ICoRSI

Independent Council for Road Safety International

International Symposium

# Road Safety Around the World: Future Concerns

19 March 2018

## Global road safety and future directions

Mark Stevenson, Kavi Bhalla and Christer Hyden

THE UNIVERSITY OF CHICAGO CENTER IN PARIS

***Acknowledgement***

ICoRSI has received support from:

*Institutional donors*:  Tata Education & Development Trust, Mawana Sugars, University of Chicago Center in Paris, Veolia

***Recommended citation***

Stevenson, M., Bhalla, K. & Hyden, C. (2018) Global road safety and future directions. In *Global Road Safety Issues: Discussion Papers.* Independent Council for Road Safety International*, www.icorsi.org/icorsi-pblications.*

***Declaration***

The papers included in this volume were prepared for discussion at the ICoRSI International Symposium *Road Safety Around the World: Future Concerns,* 19 March 2018, Paris. The papers may be published subsequently a different form.

# Global road safety and future directions

**Mark Stevenson, Kavi Bhalla and Christer Hyden**

## 1 INTRODUCTION

Significant reductions in road deaths have been observed across many high- and middle-income countries that have adopted comprehensive road safety strategies with measurable targets and government agencies responsible for achieving such targets. However, declines in road deaths have either stabilised or increased in many high- middle-income countries over the past 5-10 years highlighting the complex environment in which road safety is operating and the need to consider a broader more comprehensive systems-based approach if reductions in road deaths are to be observed over the ensuing years. This paper highlights the global approach to road safety since the mid-20th century and outlines the future direction for road safety, highlighting that the current framework adopted by many countries is not sufficient and outlines the need for road safety and urban and transport planning to be integrated to create safe and sustainable future transport systems.

Declines in the annual number of road deaths since 2000 have been evident across many high-income, highly motorised countries, as reported on an annual basis by the International Traffic Safety Data and Analysis Group (IRTAD, ITF/OECD). Importantly over this period, almost all countries experiencing these declines have implemented comprehensive road safety strategies with well-defined actions, built on over 6 decades of consolidated road safety approaches (Kahane, 2016).

The best performing countries, namely Sweden, the United Kingdom, and the Netherlands have achieved significant reductions in road deaths since the implementation of their road safety strategies, and have provided a rich source of inspiration, globally, for road safety professionals. The SUNflower Report, (Koornstra et al., 2002) investigated the road safety performance of Sweden, the United Kingdom and the Netherlands with a view to identifying the underlying success factors and country differences. The findings highlighted the risk per vehicle kilometre travelled was lowest on freeways/motorways in each country, the risk for private motor vehicle users was lower in the United Kingdom due, in part, to greater use of roundabouts at junctions, whilst the risk for cyclists in the Netherlands was lower due to the extensive implementation of cycling facilities. What the report did not take account of however, is the influence of urbanization levels and population demographics on road safety measures between jurisdictions. In fact, such features have been reported as potentially masking the effectiveness or ineffectiveness of certain policy schemes (O'Neill & Kyrychenko, 2006; Kahane, 2016). More recent research concurs with this, with a recent comparison of United States jurisdictions with other high-income countries concluding

> "…an apparent global similarity in traffic safety among jurisdictions with comparable economic, demographic, environmental and population density characteristics".
> (Kahane, 2016, p 5)

Despite the reported decline in the rate of road deaths between 2000 and 2015 across numerous high-income countries, many jurisdictions are observing a rise in deaths among vulnerable road users including cyclists, motorcyclists and pedestrians over the same time-period (WHO, 2015). Furthermore, Sweden, the United Kingdom, and the Netherlands have also observed recent increases in the rate of road deaths of 4%, 2% and 9%, respectively. Interestingly, these countries share similarities in terms of institutional arrangements, vehicle fleets and key strategies. These findings highlight that for many high-income and highly motorized countries, there is a growing change in motorization. For example, there is a growing use of public transport (Davis, Dutzik & Baxandall, 2012), reduced private motorization among those aged 18 to 25 years (Delbosc & Currie, 2013), increasing shared mobility, unprecedented urbanization, ageing road infrastructure, increasing vehicle autonomy and fiscal constraint with respect to investment in the road transport system. These are just some, of a myriad of elements, that effect either positively and/or negatively road safety in the 21st century. Importantly, what these road safety enablers or constraints highlight is the complex environment in which road safety is operating and the need to consider a broader more comprehensive systems-based approach if reductions in road deaths are to be observed over the ensuing years.

## 2 THE APPROACH TO ROAD SAFETY: 1970 ONWARDS

Since a broader more comprehensive systems-based approach is advocated to achieve future success in reducing global road deaths, it is pertinent to consider what approaches have been implemented over recent years.

