CHAPTER 2

Road Traffic Injury as a Public Health Problem

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CONTENTS

ABSTRACT

In this chapter we have outlined the conceptual basis of injury control and emphasized the fact that the issue of road traffic injuries has to be treated as a public health problem and must be dealt with as we would tackle any serious disease. It is important to understand that we must move away from finding fault with victims, and seeking retribution, to a more reasoned approach with dealing with systemic improvements and finding solutions which by and large do not put an extra burden on road users. Road traffic injuries result from a complex interaction of sociological, psychological, physical and technological phenomena. Since injuries result from an exchange of energy between the environment and the human body, it is possible to develop

safety policies and strategies in a scientific and comprehensive manner. Haddon's ten strategies and the Haddon Matrix have been discussed in this chapter that help us organise our thoughts and for resource allocation analysis, strategy identification, and planning.

Key Words: Road traffic injury; public health; injury control; Haddon's matrix

2.1 INTRODUCTION

In this chapter, we demonstrate that control of traffic deaths and injuries must follow the same principles as control of any other public health problem. In the past, most of the products people used, the homes they lived in, and the infrastructure around them was built and created by them or with the help of people they knew. If they suffered any harm or injury from such arrangements, they blamed themselves and the community around them. If there was a solution to the problem, the responsibility for implementing it lay with the community. Modern systems, however, do not allow us to live in isolation or independent of larger systems. Normal activities all too often preclude individual choices. For example, most of us cannot choose the time at which we travel to work or the roads we use. Almost all of us have to be a part of traffic as motorised or non-motorised road users every day and this is not always by choice. The vehicles we use, the highways we travel, and the infrastructure around us is mostly designed, built and maintained by people we do not know and are unlikely to meet.

The potential hazards that may be built into these systems can also be unknown to us. Since almost all of us have to participate in the transportation system every day, all of us are also constantly exposed to the probability of being hurt, disabled, or killed. This is no different from being exposed to bacteria or viruses in the air, water and food, that we breathe, drink and eat every day. If a number of people suffer from diseases due to something in the environment we refer to it as a public health problem. Therefore, a large number of people suffering injuries while traveling can also be defined as a public health problem.

In 1961 Gibson, an experimental psychologist, introduced the concept that we could think of accidents in relation to the 'ecology of dangers' (Gibson 1961). He gave us the idea that dangers are 'environmental facts' and theoretically it should be possible to 'locate and specify all sources of danger in the geographical, the artificial, the animate, and the social environments'. He goes on to state that 'I exclude from consideration disease, or at least infection, as a source of danger because it is a special type of danger with its own peculiarities ... Injuries to a living organism can be produced only by some energy interchange'. This understanding of injuries logically leads us to the fact that bodily injury is just one kind danger along with infectious and contagious diseases. Therefore, in Gibson's words:

> 'The term "accident" it seems to me, refers to a makeshift concept with a hodgepodge of legal, medical, and statistical overtones. Two of its meanings are incompatible. Defined as a harmful encounter with the environment, a danger not averted, an accident is a psychological phenomenon, subject to prediction and control. But defined as an unpredictable event, it is by definition uncontrollable. The two meanings are hopelessly entangled in the common usage. There is no hope of defining it for research purposes. Hence I suggest that the word be discarded in scientific discussion'.

Gibson's approach to thinking of all injuries as being produced by some energy interchange and in principal etiologically similar to any other disease, was shared by many other researchers of the time. Dr. William Haddon was on of the first public health professionals to formalise this approach and promote the idea that road traffic injuries be considered a serious public health problem (Haddon 1968).

Road traffic injuries result from a complex interaction of sociological, psychological, physical and technological phenomena. This understanding of injuries has helped us design safer products, environments, and roads and traffic management systems. Once we accept that injury control is a public health problem, it becomes our ethical responsibility to arrange for the safety of individuals. This, in turn, makes it possible to initiate a scientific policy for injury control and safety promotion.

