A toolkit for saving lives

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Unless dramatic action is taken, it is projected that by 2030 road traffic injuries will become the fifth leading cause of death globally. Each day, around 3500 people are killed on the world's roads, with many of those being children. In Vietnam, for example, children aged 0-9 years are most likely to be killed as pedestrians, while those aged 10-14 are most likely to die while riding a bicycle. Adolescents aged 15-19 are most likely to be killed while riding a motorcycle [1].

Thankfully, global momentum for safety is building. This year marks the beginning of the United Nations Decade of Action for Road Safety, setting an ambitious target of halving the growth in deaths by 2020. To achieve that, though, there will need to be major ramping-up efforts. It won't be easy. One of the major stumbling blocks is simply finding the resources and expertise to make it happen – a particular concern for low- and middle-income countries where 9 out of 10 of the world's road deaths occur.

Tools for safer roads

The *Road safety toolkit* is available at http://toolkit.irap.org (see Figure 1). It is designed to help address the need – as

Figure 1. A screenshot from the Road safety toolkit

identified by the World Health Organization's 2004 *World report on traffic injury prevention* and the World Bank's 2009 study on implementing the world report – for resources and tools that target initiatives on a scale capable of reducing significantly and sustainably the global road death toll.

An initiative of the International Road Assessment Programme (iRAP), the toolkit has been supported by the Global Transport Knowledge Partnership, the World Bank Global Road Safety Facility and Australia's ARRB Group. It builds upon a concept first put into practice by the Australian road authorities (through Austroads). It is a comprehensive and easy-to-use resource that helps engineers, policy-makers and safety practitioners from around the world find the best and most affordable countermeasures to reduce casualties.

A major strength of the toolkit is that it is freely available to all via the internet and is a 'living document' that can be updated as the knowledge base improves. In creating the toolkit, the partners were conscious that the situation can be dramatically different from country to country, and that there is a need for more research and case studies from low- and middle-income countries.

Nevertheless, as the Transport Research Laboratory (TRL) [2] stated in 1991, many of the principles underpinning road safety engineering planning and design are to some extent universal. For example, from time to time we all make mistakes or poor judgements when using the road. Similarly, people around the world are more or less equally vulnerable to high-energy impacts. Road systems, wherever they are, can be made safe by keeping these principles in mind.

By sharing the best information, all countries can learn from successes and avoid mistakes of the past. For each treatment, an estimate of the reduction in casualty crashes is provided, based on research from around the world. For example, after reviewing studies from Sweden, Denmark, the UK, New Zealand and the USA, Elvik et al. [3] estimated that by increasing the radius of a curve from 400-600m to 600-1000m, the number of crashes declines by 23%. It is important to note that crash-reduction estimates are generally not cumulative, and are often comparable between treatments. This is because different treatments get used in different circumstances.

Drawing on the information contained in the toolkit, in no particular order, the following provides 10 ways that death and serious injury can be prevented around the world.

Create space for two-wheelers

Motorcyclists and cyclists are arguably the most vulnerable people using the roads, mixing with heavier, faster-moving traffic, travelling at relatively high speeds and lacking the physical protection of vehicle occupants. In many regions, such as South-East Asia, motorcycles are a popular form of transport as they are relatively cheap, so motorcyclists subsequently make up a large proportion of deaths. But even in areas where motorcycles are not so popular, casualties can form a big part of the crash problem. In Australia, the death rate per 10,000 vehicles is 4.5 times higher for motorcycles than it is for all vehicles.

In Malaysia – where around 60% of vehicles are motorcycles – world-leading efforts have been made to safely cater for motorcyclists. There, 'inclusive' and 'exclusive' lanes (see Figure 2) have been used to cut casualty crashes by 25% to 40% at medium cost.

Figure 2. An exclusive motorcycle lane in Malaysia (Photo courtesy of Raymond Teoh Joo Han, JKJR, Malaysia)

Malaysia built the world's first exclusive lane in the 1970s as part of a World Bank project. The lanes use a carriageway that is completely separate from that used by other vehicles. A review of the lanes found a 39% reduction in motorcycle crashes as a result of fewer conflicts between motorcycles and other vehicles, as well as a lower speed differential between vehicles.

Malaysia has also made wide use of non-exclusive motorcycle lanes. They are built along trunk roads where access to and from the lanes is not controlled. Road signs and central hatching are used to indicate that motorcycle lanes are installed, to help riders understand the intended usage.

