accidents and injuries in developing countries

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# Acronyms

| | |
|---|---|
| CBA | Cost Benefit Analysis |
| DALYs | Disability Adjusted Life Years |
| DoA | Decade of Action on Road Safety |
| FIAF | FIA Foundation |
| GDP | Gross Domestic Product |
| GNP - | Gross National Product |
| HICs | from High Income Country |
| HCA | Human Capital Approach |
| HICs | High Income Countries |
| iRAP | International Road Assessment Programme |
| LICs | Low Income Countries |
| LMICs | in Low and Middle Income countries |
| MICs | Middle Income Countries |
| RSA | Road Safety Audit |
| SIBs | Social Impact bonds |
| VoSL | Value of a Statistical Life |
| WHO | World Health Organisation |
| WTP | Willingness to Pay |

# Report summary

This study has identified the evidence that exists on the economic impact of road traffic accidents and injuries on developing countries; it has also indicated the gaps in this evidence. The research included the assessment of whether road safety is of macroeconomic significance and has indicated what the strategies and countermeasures are that can be implemented to hasten the reduction of road traffic accidents and the associated economic losses.

The study identified that poor crash and injury data collection in conjunction with inconsistencies in crash costing efforts across countries mean that identifying the macro impacts of crashes with real precision is not currently possible.

Conservative estimates put the global burden of crash costs as being at least 1% of total GDP (Gross Domestic Product) but this is most likely much higher. Extrapolation from High Income Country (HIC) estimates of crash costs indicate that the costs could be as high as 5% for Low and Middle Income Countries (LMICs), but these estimates are based on untested assumptions. Losses due to poor safety are accepted to be very significant and to warrant greater funding and investment than they currently receive.

The problem of poor data and information, particularly for LMICs, means that it is not possible to estimate clear patterns between country development levels and the over-all economic burden of road crashes empirically. It is possible that the economic losses due to crashes may increase proportionately, as countries develop from low to middle income and then fall as countries become HICs. This is based on the assumption that costs of crashes and injuries are proportionate to GDP/Capita and also on a range of very simplified assumptions concerning increases in motorisation rates and changes in safety levels as countries develop.

Economic development and increasing motorisation will lead to higher accident rates with higher road deaths but the number of annual road fatalities begins to decrease with economic development when motorisation rates slow, but also, fatalities per vehicle decrease as a result of organised and active management and investment in road safety measures.

There are a wide range of measures (spanning legislation, enforcement, engineering (roads and vehicles), education and post-crash response) which can be implemented to reduce the impact of road safety. However these measures have primarily been developed for HIC road conditions and there is concern that many strategies may not work as expected in LMIC conditions. Poor data and detail on the occurrence of crashes in many LMICs has prevented evaluation of individual countermeasures, and made assessing the effectiveness of larger programmes difficult. This lack of information on the effectiveness has led to uncertainty about how to best tackle the problem of road safety in LMICs.

Key research priorities that would contribute significantly to the gaps in the current knowledge base have been identified and described.

# SECTION 1

# Introduction and context

## 1.1 The Aim of this Study

The following document provides an overview of road safety and development issues that must be understood before it is possible to make the economic case for investment in road safety. The objective of this report is to assess the strength of the evidence base for the reported economic impacts of road crashes; in Low and Middle Income countries (LMICs) resulting from road deaths, injuries and all other associated costs. The report also provides an overview of how indicators of general levels of road safety may vary systematically with broad economic development levels of countries. A range of strategies and approaches that can improve road safety significantly have also been identified with a main focus on measures which are most appropriate for LMIC conditions. The evidence for the effectiveness of measures in LMICs from evaluations has also been assessed as a priority focus.

The background to this study is that road safety is frequently stated as being a major global public health problem and one which is associated with the economic development. The current the UN Decade of Action on Road Safety (DoA) and the “Bloomberg RS10” initiatives have specifically been initiated because it is strongly perceived that there is a major lack of funding and attention paid to the issue of road deaths and injuries, particularly in LMICs.

**Section One** gives a broad general introduction to the overall study and sets out the broader questions for which it aims to provide information and answers.

**Section Two** details how road crashes and injuries impact Gross Domestic Product. It is divided into subsections with the following themes:

- Information used to describe road safety
- How crash and injury costs are estimated
- Evidence for the micro economic impacts of road crashes
- Incentive effects
- Global economic aspects
- Case Study detailing the use of the iRAP costing method for Ethiopia

**Section Three** sets out knowledge about the relationships between road crashes and GDP in Low and Middle Income Countries. It is divided into subsections with the following themes:

- How crash occurrence varies with country development level
- How the proportion economic of crashes is proposed to vary with broad country income levels
- How factors associated with economic development may affect patterns of road crash occurrence

**Section Four** gives information on recommended policies and measures which may improve road safety levels in LMICs. It is sub split into sections detailing:

- Information on engineering measures
- The evidence base for effectiveness of engineering measures
- The strength of evidence for the effectiveness of wider road safety programmes and strategies

**Section Five** details the findings and some specific research gaps which have been identified by this study

# SECTION 2

# Impact of Crashes on GDP in LMICs

## 2.1 The Evidence Used To Quantify the Road Safety Problem

The primary evidence referenced to indicate the impact of road crashes on countries in the global context is the series of World Health Organisation (WHO) Global Status Reports on Road Safety (WHO, 2009; 2013). These report data from countries on road fatality numbers and a range of information on the management of safety. These figures are critical because the economic impact of crashes relates to the number of crashes and fatalities/injuries which are occurring. Some of the key quotes from the first Global Status Report are given in Box 1.

The reports (WHO 2013) show that from the data collated for countries for 2010 whilst LMICs have only 53% of the world's registered vehicles, they suffer around 92% of the road deaths.

The figures in the WHO reports are used to compare road traffic injury as a cause of death against other major health issues and problems. As economic development occurs and especially as Low Income Countries (LICs) become Middle Income Countries (MICs), it is predicted that road deaths will move from being the 9th leading cause of death to being the 5th by 2030 if nothing is done to counteract the safety problems associated with greater motorisation.

**Box 1 Global Under-Reporting of Road Deaths**

Global Status Report on Road Safety Time for Action, WHO 2009
The WHO conducted a major exercise to gather statistics on road deaths and injuries in member states, as well as on the status of traffic laws and levels of enforcement. The results indicated that surveillance of road deaths globally is poor, especially, but not exclusively in LMICs.

*"The report shows that huge gaps remain in the quality and coverage of the data that countries collect and report on road traffic injuries. Reliable data on fatalities and non-fatal injuries are needed by countries to assess the scope of the road traffic injury problem, to target responses to it, and to monitor and evaluate the effectiveness of intervention measures. Underreporting of road traffic fatalities remains a big problem in many countries, and the situation is even worse with regard to non-fatal injuries."*

The process also undertook a modelling exercise, which took account of population, vehicle fleet and other factors to estimate what the realistic road death numbers could be, with some startling differences identified between official numbers and the probable actual numbers.

*"The total number of deaths reported in this survey is approximately 660 000 (using a 30-day definition for fatalities), indicating vast underreporting. When these data are modelled the total 30-day number for the 178 countries included in the study is 1.23 million".*

These comparisons are used to justify the argument for greater spending on road safety along with other 'unintentional injuries' which are viewed as being heavily under-funded

public health issues (Norton et al., 2006). 'Unintentional injuries' tend to impact upon the young and on males more than females. In LMICs, road crashes also tend to be the main cause of death for older children and young people. This impact on the younger and economically active age groups means that road crashes tend to remove more Disability Adjusted Life Years (DALYs) than other causes of death and injury, and will therefore have a significant economic impact in terms of loss of earning potential and contribution to society.

## 2.2 How Costs Associated with Road Crashes are Estimated

The broad methodology used to estimate the Value of a Statistical Life (VoSL) and injuries greatly affects the magnitude of the costs derived (see SWOV, 2014). The costs of road deaths injuries and crashes are used:

1. To estimate the losses in terms of GDP to countries/regions
2. As the basis for values used in economic appraisal e.g. Cost Benefit Analysis (CBA).

The costs of road crashes or values of lives lost should include all possible costs to any party involved in the incident or any party affected by the event in any way. Two methods are in use currently, these being the Human Capital Approach (HCA) and Willingness to Pay (WTP).