2.2 TRANSPORTATION SYSTEMS AND HUMAN ERROR

Injury control, the safety of individuals, and societal arrangements are all interlinked. William Haddon wrote seminal pieces on the folly of focussing on "human error" as the main cause in the occurrence of traffic injuries and fatalities (Haddon and Baker 1981; Haddon 1968, 1970a, 1972, 1973, 1980). He also did not like the use of the word "accident" as he thought that this leads a feeling of inevitability to the occurrence of these incidents. Further, he was also convinced that the term "accident prevention" was too limiting and prevented the evolution of other safety countermeasures useful in limiting the severity of injury and in injury management after the event. Instead, he promoted the use of the phrase "injury control" as being more neutral and scientific. But, he did not address the issues of ideology and the power of the elites that influence societies and the policies the latter promote.

Perrow on the other hand, agrees with Haddon that individuals cannot always be held responsible for "human error" under the system they operate in, but he provides a more sophisticated model of systemic imperatives (Perrow 1994, 1999): "I wish to point away from the basic and pervasive sin identified by those who casually examine organizational failures, that of operator error; this is given as the cause of about 80% of the accidents in risky systems. I would put it at under 40%. I will suggest that what is attributed to operator error stems primarily from the structure they operate in, and thus, stems from the actions of elites. Elite errors and elite interests stem from their class and historical power positions in society, and changes in these positions are glacial."

Policy makers and traffic safety professionals in every country find it very difficult to institute changes that actually result in a dramatic decrease in traffic fatalities and injuries in a short time. Experience has also shown that not all individuals follow all the instructions given to them to promote road safety. Attempts to "educate" people regarding safety are also not always very effective and wide variations are found between people's knowledge and their actual behaviour (Williams 2007; Robertson 1983). This is partly because we cannot select who is going to use the road and who is not. While some control can be exercised in licensing drivers of motor vehicles, almost no control is possible in selection of pedestrians and bicyclists. Almost everyone in a population can be a road user and this has implications on how we deal with the issue of traffic injuries as a public health problem.

Systems that ensure a life safe from injury cannot be put in place without a societal and political understanding of the ethical responsibilities of the state and civil society to ensure all individuals a right to life, according to currently available knowledge and technology. This right is implicit in the public health approach followed in controlling communicable and non-communicable diseases. As in the case of all diseases, we should be able to assume that most human beings would try to prevent the occurrence of an episode of ill health if they are able to. This involves an understanding of the phenomenon to a certain extent and at the same time the provision of means to individuals and societies to be able to do something about it. Research has revealed severe limits to ensuring individuals' safety by "educating" them, and that there is a wide variation between people's knowledge and their actual behaviour (Robertson 1983).

Traffic systems must be designed safely for all those who might make mistakes or judge the environmental cues inaccurately. Such designs, rules, and regulations would reduce the probability of people hurting each other or themselves, even when someone makes a mistake. Perrow states this issue forcefully: 'Above all, I will argue, sensible living with risky systems means keeping the controversies alive, listening to the public, and the essentially political nature of risk assessment. Ultimately, the issue is not risk, but power; the power to impose risks on the many for the benefit of the few' (Perrow 1999).

2.3 ROAD TRAFFIC INJURY AS A DISEASE

Certain principles of public health need to be understood so that the same can be applied to the control of traffic related injuries:

2.3.1 There is no basic difference between traffic injuries and the occurrence of any other disease

When we go to a doctor with a complaint of ill health the doctor does not spend a great deal of time trying to fix blame on individuals on why the problem may have occurred in the first place. The police are also usually not involved in trying to solve the problem. Law makers, police departments and others usually get involved if the treatment given is wrong, if some public health authorities have not been doing their jobs properly, or if the problem is so serious and wide spread that societal intervention is necessary. We have understood for a long time that we should not blame the victims for contracting a disease if we want to solve the problem. This approach has helped us in improving our health status through the centuries. The same approach has to be adopted for road traffic injuries as a new disease of the twentieth and twenty-first centuries.

