Road Traffic Crashes and Effective Countermeasures

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Introduction

There are many risk reduction strategies available for dealing with the problem of road traffic crashes and injuries. While such strategies may have the general aim of preventing crashes and/or injury, it is more constructive to regard the objective of road safety countermeasures as being to minimise the consequences of crashes. This allows many more options to be considered.

There are also many classification systems which can be used to categorise the factors leading to crashes and injuries for the purpose of analysis or discussion, eg primary, secondary and tertiary prevention, or, the Haddon matrix of human, vehicle and environment, which can be applied to each of the pre-crash, crash and post-crash phases. Using such a matrix, it is possible to target reduction in the number of crashes and/or their severity and/or minimise the severity of injury and/or improve the outcome of injury, all of which lessen the consequences of crashes. The consequences might be measured in terms of numbers and types of injuries, their severity in relation to costs and/or long term disability outcomes.

Another approach to the classification of strategies or programs is to group them according to their broad target areas (Trinca et al, 1988):

- Exposure control, eg, encouraging lower risk modes of travel, eg, use of larger rather than smaller cars, older rather than younger drivers, public rather than private transport, etc.

- Behaviour change, ie, encouraging use of seat belts, modification of drink and driving behaviour.

- Crash prevention, ie, road and traffic engineering measures, eg median barriers, traffic signals.

- Injury control, ie, modifying the severity of injuries from a given impact, eg seat belts, air bags, frangible lighting poles etc.

- Post-injury management, ie, the provision of "best practice" medical care directed at improving outcomes from a given injury.

- Road safety program organisation and management, eg, coordinating more effectively the activities of the agencies with responsibility for road safety, targeting particular population groups effectively.

Much of the following discussion is based on the arguments in 'Reducing Traffic Injury - the Global Challenge' by Trinca and colleagues (1988).

Exposure control

One method of reducing the consequences of crashes is to reduce the total risk of collisions by reducing the total amount of travel. Through appropriate planning of land use and the transport system of a region it is possible to minimise the amount of travel in the community, and to make provisions which encourage the use of low risk modes of transport over high risk modes. Reducing travel is an aspect of transport policy which should be considered at each stage of development. Encouraging lower risk over higher risk forms of transport, eg, encouraging

public transport, discouraging motorcycles, limiting the exposure of younger drivers are all options available in the appropriate circumstances.

Financial controls such as taxation or other charges can be used to bring about changes in the required direction. The effect of a tax on fuel is a good example of the consequences of such a policy. In the USA, low fuel taxes and cheap fuel has lead to the development of larger vehicles with large motors and high fuel consumption. In Europe, high fuel taxes have lead to the development of smaller vehicles with small, efficient engines and low fuel consumption. Larger vehicles have been found to be associated with fewer injuries than small vehicles, leading to a trade-off between fuel economy and the risk of injury.

Other measures can be used to control exposure, eg, in Beijing very high registration charges have been placed on motorcycles, so that there are relatively few in in use in that city. The government of Kiribati, in the Pacific, has prohibited the importing of motorcycles with a capacity greater than 125 cc. Both of these measures are in recognition of the much higher risk of involvement in a crash, and the much greater risk of injury once involved, of motorcycles and their riders.

Limiting modes of transport leads to a conflict between the freedom of movement or action of an individual and the greater good of the community. As examples are the requirement for car occupants to wear seat belts, or for motor cyclists to wear helmets. Other examples are the limits on age for drinking alcohol, the blood alcohol concentration limits of zero or 0.02 gm% for probationary licences, or curfews on night driving which have been suggested for those under 21 years.

In each case, the community has decided that the benefits outweigh the limiting, in a minor way, of the freedom of the individual. Communities every where accept, to a greater or lesser extent, speed limits which are imposed on the grounds of limiting travel at higher speeds with the accompanying greater risk of injury.

Medical fitness to drive

The health sector has a role in determining the fitness to drive of persons with medical conditions which are considered to have a higher risk of crash involvement. There are a wide range of problems where the ability to drive may be compromised, eg, poor peripheral vision, cardiovascular problems, neurological problems such as epilepsy, or stroke, cognitive problems, eg, dementia, musculo-skeletal problems, eg, arthritis, amputation, limitations in cervical spine mobility and also, alcohol problems.