Over the 20 years to 1970, road safety was poorly resourced and comprised isolated one-off interventions (Trinca et al.,1988), interventions that tended to be directed at the driver, pedestrians and children with an emphasis on policies focused on legislative rules and penalties along with social marketing focused on appropriate (and safe) driving behaviours (Bliss, 2004). Many campaigns to reduce road trauma target the driver despite the fact human error is a component cause of road trauma and not the sole or sufficient cause of road crashes. Consequently, blaming the driver (or other road users) for the crash has impeded progress and distracted the road agencies from embracing their responsibilities for a safer road transport system (Rumar, 1999).

*Many campaigns to reduce road trauma target the driver despite the fact human error is a component cause of road trauma and not the sole or sufficient cause of road crashes. Consequently, blaming the driver (or other road users) for the crash has impeded progress and distracted the road agencies from embracing their responsibilities for a safer road transport system.*

*Building on Haddon's approach, the 1990s could be considered an evidence-based period; a period where focused road safety plans were implemented and empirically measured outcomes sought and where road safety targets and ongoing evaluation of targeted interventions became mainstream.*

Through the 1970s and 1980s, road safety moved from a focus entirely on blaming the road user to one that could be considered the precursor to the late twentieth century 'safe-system' (Wegman & Aarts, 2006) or 'Vision Zero' (Business Sweden, 2013) approach namely, a prevention matrix described by William Haddon, an epidemiologist who at the time, headed the United States, National Highway Safety Bureau, (the predecessor to the National Highway Traffic Safety Administration (Haddon, 1968). Haddon's systematic framework for road safety was based on a public health model in which prevention efforts were considered across 3 elements namely human, vehicle and environment attributes (Haddon, 1968). Following a research focus on mitigating the exchange in kinetic energy generated by the vehicle in a crash, the prevention of road deaths and injury broadened to include policies that dealt with elements related to the driver in the pre-cash phase, in-crash protection (both for roadsides and vehicles) and post-crash care. For the first time, Haddon provided a response to road safety that applied a system-wide approach.

Although Haddon's approach to road safety profoundly influenced road safety practice in many motorised and rapidly motorising countries, a focus on the institutional management or governance requirements needed to deliver effective programs was implicit in Haddon's approach. Although a number of countries (including the United States) embraced the institutional management approach in the late 1960's and early 1970's, it was not until the 1990's that the approach was comprehensively addressed (Bliss, 2004, Bliss and Breen, 2009).

Building on Haddon's approach, the 1990s could be considered an evidence-based period; a period where focused road safety plans were implemented and empirically measured outcomes sought and where road safety targets and ongoing evaluation of targeted interventions became mainstream. Importantly, the evidence during this period highlighted the notion that increased motorisation did not confer increased road trauma but rather, with planned investment in the road network, reductions in road deaths and serious injury could be achieved. The United Kingdom, for example, halved its death rate (per 100,000 population) between 1972 and 1999 despite a doubling in motorised vehicles (Evans, 1999). What is evident from this period is the greater emphasis on institutional management with strong expressions of political will and institutional management functions (Trinca et al., 1988). The institutional management was linked to stronger leadership roles, enhanced coordination between government agencies and funding and resource allocation that was aligned to explicit road safety targets (Peden et al., 2004; Wegman & Aarts, 2006).

From the late 1990's and early 21st century, the systems approach (albeit an approach that promoted system-wide *interventions* across discrete pre-crash, crash and post-crash elements) was extended. The *Sustainable Safety* initiative promoted in The Netherlands (Wegman & Aarts, 2006) and the *Vision Zero* strategies in Sweden (Business Sweden, 2013), embraced systems-thinking (Cabrera & Cabrera, 2015) by setting ambitious goals to make the road system safer (Wegman & Elsenaar, 1997; Tingvall, 1995). The strengths of this approach are becoming increasingly evident in some jurisdictions. Although not dissimilar in approach to that espoused by Haddon in that it involves all elements of the road system, what is now referred to as the *Safe System* approach targets interventions that are significantly more ambitious. Nonetheless, as evident from Australia's description of the *Safe System* (see Figure 1 - taken from Australia's National Road Safety Strategy (Australian Transport Council, 2017)) the approach merely enhances what is known about road safety, and encourages the implementation of known and efficacious interventions to reduce the burden of road deaths and serious injuries. It does not for example include pedestrians and cyclists as active road users. Instead, it stipulates a speed threshold (30km/hr) in which no vehicle should collide with a pedestrian or cyclist. This continues to be a limitation of such approaches given few jurisdictions have delivered on such speed thresholds.