2.3.2 Road traffic injury can be defined as a disease that results from an acute exposure of the human body to a transfer of energy from the environment around it

There are no basic scientific distinctions between injury and disease (Baker and Haddon 1974). When some fluid collects in the brain due to a disease one may die or be disabled permanently if the problem is not controlled. The cause of death due to a head impact with the road in a motorcycle crash could be the same – cerebro-vascular oedema. While the immediate cause of death or disability would be the same in both cases, most of us would have different approaches in trying to solve the problem. Any infectious disease may cause fever, pain, disability, or death. Injuries do the same. Therefore, the concept of injury is coextensive with the concept of disease. Table 2.1 illustrates this relationship.

Once all of us start looking at traffic injuries as diseases, the community may stop viewing them as events resulting primarily from carelessness of the victims as individuals. Long ago we learned that it does little good to blame the victim of a disease for being sick. For example, when a patient goes to a doctor with malaria, the doctor does not blame the victim for not killing the mosquito before it bit her. The most effective disease control measures often consist of modifying the environment and helping people to be in better control of their lives under most situations. Measures that attempt at trying to make individuals behave in an "ideal" manner have little chance of succeeding. Up to now, our efforts at traffic injury control in many countries

TABLE 2.1 Comparative Epidemiology of Malaria and Skull Fracture (as sustained by an unhelmeted motorcyclist crashing into a tree).

Pathological Condition	Host	Agent	Vector/ Vehicle	Interaction
Malaria	Man	Plasmodium sp.	Mosquito	Mosquito bite
Skull Fracture	Man	Mechanical energy	Motorcycle	Crash with tree

TABLE 2.2 Some Strategies For Control.

General Principle	Malaria	Skull Fracture
1. Prevent creation of hazard.	Keep mosquitoes from breeding.	Ban manufacture of motorcycles.
2. Eradicate existing hazard.	Kill mosquitoes by fumigation, etc.	Ban use of motorcycles. Remove trees near roadsides.
3. Interpose barrier.	Use mosquito nets.	Place a barrier between roadway and hazards like trees.
4. Minimize result of host-agent interaction.	Take appropriate anti-malarial medication when in malaria infested area.	Use helmets when riding motorcycles.

have often been retarded by a preoccupation with fixation of blame. This has led to repeated attempts to prevent injuries by changing the behaviour of their potential victims. Such attempts are usually costly, not often successful, and have added to the public's sense that injuries are an unavoidable evil. However, as Table 2.2 demonstrates, the same general principles used in disease control may successfully be applied to injuries.

2.3.3 "Accidents" and injuries are not "Acts of God"

It is a vital first step to realize that the occurrence and outcome of events which may cause injury, are predictable and subject in many cases to human control. We are able to predict the situations under which the probability of road crashes are likely to increase, and the designs of vehicles and the road environment which would result in less severe injuries during a crash. Often an injury can be prevented even where an "accident" cannot. We may not be able to prevent all motorcycle crashes but in a motorcycle crash, the occurrence and severity of head injury depend on whether or not a helmet was used and on the quality of the helmet. Even the so-called natural disasters are not really "natural." If they were, then the effects of floods and earthquakes would be the same in the rich and poor countries.

How a physical event influences human beings is very largely influenced by human beings themselves. Even the occurrence of the physical event itself is very often a result of man's activity. For example, floods may be caused by deforestation, faulty design of dams, blocking up of drainage in cities, etc. Therefore, human beings and how they organise their societies have a great deal to do with whether or not harmful events and disasters take place and how these events affect us. We can design our environment and products such that the incidence and effects of road traffic crashes and disasters are minimized.

2.3.4 Not all injuries can be prevented

Most efforts to reduce traffic injuries are termed "accident prevention" campaigns. We should be clear that *accident prevention* is just one aspect – and not always the most rewarding one – of a much larger range of countermeasures used in effective road traffic injury control programmes. It is important that all programmes also include measures of reducing injury severity if a crash does occur, and well-designed systems for emergency care, treatment and rehabilitation after the crash. This is because making mistakes is very "normal" and not "abnormal" in activities that involve a vast majority of persons from a given population. It is normal for professional drivers to be distracted during some periods of their long driving hours; it is normal for executives driving to work to be day-dreaming at some point in the journey; it is normal for a teenager to take more risks than an elderly person while driving a motorcycle; and it is normal for children to do the unexpected and hurt themselves as pedestrians or bicycle riders. In short, we will never eliminate carelessness, absentmindedness, and even neglect in day-to-day activity. However, by designing our products and environment to be more tolerant of these normal variations in human performance, we can minimize the number of resulting accidents and injuries.