Studies of the role of medical conditions in crashes are few. Grattan and Jeffcoate (1968) in the United Kingdom and Ysander (1970) in Sweden, estimated that about 1 to 2 in 1000 police reported injury crashes were due to an illness or medical condition in the driver. Ryan et al (1978) in a case control study of crashes to which an ambulance was called in Melbourne, found that the controls had a higher incidence of self-reported medical conditions than the crash-involved drivers, possibly because they were younger. Ysander (1970) made a similar observation. Waller (1965) found in California that drivers with chronic medical conditions had higher crash involvement rates. In another study, commercial truck drivers with sleep disordered breathing were found to have higher crash involvement rates (Stoohs, Guilleminault, Itoi and Dement, 1994), as had older drivers with cardiac conditions, diabetes, and other medical conditions (Foley, Wallace, Eberhard, 1995; Koepsell, Wolf, McCloskey et al, 1994).

The question of assessing fitness to drive, of evaluating a person's ability to drive 'safely' is not easy. While, at a commonsense level, it is obvious that there is a minimum level of visual function, muscular strength, range of movement of joints, and level of mental functioning required to drive a vehicle safely, when any of these requirements are examined closely, there

is very little objective evidence available to provide anything but the most general guidelines. The minimum requirements of the driving task have not been defined in sufficient detail against which it might be possible to measure the ability of a person with a medical problem. In the absence of objective measures, a series of general guidelines have arisen which provide guidance for medical practitioners faced with the problem of giving an opinion on a person's fitness to drive. A good example is the set of guidelines for commercial drivers recently produced in Australia for the National Road Transport Commission, by the Faculty of Occupational Medicine of the Royal Australasian College of Physicians (Piterman and Hocking, 1994). This document acknowledges the limitations in the available knowledge and provides 'best practice' guidelines.

There is a general deterioration in function with age, which accelerates above about age 75 years, reflected in an increasing rate of crash involvement, particularly in females (Cooper, 1990). In response to this evidence, some jurisdictions require testing at intervals to determine fitness to drive for persons above some arbitrary age. Because some people retain their driving abilities much longer and to a much greater extent than others, the placing of limitations on driving for older drivers should not be based on chronological age, but on a test of driving ability. The driving test should include passing through intersections and a turn across oncoming traffic, both situations where older drivers have difficulty as shown by increased crash involvement.

Ball et al (1993) showed that useful field of view was a very good predictor of crash involvement, independent of age and mental status. The majority of the elderly stop driving themselves, but a minority have no insight into their failing abilities and require other measures (Persson 1993, Campbell, Bush, Hale 1993). There are conflicts between individual freedom and mobility and the public good, particularly for the elderly, who may depend on the car for social interactions and daily necessities.

In a related situation, it has been shown that persons with brain damage should have a multi-disciplinary assessment which includes a medical assessment, a neuropsychological assessment, and an on-road test of driving (Fox, Bashford, Caust 1992).

Surveys in the United Kingdom have shown that doctors have little knowledge of their responsibilities and of what is required in determining fitness to drive for different conditions (King, Benbow, Barrett 1992; Nouri 1988; Fisher, Storer, Frier, 1985). This raises doubts as to the extent of implementation of any published guidelines.

Although medical conditions are a factor in relatively few injury producing crashes there is obviously potential for improving our ability to define what are hazardous characteristics for a whole range of medical conditions which may potentially affect the performance of the driving task. There is also potential to improve the precision of the judgements and evaluations of fitness to drive, and to evaluate the effects of these actions.

Crash Prevention

Within the area of crash prevention are two broad domains, road engineering and vehicle engineering.

Road engineering

A basic necessity for safe transport of people and goods is an adequate road system. Within the road system, the design, construction, and maintenance of roads influence the level of safety achieved in operation. Appropriate standards have been developed and documented over a great number of years in every motorised country. However the rate of change of road infrastructure is much slower than the demographic changes that may be occurring in a particular country. It takes a long time to build, or up-grade a road network in response to

population changes or changes in land use brought about by new developments. Any deficiencies built into the network or particular locations are likely to be felt for many years.

Compare the grid of streets in Adelaide with its multitude of four-way intersections, each with many conflict points, and the street layout in Canberra, which was designed to minimise conflicts between pedestrians and pedal cyclists and motorised traffic. This has produced a layout which appears to have a minimum of conflict points for traffic, but which is notoriously confusing for visitors.

Freeway standard roads have the lowest crash rates, because traffic streams are separated, there are no sharp corners, there is room to overtake easily, and the opportunities for conflicts are minimised. They are also very expensive, so there is a trade off between safety and expense.

Separation of traffic streams spatially, as in divided roads, or pedestrian footpaths, or, bicycle paths, or in time, as with traffic signals, are very effective in reducing conflicts and potential crashes. The identification of locations with an excess number of crashes ('black spots') and their subsequent treatment or modification has been shown to be very effective in producing a marked and lasting effect on the crash rate at the improved sites.

