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ARTICLE

Cost analysis of global road traffic death prevention: Forecasts to 2050

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Abstract

Road traffic safety initiatives are gaining momentum worldwide as more governments and international organizations recognize the implications of traffic accidents on economic and human development. In 2015, as part of its Sustainable Development Goals, the United Nations Development Programme set a global target (3.6) to halve the number of traffic deaths and injuries by 2020. This article uses the International Futures integrated forecasting system to explore the plausibility of achieving that goal and the potential forward linkages of such an intervention. We find that halving annual deaths caused by road traffic accidents is likely to be overly ambitious, and examine more reasonable road traffic death-rate targets using an approach derived from road traffic death rates relative to income level.

KEYWORDS

public health, road traffic deaths, Sustainable Development Goals

1 | INTRODUCTION

Until recently traffic fatalities were largely ignored as a global public health issue, overshadowed by other development-related issues like malnutrition, diarrhoea and HIV/AIDS. However, with the announcement by the United Nations (UN) of the *Decade of Action for Road Safety* in May 2011, donors,

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aid agencies and policy-makers have placed more emphasis on the threat that deaths from road traffic accidents (RTAs) pose to countries at all levels of development. UN Secretary General Ban Ki-moon called on the international community to organize prevention and response mechanisms designed to reduce the occurrence of and impact from RTAs, and the UN, World Health Organization and World Bank have been actively trying to co-ordinate these responses. Emboldened by this momentum, the UN Development Programme (UNDP) adopted the following target in Goal 3 of its Sustainable Development Goals: 'By 2020, halve the number of global deaths and injuries from road traffic accidents.' This target, while extremely ambitious, will serve as a template for our analysis.

With the growth of infrastructure-based development projects (including roads) in some parts of the world (Mold, 2012), as well as research suggesting that access to transportation and roadways is an important determinant for the effectiveness of certain development efforts (Swain & Varghese, 2011), RTAs could rise as the result of the development process. Unlike many public health challenges faced by developing countries – which typically decline with increased incomes – the human, physical and social costs from traffic accidents tend to rise alongside income to a certain level of development. Later in the development process the human cost tends to decline, but the economic costs tend to continue rising. For countries that are not members of the Organisation for Economic Co-operation and Development (OECD), the number of motorized vehicles will grow significantly over the next several decades and, with that growth, the number of RTAs should rise as well. Thus, as incomes grow across the developing world, RTAs are likely to become an increasingly important development issue.

This article attempts to measure the cumulative costs and benefits over time of reaching global and relative reduction targets, using forecasts from the International Futures (IFs) integrated forecasting system. We have relied on cost estimations published by the World Bank Group's International Bank for Reconstruction and Development and the Commission for Road Safety (Norton, Hyder, Bishai, & Peden, 2006; Ward & Billingsley, 2011). The *Base Case* of IFs forecasts the total number of global deaths from RTAs to grow from less than 1.3 million annually in 2014 to nearly 1.5 million by 2020 and more than 2.4 million by 2050.[2] Of this increase, the non-OECD country share is forecast to grow from about 92% today to around 96% by 2050. Additionally, the IFs *Base Case* forecasts that, without intervention, deaths from RTAs in non-OECD countries have already passed malaria deaths, and will pass the 2014 total for diarrhoeal deaths by 2025 and the 2014 total for AIDS deaths by 2030. This article examines the potential financial and humanitarian impact of interventions to reduce RTAs. For this analysis we use Target 3.6 of the Sustainable Development Goals – a 50% reduction below forecasted road fatalities from traffic accidents to 2020 – as the *Universal Reduction* scenario. A reduction of 50% compared with forecast values is very ambitious, particularly when so few countries have developed national plans for intervention.[3] Additionally, we created alternative, potentially more plausible, targets that rely on less ambitious reductions of road traffic fatalities related to standard error targets around a regression function.

2 | CONCEPTUALIZING DRIVERS AND IMPACTS OF TRAFFIC DEATHS

2.1 | The drivers of traffic deaths

Traffic fatality rates are already dramatically higher in non-OECD countries – in some cases by more than 10 times those in European countries, the United States or Canada (Downing, Baguley, & Hills, 1991) – a problem that will be exacerbated by rapid growth in the number of vehicles on roads in

[2]Version 7.22 of the International Futures (IFs) model was used for analysis in this article. The model can be downloaded at http://www.ifs.du.edu/ifs/index.aspx. For perspective, the IFs model estimates that more than 1.6 million people died from AIDS in 2014.