For bicyclists, dedicated lanes can be made by allocating part of a road to bicycles or by building off-road paths. On-road bicycle lanes should be located on the outer edge of the road surface and are usually between 1.5m and 3m wide. If traffic speeds or volumes are high, wider lanes are needed, to allow more space between through traffic and bicycles. Off-road paths are safer than on-road lanes, and can be used as part of on-road lanes to bypass road sections where mixing vehicles and bicycles is unsafe.

Get helmets on heads

There are enormous safety benefits associated with helmet use. But the WHO reports that just four in 10 countries have a motorcycle helmet law that covers both rider and passengers, and mandates that helmets meet a national or international standard. [4]

The best strategies legislate compulsory helmet wearing for all riders (including pillion passengers) and promote improvements in the quality of helmets sold through the enforcement of standards. Similar to seatbelt wearing, helmet legislation needs to be supported by education and rigorous enforcement.

In Khon Kaen, Thailand, for instance, helmet-wearing rates were once low and the mortality rate in motorcycle crashes extremely high. When the government introduced helmet-wearing legislation combined with public education and police enforcement, within 12 months it led to a helmet-wearing rate of over 90%, a reduction of 40% in head injury and a reduction of 24% in mortality in motorcycle crashes.

In addition to helmets, protective clothing is also essential if serious injuries are to be minimised. Even in a relatively low-speed motorcycle crash, abrasion is common and can be severe. Hands and feet are particularly vulnerable, and both abrasion and fractures of the lower body and legs are very common, followed by injury to the upper body and arms.

Protective clothing protects against abrasion, reduces the risk of burns from contact with hot metal, and prevents or reduces the severity of some fractures. It also lowers the risk of infection from dirt entering wounds. However, protective clothing is typically not worn by motorcyclists in developing countries, which is more than likely influenced by cost and also perceptions of discomfort due to the local climate. Bright and/or reflective material also assists other road users to notice cyclists and motorcyclists.

As the cost of protective clothing is considerably higher than helmets, clothing campaigns naturally take a lower priority in low-income countries. However, in countries with greater helmet-wearing rates, public education campaigns on protective clothing would be valuable.

Buckle up

One of the most effective ways to prevent injury or death in a crash is to make sure everyone in the vehicles is using seatbelts. A seatbelt can reduce the likelihood of adults dying in a crash by up to 50%, yet the WHO reports that only about half (57%) of all countries require seatbelts to be used by passengers [4].

The 'Por amor' campaign in Costa Rica is a key example of how seatbelt-wearing rates can be vastly improved by combining legislation and penalties, standards and regulations for equipment, enforcement of legal requirements, and publicity campaigns and incentives. From autumn 2003 until summer 2004, the FIA Foundation supported a nationwide campaign to promote seatbelt wearing in conjunction with the Costa Rican Ministry for Transport, the National Road Safety Council, the National Insurance Institute and the Costa Rican Automobile Club.

The campaign was a pilot project based on the principles of best practice developed in the FIA Foundation seatbelt toolkit, which was prepared by TRL and is especially targeted at emerging countries. In the 1990s, compulsory seatbelt legislation was challenged by a group of radical libertarians and the law was overturned. Seatbelt-wearing rates fell to 24%. The main aim of the campaign was to reinstate a seatbelt law, an objective that was achieved in May 2004 when new legislation once again made seatbelt use compulsory for front and back seat car occupants. The target was to achieve a seatbelt wearing rate of 70%. A national survey from August 2003 confirmed that this had been exceeded and seatbelt-wearing rates for drivers went from 24% to 82%.

Build pedestrian crossings and footpaths

Pedestrians are among the most vulnerable of road users. According to the WHO, they account for a significant proportion of deaths in many countries, such as in Kenya, where pedestrians make up 47% of those killed on the roads, while in Chile the figure is 40% and in Bangladesh 54%. [4] They are vulnerable in almost every situation: walking into the path of a vehicle (especially while trying to cross roads), walking along the roadside or on the road, playing or working on the road, boarding or leaving public transport vehicles, and even while standing or walking on footpaths.

A multitude of infrastructure treatments can help pedestrians to cross roads safely. The most recognisable is the unsignalised crossing (or zebra crossing), which consists of signs and painted road markings. The intention is that pedestrians have right of way over vehicles, and where this is the case, zebra crossings have been shown to prevent 25-50% of casualty crashes at a low to medium cost.