Vehicle engineering

In contrast with roads, vehicle design and manufacture is a function of private enterprise, with governments setting standards for safety performance. The design and operating characteristics of vehicles are international rather than local issues as motor vehicles are designed and built on a global basis. However, in-service condition is a national or local responsibility. In less developed countries, 'mechanical illiteracy' is a problem, with vehicles being used inappropriately, being badly maintained, and badly repaired. It is probable that in these circumstances that vehicle defects may become an important factor in crash causation. This is

unlike the situation in motorised countries where vehicle defects play a very small role in crashes (Ryan et al, 1978).

The minimum requirement for vehicles is that they should be able to be easily seen by day and by night, and that the driver should have an adequate range of vision out of the vehicle. The vehicle should also be able to stop rapidly in an emergency situation. Observation would suggest that these characteristics are not always attained in some countries in the world.

Recent developments in vehicle guidance and collision avoidance systems have made use of electronic 'intelligent' systems to assist the driver in detecting potentially dangerous situations. However, for the foreseeable future, the human driver will have to make do with his senses and natural abilities in coping with the deficiencies in the road system and his vehicle in avoiding disaster on the road.

Behaviour change

The initial programs in this area arose from the simplistic view that 'bad' behaviour 'causes' crashes, and therefore it is necessary to improve the behaviour of the 'bad' driver. However, with the recognition that multiple factors are involved in the web of causation that leads to a crash, and with the application of the appropriate educational concepts it has been possible to define the characteristics which will enhance the likelihood that a program to change behaviour will be successful. Behavioural programs are more likely to be successful if they have a realistic goal, and they are aimed at an identifiable segment of the population, which has an identifiable problem which can be affected by education. Successful programs have used threats such as loss of driving licence, or rewards, such as for wearing a seat belt (Trinca et al, 1988).

Driver Education

Despite their intuitive appeal, driver education programs have not been shown to decrease the rate of involvement in crashes of the participants (Horneman, 1993). This is true in motorised countries where there is already a high level of knowledge of required road behaviour. In countries with a low level of motorisation this may not by true, and there may be some advantage to be derived from widespread driver education. All road users, drivers, pedal cyclists and pedestrians, should at the minimum, have knowledge of the rules of the road and of road signs.

The law

Use of the law is often regarded as the major weapon in dealing with problems of road and traffic safety. Traffic laws aim to control behaviours and punish activities which are regarded as anti-social or lead to collisions. However a law must be accepted by the majority of the population to .be effective in controlling behaviour. There must be also the necessary infrastructure for effective enforcement. The presence of a law on the statute books, of itself, will not bring about change unless it is felt to be fair and appropriate, and there is adequate enforcement.

The combination of an education program, closely linked to an accompanying enforcement program has been found to be very effective in the control of drink-driving in Victoria(Newstead et al, 1995). In this state, a well-organised and intensive campaign of random stopping of vehicles and breath testing the drivers, in combination with an intensive educational campaign on television, radio and the newspapers, has had a marked effect on drinking and driving behaviour. Similarly, intensive use of speed cameras and mass media has produced marked reductions in speeding in drivers in Melbourne in particular. In developing these programs the behaviours to be affected were identified, and were under the direct control

of the driver; the target audience was specified, and the specific message clearly identified, using knowledge of the local situation and culture. The television advertisements used became well known for their realism. The media and the enforcement campaigns were planned jointly by the agencies concerned.

The private sector

In the private sector, the managers of fleets of vehicles have the opportunity to influence driver behaviour because they can control the selection and training of drivers, and apply discipline through the application of sanctions. The effectiveness of their control programs can also be measured by keeping the appropriate record systems.

Health Promotion

In health care settings, the use of child restraints, helmets, or seat belts, can be encouraged through the techniques of health promotion and health education. These interventions will re-inforce, and be re-inforced by other community education programs on eg, restraint use, drink driving, or speeding, particularly if they are accompanied by feed-back to the community of relevant information on crashes and injuries and their relation to the behaviours being modified, as has been demonstrated in Sweden (Ytterstad, Wasmuth 1995).