[3]There were 17 national plans published on the WHO Decade of Action website as of August 2016.

developing countries. Rapidly developing low-income countries experience the greatest increases in levels of motorization because vehicle ownership rates tend to rise alongside increases in gross domestic product (GDP) per capita. This is important because deaths per vehicle tend to decline only after income rises past $17,500 in 2005 dollars (Kopits & Cropper, 2005). As income in non-OECD countries continues to rise, the size of their vehicle fleets is expected to increase dramatically, from just over 88 vehicles per 1,000 people in 2014 to roughly 253 per 1,000 people in 2050.[4] With dramatically increased levels of motorization, those countries are likely to experience sharp increases in the number of RTAs that occur. Unless something is done to address the risk factors associated with higher road traffic death rates, the public health and development burdens from RTAs will continue to grow dramatically.

2.2 | Risk factors

Variables that influence road traffic accident mortality rates include vehicle and road densities, speed control, the use of alcohol, the availability of public transit and domestic healthcare systems (Peden et al., 2004). Developing countries face the additional challenges of rising motorization levels, inadequate levels of infrastructure, a lack of oversight, and the lack of research on the causes and consequences of RTAs.[5] Additionally, increasing levels of urbanization in much of the developing world bring more cyclists, pedestrians and other non-motorized roadway users into contact with motor vehicles.

Those affected by traffic accidents are not always drivers or passengers in personal vehicles, as a significant portion of the world's road fatalities involve what are known as 'vulnerable road users' (VRUs). Today, VRUs – defined as pedestrians, cyclists and persons using motorized two-wheelers – account for half of the world's traffic-related deaths (World Health Organization, 2013). In countries where public transit vehicles are unsafe, unregulated and overcrowded, transit riders also are often considered VRUs (Toroyan, 2009). These road users are at the highest risk of injury and death, in large part because they do not possess any of the basic safety features of even a poorly maintained automobile, such as a protective body surrounding them in the event of a crash. However, the interventions made to improve traffic outcomes are most often targeted at private vehicles rather than VRUs, who are particularly vulnerable to road traffic injuries.

2.3 | Development and traffic accidents

Figure 1, supported by historical data, stylistically represents both the human and the financial costs of traffic accidents in relation to a country's level of development. The black, dashed line in Figure 1 represents the loss of human life, while the grey, solid line represents the loss of material resources, including the impacts on economic output. At low levels of development, countries experience a low death rate from traffic accidents, as there are very few motorized vehicles in operation. As a country develops, this rate tends to grow rapidly. However, as noted earlier, once a country arrives at a certain level of development, the rate of people dying from RTAs declines (Kopits & Cropper, 2005). This drop occurs because road traffic rules become embedded norms, infrastructure improves and safer (more expensive) cars can be purchased. While the burden of traffic accidents on human life decreases at very high levels of development, it still exists to some extent, as high rates of speed and

[4]International Futures v7.22 forecasts vehicle fleet per capita (per 1,000) in non-OECD countries to be 88.6 in 2014 and 253.9 in 2050.

[5]Global research and development (R&D) spending on road traffic injuries in 1996 was between $24 million and $33 million, while R&D spending on HIV/AIDS in 1996 was over $900 million (Lagarde, 2007).