The HCA is considered to be the easier method technically (see Ross Silcock/TRL, 2003), since it involves identifying all the costs for a sample of crashes and for those killed or injured. The largest cost component in VoSL is lost earnings of those killed. This is calculated by identifying the mean age at which persons die in road crashes, identifying average life expectancy (or retirement age), obtaining average wage figures and simply working out how much earning potential is lost by those killed in crashes. This has a consequence that VoSL can be a very low figure particularly for Low Income Countries (LICs) (i.e. if wages and life expectancy are low). A value for less tangible "Pain, Grief and Suffering" (PGS) can also be added but this tends to be a particularly difficult component of VoSL for countries to cost and justify (e.g. Mohan 2002, Ross Silcock/TRL, 2003).

For WTP, all the values of the HCA are generally estimated. In addition, a sum which a representative sample of the population are prepared to pay (theoretically) for a modest reduction in the level of risk of injury in a road crash is estimated, this value is extrapolated up to give a value that the sample would be willing to pay to save a road death. This can be estimated from a questionnaire based Stated Preference method. Revealed Preference methods can also be used. This method generally results in much higher estimates for VoSL and crash costs in general. This method is considered relatively difficult to perform. WTP generally also encompasses the production losses of those who are killed, so double counting of this element needs to be avoided (see SWOV 2014).

Mohan (2002) summarised the problems with a number of HCA costing exercises which were performed in India over the years which arrived at low cost values. The author indicated that when missing information was accounted for, and if WTP was applied, the estimate of the estimate of lost GDP increased from less than 1% to 2%. He also indicated that the most significant losses related to those injured (and not killed) in road crashes (see Box 1) are not adequately captured by HCA and therefore WTP is a better methodology in this regard.

## 2.3 Micro Economic Impacts of Road Safety in LMICs

There is very little available robust information indicating the specific social and financial impacts of road deaths and injuries on individuals and families in LMICs.

Crash costing exercises should clearly estimate the impact of road crashes on health and other sectors. Really comprehensive and rigorous costing exercises, especially for LICs, have not been done. When costing exercises have been done in LMICs they frequently arrive at very low values. This is suspected to result because inexperienced staff often carry out the exercise and miss some costs, or the data needed are not available.

**Box 2 The Role of Road Injuries in Increasing Poverty**

TRL, together with local partners conducted large-scale house-hold surveys to assess both the scale and longer-term consequences of involvement in road crashes in two locations in North Asia. Stratified cluster sampling of 83,199 households in Bangladesh and 19,797 Bangalore (India) in pre-selected rural, urban and slum areas, was carried out. The interviews were supplemented by contacting 156 bereaved households (from police records) and 367 seriously-injured victim households (from hospital records) in Bangalore (see full report for details). The main results were as follows:

Impacts on households
While only one household member may be involved in a crash, the impacts will be felt by the whole household, which includes, on average, another four people.

Direct and indirect costs
Road crashes impose a double financial burden on poor households. At the same time that they face unexpected medical, if not funeral, costs, they also lose the income of the victim and/or carer. Urban poor Bangladesh households paid the equivalent of almost three months household income on funerals, a significantly greater proportion of household income than the non-poor.

Consequences
Over seven out of ten poor families suffered a decrease in total household income after a member was killed or seriously injured in a road crash. Less income means less food to eat. Seven out of ten Bangladesh poor bereaved households reported food consumption decreased after a road death. While the impact was slightly less on the seriously injured households, the poor were significantly worse affected than the non-poor (59% of urban poor versus 25% non-poor). The burden from road crashes appears particularly high, tipping many households into poverty. In Bangalore 71% (urban) and 53% (rural) of poor households interviewed were not poor before the fatal crash.

TRL Aeron-Thomas, et al. (2004). The involvement and impact of road crashes on the poor.

TRL/Ross Silcock developed a Human Capital approach for LMICS in 2003. As part of this exercise major house-to-house surveys were conducted India and Bangladesh. These surveys generated considerable information on the social and economic impact of road crash injuries on families, the report remains one of the few pieces of work to actually investigate these impacts directly. A synopsis of the main results is given in Box 2.

Borse and Hyder (2008) systematically reviewed the available medical literature (listed in PubMed) to identify whether the production of papers reflect the importance of the issue of unintentional injury, including road traffic injury, as a source of DALYs and also if more literature on the issue had been produced after a series of international initiatives in 2004 to

raise the importance of the issue. They found that although unintentional injuries contributed 18% of the over-all burden of Disability Adjusted Life Years (DALYs) globally, the medical literature that had aspects of unintentional injuries as a study focus constituted just 2% of the total papers. 77% of the overall literature was from the US or Western Europe implying that the production from less developed regions and countries was disproportionately lower.

The PubMed definition for "unintentional injuries" included accidents, poisoning and burns; the subset of "Accidents" included falls, drowning and road traffic injuries and similar. When the number of publications on the broad and disaggregated causes was converted to a rate of papers per 1000 deaths from the related cause, it was clear that road traffic deaths were disproportionally poorly represented compared to papers on unintentional injuries overall and also accidents overall (see Table 1 ).

**Table III.** Injury articles published per 1,000 deaths by country or cluster

| Country/cluster | Articles published per 1,000 deaths⁺ | | |
|---|---|---|---|
| | Unintentional injuries* | Accidents** | Road traffic injuries |
| Australia | 522.9 | 352.6 | 386.0 |
| United States | 224.5 | 188.6 | 82.9 |
| Europe (Except Eastern Europe) | 153.5 | 100.9 | 85.8 |
| Eastern Europe | 49.1 | 49.3 | 16.6 |
| Far East (other than China) | 32.6 | 13.6 | 8.2 |
| Middle East | 9.2 | 4.9 | 3.0 |
| South America | 8.1 | 3.3 | 1.9 |
| Northern Africa | 5.7 | 2.2 | 0.9 |
| Other Regions | 5.5 | 3.5 | 3.6 |
| Russia | 4.5 | 4.7 | 1.8 |
| Sub Saharan Africa | 3.9 | 1.7 | 1.5 |
| India | 1.5 | 0.8 | 0.3 |
| China | 1.1 | 0.5 | 0.3 |
| World | 18.1 | 13.8 | 8.3 |

⁺Data Source for Deaths: WHO Mortality Data estimated total deaths by cause and WHO Member State, 2002[9]
*Unintentional injuries includes Accidents [MeSH] + Poisoning [MeSH] + Burns [MeSH]
** Accidents [MeSH] includes falls, drowning, road traffic injuries, home injuries, occupational injuries and other injuries related to radiation and aviation

**Table 1 Papers on unintentional injuries, accidents and road traffic injuries by country and broad region (from Borse and Hyder (2008))**

The authors found that globally the volume and rate of work researching unintentional injuries was lacking in comparison with its impact as cause of loss of life and quality of life, and further, medical research on road crashes as a cause of death was even more lacking (see Table 1 ) in comparison to its impact. The volume of literature concerned with road safety originating from LMICs was found to be very low in relation to richer countries and in comparison to the impact of this factor as a problem leading to death and serious long-term disability.

The authors make the point that health and general spending on mitigation of road injuries is clearly low in comparison to the scale of the issue and in comparison to other identified public health problems, but the information available to support the case for greater focus

and intervention is not as strong as it might be since the evidence base is poor. They make the point that research is required specifically in LMICs on the issues so appropriate countermeasures and strategies can be developed. These results are supported by Lagarde (2007) who focused specifically on road safety research in Africa. The author stated that it has been reported that “In 1990, expenditure per one DALY lost was US$85 for HIV/AIDS and US$0.83 for road traffic injuries”. It is symptomatic that a paper from 2007 refers to information on estimated expenditure levels for different health issues for 1990.

More recently, Nunez et al. (2011) investigated the direct costs to casualties injured in road traffic crashes as part of a costing exercise in Mexico. They followed a sample of injured out-patients for 1 month and hospitalised persons for 8 weeks, they used the HCA. The results were as follows:

- More than 8% of injured attended only the Emergency Room and 80% of those hospitalised reported out of pocket expenditures of 30% or more of their total monthly income
- Indirect cost associated to time lost for caregivers and companions represented 20% of the total indirect cost. Note this is an important cost category seldom estimated in similar studies
- Economic costs that hospitalised injured people face within 8 weeks of hospital discharge are important, representing 30% of the total cost documented in this work
- During 2007, the society lost more than US$329,061,813 for GMA and US$650,908,924 at the state level (1.3% of State GNP - Gross National Product)

Nunez et al. reported that if WTP was used, costs could be expected to be 2 to 3 times higher.