However, these benefits are significantly reduced in many regions where drivers simply do not stop for pedestrians, so efforts are needed to improve education and enforcement.

Various other safety devices can be included at crossings, such as refuge islands (see Figure 3), advanced warning signs and pavement markings, street lighting and flashing lights. Grade-separated crossings are the top of the range, and can prevent 60% of casualty crashes, although they are relatively expensive. An issue that planners need to be aware of, though, is that pedestrians will only use crossing facilities located at – or very near to – where they want to cross.

Figure 3. A pedestrian refuge island in Ghana (Photo courtesy of John Fletcher, TRL)

Similar to grade-separated crossings, footpaths reduce crash risk by physically separating pedestrians from fast-moving traffic. In fact, it is estimated that, at low to medium cost, they can prevent casualty crashes by 10-25%.

In urban areas, raised footways are frequently a standard part of the road cross-section, although obstructions (e.g., parked cars) almost as frequently force pedestrians to walk on the road. Unfortunately, in rural areas, footways are often not provided, even where pedestrian volumes are high, such as in East Africa. Here, a footpath may be as simple as a wide flat road shoulder and can be made cheaply by using a grader to flatten and clear one, or ideally both, sides of the road.

Improve intersections

Intersection crashes are one of the most common types of crash problem, particularly in urban areas. In rural areas or where speeds are high, the consequence of collisions at intersections can be particularly severe. There are a number of causes of these crashes – for instance, inadequate sight distance to oncoming vehicles, high approach speeds, or lack of intersection visibility.

One of the more popular intersection treatments is the roundabout. These can be reasonably expensive to build (in the medium to high range), but the costs are invariably outweighed by the savings associated with crash reductions. Roundabouts can cut casualty crashes by up to 70% in rural areas and 55% in urban areas.

The secret to a safe roundabout is its geometric design. Curves on the approaches require all vehicles to slow down before entering. The centre island layout ensures that traffic moves in a one-way direction and that slow speeds are maintained around it and at exits. Drivers approaching need to reduce their speeds, look for potential conflicts with vehicles already in the roundabout and be prepared to stop. Once in the roundabout, drivers should not need to stop and can proceed to their exit, so right-angle, left-turn (or right turn) and head-on collisions are virtually eliminated.

Alternative intersection improvements include better delineation, signalisation, turn lanes and grade separation.

Tackle crashes head-on

Head-on crashes are generally the most severe of all vehicle crash types, and are more likely to occur at bends and where overtaking demand is high. Road shoulders can have a significant influence on the risk of head-on crashes occurring. When a driver has accidentally travelled onto the edge of the road, the risk of crashing will be reduced if the vehicle can either stop on the shoulder or steer the vehicle back onto the road at a shallow angle, reducing the chances that the driver will 'overcorrect' and travel into oncoming traffic. It is estimated that sealed shoulders can cut casualty crashes by 25-40%, at a medium to high cost. However, shoulders should not be too wide, otherwise drivers may use them as an additional lane.

Edge lines can be improved at the time of upgrading the shoulder to further reduce risk. Median barriers generally do not help reduce the risk of a crash occurring, but they can dramatically reduce the severity of a crash. That noted, experience in some countries has shown that the visual narrowing caused by a median barrier can result in slower and more careful driving.

Median barriers (see Figure 4) prevent deaths and injuries by physically separating opposing traffic streams and helping to stop vehicles from travelling into opposing traffic lanes. They are often built on the centre of wide urban multilane roads where they can be used to stop pedestrians crossing at unsafe places. Median barriers can also be used to limit turning options for vehicles and shift these movements to safer locations. It is estimated that median barriers can reduce casualty crashes by 40-60%, often at high cost.

Figure 4. An example of the Coast Road median barrier in New Zealand (Photo courtesy of the New Zealand Transport Agency)

Like roadside safety barriers, median barriers can come in many shapes and forms. The decision about what type of barrier to be used should be based on several factors, including traffic volume, speed, vehicle mix, median width, the number of lanes, road alignment, crash history, and installation and maintenance costs.

Make roadsides forgiving

'Run off road' crashes are common, especially in high-speed areas. They occur at bends and on straight sections of road, and in high-speed environments they can have severe consequences, particularly if a fixed object is hit (for example, a tree or pole), or there is a steep embankment or cliff.