Moving to a *Safe System* approach also linked well to the global ambitions proposed under the United Nations Sustainable Development Goals (UN, 2015). As alluded to by Bliss and Breen (2009) "a *Safe System* is dedicated to the elimination of deaths and injuries that undermine the sustainability of road transport networks. The Safe System focus on safer and reduced speeds harmonises with other


**Figure 1. Safe System Approach as described in the Australian National Road Safety Strategy.**

efforts to reduce air pollution, greenhouse gases and energy consumption. As well, it prioritises protecting all road users with inclusion of vulnerable road users such as pedestrians, cyclists and motorcyclists" (p36).

*A Safe System is dedicated to the elimination of deaths and injuries that undermine the sustainability of road transport networks. The Safe System focus on safer and reduced speeds harmonises with other efforts to reduce air pollution, greenhouse gases and energy consumption.*

Notwithstanding the ambition of the Safe System approach, there is a tendency to focus on safe people, safe vehicles, safe roads and safe speeds thereby diverting attention away from the integration of these and importantly, the road network in its entirety. As well, continually focusing on achieving the short- to mid-term road safety targets (under the safe system approach) also inhibits innovation, to the extent that targets are bounded by what is deemed to be technically feasible and institutionally and politically manageable.

## 3 GLOBAL ROAD SAFETY PERFORMANCE

Since the 1970s there have been sustained efforts to reduce road deaths across many high-income countries and more recently, among low and middle-income countries (LMICs). In 2010 the United Nations General Assembly proclaimed the ten-year period 2011-2020 as the Decade of Action for Road Safety and set a target to "save 5 million lives and prevent 50 million serious injuries" (UN, 2010). Agencies, including the World Health Organisation (WHO), the World Bank, the Federation Internationale de l'Automobile and philanthropic foundations such as Bloomberg Philanthropies, have focused on supporting many LMICs over the period in identifying the limitations of current infrastructure and implementing known and efficacious interventions to reduce road deaths and serious injury. Given the efforts surrounding the Decade of Action for Road Safety, it is pertinent to assess whether there are observable reductions in road deaths, globally.

*Continually focusing on achieving the short- to mid-term road safety targets (under the safe system approach) it also inhibits innovation, to the extent that targets are bounded by what is deemed to be technically feasible and institutionally and politically manageable.*

The most robust global estimates of road deaths are collated by the Institute for Health Metrics Estimates - Global Burden of Disease study (IHME-GBD). Figure 2, Graphs A to D, highlight the annual number of road deaths by global region for the years 2000 to 2014. It is evident from Fig 2C that high income countries in North America, Western Europe, Australasia and the Asia-Pacific (namely, Japan and South Korea) have had declining road deaths since 2000, albeit rather stable for Australasia. Similarly, Eastern Europe (Fig 2A) and Central Europe (Fig 2B) have observed declines in road deaths from 2006 onwards. Most other regions highlighted in Fig 2A-C have relatively stable trends or rising trends. Overall, there was a decline in global road deaths (see Fig 2D) from 2006 which continued through to 2012; a gradual increase in road deaths has been observed thereafter.

*Given the efforts surrounding the Decade of Action for Road Safety, it is pertinent to assess whether there are observable reductions in road deaths, globally.*

The notable exception in trends of road death is in South Asia where road deaths have continued to increase over the 14 years (Fig 2A). Although there has been a decline in road deaths since 2006, the global trend in road deaths is influenced by East Asia which is represented, predominantly, by China; China accounts