Costing exercises from some HICs have identified that medical costs as a proportion of all the costs are relatively low; however, this may not be the same case in LMICs especially in a relative sense. In addition crash costs have been identified to be greater over-all than other externalities such as congestion.

## 2.4 Incentive Effects

A specific request for this study was to review possible incentive effects in the sphere of road safety. The use of Social Impact bonds (SIBs) is increasingly being proposed as a way to get greater investment in road safety by making the significant but hidden benefits arising from improved road safety levels more tangible. SIBs should encourage (social) investors to fund the organisations responsible for delivering the improvements to a much greater extent. The exact methodology and details of how SIBs would be used to increase funding and implementation of effective road safety improvements, at present, lack clarity and any actual practical detail.

The use of SIBs has so far only been piloted in the UK; it has been used in a proof of concept trial to encourage better performance by probation services to attain significantly lower rates of re-offending by ex-prisoners. The scheme is similar to a “Pay by Results” approach to solve a societal problem. In contrast to the “Pay by Results” model, social investors put up the funding for the activities (typically done by a charity or similar) and the funder get the majority of the benefits if the project is successful. One stated advantage of SIBs is that the organisation that does the work gets paid whether the project is successful or not, in a “Pay by Results” they risk not getting paid which can lead to organisations becoming insolvent.

The SIBs is stated to have advantages such as letting the experts get the results anyway they see fit with less interference, they encourage a results focus and may get away from government “short termism” in funding. In addition it is stated that SIBs may remove the risks from the implementers to the funders, who are better able to judge and accept risks.

This UK trial has been viewed as a success, however it has not been officially evaluated yet, but the UK government is apparently letting many more SIBs currently (Ainsworth 2014 http://www.civilsociety.co.uk/finance/blogs/content/17532/six_issues_with_social_impact_bonds).

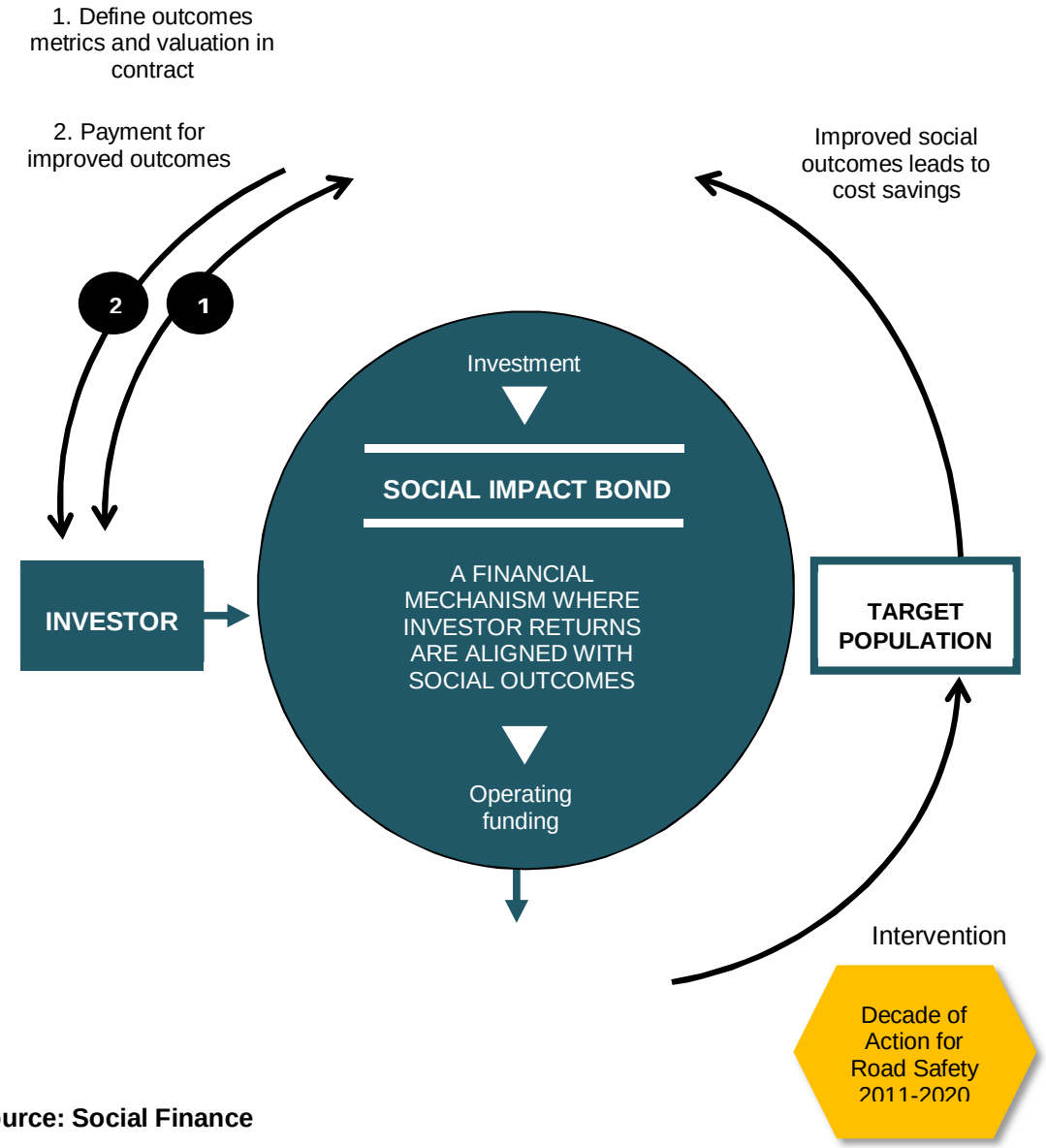
A major problem with the societal costs of road crashes and injuries is that they are largely invisible and any savings from investment which has improved safety are similarly hidden. Those government arms that are most burdened by the financial impact of crashes (health services, social welfare etc.) are not those with the direct responsibility of taking preventative action (e.g. road authorities, educationalists, police etc.). If there is no strong belief and understanding that the savings which are reported to be possible (e.g. the VoSL) by reducing crashes and saving lives, then there is very little incentive for stakeholders (or governments) to invest money in road safety because the benefits are not readily apparent, tangible or obvious. The use of SIBs may get around this issue and unlock longer term, sustainable funding for road safety improvements.

Ideas are currently being proposed by several donor banks (such as the Inter-American Development Bank) and international charities (FIAF, iRAP) to encourage investment in road safety related infrastructure by leveraging very low interest loans to toll road franchises and road authorities based on demonstrated improvement (see

Figure 1 ). This is very dependent on there being very clear and quantifiable improvement in safety such as reduced road deaths and serious injuries on the highways for which they are responsible. Related schemes where road concessionaires have been made responsible for all insurance and costs resulting from crashes in Mexico have been reported to be successful, but the results for this are not currently available from a credible published source.

It has been proposed to use an SIB system to make the benefits accruing from better road safety more apparent by measuring decreases in the numbers of those injured in crashes that attend medical facilities for example and reductions in the associated direct medical costs being available to road authorities for example to invest further in road safety. A key issue for SIBs is that the measured improvement needs to be clearly related to the work done by the implementing organisation and this issue may be difficult to demonstrate unequivocally in the road safety situation, since many factors may influence the numbers of casualties. The benefit needs to be very clearly linked to savings in government spending. This is an essential point.

**Figure 1 proposed application of SIBs to road safety**




**Source: Social Finance**

Adapted from:
http://www.roadsafetyfund.org/Documents/Policy_Forum_2014/PolicyForum2014_Saul_Billingsley.pdf

Published information about the detail of these proposed schemes is not available at this time. It is unclear whether any schemes in different sectors which could be broadly analogous to their application for road safety have been trialled or have been successful so far.