Crashes are the result of a temporary imbalance between an individual's performance and the demands of the system in which (s)he is functioning. They can be prevented by alterations in either, but most effectively by focusing on the system as a whole, and not on its user alone. A crash can occur when the victim was in fact performing quite well in absolute terms but the demands of the system exceeded the current performance level of the user. In many areas of public health we understand this very well. We know that drinking water should be purified at its source; it is unreasonable to expect everyone to boil his water before drinking it. Those societies, which depend upon individuals to purify their own drinking water suffer from much higher rates of communicable diseases than those which purify water at the source. Ironically, it is quite common to create a product or environment that is likely to cause injury, warn the user to be careful, and then blame the user if a mishap occurs. We would never tolerate a person who introduced cholera germs in a city water supply and then asked every citizen to boil the water before drinking it, using the argument that those who knowingly don't do so would be responsible for getting sick. Nevertheless, this is the kind of argument we all too often use when dealing with matters concerning road safety. We put in place hazardous roads, vehicles and driving rules and then expect road users to be safe by behaving in some ideal manner.

2.3.5 Injury control measures can be developed systematically

When we evaluate traffic injuries as a health problem, we find it very difficult to think of all the possible countermeasures because the problem appears to be too large and unwieldy. It is generally easier to work in a systematic manner. One useful approach is to consider each traffic injury problem as resulting from an interaction between several discrete factors, occurring over distinct phases in time and space. Each phase – pre crash, crash and post crash can then be analysed systematically for human, vehicle, road and environmental factors. Another way to analyse a traffic safety issue is to concentrate on managing the excess energy that may contribute to the occurrence of a crash that causes injuries during the crash. Once the multiple factors associated with the crash are identified and analysed, their countermeasures can be discussed and prioritised for implementation over short and long term periods. These approaches are discussed in the next section.

2.4 DEVELOPING INJURY CONTROL MEASURES

2.4.1 Safe infrastructure and systems

Road safety management is a systematic process in which we consider the road infrastructure, the road users, and the vehicles as integral components of a complex interactive system as shown in Figure 2.1. Each part of the system interacts and is influenced by the others and can produce unexpected results. The road transport system has to be developed in a way that does not jeopardise the environment or public health and welfare of its participants. In this approach, it is essential that a road environment be created that minimises the risk of road users making mistakes and that prevents serious human injury when designing, operating and maintaining the road network. The entire traffic and transport system must be designed to account for the limitations and capabilities of road users.

In the road transport system the design of vehicles, infrastructure and policing methods have to be aimed primarily at the prevention of traffic crashes irrespective of the characteristics and

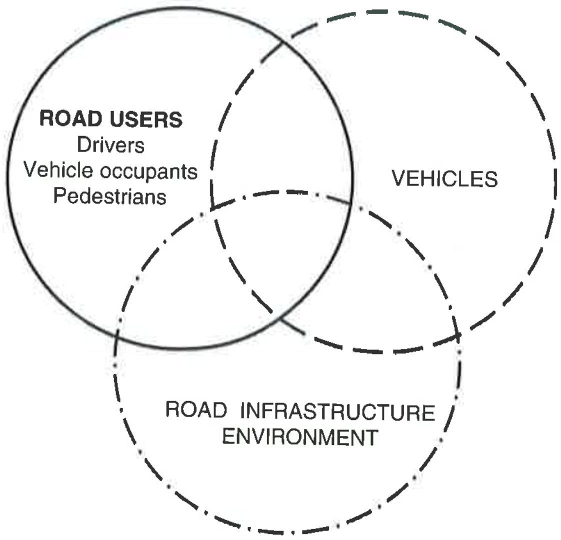

Figure 2.1 Road safety management as a complex system in which we consider the road infrastructure, the road users, and the vehicles as integral components of an interactive system.

skills of the road users. In the event of a crash the system has to be designed such that the consequences are kept to the absolute minimum. The requirements of such an infrastructure are (adapted from reference (SWOV 2003)):

1. *Functionality*: Traffic should be distributed over the road network as was intended.
2. *Homogeneity*: For road users using the same space there should be small speed and mass differences between transport modes that can collide.
3. *Recognition*: Traffic situations should, to a great extent be predictable. The road infrastructure should provide clear indications on what behaviour is expected from you and from other road users.