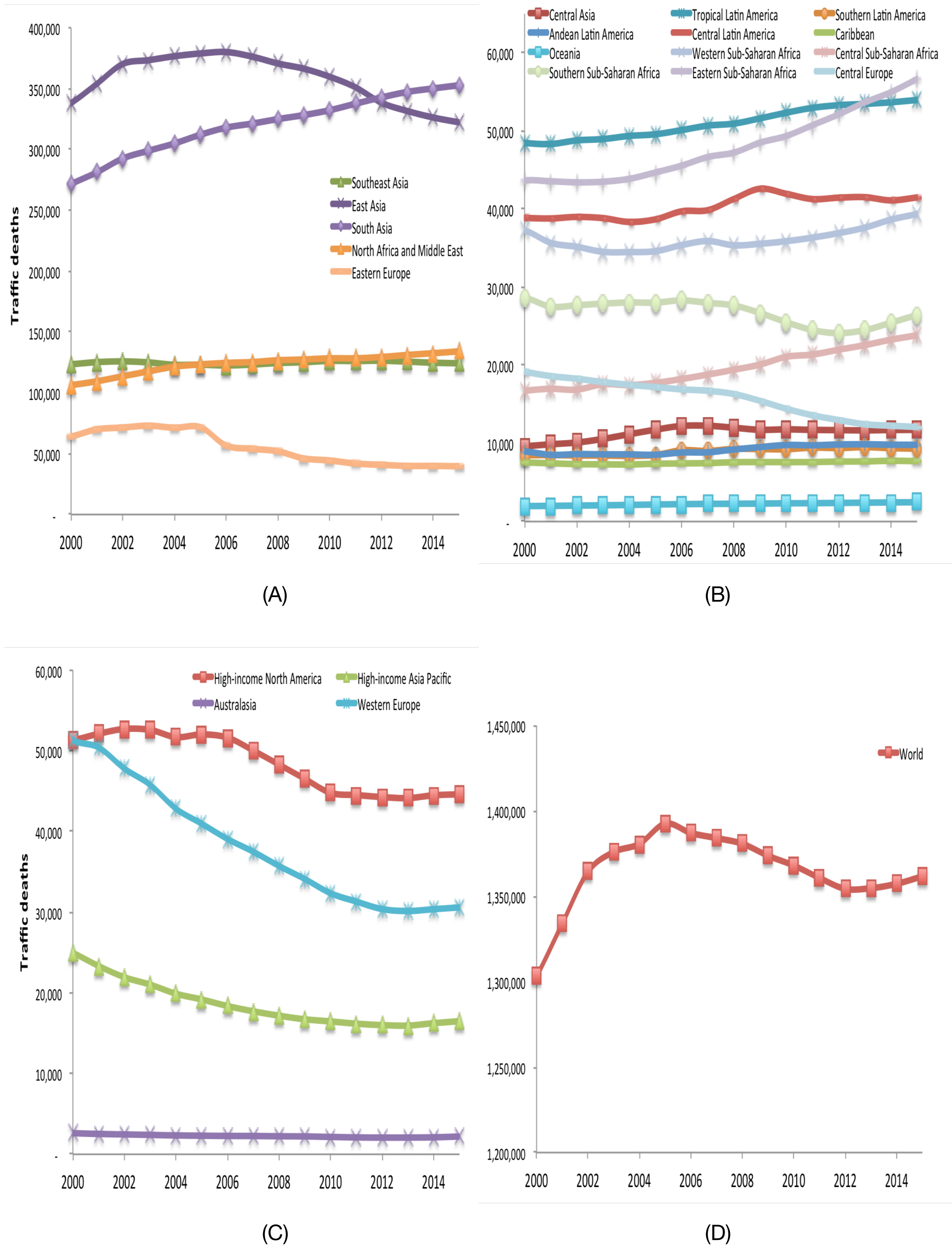


**Figure 2. IHME-GBD estimates of road traffic deaths for (A) GBD regions – 1, (B), GBD regions – 2, (C), GBD - 3 regions, and (D) World. [Source: GBD 2015].**

for approximately 25% of global road deaths. Consequently, we compared 3 independent data sources of road death estimates for China namely, the IHME-GBD, the WHO-Global Health Estimates (GBE) (WHO, 2014) and road traffic statistics compiled by the police.

*The global estimates of road death point to declining road deaths across many Organization for Economic Cooperation and Development (OECD) countries either from 2000 or from 2006, highlighting that declines in road death pre-date the recent global road safety activity spearheaded under the Decade of Action for Road Safety.*

Fig 3 illustrates the uncertainty in the China estimates with estimates from the IHME-GBD and the GBE approximately five times those reported by the country's official road traffic statistics reported by the police. Importantly, the IHME-GBD estimates are substantively different from those reported by the GHE although both the IHME-GBD and the GHE estimates have substantial uncertainty (i.e. wide 95% CI)

The global estimates of road death point to declining road deaths across many Organization for Economic Cooperation and Development (OECD) countries either from 2000 or from 2006, highlighting that declines in road death pre-date the recent global road safety activity spearheaded under the Decade of Action for Road Safety. Further, the estimates of road deaths obtained from the IHME-GBD suggest there is no reason to believe that trends in road deaths have changed in other regions because of interventions in recent years. China, because of its large contribution to global road deaths, influences the global estimates. Although the estimates reported here suggest road deaths have declined in China, there is significant uncertainty surrounding the estimates for China as highlighted above. In relation to LMIC, the trend in road deaths over the 14-year period has remained the same.