## 2.5 Global Economic Aspects

The economic losses to countries are used to argue for greater resourcing of road safety measures and counter-strategies. The argument is that if this issue results in significant losses, it is an issue where investment to counteract the problem will result in significant savings and benefits. The GDP loss argument attempts to increase the priority for road safety for Governments and lenders/donors.

The fatality, injury and crash numbers are important because these are used to estimate the over-all costs of road crashes to countries in conjunction with their associated costs. Commonly quoted values for the impact of crashes on country GDPs are that they are within the range 1 to 3%, but figures of up to 5% are also stated (e.g. FIA 2005). To some extent these kinds of values have taken on a 'life of their own' within both the academic and grey literature, that is to say authors frequently quote a secondary source for the origin of stated figures. For example Bliss and Raffo (2013) quote 1-3% in a World Bank document and cite Peden et al 2004 as the source, but Peden et al. actually state:

> *"The economic cost of road crashes and injuries is estimated to be 1% of gross national product (GNP) in low-income countries, 1.5% in middle-income countries and 2% in high-income countries."*

This was attributed to Jacobs et al. (2000) which is the primary source. The authors of this report state that the GDP loss levels they estimated were based on little firm information since few robust costing exercises had been undertaken at that time. These often cited values were approximate. In defence, these are likely to be conservative estimates.

iRAP has more recently stated that the real loss to GDP in LMICs is actually 5% and it is 2% on average for HICs. This is discussed in more detail in following sections.

Other authors quote the range of 1-5% on the basis that some HICs have estimated their total costs to be more than 4% GDP using WTP (e.g. FIA, 2005).

What is clear is that however it is estimated, road crashes are almost certainly a very significant drain on GDP in all countries. The current recommended rigorous method (WTP) to calculate costs has not been applied in LICs and only infrequently in MICs, so the true impact can only be inferred from the information that is available. The problem that very firm knowledge of impacts is not known with great confidence is likely to also impact upon other significant public health and development issues.

## The iRAP VoSL Estimation Method

iRAP (International Road Assessment Programme) (2008) has developed a method to obtain estimates for VoSL and for serious injuries for countries where no robust costing has been calculated. Their approach is based on a good relationship between VoSL for a range of countries (primarily but not exclusively HICs) and GDP per capita values. Because they have derived a straight line equation for the relationship, providing you have figures for 1) GDP and 2) a population figure you can use this equation to derive an estimated of VoSL. The resulting equations are given in

.

There are several concerns with this approach. Firstly economists state that costing exercises should be done in each individual country and extrapolating from one country to the next is not a technically valid method. Secondly the method requires extrapolation of the relationship beyond the range of values from which it was derived. Any relationship between VoSL and GDP per capita may not be linear across the whole range of values across which it is being used. Although the relationships identified were stated to be statistically significant, the sample of countries which used WTP is small, it is not clear if the relationship for WTP developed would be significant if the HCA estimates were not also included in the base model.

Table 10: iRAP economic appraisal model values

| | Lower | Central | Upper |
|---|---|---|---|
| Value of Fatality | 60*GDP/Capita | 70*GDP/Capita | 80*GDP/Capita |
| Value of Serious Injury | 12*GDP/Capita (20%VSL) | 17*GDP/Capita (25%VSL) | 24*GDP/Capita (30%VSL) |
| Number of Serious Injuries to number of Fatalities | 8 | 10 | 12 |

**Table 2 iRAP derived equitions for estimating VoSL and value of severe injuries**

The method has not been peer reviewed, and the authors do urge caution for its use. In the absence of any rigorous crash/injury costs for an individual county this method is a very useful tool to get an indicative idea of what the order of real costs of road deaths and serious injuries might be. The primary use for this method is to provide costs for the iRAP Cost-Benefit economics estimation module associated with their main road assessment tool.

**iRAP has used the methodology to estimate that the GDP loss to LMICs is 5% and it is 2% on average for HICs (see**

) (from McInerney, 2013) .

| Income Group | Fatalities | Economic Cost* | % of GDP |
|---|---|---|---|
| Low (36) | 130,000 | US$ 20 billion | 5% |
| Low-Middle (52) | 495,000 | US$ 205 billion | 5% |
| Upper-Middle (54) | 510,000 | US$ 780 billion | 5% |
| High (51) | 95,000 | US$ 850 billion | 2% |
| TOTAL | 1,230,000 | US$1,855 billion | 3% |

*Preliminary results (rounded): WHO (2013), iRAP (2013)

**Table 3 Preliminary estimates of GDP losses by iRAP**

## 2.6 Case Study: Application of the iRAP Costing Method: Ethiopia

To illustrate the practical application, the iRAP method has been used to estimate VoSL and the cost of serious injuries for Ethiopia (see Table 4). The exercise also made use of the latest WHO Global Status results which gave reported and estimated fatality numbers for the country for 2010.

In the exercise the mid estimate for VoSL iRAP equation (70 * GDP/Capita, see

) has been used. The process used the typical data available to researchers and engineers for GDP figures and the population estimates, identified in this case from internet searches which identified reasonably credible information.

The exercise estimated that VoSL for Ethiopia using the iRAP methodology is just over USD $30,000 at 2010 prices. To put this into some perspective, the current US VoSL is over $6 Million.

Using reported fatality figures and the iRAP VoSL and cost for serious injuries (assuming serious casualties are 10 times fatal numbers), a GDP loss to Ethiopia from crashes of 0.8% is obtained. Note this does not include costs of minor injuries and damage crashes, so the estimate is conservative.

Using the WHO's corrected (modelled) estimates for the number of road deaths, the GDP lost as a percentage rises to 4.3% which is close to iRAP's 5% general figure.

| | | USD $ | |
|---|---|---|---|
| | GDP Ethiopia | 35,684,259,259 | GDP Ethiopia(2010)= USD35,684M |
| | Population | 83,000,000 | Population estimate (2010) = 83m |
| | GDP/Capita | 429.93 | GDP per capita ($/person, (2010 prices) = USD 430 |
| | | | Factor to multiply GDP per capita to obtain fatality cost= 70 |
| Value of Statistical Life | 70 times GDP/Capi | 30,095.16 | Fatality cost ($/fatality) = USD 30,095 |
| | | | Serious injuries cost as a percent of fatality cost = 25% |
| Value of Serious Injury | 25% of VoSL | 7,523.79 | Serious injury cost ($/serious injury) = USD 7,523=4 |
| | | | |
| | | | |
| | | | |
| | | | |
| 2010 CASUALTY FIGURES from WHO Global Status report | | | % GDP |
| Reported Fatals | 2581 | 77,675,603.86 | |
| 10* Serious | 25810 | 194,189,009.65 | |
| | | 271,864,613.51 | 0.8% |
| | | | |
| WHO modelled figures | 14606 | 439,569,883.76 | |
| 10* Serious | 146060 | 1,098,924,709.39 | |
| | | 1,538,494,593.15 | 4.3% |
| | | | |
| GDP figures from: | http://www.gfmag.com/gdp-data-country-reports/275-ethiopia-gdp-country-report.html#axzz23FG48K5e | | |
| Population estimates source: | http://www.prb.org/pdf07/07WPDS_Eng.pdf | | |

**Table 4 Results from applying the iRAP method for Ethiopia**

This exercise indicates that the VoSL and consequently the crash costing for a typical LIC can be very low, even when using methods which give the highest possible values. This means it can be difficult to justify road safety measures using classic Cost Benefit Analysis methods. Again the problem of low VoSL will also be relevant in the application of similar methods for justifying countermeasures for other public health issues.

# SECTION 3

# Relationships between Crashes and GDP in LMICs

## 3.1 How Crash Occurrence Varies with Country Development Level

Sivak and Schoettle, (2013) analysed the WHO data from the 2013 Global Status Report by broad income category (High, Middle and Low income using World Bank definitions based on average incomes).

They found that Road deaths (per capita) follow an inverted U shape (a well-known pattern in the literature), so fatalities per capita are low in LICs and HICs and higher in MICs. Deaths per vehicle decreased with development level and also the representation of pedestrians amongst all fatalities fall as average income increases in countries. They explain these patterns as the result of interplay between differences in the increases in motorisation rates as countries develop and an interaction with the safety level per vehicle.

Other broad policies (e.g. Speed limits, Seatbelt wearing rules, Blood Alcohol Concentration limits, Police enforcement activity, vehicle standards) associated positively with safer roads and travel increased with increased development level.