It is far more effective to provide *automatic protection* than to hope that people will behave in a "safe" way. Automatic approaches protect individuals without their having to perform some action or behave in a specific manner. For example, a person who chooses not to use her manual seat belt (or who forgets to buckle it) has no protection in the event of her car crashing. If there is an air cushion system in her car, however, it will inflate to protect her regardless of her state of mind, level of inebriation, or intelligence.

2.4.2 The energy control approach and Haddon's ten strategies

The idea that injuries result as a consequence of energy exchange between the environment and the human body had gained currency in the 1960s (Gibson 1961), but it was Haddon who formalised the concept and used it to suggest a systematic way of conceptualising a host of safety countermeasures for a specific problem (Haddon 1970b). The principles as outlined below focus on eliminating the source of energy, reducing the amount of energy released and reducing its harmful effects.

Ten basic, generalized, strategies for reducing damage by control of energy transfer (Adapted from Reference Haddon 1973 and Robertson 1983).

1. To prevent the creation of the hazard in the first place. *Examples*: prevent production of plutonium, thalidomide, LSD, banning use of dangerous vehicles.

2. To reduce the amount of hazard brought into being. *Examples*: reduce speeds of vehicles, lead content of paint, mining of asbestos.
3. To prevent the release of the hazard that already exists. *Examples*: pasturizing milk, bolting or timbering mine roofs, impounding nuclear wastes, design of petrol tanks so that they do not explode.
4. To modify the rate or spatial distribution of release of the hazard from its source. *Examples*: brakes, shutoff valves, reactor control rods.
5. To separate, in time or space, the hazard and that which is to be protected. *Examples*: isolation of persons with communicable diseases, walkways over or around hazards, evacuation, banning of trucks moving through cities in the daytime.
6. To separate the hazard and that which is to be protected by interposition of a material barrier. *Examples*: surgeon's gloves, containment structures, childproof poison container closures, sleeve around the exhaust pipe of a motorcycle.
7. To modify relevant basic qualities of the hazard. *Examples*: altering pharmacological agents to reduce side effects, using breakaway roadside poles, making crib slat spacings too narrow to strangle a child, designing cars with crumple zones, etc.
8. To make what is to be protected more resistant to damage from the hazard. *Examples*: immunization, making structures more fire- and earthquake-resistant, giving salt to workers under thermal stress.
9. To begin to counter the damage already done by the environmental hazard. *Examples*: rescuing the shipwrecked, reattaching severed limbs, extricating trapped vehicle occupants.
10. To stabilize, repair, and rehabilitate the object of the damage. *Examples*: posttraumatic cosmetic surgery, physical rehabilitation, rebuilding after fires and earthquakes.

2.4.3 Resource allocation analysis, strategy identification, and planning – Haddon's matrix

Over fifty years ago, Edward McGavran, Dean of the University of North Carolina School of Public Health, articulated the concept of treating the community as if it were a patient (McGavran 1958), and a few years later Patricia Z. Barry further wrote that "Traditional health program efforts toward the prevention of injury have been based on assumptions of individual responsibility for safety. The degree of impact which such programs have on injury incidence rates has not been determined. Health personnel are urged to adopt an orientation to the community, rather than to individuals, in approaching problems in injury control. The theoretical implications of individual versus community orientation are discussed using illustrative material from injury problems in childhood" (Barry 1975). A consensus was emerging that if traffic injuries had to be controlled, greater success would be possible if there were a substantial shift from blaming individuals to examining the problems a community faces with respect to its environment and the products in use.