One of the most effective means of reducing risk is making the roadsides 'forgiving'. The concept of 'forgiving' roadsides is by no means new – Robert Baker's 1975 *Handbook of highway engineering* [5] made the point that they are a necessity for safety. Unfortunately, roadsides are still a tremendous problem 35 years later.

Roadside safety barriers are designed to absorb the impact of the crash so that injuries are minimised. There are three main types of barrier. Flexible barriers are often made from wire rope strung between removable posts, and they are the best option for minimising injuries to vehicle occupants. Semi-rigid barriers are usually made from steel beams, which deflect less than flexible barriers and so can be located closer to the hazard when space is limited. Rigid barriers are usually made of concrete and do not deflect, so these should be used only where there is no room for deflection of a semi-rigid or flexible barrier.

Much of the benefit from the use of barriers comes from a reduction in crash severity. Although a crash may still occur, it is likely to have a safer consequence than colliding with the object that the barrier is protecting. Barriers can reduce casualty crashes by around 25-50%, at a medium cost.

Unfortunately, poorly designed barriers can be hazardous. End points of barriers can act like a knife that is able to slice through any car that strikes it. Poorly planned barriers can obstruct pedestrians, forcing them to more risky alternative crossing points. Barriers can also be complemented with treatments that help drivers stay on the road (e.g., advanced information about curves), alert them that they are leaving the road (e.g., rumble strips), and improve the chance of recovering control if a vehicle does leave the road (e.g., shoulder treatments) or reduce the severity of the outcome (e.g., clear zones and crash barriers).

Manage speed

Speed management is fundamental to road safety and is recognised by the international community as a key risk factor. Research shows that the chances of avoiding serious injury or death reduce dramatically above 50km/h (31mph) for side impacts at intersections for the most modern types of cars, and are far less for older vehicles and, particularly, for vulnerable road users. Furthermore, even in the most modern cars, the chances of surviving a head-on crash at speeds above 70km/h (43mph) are greatly reduced. The chances of a pedestrian surviving an impact with a motorised vehicle reduce dramatically above 30km/h (19mph), and even at lower speeds than this, serious harm can be caused [6].

According to the WHO, the global response to managing speed has been poor, with only 29% of countries reportedly meeting basic criteria for reducing speed in urban areas, and less than one in 10 countries having effective enforcement in place [4]. Infrastructure can be effective in reducing speeds when used as part of an area-wide scheme rather than in isolation. Low-profile raised structures on the road (such as speed humps) slow drivers down, especially in urban areas at locations where there are likely to be pedestrians.

Gateways or threshold treatments are used to mark a change in speed environment, including the transition from a high-speed road to a lower-speed environment, such as a village. Gateway treatments usually include road markings to narrow the perceived width of road, large speed limit signs, and pavement markings and other features (such as traffic islands and landscaping) to indicate that a threshold is being crossed. As drivers tend to travel faster on wider roads (possibly because they perceive less risk of running into roadside objects), narrower roads in urban areas tend to slow traffic. Even narrowing the perceived lane width using painted markings can achieve moderately slower speeds.

Overall, it is estimated that these treatments can cut casualty crashes by 40-60%, often at low cost. It is also clear that a program of safety engineering improvements will be more effective if it is complemented with speed enforcement. The experience of high-income countries shows that rules will only be obeyed if people believe that not obeying them will result in unwanted outcomes such as fines or licence cancellation. The perceived likelihood of being caught and penalised for disobeying rules must be high for enforcement to work.

The police responsible for enforcing the rules must be trained and given the tools (e.g., speed detection and alcohol-testing equipment) to do their job properly, and a system should be created to ensure that fines are not taken by officials for themselves.

It is generally accepted that enforcement influences driving behaviour via two processes. General deterrence occurs when road users obey rules because they perceive a high risk of being detected and punished if they do not. Specific deterrence occurs when someone who has broken the rules is punished and stops the unlawful behaviour as a result.

Reduce drunk driving

Drunk driving is acknowledged internationally as a key road safety risk factor. Research shows that at a blood alcohol content (BAC) of 0.15 grams per decilitire, a driver's risk of crashing is over 20 times that of a driver who has a BAC of zero [4].