This trend in road deaths with country development level has been investigated and explored in a number of papers. Kopits and Cropper (2003) identified that the point at which fatalities per capita starts falling is broadly when GDP/Capita reached $8,600 at 1985 prices. The authors state this is very similar to the point when countries begin to manage/reduce other negative environmental externalities such as pollution. Some have interpreted this result to mean that there is no point trying to improve road safety until countries attain this economic development level; however the authors indicate that application of effective road safety counter measures and strategies should alter the occurrence of the turning point.

Koren and Borso (2013) suggest that countries go through the following phases:

a) Declining road safety: Increasing fatality rate per population dominates due to growing traffic volume, the economy is weak, and there is no social attention to road safety.
b) Turning point: The road safety situation is quite bad; however, the economic performance makes the change possible, if there is adequate social and political will.
c) Long-lasting improvement: The pace of economic and technological development as well as the change in social attitude is higher than the growth in traffic volume.

They categorised the turning point in terms of vehicle ownership levels (when they reached 0.2 to 0.3 vehicles per person). They acknowledge that this will correlate with GDP/capita levels. They also indicated that countries hit a level of between 15 and 30 fatalities per 100,000 population and that differences may relate to variance in social attitudes and differing tolerances to the problem. Their analysis was clearly hampered by poor data and under-reporting of road fatalities in many countries.

Grimm and Treibich (2010) make the case that the majority of the work compares the situation across countries at a high level and that the understanding of the factors that lead

to poor road safety in individual circumstances has seldom been investigated, especially for LMICs. They focussed mainly on behavioural aspects and they state that specific poverty related issues and consequences are not adequately taken into account by the Safe System approach (which has been adopted by the major international road safety stakeholders). They also indicated that road safety may contribute significantly to poverty but gave no direct evidence for this.

There is some indication (WHO, 2013) that some LICs (5) and more MICs (41) have reduced road deaths from 2007 to 2010; however variability in their reporting practices and also the recent global economic down turn may have an important role to play in these results which are not broken down further by WHO.

## 3.2 Costs of Crashes in Relation to GDP/Capita Levels

How the economic burden of crashes may vary systematically with country development levels is far from clear. Jacobs et al. (2000) indicated that the relative burden of crashes and injuries in LICs is lower than that in MICs which is lower than that in HICs in terms of percentages of GDP (e.g. 1%: 1.5%: 2%).

Variation in the costing methods used and how comprehensively the exercise is performed means that it is very hard to make clear comparisons between countries.

Because HICs may estimate costs using WTP their costs can be very significantly higher than LMICs which tend to use HCA. Extrapolating the WTP level costings using the iRAP method indicates that the actual relative costs may be higher (and consistent at 5%) in LMICs than in HICs (2%).

What is generally agreed by all stakeholders is that crash and injury costs constitute a significant loss of GDP in all countries (whatever method is used to estimate VoSL) which warrants more resources and attention than it currently receives.

## 3.3 Economic Development Influences: Micro Level

There is a lack of detailed analysis of how poverty and aspects of development influence and interact with the patterns of road safety which have been observed in relation to development level (Grimm and Treibich 2010). There is some evidence that road crashes disproportionately affect those who are relatively poorer in societies in LMICs (TRL 2003, Thwe et al 2013), however this kind of study is rare. The cross-sectional studies that investigated the patterns in the relationships between fatality rates and economic development (Kopits and Croper (2003), Koren and Borso (2013)) have concentrated on describing the patterns and interactions with available parameters, but these metrics are unlikely to be directly causal but correlated with other relevant factors.

As so little good crash and injury data have been available from LMICs previously, really good “epidemiological” studies of the occurrence of crashes have not been done at this point. This means we don’t know with any certainty, for example, how safe the urban roads are in comparison with rural roads in LMICs.

A major influence on accident patterns is exposure, so there are well established direct relationships between the levels of motorisation and levels of road deaths and injuries. More vehicles will result in more crashes, unless effective measures are introduced to make road travel safer which is where complexities in the relationship arise. Since growth in the economy results in greater vehicle ownership and more road building (indicative and necessary for economic development), greater road crashes, injuries and road deaths would

be expected due to increased exposure (Naci et al 2008). This increase in fatalities will be significantly higher per vehicle kilometre travelled compared to the HIC situation because measures, which are standard in most HICs, to enhance road safety are often not in place in LMICs.

# SECTION 4

## Recommended policies

There are many potential policies and actions that will likely promote better safety in LMICs. The attitude of the leading international stakeholders (Peden et al., 2004) for road safety is that a range of proven HIC approaches should yield very significant benefits if applied in LMICS, and that some general "common sense" measures so clearly promote safer roads that their use doesn't need any justifying (Norton et al., 2006). Whilst this is likely true, a number of authors also note clearly that many measures designed for HIC conditions may actually be inappropriate in LMICs conditions.

Some authors have sought to suggest a range of measures and policies which are particularly suitable for application in LMICs. (e.g. Norton et al., 2006, Ameratunga et al., 2006).

These works have tended to identify measures which may have more success on the basis that they are effective independently of the need for active enforcement or educational campaigns for example, or that they focus on promoting the safety of vulnerable road users.

Norton et al. indicated a range of measures which may be effective in LMIC situations (see **Table** 56).

| Injury | Promising interventions | Interventions shown to be effective in LMICs (references) |
|---|---|---|
| Road Traffic Injuries | Reducing motor vehicle traffic: efficient fuel taxes, changes in land-use policy, safety impact assessment of transportation and land-use plans, provision of shorter and safer routes, trip reduction measures | Increasing the legal age of motorcyclists from 16 to 18 years (Norghani and others 1998) |
| | Making greater use of safer modes of transport | |
| | Minimizing exposure to high-risk scenarios: restricting access to different parts of the road network, giving priority to higher occupancy vehicles or to vulnerable road users, restricting the speed and engine performance of motorized two-wheelers, increasing the legal age for operating a motorcycle, using graduated driver's licensing systems | |
| | *Safer roads* | |
| | Safety awareness in planning road networks, safety features in road design, and remedial action in high-risk crash sites: making provisions for slow-moving traffic and vulnerable road users; providing passing lanes, median barriers, and street lighting | |
| | Traffic calming measures, such as speed bumps | Speed bumps in reducing pedestrian injuries (Afukaar, Antwi, and Ofosu-Amaah 2003) |
| | Speed cameras | |

| Injury | Promising interventions | Interventions shown to be effective in LMICs (references) |
|---|---|---|
| | *Safer vehicles* | |
| | Improving the visibility of vehicles, including requiring automatic daytime running lights | Daytime running lights on motorcycles (Radin Umar, Mackay, and Hills 1996; Yuan 2000) |
| | Incorporating crash protective design into vehicles, including installing seat belts | |
| | Mandating vehicle licensing and inspection | |
| | *Safer people* | |
| | Legislating strategies and increasing enforcement of, for example, speed limits, alcohol-related limits, hours of driving for commercial drivers, seat belt use, bicycle and motorcycle helmet use | Increases in fines and suspension of driver's licenses (Poli de Figueiredo and others 2001) Legislation and enforcement of motorcycle helmets (Ichikawa, Chadbunchachai, and Marui 2003;Supramaniam, Belle, and Sung 1984) |

**Table 5 Promising measures identified by Norton et al. (2006)**

The United Nations Road Safety Collaboration has also coordinated a series of "Good Practice" manuals which are focussed on the key areas where the largest and quickest road safety improvements can be obtained if significant investment is made.

These manuals cover alcohol (drink driving), seat belt use, motorcycle helmet wearing and speed control. More recent manuals cover crash data systems and pedestrian safety. These manuals are designed for use by practitioners and decision makers and cover all aspects from enforcement and engineering to education campaigns. The manuals are available to down load in a series of languages from the WHO web site (see: http://www.who.int/roadsafety/publications/en/).

## 4.1 Engineering Measures

Many elements of good road engineering design are universal, however very different behaviours and much more diverse traffic mixes in LMICs mean that some HIC designs and features may not always be appropriate.