*The estimates of road deaths obtained from the IHME-GBD suggest there is no reason to believe that trends in road deaths have changed in other regions because of interventions in recent years.*

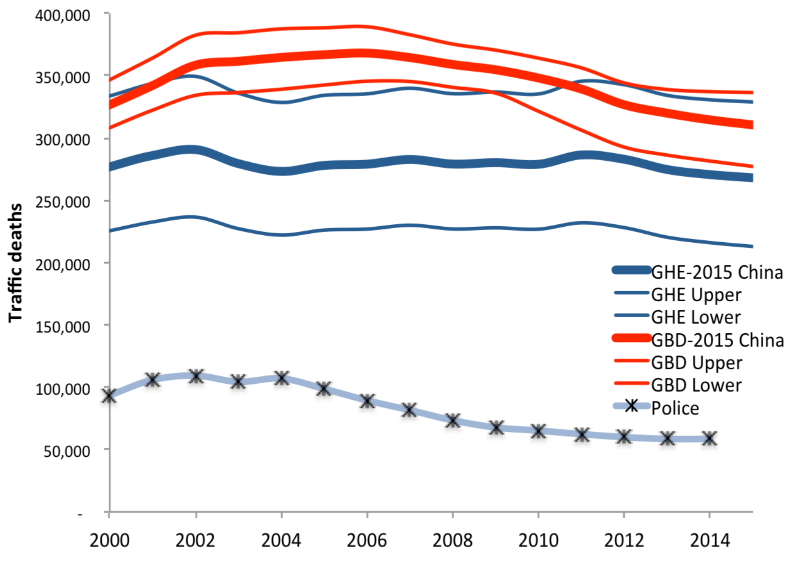


**Figure 3. Official statistics (police data) compared with GBD and GHE estimates of road traffic deaths in China (and associated 95% CI).**

## 4 FUTURE DIRECTIONS IN ROAD SAFETY

Globally, substantial change in population demographics is afoot with 65% of the world's population estimated to live in cities by 2050 (UN, 2014). This unprecedented urbanisation will significantly impact a country's infrastructure particularly its transport system and will create significant uncertainty surrounding the structure and design of future transport systems and how best to safely operate them.

Such challenges are not insurmountable. Considerable safety benefits can be achieved by integrating road safety within the entire transport system. For example, Stevenson et al. (2016) assessed a modal shift from private motor vehicle use toward alternative modes of transport that included a mix of public transport, cycling and walking highlighting the net safety benefit generated when public transport is the primary recipient of vehicle kilometre travelled (VKT) transfer from private motor vehicles. For example, Malaysia has estimated that the introduction of 2 rapid transit lines in Kuala Lumpur will achieve modal shifts away from private motor vehicle VKT to public transport, substantial reductions in road deaths and serious injuries per year and other co-benefits in relation to health and the environment (Kwan, et al., 2017). The net safety benefit associated with a modal shift toward walking and cycling is more complex as advocating for greater cycling and walking in most countries means moving populations to a mode of transport associated with greater risk of injury per vehicle kilometre travelled. Consequently, there is an urgency to deliver safe, separated infrastructure and for some jurisdictions this is a considerable challenge. For example, Stevenson et al (2016) estimated that cities such as Melbourne, Boston, and London would need large investment in separated pedestrian and cycling infrastructure (equivalent to approximately 40%, 30%, and 35% of total pedestrian and cycling VKT, respectively) to minimise the likelihood of increased pedestrian and cyclist deaths associated with a modal shift to active transport.

Opportunities evolving from information and communication technologies (ICT) applied to urban transport systems have the potential to also deliver important road safety outcomes. There have been considerable advances in intelligent transport systems (ITS) over the past decade. Many extensive evaluations of in-vehicle technologies have been trialled with considerable benefits being reported (Anderson et al., 2011, RTA, 2011). Most of these relate to safety gains achieved from in-vehicle system technologies associated with forward collision detection and crash avoidance. These include emergency brake assist, city-safe low speed obstacle detection, autonomous braking and adaptive cruise control; with estimates of a 20-40% reduction in fatal crashes once technologies are realized throughout the vehicle fleet (Anderson et al., 2011).

The introduction of in-vehicle telematics is a technology that also holds considerable promise with respect to reducing road deaths and serious injury. In-vehicle telematics enables drivers, insurers or employers (in relation to commercial vehicles) to collect safety-specific information on a driver's on-the-road behaviour and performance (Horrey et al, 2012). For example, drivers receive direct feedback regarding their driving in relation to attributes such as speed relative to speed zone, driving times, distance travelled, crash events and near miss events. In-vehicle telematics technology will also enable large-scale data collection of driving behaviours as the in-vehicle device records driving behaviours of the corresponding driver using GPS information. The device records GPS information frequently, from which acceleration and deceleration can be derived. Furthermore, speeding can be identified from telematics data by mapping actual speeds recorded by the device to speed limits based on the current GPS location, thereby providing insight in relation to actual speeds across the entire road network. In-vehicle telematics will not only provide valuable feedback to the driver but it is also a revolutionary way to manage speed across the network thereby providing an approach beyond current police enforcement practices.