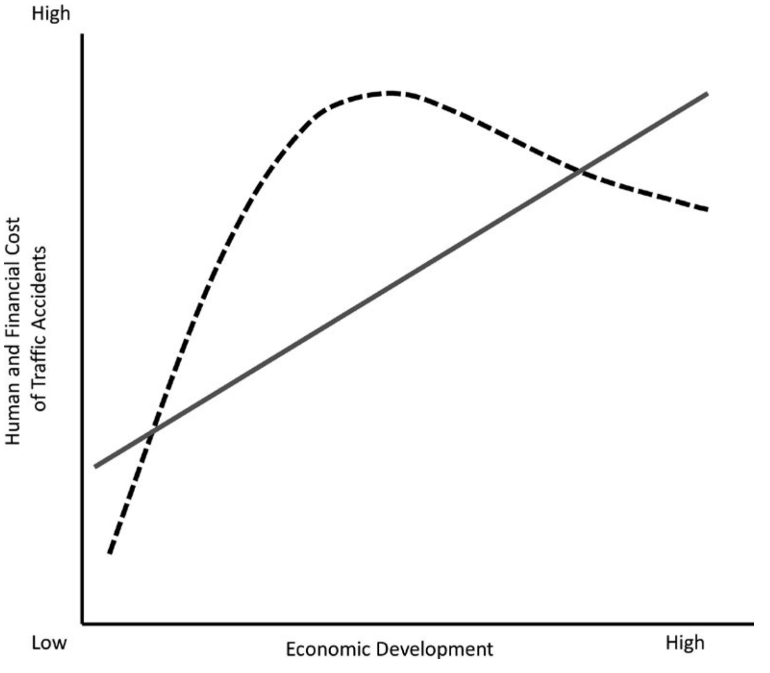

FIGURE 1 Relationship between development and traffic accident burden Source: The authors. The black, dashed line represents fatalities associated with traffic deaths and the solid, grey line represents financial cost of traffic-related deaths.

other distractions, even in very safe cars on well-regulated roads, still result in accidents. It is worth noting, however, that the anticipated roll-out of self-driving cars across the world could change how these dynamics play out in the long term.[6]

While the rate of death from traffic accidents declines after certain levels of development, Figure 1 shows that the economic burden does not. A study of road collisions in 21 developed and developing countries found that the annual cost of road crashes was about 1% of gross national product (GNP) in developing countries, 1.5% of GNP in transitioning countries and 2% in highly-motorized developed countries (Peden et al., 2004). According to the WHO, these estimates bring the annual economic costs of traffic accidents globally to $518 billion, and represent proportions of national GNP ranging from 0.3% to almost 5%, depending on the country (Peden et al., 2004). Due to the rampant underreporting of traffic accidents – particularly in developing countries – and the exclusion of the indirect costs of traffic accidents, these estimates may be much lower than the actual global total. Supporting this, some researchers suggest that the cost of RTAs was as high as $880 billion in 2005, or roughly 2% of global GDP (Zietlow, 2006). In addition, the annual cost of RTAs in developing countries ($65 billion) exceeds the amount of development assistance received by those countries, raising concerns over how to best fund and utilize prevention and response mechanisms (Peden et al., 2004).

2.4 | The cost of reducing deaths from road traffic accidents

The *Global Plan for the Decade of Action for Road Safety 2011–2020* recommends that countries raise national road safety funding to $200 million per year, or $2 billion for the entire decade (United

[6]All IFs forecasts included in this analysis assume that humans will continue to operate personal vehicles.

Nations, 2010). In low-income countries, some suggest 3% to 5% of total road budgets should be devoted to road safety initiatives (Zietlow, 2006). Research from the World Bank shows that the cost of each DALY (disability adjusted life-year) averted, due to interventions to create, publicize and enforce speed limits and other road regulations, varies significantly across countries and regions, ranging from as little as $5 to almost $170 (2001 US dollars) (Norton et al., 2006).[7] Low-income countries, especially, would thus be able to benefit immediately from targeted investment. Other research demonstrates that preventing each road traffic death in these countries could cost as little as $2,000, while for middle-income countries that cost is estimated to range between $7,000 and $30,000 (Ward & Billingsley, 2011). We will use these cost estimates in our analysis.

Though they were not included in the cost estimations used here, other potential interventions would likely consist of the placement of speed bumps and improved traffic signals and lighting, automated or stationary enforcement, such as speed cameras, and better licensing and education. As countries develop, however, the cost of infrastructure improvements, such as built-for-function roadways or safer junctions, and other interventions becomes much higher.

3 | MATERIAL AND METHODS

3.1 | The International Futures model

This analysis was completed using International Futures (IFs), an integrated-assessment modelling system used for thinking about long-term trends and policy outcomes. IFs analyzes relationships across key global systems and provides forecasts for 186 countries to 2100. The tool is open source and can be downloaded or used online for free at www.pardee.du.edu.