The iRAP Toolkit (www.toolkit.irap.org) lists a comprehensive range of mainly engineering countermeasures and design concepts for roads, together with background information on where they should be applied. Measures are associated with main crash and road user types, potential problems and also some indication of cost and effectiveness. The list of possible measures is too long to list here so it is suggested that the Toolkit is accessed for this information. It has been created specifically for use in LMICs but it is based primarily on HIC evidence and evaluations.

There is a strong perception that roads in LMICs are often built lacking some fairly fundamental safety features. This includes basic signing and lining (white paint) for example, as well as adequate provision for vulnerable road users such as pedestrians and bicyclists. This is evidenced by iRAP surveys carried out in LMICs.

New roads with poor safety levels are often constructed due to a lack of capacity in client organisations, financing agencies and contracting consultants. Often the cost of construction is a major factor when considering different options that will have different safety impacts. For example, turning a single carriageway road that runs through a settlement into a dual carriageway can be achieved with relatively little expense when compared to a by-pass with a connection to the town. Although the construction of a by-pass would no doubt cost more money than a simple upgrade of the existing road, often communities are divided and significant road safety issues emerge as higher speed traffic use the new facilities and pedestrians still need to get from one side of the town to the other. Approaches such as Road Safety Audit (RSA) can be effective in improving safety, though these are rarely applied at all of the necessary stages of design (feasibility studies, preliminary design and detailed design) and construction. Often RSA is viewed as being expensive and difficult to achieve because of the lack of local Road Safety Auditors.

## 4.2 Engineering Evidence

There are few studies that evaluate the performance of infrastructure treatments when applied in LMIC roads. This information can feed into economic appraisal processes (as crash reduction factors)

There has been virtually no credible evaluations of the performance of engineering measures, especially from Low Income Countries (Ameratunga et al., 2006). In 2004, the "World Report on Road Traffic Injury Prevention" (Peden et al., 2004) could only find one such study from an LMIC which was a before/after analysis of speed humps effectiveness from a Ghana. The lack of evaluations of engineering interventions to reduce for road traffic injuries in LMICs represents a serious research gap and hinders the implementation of effective strategies in those countries. Borse and Hyder (2009) state "to be effective, policies on traffic safety in developing countries must be based on local evidence and research, and designed for the particular social, political, and economic circumstances found in developing countries."

One of the most practicable ways to get road safety improvements is through improvements to road infrastructure, because getting major road user behavioural change is considered to be more difficult and will necessarily take longer to achieve.

This lack of research from LMICs means that when engineers try to apply "best practice" to select and economically prioritise treatments or to build safe roads, they must use values based on HIC experience. There is strong reason to suspect that measures which are successful in HICs may behave very differently in LICs.

This means that inappropriate measures are probably being implemented widely in LMICs. In addition the available information is biased heavily towards HICs issues and not on vulnerable road users (a greater proportion of whom are killed or seriously injured in LMICs when compared to HICs). These issues mean that money spent currently may be being wasted or may even be making roads less safe (Legarde, 2007).

This lack of research from LMICs also means that even where we know that features behave differently there is a lack of willingness to act on this information. For example a study by TRL (TRL, Kirk et al 2005) identified that wide shoulders on undivided 2-lane roads are less safe than narrow shoulders (<2.5M) on rural roads in a number of LICs in Africa, yet engineers are not willing to reduce shoulder widths since this is contrary to the HIC practice and experience.

## 4.3 Strength of Evidence for Effectiveness of Broader Safety Strategies in LMICs

Robust evaluations of specific measures in LMICs are extremely rare. These measures need to be applied in LMICs but they should be evaluated fully to asses that they are locally and socially appropriate and that they do indeed reduce road crashes and the resulting injuries efficiently. The simplest monitoring and evaluation is based on statistical analysis of patterns in crash numbers before and after implementation in comparison to suitable comparator locations which have not been treated; but this requires good and consistent crash data to be available. Evaluation and monitoring is not often straightforward, where several measures have been implemented at the same time, which is often the case, it is extremely difficult to identify the effectiveness of the individual components (see Sebego at al 2014).

A major challenge with road safety is that it is multi-disciplinary in nature and success can only really be achieved when many stakeholders are engaged and coordinated. More recent initiatives at the World Bank have endorsed larger scale multidisciplinary projects with a focus on “learning-by-doing”, as a way to get new approaches implemented and ideally evaluated as fully as possible. There is a recognition that evaluation is difficult and although the adopted “Safe System” approach has a very clear primary focus on reducing road fatalities and serious injuries, it is recognised that intermediate indicators of performance (e.g. seatbelt wearing rates, average speeds) need to be monitored.

The most significant work that has been done to try to quantify the cost effectiveness of road safety measures for LMICs has been done by modelling and extrapolating from the scant LMIC evaluation information and also by making assumptions based on some HIC knowledge (Bishai and Hyder, 2006; Hyder et al., 2013b). These reports make the point that the results would be significantly strengthened by having more solid evaluation evidence from LMICs.

Bishai and Hyder estimated that a range of road safety measures, from fairly broad police enforcement improvement and speed control, road humps, bicycle helmets and motorcycle helmets are all estimated to have low costs per DALY saved.

Hyder et al. (2013a) identified that the RS10 initiatives should be highly (cost) effective even taking the most pessimistic view of potential effectiveness of the measures being introduced (these being improved speed control, seatbelt use, drink driving and helmet use). Again the lack of hard evidence is emphasised, and the authors acknowledge the many assumptions they needed to make, to produce the estimates of effectiveness.

Hyder et al. (2013b) have also proposed a range of methods to evaluate road safety programmes (RS10) in LMICs. These methods are not simple and it is doubtful that they could be applied readily given capacity levels of stakeholders generally in LMICs.

# SECTION 5

## Findings and research

### 5.1 Main Findings

The macro-economic impacts of road accidents on the economies of the world and also for many individual economies cannot be identified with any accuracy. The best and conservative estimates put these as being at least 1% of GDP but most likely, much higher. There is too much inconsistency in the available data and methods used to derive the full figures required. Extrapolation from mainly WTP HIC estimates indicate that the costs could be as high as 5% of GDP for LMICs, but these estimates are based on untested assumptions. In any case the losses are very significant and investment in road safety across the board is reported to lag, in comparison to that applied to other public health issues. A firmer evidence base (such as better reporting of casualties) would strengthen the arguments; however, there is no evidence that there is better information available for the impact of communicable diseases, for example, which appear to attract more attention and funding.

The inconsistency in costing exercises between countries (especially for LMICs) means that it is not possible to discern clear patterns, between development levels and the over-all economic burden of road crashes. In theory, if VoSL and other costs have a direct relationship with GDP/capita, this will interplay with numbers of crashes (as vehicle ownership increases and crashes increase). So it is possible that the relative economic burden of crashes to GDP may increase greatly as countries develop and then fall relatively as they become HICs (as motorisation slows and crash and fatality numbers decrease). No literature, on the nature of these relationships, was identified. This is not the pattern estimated by iRAP.

Economic development and increasing motorisation will definitely lead to greater number of accidents and resulting road deaths and injuries. At a certain point in a countries' development, the numbers of annual road fatalities start to decrease, because motorisation rates slow but also because fatalities per vehicle decrease. Safety per vehicle is reported to improve as a result of organised and active management and investment in road safety strategies and actions, but the detailed relationships are not known. Detailed investigation is hampered by poor availability and inconsistency of data.

Information from costing exercises is available for HICs which can indicate the detailed breakdown of the losses by headings such as health sector, police etc., however similar good quality information is not available for LMICs. It is possible that health costs as a proportion of over-all costs may be higher for LMICs. The information available on the range of costs may not be available in LMICs.

There are a wide range of measures (spanning enforcement, engineering and education) which can be implemented to reduce the impact of road safety, but for the most part robust evaluations for their effectiveness in LMICs is missing.

## 5.2 Research Gaps

### Crash Data Systems

A primary issue which obstructs a clear understanding of the real scale of the road safety problem (and the costs), and also prevents good quality research, is the lack of resilient and accurate data systems for crashes and injuries in the police and medical sectors.

This has led to a lack of robust evaluation of what road safety measures actually work in LMIC situations, this in turn means that it is difficult to design strategies based on “proven” methods; this also inhibits investment in road safety.

**Significantly improved crash data systems in LMICs**

The economic benefits of having good data have not been estimated and these may also accrue mainly in the mid to longer term. This can make investment less attractive when compared with other actions that result in more visible results faster.