Health personnel have an opportunity during personal consultations with clients and patients to provide information and influence behaviour. In North America, a variety of interventions based on family or specialist practice have proved effective in increasing observed seat belt and child restraint wearing rates (Hempel 1992, Gordon 1989, Macknin, Gustafson, Crossman 1987) and bicycle helmet wearing rates (Labrecque, Dostaler et al, 1994, Cushman, Down et al 1991)

Although these interventions have been shown to be effective, surveys in North America have shown that relatively few specialist or general physicians used the opportunity of consultation in any systematic way for appropriate counselling (More, McCance, Smith 1991; Lewis, Clancy, Leake, Schwartz 1991; Mullen, Gottlieb, Biddle et al, 1988) Pre-natal education classes (Goodson, Buller, Goodson 1985) and the time of discharge from a paediatric or obstetric hospital provide an opportunity to encourage the use of infant and child restraints among parents (Decker, Bolton Dewey et al 1988).

Seeking medical care following injury also provides a setting for counselling, which in Finland, has been shown to be effective in modifying alcohol consumption among drivers who were heavy drinkers (Antti-Poika, Karaharju, Roine, Salaspuro 1988)

Injury control

The intention in this broad strategic area is reduce the severity of injury occurring during an impact. This is a function of the design and construction of vehicles and of the road side environment.

Vehicle design

Vehicle design for injury reduction is carried out on an international basis. Europe, North America, Australia and Japan all have vehicle standards that are directed at reducing the severity of injury suffered by vehicle occupants in an impact. The occupant space is designed to maintain its integrity in an impact, thus preserving space for the occupant's survival. The interior of the vehicle, ie the doors, instrument panel, glass, steering wheel and column, seats and restraint systems are designed to minimise injury to the occupants. The test procedures involve impact testing of the whole or part of the vehicle, at a velocity equivalent to 48 km/h. The standards required reflect the level of knowledge of twenty or more years ago, due to the

complexities and inertia involved in standard setting on a national and international scale. A program of testing whole cars at impact velocity above that required by the standard has promoted improvement in vehicle crash performance in the USA and in Australia. (Griffiths et al, 1994)

Attention is also being paid to the exterior of the vehicle in terms of impacts with pedestrians and pedal cyclists. Changes to vehicle exterior brought about by the search for aerodynamic efficiency have changed patterns of injury to pedestrians, reducing pelvic injury, with head injury being unchanged. Impacts between cars and pedestrians and bicyclists are relatively more frequent in the less motorised, and in the rapidly motorising countries. In these countries, collisions between pedestrians and buses and trucks are very frequent, and therefore consideration should be given to making the fronts of these vehicles 'pedestrian friendly'.

The health sector can play a very important part in recording accurately the position and nature of injuries received by persons injured in collisions, and by recording accurately their road user type and seated position. This information is invaluable in monitoring and evaluating the performance of vehicles in actual crashes, as compared with laboratory testing using dummies.

Road environment

Collision with roadside objects is a source of injury in a substantial number of crashes. These objects include bridge piers and abutments, retaining walls, embankments and ditches. Other, manmade, features include signs and their supporting structures, poles supporting power lines and street lights. Natural objects include trees and rocks. Design standards for roads include a provision for a cleared area either side of the roadway to provide space for the motorist to recover in the event of leaving the road of any reason. Frangible poles, fences or barriers that deflect vehicles can be used to reduce the severity of the

injury. Again, accurate record keeping of injury information will aid the evaluation of the performance of these roadside objects.

While most of the road side environment is the responsibility of the road agency, power poles and telephone poles are owned by agencies which often have no interest in safety, even though their poles may be a significant source of injury and damage. Measures such as placing power lines underground have significant safety implications as well as aesthetic advantages. This may not be recognised, as the costs and the savings are borne by different agencies.

Post Injury Management

In motorised countries, injuries from road traffic crashes consume about 10% of hospital resources, excluding rehabilitation and long term care, and the costs of long term disability (Trinca et al, 1988). In turn the costs of medical care make up about 10% of total crash costs.

About 50% of those who die from road traffic crashes, do so in the first 15 minutes from injuries to the brain, heart and large blood vessels. A further 35% die in the next one to two hours of head and chest injuries, and 15% die over the next 30 days from sepsis and organ failure (Trunkey, 1987). The time between injury and initial stabilisation is the single most important factor in patient survival (Moylan et al, 1988).

Estimates of the potential number of lives that could be saved by improved emergency services vary widely, from 1% in Sweden (Ottoson and Krantz, 1984) to 5% in Philadelphia (Fitts et al, 1964), 11% in rural New South Wales (Papadimitriou, Mathur and Hill, 1994) and 23% in Vermont (Perrine et al, 1971). These estimates depend heavily on assumptions made with regard to availability of particular levels of care and their effectiveness, as well as on the methods of evaluation employed and the level of services available in the region under study. Consideration of survival times in those dying, and the distribution of response times of the

ambulance service, suggested that less than 5% of deaths could be affected by improvements to the ambulance service in the United Kingdom (Ruffel Smith, 1970) and in Australia (Clark et al, 1971).