The model was originally developed by Barry B. Hughes (Hughes, 1999), and is now hosted and developed at the Frederick S. Pardee Center for International Futures at the Josef Korbel School of International Studies, University of Denver. Version 7.22 of IFs was used for the development of this article.

The model is used widely for analysis, from the National Intelligence Council's recent *Global Trends 2030* report to previous UNDP Human Development Reports. Previous projects have been sponsored by the United Nations Environment Programme, the European Commission, the African Union's New Partnership for Africa's Development, among others.

IFs has formal and detailed representations of the following development systems for 186 countries: demographics, economics, education, health, infrastructure, agriculture, technology, energy, environment, governance, government finance and international politics. Each system is dynamically connected within the broader IFs framework. The block diagram below presents a stylized representation of the systems and their connections.

The model has been widely documented and further information can be found through academic sources (Hughes et al., 2009; Hughes, Dickson, & Irfan, 2010; Hughes et al., 2010; Hughes, Irfan, Moyer, Rothman, & Solórzano, 2012; Moyer & Hughes, 2012).

3.2 | Modelling traffic deaths in IFs

The quality and quantity of historic data on deaths from traffic accidents is limited, therefore IFs uses a calculated function to arrive at figures for each of the 186 countries in the model. To calculate

[7]The cost per DALY averted estimations used by Norton et al. (2006) consider interventions to increase the number of police officers to adequate levels, defined as one officer for every 5,000 vehicles. This is based on a study in Brazil, which found that these levels of interventions had the potential to reduce road traffic deaths by 25%. The estimates 'do not include potential cost offsets from savings derived by preventing expenditures on medical care or vehicle repair'.

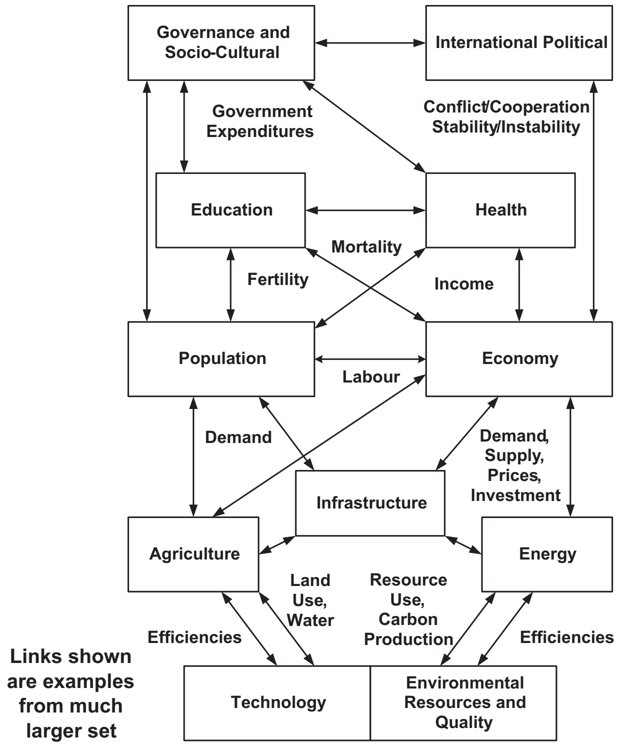

FIGURE 2 Main Structure of International Futures (IFs) Model

deaths from traffic accidents IFs draws upon Smeed's Law, which is a function of the population size and number of registered vehicles in a given country (Smeed, 1949).[8] This technique means that there are countries which are potentially underestimated or overestimated in our initial forecast year, but the relative lack of accurate historical data on a global basis gives us few alternatives to this method of estimation.

For this study we used the IFs *Base Case* forecast and three alternative scenarios to examine the potential impacts of prioritizing RTAs as a public health issue. The first scenario – *Universal Reduction* – simulates a forced reduction of traffic deaths in line with the Sustainable Development Goals (SDG) target of a 50% reduction in global deaths by 2020, a level which is held constant to 2050. The second and third alternative scenarios – the *Reasonable Relative Improvement* and *Aggressive Relative Improvement* scenarios – consider each country's per capita income at purchasing power parity as a driver of relative target-setting across 100-year and 40-year time frames respectively.