Dedicated short range communication technologies (DSRC) will lead to significant advances in the transport system in the foreseeable future. With DSRC, information is exchanged between neighbouring vehicles (Vehicle-2-Vehicle: V2V), between vehicles and the infrastructure (Vehicle-to-Infrastructure: V2I) and between vehicles and any object that may affect a vehicle

(Vehicle-to-Everything: V2X). The accumulation of this information provides several opportunities for improved transport system management including, real-time traffic management for emergency vehicles, or the provision of priority road corridors for heavy vehicles enabling safer and more efficient freight corridors. Similar to in-vehicle technologies, V2V and V2I technology have numerous safety applications. The US Department of Transportation estimates V2V technologies could successfully address 80% of unimpaired crash scenarios alone (US Dept. of Transport, 2010) Importantly, measureable road safety gains can be achieved with as few as 5%-10% of cars using the DSRC technologies (US Dept. of Transport, 2010).

*While the technology is racing ahead, our understanding of advanced automated systems and their likely impact on behaviour is not keeping pace. The rapid introduction of advanced automation has the potential to increase the likelihood of road deaths and injury during the transition period.*

A key disruptive technology is autonomous vehicles that will fundamentally change the transportation system over the next two decades (Luettel, Himmelsbach, & Wuensche, 2012). Extending DSRC technologies to full autonomy is already revolutionising the 21st century transport system with different levels of autonomy being deployed by major car companies.  Globally, large information technology and automotive companies are investing in technologies that will transform our current transport system. This will require vehicles and people to adapt to a vast range of situations, from coordination of driver operated vehicles that must adhere to an array of existing transport policies, to a more distant future incorporating full automation of all vehicles where policies and protocols governing the operation of vehicles will no longer require regulation of driver behaviour; this alone will have significant road safety implications.

*There is scant research given to how autonomous vehicles will interact with non-motorized road users namely, cyclists, pedestrians and importantly, to what extent automation will influence the transport system across many LMIC in which motorcyclists and tuk-tuks are the predominant people carriers.*

The shift toward full automation is occurring within already complex and poorly understood road systems (Salmon & Lenne, 2015). Added to already intractable issues such as speeding and driver distraction, the time between now and fully automated driving will see new emergent driving behaviours, new interactions between drivers and technologies, and ultimately, new variants of road traffic crashes. While the technology is racing ahead, our understanding of advanced automated systems and their likely impact on behaviour is not keeping pace (Banks & Stanton, 2016). The rapid introduction of advanced automation has the potential to increase the likelihood of road deaths and injury during the transition period; a period of up to 15 years in which the majority of vehicles on the road network move from the current state of predominantly non autonomous (Level 0), where the driver is in control of all aspects of the driving task, to full automation (Level 5), where the vehicle is completely in control of the driving task and the driver is not required to monitor the system or roadway (Luettel, Himmelsbach, & Wuensche, 2014). Also, there is scant research given to how autonomous vehicles will interact with non-motorized road users, namely cyclists and pedestrians, and importantly, to what extent automation will influence the transport system across many LMIC in which motorcyclists and tuk-tuks are the predominant people carriers.

*Considerable safety benefits can be achieved by integrating road safety within the entire transport system.*

Despite the current level of investment by individual technology developers, there is limited preparation across many transport agencies, internationally, with respect to the effect of autonomous vehicles. For example, without appropriate policy and legislation there will be negative impacts around issues such as crash culpability in the event of system failures. Hence, there is considerable urgency for road safety research that provides insight on how best to proactively manage the problems of automation before they emerge.

The ability to reduce road trauma and maintain a level of equilibrium with respect to the rates of road deaths and serious injury, particularly across many OECD countries, has relied on governments regulating road user behaviours and prioritising measurable (and accountable) road safety targets. Road safety governance and management have been critical throughout the latter stages of the 20th Century in relation to road safety. However, in an ever-increasing neoliberal environment, government agencies are tending to broker voluntary agreements, at least with manufacturers, to ensure technological solutions reach the consumer rather than establish regulation to force manufacturers to comply. This is a changing landscape with respect to governance and one that points to reduced government influence over the road transport network with unknown implications with respect to road safety.