The above estimates apply to motorised countries, where there are well-organised emergency ambulance services and hospital systems, and where the potential for improvement lies in the second and third phases, that is after the first 15 minutes. In less developed countries the situation may well be different. The crowded streets of cities of the region may well prevent an ambulance service delivering an injured person to a hospital faster than the current ad hoc transport system, but the standard of care to the airways and control of haemorrhage would be higher. However, since the emergency departments of hospitals are often lacking in resources to provide effective care, there may be more potential for improvement in upgrading hospital resources rather than investing in the development of an emergency ambulance service which may just move the location of death from outside to inside the hospital.

An effective emergency medical service system should cover pre-hospital and in-hospital care. It should have:

- An effective notification and communication network.
- Central control and command of the activities of the service.
- Effective transport vehicles.
- A system of training and evaluation of staff performance.
- Clear and appropriate documentation of the operations and care provided.

There are two schools of thought in the provision of emergency care. One approach is to provide first aid and emergency care at the scene of the incident and then carry the injured to hospital as fast as possible. This approach is taken in Australia, New Zealand and the United Kingdom. The second approach is to carry the skilled care to the scene and there provide

appropriate treatment, as in France, Russia and Germany. Unfortunately, there is no evidence to show that one approach has better results than the other.

It has been recognised that there can be a discontinuity in the flow of information and care at the door of the emergency department (Ryan, 1974). This led to the development of systems of review of trauma management within hospitals (Deane et al, 1988; Alberts, Brismar and Nygren, 1993; Demetriades et al, 1995) and within regions (Cales, 1984). Improvements in hospital care, the use of a systematic approach, categorisation of hospitals into levels of trauma capability, and regionalisation of emergency care have been shown to contribute to decreases in preventable trauma deaths (Cales and Trunkey, 1985; Reines et al, 1988).

The potential of changes to rehabilitation and long term care to improve outcomes is still being investigated, particularly for conditions like brain injury where the consequences can be profound.

Organisation and Management

A recent review of road safety programs and their organisation and management in several states of Australia found that it was important that there was effective coordination between agencies with responsibilities in delivering programs (Ryan and Hendrie, 1995). Since multiple factors operate in the causation of road traffic crashes, multiple disciplines are involved in effective countermeasures, and no single agency can hope to have all the necessary expertise. There is often one lead agency with the prime responsibility for road safety programs, but it acts more as a coordinating body in bringing together the resources of expertise, money and physical equipment. It is also important that the development, implementation and evaluation of road safety programs be carried out on the basis of scientific principles in the appropriate disciplines. The development of programs and countermeasures on the basis of 'common sense' has resulted in the diversion of funds from effective programs. Therefore there must be

sufficient scientific support for the development and evaluation of policy and advice for the coordinating body. A third important point is that there appears that sufficient resources should be committed to the road safety programs for them to be effective. A commitment of resources of several multiples of previous spending in Victoria has had a very impressive effect on outcome measures, allowing for the effect of an economic depression on the amount of exposure.

The agencies generally involved in road safety programs have traditionally been the police, the transport, and the road building and maintenance agencies. There is an increasing recognition that the health sector should also be involved. The health sector should have an active role in road safety programs as an appreciable proportion of its resources is consumed in dealing with the results of the impacts. Therefore it should take an active part in the planning, implementation and evaluation of road safety programs and strategies. Health personnel have skills to offer in the use of a scientific approach to evaluating evidence in identifying problems or evaluation of countermeasures, using epidemiological techniques. They also have expertise in establishing the economic and other costs of injuries and associated losses. Health care personnel in patient contact can bring about change in behaviour at the individual level. At the community level health sector personnel can assist in the development of drink-driving and seat belt wearing campaigns, for instance, using known and effective health promotion and health education principles. Finally the health sector can bring to bear on other agencies in the community considerable pressure to bring about change.

Conclusion

The overall aim of a road safety strategy should be to minimise the consequences of road traffic crashes. This viewpoint allows the consideration of a large number of options and alternatives. The development and evaluation of specific programs should be based on

scientific principles and the consideration of accurate data on injury and other outcomes. The range of strategies available include altering modes of travel, changing the behaviour of road users, preventing or modifying impacts, and better managing injuries. Successful programs are multi-disciplinary and inter sectoral and coordinated between agencies.

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