4 | RESULTS

The UNDP SDG Target 3.6 proposes reducing the number of deaths by 50% globally by 2020. In the first traffic-related scenario, *Universal Reduction,* we model what would happen if that target were met, with interventions starting as early as 2015. To accomplish this, we used a multiplier (*hltmortm*)

[8]Smeed's Law: D = .0003(np^2)^(1/3); where D is annual road deaths, n is number of registered vehicles, p is population (Smeed, 1949).

to reduce global traffic fatalities by half to 2020, proportionally reducing traffic deaths across all the 186 countries modelled in IFs. The scenario maintains that level to 2050 and beyond.

This reduction in traffic fatalities avoids almost 2.1 million deaths by 2020 and upwards of 31 million deaths by 2050. Comparing the *Base Case* to *Universal Reduction*, DALYs decreased by 122.2 million to 2020 and close to 1.7 billion to 2050. Life expectancy worldwide increases in this scenario by approximately 0.29 years in 2050, with the greatest improvements forecasted in sub-Saharan Africa (an increase of 0.23 years in 2020 and 0.37 years in 2050), South Asia (an increase of 0.23 years in 2020 and 0.32 years in 2050) and the Middle East and North Africa (an increase of 0.27 years in 2020 and 0.32 years in 2050).[9]

These improvements in health outcomes lead to larger overall populations. By 2020, the world's population in *Universal Reduction* is 0.017% larger than the *Base Case*. By 2050, the scenario leads to a population that is 0.26% larger (9.554 billion in the *Base Case* and 9.579 billion in *Universal Reduction*). The largest percentage increases in population from the brute force multiplier in 2050 occur in sub-Saharan Africa (0.27%), Latin America and the Caribbean (0.26%) and the Middle East and North Africa (0.23%).

This larger population leads to an expansion of the labour supply, which increases overall economic output. By 2020, the global pool of labour is larger by more than 660,000 and by 2050 the labour pool grows beyond the *Base Case* forecast by nearly 11 million workers. As expected, the largest absolute increases occur in countries that experienced the largest declines in road traffic deaths as a result of the intervention. In 2050, the size of the labour force would expand by nearly 2.1 million in China, 1.7 million in India and 865,000 in Nigeria compared with the *Base Case*. In addition to the gains countries experience from an expanded labour supply, fewer life-years living with disability also increases overall productivity into 2050.

The modelled changes in traffic mortality patterns have minor impacts on other areas of human development as well. In the *Universal Reduction* scenario, the Human Development Index score increases by 0.15% in 2020 and 0.17% in 2050 compared with the *Base Case*. However, because more people survive traffic-related deaths, more die prematurely of other causes. Cumulatively, AIDS deaths increase by nearly 56,000 to 2050 (again, comparing the *Universal Reduction* with the *Base Case*), and increases are shown across many WHO Global Burden of Disease categories.

While there is intrinsic value in reducing traffic fatalities, there are also financial gains that accompany effective intervention. A study by Norton et al. (2006) estimated the regional costs of reducing DALYs stemming from traffic fatalities (Norton et al., 2006). These estimates ranged from $5 per DALY in South Asia on the low end to $169 in Latin America and the Caribbean on the high end.

The table below summarizes the cost and benefit of this very aggressive traffic fatality reduction scenario using the Norton et al. (2006) cost estimates for DALY reduction. The table multiplies the reported cost of averting a DALY against the total number of DALYs reduced cumulatively to 2050. This provides a total cost number in billions of US dollars. The fifth column reports the cumulative difference between the two scenarios for GDP at Market Exchange Rates, discounted at 3% annually.

While the economic benefits clearly outweigh the costs, the scenario itself is unrealistic. Using a brute force multiplier to reduce traffic fatalities by an even proportion across the world may be overstating what is actually possible, especially within the limited five-year time frame.

A second problem with the *Universal Reduction* scenario is that it suggests that countries at lower levels of development that are growing rapidly will be able to dramatically reduce fatalities. For example, this very aggressive scenario reduces Chinese road fatalities from 281,000 in 2015 to 158,000

[9]Based on WHO regional groups.