In most high-income countries, about 20% of drivers killed in crashes have illegally high levels of alcohol in their blood, and in low- and middle-income countries, research has shown that between 30% and 70% of drivers killed consumed alcohol before the crash [4]. Even though nine out of 10 countries have some kind of national drunk-driving law, only about half stipulate a legal limit of less than or equal to 0.05 grams per decilitire.

An effective strategy for reducing alcohol-related crashes will include several components. In general, a law that defines an upper legal BAC limit is required so that police can enforce laws against drunk driving. Most countries have adopted a BAC limit of either 0.05 or 0.08 grams per 100ml of blood. The European Commission recommends a limit of 0.05 for all drivers and 0.02 for novice and professional drivers.

Having sufficient enforcement activities – such as providing police with powers to stop and test motorists at the roadside, random breath testing and compulsory testing of all drivers involved in a crash – is useful to show drivers that they are likely to be caught if they disobey BAC laws. Penalties are also important in discouraging drunk driving.

Having designated drivers is useful for young people who often share a vehicle and can take it in turns to be the non-drinker. Ride service programs also provide transport for people who have consumed alcohol and may otherwise drive. An alcohol ignition interlock can also be fitted to vehicles. This technology is being used successfully in some developed countries to stop repeat drunk-driving offenders.

Require safe vehicles

In high-income countries vehicle safety has improved dramatically, but low- and middle-income countries lag behind. A first step to allow for catch-up is to ensure that all vehicles meet a minimum set of safety standards to be driven legally. Many countries also require that vehicles are tested by inspectors at regular intervals to make sure that they continue to meet these standards. Motor vehicle standards cover requirements such as controls, displays, rear view mirrors, the order of gear-shifting and brake systems. Additionally, they cover headlamps, brake lights, indicators (turning signals), reversing lights, tyre and tyre rim standards, safety glass, seatbelts (and anchoring them correctly), noise and smoke/gas emissions.

Standards also go beyond what is required to make a vehicle safe to drive. For example, many countries have minimum standards of crashworthiness, including aspects such as how resistant the vehicle is to having its roof crushed, whether the side is able to resist side impact and the quality of the safety glass.

Crashworthiness programs – including the consumer-based NCAP – have helped drive the inclusion of more advanced safety features. Such safety features are varied. Airbags and their placement can range from only in the dashboard to the knee well, the door pillar and curtain airbags (an airbag that inflates and covers the side windows). Head protection comes in the form of soft materials in headrests and vehicle side pillars. Adjustable mirrors help the driver monitor what is happening and make it safer to change lanes if they are correctly adjusted. Anti-lock brakes can automatically prevent locking brakes and the resultant skidding in a braking emergency, while traction control is used to stop the wheels spinning or slipping if the driver applies too much power.

Electronic stability control works alongside anti-lock brakes and is designed to help the driver keep control of the vehicle (usually in emergency situations) to stop it spinning out of control. This technology in particular has been found to be very effective in reducing deaths, and will be compulsory in new vehicles in some countries in the near future.

Minimising vehicle defects is also important. Research in developed countries suggests that vehicle defects cause about 3-5% of crashes, and it is likely that the figures are much higher in low- and middle-income countries as the vehicle fleet is likely to be older and less well maintained [7]. This is especially true of heavy vehicles, which are used to move freight and passengers.

Although research in developed countries has not shown that regular vehicle inspections by trained authorities significantly reduces injury crashes, it is a useful tool when starting a nationwide program to improve road and vehicle safety, because it removes dangerous vehicles from the road (or allows time to repair them) and makes sure that the vehicles that are on the road have a suitable level of safe roadworthiness.

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iRAP Malaysia training course: Decade of Action for Road Safety

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Abstract

The International Road Assessment Program (iRAP) is a not-for-profit organisation that works in partnership with governments and non-government organisations in all parts of the world to make roads safe. The iRAP Malaysia pilot study on 3700km of road identified the potential to prevent 31,800 deaths and serious injuries over the next 20 years from proven engineering improvements. To help ensure the iRAP data and results are available to planners and engineers, iRAP, together with staff from the Centre for Accident Research and Road Safety – Queensland (CARRS-Q) and the Malaysian Institute of Road Safety Research (MIROS), developed a five-day iRAP training course that covers the background, theory and practical application of iRAP protocols, with a special focus on Malaysian case studies. Funding was provided by a competitive grant from the Australia-Malaysia Institute.

Introduction

The International Road Assessment Program (iRAP) is a not-for-profit organisation that works in partnership with