Crash data systems are not straightforward to implement successfully, but this has been managed well in some LMICs. A review of factors which promote success and those which result in failure in LMICs should be undertaken, in particular, on recent attempts and existing successful initiatives.

### Gaps in Economic Costing and Appraisal Methods

There are considerable gaps in the application of good costing exercises done using WTP for LMICs. This means that the true costs of crashes are not known. The micro-economic impacts are also not well-understood such as losses to health systems and to individuals and families. It would be very valuable to identify whether WTP for crash costing can be done in LMICs, particularly since it has been applied to other transport costs in LICs.

**Testing of WTP as a viable costing method in LICs & further related large scale house-to-house surveys**

The costing work by iRAP needs to be more rigorously assessed to confirm if it produces reasonably accurate and also defendable estimates of VoSL. The best test would be to actually do some comprehensive WTP costing exercises in a number of LICs and to compare the iRAP method estimates with the rigorously calculated values.

**Review of the iRAP costing methodology**

A significant gap in our understanding and in the current literature is whether the classic economic appraisal approaches, which are used, reasonably routinely, in HICs, actually apply or work, particularly for LICs, but also for MICs. The low VoSL in LICs even when using the iRAP WTP proxy method (which typically gives higher costing estimates) can result in relatively low values (compared to typical HIC estimates) so justifying safety measures using classic Cost Benefit Analysis may be difficult or actually inappropriate.

**Assessment of whether classic economic approaches work and are appropriate for LICs and potentially MICs. Review of how higher spending on other broadly similar public health issues is justified decided and evaluated**

This issue of low VoSL will also influence spending on medical interventions for other public health issues. This raises the question of how other issues attract attention and investment. There may be lessons that road safety practitioners can learn from other domains.

## Evaluation

Clear evaluations of a wide range of road safety strategies and countermeasures are required in LMIC conditions. This could be achieved in a number of countries (mainly MICs) which actually do have reasonably good crash data systems.

**Evaluations of a range of counter-measures and strategies in LMICs that have good quality crash data**

Complex evaluation schemes have been developed and suggested to cope with poor data availability and low crash numbers, if simpler but clear and robust methods could be developed these are more likely to be applied in LMICs.

**Development of relatively simple evaluation techniques that can be applied by workers in typical LMICs are needed. This should include detailed assessment of how different elements of the road system interact in LMICs to result in greater crash numbers and rates, and an assessment of the interaction of design elements with LMIC road users**

Related to this, the relative contribution of the different elements (vehicle standards, road standards and quality, road user behaviours and speeds) which effect road safety in LMICs is not known. Some basic research to identify more precisely what leads to much less safe road travel in LMICs is required. The interaction of typical LMIC road user behaviour and traffic mixes with infrastructure elements is also required.

# SECTION 6

## Annotated references

The following gives a synopsis and main points of particular relevance to the study for quoted sources. A highly relevant source which is recent and ideally peer reviewed or from a highly reputable source was given 1. Technical work (not peer reviewed) that was very relevant, or less relevant and recent peer reviewed work was given "2". Work that was very old, was not what could be termed academic in origin (grey literature) and was less relevant was assigned 3.

| | Study | Research Design and Methodology | Synopsis and Review |
|---|---|---|---|
| 1 | WHO 2009 Global Status Report on Road Safety | 1 Secondary Survey very relevant | This work aimed to collect a comprehensive range of road safety information from all UN countries. This included numbers of fatalities and those injured (for 2007) and information on a range of factors which potentially affect safety such as registered vehicles. |
| 2 | WHO 2013 Global Status Report on Road Safety | 1 Secondary Survey very relevant | This work repeated the previous exercise for 2010 numbers, however numbers injured was dropped and greater information on medical facilities and resources was sought. |
| 3 | Norton, R, Hyder, A, Bishai, D and Peden, M. (2006) Chapter 39 Unintentional Injuries: In Disease Control Priorities in Developing Countries. 2nd edition. | 2 Review | This compendium chapter summarises the underfunded public health area of unintentional injuries with a strong emphasis on road deaths/injuries. The authors list some promising countermeasures which may be effective in LMICs. |
| 4 | TRL (2004) The involvement and impact of road crashes on the poor: Bangladesh and India case studies Aeron-Thomas, A, Jacobs, G, Sexton, B, Gururaj, G and Rahman, F. Published Report PPR 010 | 2 Published technical report (not peer reviewed) | The authors conducted major house to house surveys as part of exercises to estimate crash costs in India and Bangladesh. The surveys identified under reporting rate and the also the scale of the impact of involvement of a family member on family units. Road deaths and injuries were found to push families into poverty. |
| 5 | Mohan, D (2002) Social Cost of Road Traffic Crashes in India. Proceedings First Safe Community Conference on Cost of Injury, Viborg, Denmark, October 2002, pp | 3 Review/analysis, seminar | Mohan reviewed costing exercises which had been conducted in India and identified many of the pitfalls which lead to low estimates of VoSL. He indicated that using Willingness to Pay captures more costs relevant to the poor than Human Capital method. Mohan stated using WTP would give a GDP loss for India of 2% cf 0.8% |

| | Study | Research Design and Methodology | Synopsis and Review |
|---|---|---|---|
| | 33-38. | | estimated using HCA. |
| 6 | Lagarde, E (2007) PLOS Medicine June 2007 \| Volume 4 \| Issue 6 \| e170 Road Traffic Injury Is an Escalating Burden in Africa and Deserves Proportionate Research Efforts | 2 Review (not peer reviewed) | The author emphasised the lack of research literature from Africa on road safety issues by using the results of a structured analysis of the results of a database search. Lack of crash data was cited as a major problem preventing evaluations and that this was required so research could be done to localise approaches and strategies to improve safety. |
| 7 | Pérez-Núñez, R., Ávila-Burgos, L., Híjar-Medina, M., Pelcastre-Villafuerte, B., Celis, A., & Salinas-Rodríguez, A. (2011). Economic impact of fatal and non-fatal road traffic injuries in Guadalajara Metropolitan Area and Jalisco, Mexico. *Injury prevention*, *17*(5), 297-303. | 1 Empirical study | The authors conducted a costing study (HCA) by following a sample of persons injured in crashes in Mexico. They stated that road crashes result in very significant losses to families and also to the State. They stated that WTP would result in significantly higher cost estimates. |
| 8 | FIA Foundation 2005, Counting the cost: road crashes and the poor<br>A global road safety briefing<br>in advance of the 2005 G8 | 3 (Not peer reviewed) | The FIAF produced a document to summarise the impact of road crashes globally, specifically to try to influence the inclusion of road safety in the original MDBs. It summarises issue well but does not provide scientific evidence in all access to back assertions as it is not an academic paper. |
| 9 | Bliss, T and Raffo, V (2013) Improving Global Road Safety: Towards Equitable and Sustainable Development, Guidelines for Country Road Safety Engagement | 2 Grey review | This World bank Report summarises the main points they regard as contributing to successful multi-sector, large scale road safety projects. Significant organisation is required and coordination between local stakeholders is paramount. There must be strong emphasis on monitoring. Sustainable funding sources can also significantly improve road safety in LMICs. Argentina case study - describes previous efforts to manage safety 2006-2009 as chaotic/ineffective yet fatalities fell from 2008. Public outcry listed as a main impetuous for serious action to be initiated |
| 10 | Jacobs, G., Aeron-Thomas, A., & Astrop, A. (2000). *Estimating global road fatalities* (pp. 1-35). Crowthorne: Transport Research Laboratory.<br>TRL Published Report 445 | 2 Secondary empirical/survey | The report was an early attempt to estimate Global road fatality numbers by region (accounting for underestimates in available official figures) and also the possible losses in terms of % GDP. The authors estimated of the losses as 1% for LICs, 1.5% MICs and 2% HICs these figures were derived from very limited data and as such are very approximate at best. |
| 11 | McMahon, K., & Dahdah, S. (2008). The true cost of road crashes—Valuing life and the cost of a serious injury. *London: iRAP*. | 2 Secondary empirical work, not peer reviewed | The paper uses a roughly linear relationship between Value of Statistical Life and GDP/Capita to develop a "quick and dirty" method to derive VoSLs for LMICs where no costing effort has taken place. A method to estimate value of serious injuries is also developed. The method is simple but lacks scientific rigour. |
| 12 | iRAP 2013 The Global Cost of Road Crashes, http://www.irap.net/en/about- | 3 Not peer reviewed/Grey Lit | iRAP report that using their simple fatality costing methodology and the WHO fatality estimates of corrected fatality numbers 5% of GDP is lost to road crashes globally |