TABLE 1 Cost and benefits of reducing traffic fatalities to 2050

	Cost of Averting DALY[10] (discounted at 3%)	Reduction in DALYs (millions)	Total Cost (billions USD)	Total Increase in GDP (MER, billions, discounted at 3%)	Net Benefit (billions USD)
World	$169*	1,683	$284*	$4,040	$3,756
South Asia	$5	572.2	$2.861	$732	$729
Sub-Saharan Africa	$12	424.1	$5.089	$226	$221
East Asia & Pacific	$8	324.7	$2.598	$1,397	$1,394
Latin America & Caribbean	$169	128.5	$21.717	$449	$427
Middle East & North Africa	$53	119.3	$6.323	$178	$172
High-Income	$169*	58.19	$9.834*	$831	$821
Europe & Central Asia	$137	56.13	$7.69	$226	$218
OECD	*$169**	*76.03*	*$12.85**	*$911*	*$898*
Non-OECD	*$169**	*1,602*	*$271**	*$3,129*	*$2858*

by 2020. The *Base Case* forecast, on the other hand, expects an increase to 316,000 deaths by 2020. Reducing traffic fatalities requires resources to improve infrastructure and enhance legislation, and rapidly developing countries are not always well-equipped to make such interventions, especially given the lack of planning at a national level to meet this target by 2020.

An alternative approach considers country per capita income at purchasing power parity as a driver of target-setting. For this approach – one that we argue is more reasonable than universally equal rates of reductions – we first created a cross-sectional relationship with income and traffic fatalities and ran a simple logarithmic regression. Using 2010 values as our point of analysis, we estimated the relationship as follows:

$$\textit{Traffic Fatalities per One Thousand} = 0.198 - \textit{Log}\,(\textit{GDP per capita at PPP}) * .024$$

The full regression results can be found in Appendix 1.

We assume that countries that lie above the regression line are less effective at stopping traffic fatalities than countries below the line. We used this regression to construct two additional scenarios. The *Aggressive Relative Improvement* brings countries that are currently above the regression line down to the regression line over a 40-year period.[9] The *Reasonable Relative Improvement* scenario brings countries which are currently above the regression line down to the line over a 100-year period. The results of all three of these interventions are shown in Figure 3.

The *Aggressive Relative Improvement* forecasts a continued increase in traffic fatalities on a global basis to 2030 followed by a general reduction. The *Reasonable Relative Improvement* scenario shows growth in global traffic fatalities to mid-century.

[10]In the groupings that Norton did not include cost estimates for averting each DALY, we used the highest value estimate in the set ($169).

[11]Because of computational issues around setting the target to zero standard errors, the actual parameter used was -0.00001. The parameter in IFs uses to set the standard error target is *deathrpvsetar*. The parameter used to control the speed at which the target is approached is *deathrpvseyrtar*.