# 5 SUMMARY

Although current approaches to road safety have contributed to declines in road deaths in high-income countries, the extent to which these approaches continue to deliver reductions and the utility of these approaches to LMIC settings is contestable. The current Safe System approach lacks integration across the entire transport system (including all transport modes) along with other urban systems such as housing, education, and health. It continues to focus attention on tangible short- to mid-term safety targets which tend to silo the safety response to one government portfolio, thereby reducing the likelihood of a comprehensive systems-focused approach to delivering road safety. Further, the urgency to deliver measurable outputs inhibits innovative solutions being sought at a time when the digital revolution provides new opportunities to deliver road safety.

Considerable safety benefits can be achieved by integrating road safety within the entire transport system. As highlighted earlier, transport policies that embrace new urban mobility namely policies that incentivise walking, cycling (on infrastructure separated from motorized vehicles), and public transport and, at the same time, no longer subsidise private motor vehicle use (European Commission [EC], 2011) have the potential to deliver safe and sustainable transport. However, to achieve the road safety gains needed to meet the targets set by the UN Decade for Road Safety, it will be necessary to understand the role of urban planning in reducing road deaths and serious injury. This does not imply studying master urban plans implemented across many European cities but importantly, observing 'natural' case studies from LMICs; countries bereft of urban planning approaches that have been implemented across numerous European, North American and Australasian cities. For example, in Delhi, India, where urban plans were either seldom implemented or not implemented in their entirety, a polycentric city has organically evolved (Mohan, 2016) comprising a city with significant levels of active and public transport use (Stevenson et al., 2016), and a city of short distances (minimal VKT) in part, because low-income residents are residing in informal settlements close to their place of work. Cities such as Delhi that continue to invest in 'cleaner' public transport, comprise of shorter commuter distances (albeit due to unplanned circumstances) and continues to operate a multi-modal transport system are well placed to transition to more sustainable transport solutions.

With the introduction of autonomous vehicles across the road network, a new 'operating system' is being introduced into a vast, well-established, and heavily regulated transport system. This innovation may be as disruptive as the invention of cars themselves. Such a change requires detailed research on the likely implications not only with respect to safety but across an array of disciplines including urban design, law, ethics, and public health so that unintended consequences (such as road trauma arising during the rapid motorization period) can be avoided.

## REFERENCES


Anderson, R.W.G., Hutchinson, T.P., Linke, B., & Ponte, G. (2011). *Analysis of crash data to estimate the benefits of emerging vehicle technology* [Report No. CASR094]. Adelaide, South Australia: Centre for Automobile Safety Research, The University of Adelaide. Retrieved from: http://casr.adelaide.edu.au/publications/researchreports

Banks, V. A., & Stanton, N. A. (2016). Hands and feet free driving: ready or not? In G. Di Bucchianico, A. Vallicelli, N.A. Stanton & S.J. Landry (eds.), *Human Factors in Transportation: Social and Technological Evolution Across Maritime, Road, Rail, and Aviation Domains*, (pp.213-223). Boca Raton, Florida: CRC Press.

Bliss, T. (2004). *Implementing the Recommendations of the World Report on Road Traffic Injury Prevention* [Transport Note No. TN-1]. Washington DC: World Bank.

Bliss T & Breen J (2009). *Implementing the Recommendations of the World Report on Road Traffic Injury Prevention. Country guidelines for the Conduct of Road Safety Management Capacity Reviews and the Specification of Lead Agency Reforms, Investment Strategies and Safe System Projects,* World Bank Global Road Safety Facility, Washington DC.

Business Sweden – The Swedish Trade and Invest Council. (n.d.). *Vision Zero Initiative*. Retrieved from: http://www.visionzeroinitiative.com/ [cited 20th March 2013].

Cabrera, D. & Cabrera, L. (2015) *Systems Thinking Made Simple: New Hope for Solving Wicked Problems*. Ithaca, NY: Odyssean Press.

Davis, B., Dutzik, T., & Baxandall, P. (2012). *Transportation and the new generation: Why young people are driving less and what it means for transportation policy*. Santa Barbara, CA: Frontier Group.

Delbosc, A., & Currie, G. (2013). Causes of youth licensing decline: a synthesis of evidence. *Transport Reviews*, *33*(3), 271-290.

Evans, L. (1999). Transportation Safety. In R. W. Hall (Ed.), *Handbook of Transportation Science* (pp. 63-108). Boston, MA: Springer US.

European Commission (EC). (2011). *White Paper: Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system* [COM/2011/0144 final]. Brussels, Belgium: Author.

Haddon Jr, W. (1968). The changing approach to the epidemiology, prevention, and amelioration of trauma: the transition to approaches etiologically rather than descriptively based. *American Journal of Public Health and the Nation's Health*, *58*(8), 1431-1438.

Horrey WJ, Lesch MF, Dainoff MJ, Robertson MM, Noy YI (2012). On-board safety monitoring systems for driving: review, knowledge gaps and framework. *Journal of Safety Research*, 43: 49-58.