| | Study | Research Design and Methodology | Synopsis and Review |
|---|---|---|---|
| | irap-3/research-and-technical-papers?download=201:the-global-cost-of-road-crashes-fact-sheet | | amongst LMICs as opposed to 2% for HICs. |
| 13 | Michael Sivak, M And Schoettle, B Road Safety In 170 Low-, Middle-, And High-Income Countries, Umtri-2013-37 October 2013 Working Report | 2 Secondary empirical analyses | Highly relevant. The authors analysed WHO data (road deaths by country) by broad income category. Road deaths follow an inverted U shape, deaths/vehicle decreased and pedestrian fatalities fall as a proportion as income increases. Main causes stated are differences in increases in deaths per vehicle and motorisation rates, and interplay with safety level per vehicle, by group. |
| 14 | Koren, C and Borso, A (2013) From Increasing to Decreasing Fatality Figures: Where is the Turning Point? Proceedings of the Eastern Asia Society for Transportation Studies, Vol.9, 2013 | 2 Review, some analysis of secondary sources | The authors used fatality numbers and rates from a range of countries to identify the point at which fatality numbers start falling in relation to development levels. They find that at 0.2-0.3 vehicles per person this occurs, but the fatalities per 100,000 population of this point varies greatly (between 15 to 30). |
| 15 | Grimm, M and Treibich, C (2010) Socio-economic determinants of road traffic accident fatalities in low and middle income countries Working Paper No. 504, Institute of Social Studies P.O. Box 29776 2502 LT The Hague The Netherlands | 3 Review, not peer reviewed. | The authors make the case that the majority of the work in this area is cross sectional; that is it compares the situation across a number of countries and that the understanding of the factors that lead to poor road safety in individual countries has seldom been investigated, especially for LMICs. The focussed was mainly on behavioural aspects. However, the authors seem to mix known cause and effects and also exposure in their analyses. |
| 17 | Kopits, E., & Cropper, M. (2006). Traffic fatalities and economic growth. Washington, DC: World Bank, 2003. *Policy research working paper*, *3035*. | 2 Secondary analysis (published in 2005 in AAP) | Kopits and Cropper used fatality numbers and population figures to try to estimate future numbers of road deaths globally. They identified a relationship between deaths/capita and development rate such that fatality rates start to fall in countries after they hit the $8,400 income rate (1985 prices). They indicate that counter strategies will likely influence this point. |
| 18 | Naci,H, Chisholm, D and Baker, T (2008) Distribution of road traffic deaths by road user group: a global comparison. Injury Prevention 2009; 15:55–59. | 2 Secondary analysis | From review of available sources, the authors identified that there were patterns in the fatalities by road user group by geographical region. With high rates (50%) of deaths being pedestrians in Africa and 45% in LICs in general. They emphasise the need for more research, better data collection and that counter measures need to be context appropriate. |
| 19 | Ameratunga, S., Hijar, M., & Norton, R. (2006). Road-traffic injuries: confronting disparities to address a global-health problem. *The Lancet*, *367*(9521), 1533-1540. | 2 Review | Summarises situation well, clearly RTIs are a major health issues, especially for LMICs, but data availability on the real scale of the burden and also research on effectiveness of measures is at best poor or absent. Evaluation of measures is generally for vehicle occupants and from HICs. Accurate data systems are needed to capture information on fatally and injured casualties/crashes; also work to identify measures which benefit vulnerable road users is needed. Defines some promising |

| | Study | Research Design and Methodology | Synopsis and Review |
|---|---|---|---|
| | | | approaches which are likely more appropriate to improve safety in LMICs. |
| 20 | Eds, Peden M, Scurfied R, Mohan D, Hyder A, Jarawan E, and C Mathers (2004) World Report on Traffic Injury Prevention, World Health Organization, Geneva, 2004 | 1 Expert Book | This work galvanised and initiated the more serious approaches to road safety as a public health problem that has led to the UN Decade of Action. Comprehensively describes the problem and introduces approaches which can improve safety through the "safe systems" approach, and the need for country leadership recognising that road safety is a multispectral responsibility. |
| 21 | Borse, N and Hyder, A (2008) Call for more research on injury from the developing world: Results of a bibliometric analysis. Indian J Med Res 129, March 2009, pp 321-326 | 2 Review/literature search | The authors surveyed scientific papers on Pubmed which were concerned with unintentional injuries and road injuries. They found that the literature was severely lacking in comparison with the scale of the issue, especially from LMICs. |
| 22 | TRL (2005) Kirk, S., Hills, B., & Baguley, C. Roadside, Village and Ribbon Development. *Cost and Safety Efficient Design (CaSE) Highway Design Note*, *4*(01). | 2 Technical Research report (not peer reviewed) | |
| 23 | Sebego, M., Naumann, R. B., Rudd, R. A., Voetsch, K., Dellinger, A. M., & Ndlovu, C. (2014). The impact of alcohol and road traffic policies on crash rates in Botswana, 2004–2011: A time-series analysis. *Accident Analysis & Prevention*, *70*, 33-39. | 2 Empirical study | The study from Botswana used crash data to evaluate a series of measures designed to improve road safety, including alcohol campaigns and enforcement measures. The study identifies the difficulty of disentangling the individual effects when multiple strategies are occurring. |
| 24 | Bishai, D. M., & Hyder, A. A. (2006). Cost Effectiveness and Resource Allocation. *Cost Effectiveness and Resource Allocation*, *4*, 2. | 2 Review | The authors reviewed available medical literature on injuries and road safety. They found that although unintentional injuries contributed 18% of the lost Disability Adjusted Life Years (DALYs) globally, the associated medical orientated literature constituted just 2% of the total. The volume of literature concerned with road injuries originating from LMICs was very low. They identified that far more research was needed from LMICs so effective measures could be developed. |
| 25 | Adnan A. Hyder, Katharine A. Allen, David H. Peters, Aruna Chandran & David Bishai (2013)a Large-scale road safety programmes in low- and middle-income countries: An opportunity to generate evidence, Global Public Health: An International Journal for | 2 Review/empirical | The authors develop complex/difficult and lengthy methods as a framework to evaluate large road safety programmes in LMICs. They indicate that the output from the RS10 projects should provide significant increase in knowledge of how to effectively reduce road crashes and resulting injuries. |

| | Study | Research Design and Methodology | Synopsis and Review |
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| | Research,<br>Policy and Practice, 8:5, 504-518 | | |
| 26 | Hyder, A. A., Allen, K. A., Peters, D. H., Chandran, A., & Bishai, D. (2013)b. Large-scale road safety programmes in low-and middle-income countries: An opportunity to generate evidence. *Global public health*, *8*(5), 504-518. | 3<br>Review/empirical | The authors use the rather sparse information which is available on the effectiveness of a range of counter strategies in LMICs to develop estimates of the cost effectiveness of the USD124M spend which is going into the RS10 countries. They state even being pessimistic the spend should be highly cost effective. |
| 27 | Phyu Phyu THWEa, Kunnawee KANITPONGb, and Piyapong JIWATTANAKULPAISARNc Road Crashes and Poverty in Myanmar: Yangon Case Study. Proceedings of the Eastern Asia Society for Transportation Studies, Vol.9, 2013 | 2 Empirical study/survey | This study used a questionnaire survey in Myanmar to identify the involvement of road crashes, and impacts on the household of poor and non-poor people. The results shows that the most involvement of road crashes in Yangon are lower social economic groups. The costs and impacts due to road crashes were found to be a higher burden for poor people. |
| 28 | SWOV Fact sheet 2014 Road crash costs<br><br>http://www.swov.nl/rapport/Factsheets/UK/FS_Costs.pdf | 2 review, not peer reviewed | The paper summarises the costing methodology applied in the Netherlands well, it discusses fluctuations in the total cost of crashes over recent years and also touches on why estimates for different countries can vary greatly. |