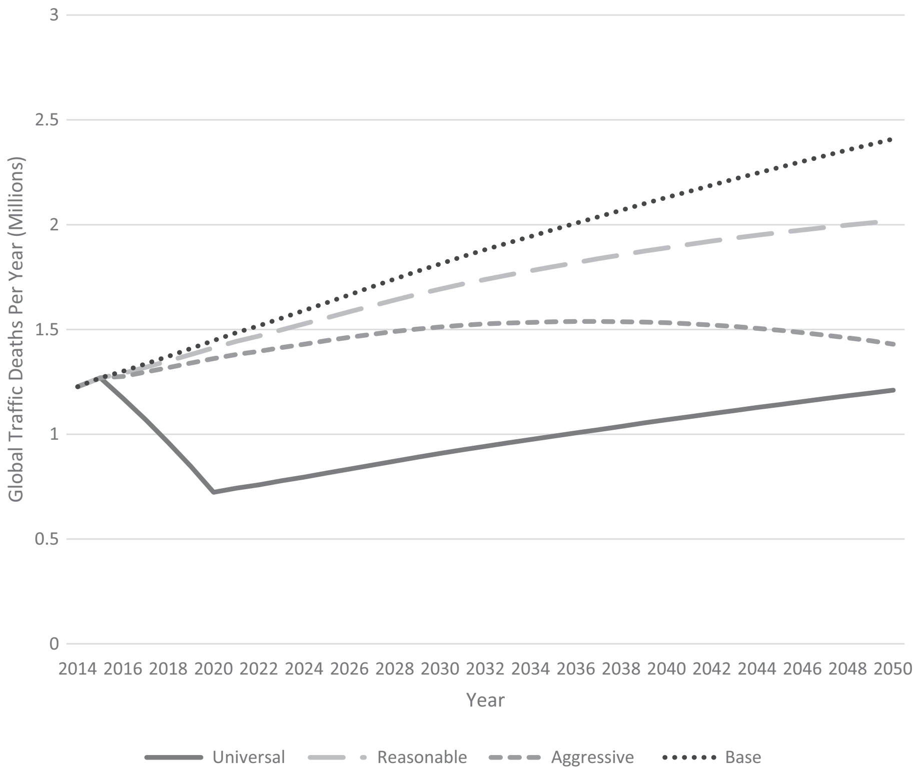

FIGURE 3 Global annual deaths (in millions) from traffic accidents for three reduction scenarios and the IFs Base Case to 2050 (Source: International Futures 7.22)

The *Aggressive Relative Improvement* scenario avoids 187,000 deaths to 2020 and nearly 15 million to 2050 when compared with the *Base Case*. The *Reasonable Relative Improvement* scenario avoids approximately 109,000 deaths to 2020 and close to 6 million to 2050 compared to the *Base Case*. Both of these scenarios lead to long-term expansions of the labour supply and improvements in relative productivity (though the changes are very small in magnitude). Overall, the global economy is larger in both of these alternative scenarios.

Table 2 below compares the economic output across the three alternative scenarios, relative to the *Base Case*, with the highest cost estimate suggested by the co-authors of the Commission for Road Safety's *Time for Action* report (Ward & Billingsley, 2011): $30,000 for each traffic death averted. To demonstrate how the effects of such interventions would vary across countries with different levels of development, we have broken down the global cost-benefit analyses according to the World Bank's four key income categories.

At a cost of $30,000 per death averted, each of the three scenarios proves cost-effective globally by 2050. In the *Reasonable Relative Improvement* scenario, the total intervention is estimated to cost roughly $178 billion, and based on the increases in GDP observed the net economic benefit is $262,100 in 2050. The *Aggressive Relative Improvement* scenario is considerably more expensive, at around $445 billion, but the economic gains of these interventions indicate that such an intervention would yield a net economic benefit of over $659 billion by 2050. The *Universal Reduction* scenario shows us that an outlay of almost $949 billion yields a return of almost $3.1 trillion by 2050.

When the analysis is broken down into the World Bank's income categories, however, the cost-effectiveness of high-cost interventions is lost on the poorest countries. As we mentioned earlier, the

TABLE 2 Monetary cost and monetary benefit of death reduction to 2050 across scenarios

	Reduction in Deaths (millions)	Cost of Reducing RTA Deaths (*millions*) *at* 30,000 per Death	Total Increase in GDP (MER, $ millions, discounted at 3%)	Net Benefit ($ millions)
Reasonable Relative Improvement	5.93	$177,900	$440,000	$262,100
High-Income	0.064	$1,920	$28,000	$26,080
High Mid-Income	1.395	$41,850	$217,000	$175,150
Low Mid-Income	3.437	$103,110	$182,000	$78,890
Low-Income	1.034	$31,020	$13,000	($18,020)
Aggressive Relative Improvement	14.82	$444,600	$1,104,000	$659,400
High-Income	0.161	$4,830	$70,000	$65,170
High Mid-Income	3.493	$104,790	$546,000	$441,210
Low Mid-Income	8.605	$258,150	$454,000	$195,850
Low-Income	2.565	$76,950	$33,000	($43,950)
Universal Reduction	31.63	$948,900	$4,040,000	$3,091,100
High-Income	2.303	$69,090	$1,029,000	$959,910
High Mid-Income	10.83	$324,900	$2,022,000	$1,697,100
Low Mid-Income	15.21	$456,300	$968,000	$511,700
Low-Income	3.288	$98,640	$22,000	($76,640)

Source: Ward and Billingsley, 2011; IFs 7.22

cost of reducing RTAs increases as countries implement the easiest and cheapest prevention mechanisms, and the cost of preventing a single traffic death can range from as low as $2,000 to over $30,000 depending on the country (Ward & Billingsley, 2011). So, while the high-cost interventions, such as highway redesigns, may be effective and necessary to avert death in higher income nations, in low-income countries a well-placed speed bump could significantly reduce the lethality of a particular stretch of roadway. Low-income countries, then, could potentially achieve the same absolute reductions – and long-term economic benefits – with interventions that cost closer to the $2,000 per death averted estimate. In fact, according to these scenarios, these countries could potentially spend more than $6,000 per death averted and still see a net benefit.