Kahane, C.J. (2016). *Comparison of 2013 VMT fatality rates in U.S. States and in high-income countries*. (Report No. DOT HS 812 340). Washington DC: National Highway Traffic Safety Administration.

Koornstra, M., Lynam, D., Nilsson G., Noordzij, P., Petterson, H.E., Wegman, F., & Wouters P. (2002). *SUNflower: a comparative study of the development of road safety in Sweden, the United Kingdom, and the Netherlands.* Leidschendam, Netherlands: SWOV Institute for Road Safety Research.

Kwan SC, Tainio M, Woodcock J, Sutan R, Hashim JH. (2017). The carbon savings and health co-benefits from the introduction of mass rapid transit system in Greater Kuala Lumpur, Malaysia. Journal of Transport and Health. https://doi.org/10.1016/j.jth.2017.06.006

Luettel, T., Himmelsbach, M., & Wuensche, H.J. (2012). Autonomous ground vehicles—Concepts and a path to the future. *Proceedings of the IEEE, 100*(Special Centennial Issue), 1831-1839.

Mohan D. (2016) Cities for Healthy People. *IIC Quarterly*, *43*(3 & 4), 77-87.

O'Neill, B. & Kyrychenko, S.Y. (2006). Use and misuse of motor-vehicle crash death rates in assessing highway-safety performance. *Traffic Injury Prevention, 7*(4), 307-318.

Peden, M., Scurfield, R., Sleet, D., Mohan, D., Hyder, A., Jarawan, E., & Mathers, C. (2004). *World Report on Road Traffic Injury Prevention*. Geneva, Switzerland: World Health Organization.

Road and Traffic Authority [RTA] (2011). *Results of the New South Wales Intelligent Speed Adaptation (ISA) Trial* (RTA/Pub 11.049). Sydney, Australia: RTA, New South Wales Centre for Road Safety.

Rumar, K. (1999). *Transport safety visions, targets and strategies: beyond 2000*. 1st European Transport Safety Lecture. Brussels, Belgium: European Transport Safety Council. Retrieved from: http://www.etsc.be/documents/etsl1.pdf

Salmon, P. M., & Lenné, M. G. (2015). Miles away or just around the corner? Systems thinking in road safety research and practice. *Accident; analysis and prevention*, *74*: 243-249.

Stevenson, M., Thompson, J., de Sá, T. H., Ewing, R., Mohan, D., McClure, R., Roberts, I., Tiwari, G., Giles-Corti, B., Xiaoduan, S., Wallace, M., & Woodcock, J. (2016). Land use, transport, and population health: estimating the health benefits of compact cities. *The Lancet*, *388*(10062), 2925-2935.

Tingvall, C. (1995). The Zero Vision. In: H. van Holst, A. Nygren, & R. Thord (eds.). *Transportation, traffic safety and health: the new mobility. Proceedings of the 1st International Conference [Gothenburg, Sweden].* Berlin, Germany: Springer-Verlag.

Trinca, G., Johnston, I., Campbell, B., Haight, F., Knight P., Mackay, M., McLean, J. & Petrucelli, E. (1988). *Reducing Traffic Injury: a Global Challenge*. Melbourne, Australia: Royal Australasian College of Surgeons.

United Nations (UN). (2010). *Resolution adopted by the General Assembly on 2nd of March 2010 64/255. Improving global road safety.* [A/RES/64/255]. New York, NY: Author.

United Nations (UN). (2015). *Transforming our world: The 2030 agenda for sustainable development* [A/RES/70/1]. New York, NY: Author.

U.S. Department of Transport. (2010). *Frequency of target crashes for intellidrive safety systems* [Report No. DOT HS 811 381]. Cambridge, MA: National Highway Traffic Safety Administration [NHTSA].

Wegman, F., & Aarts, L. (2006). *Advancing Sustainable Safety*. Leischendam, Netherlands: SWOV Institute for Road Safety Research.

Wegman, F., & Elsenaar, P. (1997). *Sustainable solutions to improve road safety in the Netherlands.* Leischendam, Netherlands: SWOV Institute for Road Safety Research.

World Health Organization. (2015). *Global status report on road safety 2015*. Geneva, Switzerland: Author.

World Health Organization. (2014). *Global health estimates: Deaths by cause, age, sex and country*, *2000-2012*. Geneva, Switzerland: Author.

ICoRSI

Independent Council for Road Safety International

www.icorsi.org

## Support

Tata Education and Development Trust

THE UNIVERSITY OF CHICAGO CENTER IN PARIS

MAWANA SUGARS

VEOLIA