5 | DISCUSSION

The prevention of road traffic deaths has only recently gained the attention of politicians and policymakers. The efforts of the UN and WHO are helping to bring attention to the public health threat posed by traffic accidents, particularly in developing countries. The purpose of this study is to examine the potential benefits of making traffic death prevention a priority in all countries. By our calculations, the global cost of improving traffic results – even erring on the high end – is offset by the benefits in overall economic production. Those improvements in economic production eventually translate into greater human development across the globe.

We modelled both a universal intervention and a 'best practice' intervention. The universal interventions to halve road traffic deaths to 2020 – the position advocated by the UN – seems unreasonably aggressive. It would require radical rethinking about road traffic standards and a massive push by governments around the world – including those that have already achieved remarkably low fatality rates.

Instead, a 'best practice' targeting approach can be used to more efficiently target countries that are performing relatively poorly. This approach – the one advocated and modelled in the *Aggressive Relative Improvement* and the *Reasonable Relative Improvement* – targets those countries that are able to make simple, cost-effective interventions.

For instance, a country that has already seen the gains from these small interventions is Ghana, where the addition of speed bumps on one of the country's major highways helped to reduce the number of fatalities by more than 50% (Norton et al., 2006).

The benefit to societies from reducing the number of deaths from traffic accidents goes beyond the intrinsic value of saving human lives. The difficulty is in finding the necessary funds up-front to cover the cost of the physical and social interventions necessary to produce reductions like those in our analysis, since the positive returns to GDP take some time to accumulate. Investment now, however, was shown to yield significant economic benefits across a wide range of countries.

The gains in GDP observed in each of our alternative scenarios occur primarily as a result of the increased size of the labour force in individual countries. Simply put, reductions in traffic fatalities leave more people to continue working, producing and consuming goods and services. Further, there are some small gains from the decrease in the overall burden of disease.

6 | CONCLUSIONS

Reducing road traffic fatalities is not a panacea for human development. However, all signs point to such fatalities being a future burden of disease that will take a measurable toll on countries experiencing rapid development. The movement by international organizations to raise awareness and help countries develop concrete plans of action is a fundamentally important step in the process of road traffic death reduction. Governments now have an opportunity to improve infrastructure, governance and education around traffic norms. Meanwhile, both governments and the private sector may already have a near-term solution with continued development of self-driving car technologies. Barring a speedy adoption of these technologies, however, this analysis shows that reasonable investment to reduce RTAs up-front is likely to have far-reaching (positive) effects in many countries in the long term, and that such investments are likely to pay for themselves as the economic returns from effective intervention accumulate.

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APPENDIX 1

Dependent Variable = Death Rate for Traffic Accidents (2010) (None)

Independent1 Variable = GDP Per Capita PPP (2010) (Log)

Coefficient X1: Independent1 = -2.39825732142921E-02

Y-Intercept =.198044688192646

R-Square =.108054552351173

Adjusted R-Square =.103126676949799

F-Value =21.9272086954612

Probability of zero coefficients =5.54012010512956E-06

Standard Error of Y-Intercept =1.13023744865105E-02

Standard Error of X1: Independent1 =5.12158168705212E-03

Beta_of_X1: Independent1 = -.328716522783958

t-Value of Y-Intercept =17.5223965927704

t-Value of X1: Independent1 = -4.68264975152549

Prob of Y-Intercept =7.70712892485364E-41

Prob of X1: Independent1 =5.54012010512837E-06

Multiple R =.328716522783953

Standard Error of Estimate =8.99960847168777E-02

Dependent Variable Average =.155259200573461

Dependent Variable Standard Deviation =9.50294165097803E-02

Dependent Variable Coefficient of Variation =.612069469369817