Haddon was responsible for putting these ideas together and coming up with an aid to resource allocation analysis, strategy identification, and planning, the so-called Haddon matrix (Haddon 1980) as shown in Figure 2.2.

The use of the matrix is illustrated by an example below.

Incident: A car approaches a road junction and goes through, passing the light which has just turned red. The car hits a motorcycle which has entered the junction from the left or right. The motorcyclist gets thrown sideways and hits a pedestrian walking on the side of the road. The car driver gets facial injuries, the motorcyclist sustains head injuries, and the pedestrian suffers a leg fracture

Use of the matrix: Each cell of the matrix is used to make a list of countermeasures that could be put in place to control damage from such incidents. The numbers in the cells of

	FACTORS		
PHASES	Human (Road users)	Vehicle(s)	Environment (Roads, infrastructure, laws, enforcement, etc.)
Pre-event (Preventing the crash)	1	2	3
Event (Control of injury during the crash)	4	5	6
Post event (Control and treatment of injury after the event)	7	8	9

Figure 2.2 Hadon's matrix adapted for resource allocation analysis, strategy identification, and planning measures for traffic safety (adapted from Haddon 1980).

the matrix show to which phase and to which factor each of the countermeasures in the list below would be assigned.

1. Training of drivers, pedestrians to walk facing traffic, motorcyclists to wear bright clothing and luminous helmets.
2. Car equipped with anti-skid brakes, compulsory use of headlights in daytime by motorcycle riders, speed control devices in vehicles.
3. Vigilant policing, red light cameras at junctions, brighter illumination at junctions, safe sidewalks of adequate width, no left turn on red light, strict roadside checks for drinking and driving, use of roundabouts instead of light-controlled junctions, law mandating use of daytime running lights by motorcyclists.
4. Use of protective clothing and helmets by motorcyclists and seat belt by car occupants.
5. Car manufactured according to best practices in crashworthiness, car equipped with seat belts and airbags, pedestrian and two-wheeler friendly design of vehicle fronts.
6. No sharp edged street furniture, mandatory laws for helmet and seat belt use.
7. Adequate arrangements for pre-hospital care, treatment in hospital, and rehabilitation if necessary.
8. Automatic switch off arrangements in vehicles in event of a crash, burst resistant fuel tanks, automatic crash notification systems in vehicles after a crash.
9. Police equipped with victim rescue tools, guidelines for managing crash scenes, emergency care system, laws regarding care of victims, universal no-fault insurance policies.

The number of counter measures listed above are not exhaustive for each cell. A multidisciplinary team of experts and policy makers would probably come up with a much longer list. The main point to be noted here is that the use of such tools helps us to come up with a host of possibilities that include all the actors in the traffic safety system and also helps us address all issues in time and space. After such lists are made, policies and strategies can be formulated and priorities set based on following considerations:

(a) Countermeasures to be put in place in the immediate, near and distant future.
(b) Knowledge and technologies available.
(c) Resources and finances.
(d) Political considerations.

2.5 SUMMARY

In this chapter we have outlined the conceptual basis of injury control and emphasized the fact that the issue of road traffic injuries has to be treated as a public health problem and must be dealt with as we would tackle any serious disease. Whenever a very large proportion of the population faces ill health and death due to a specific activity, and that activity, like travel, is almost compulsory in nature, it becomes a public health problem. It is important to understand that we must move away from finding fault with victims, and seeking retribution to a more reasoned approach to dealing with systemic improvements and finding solutions which by and large do not put an extra burden on road users.

Road traffic injuries result from a complex interaction of sociological, psychological, physical and technological phenomena. This understanding of injuries has helped us design safer products, environments, roads and traffic management systems. Once we accept that injury control is a public health problem, it becomes our ethical responsibility to arrange for the safety of individuals. This, in turn, makes it possible to initiate a scientific policy for injury control and safety promotion.

Since injuries result from an exchange of energy between the environment and the human body, it is possible to develop safety policies and strategies in a scientific and comprehensive manner. Haddon's ten strategies and the Haddon Matrix have been discussed in this chapter to help us organise our thoughts, and for resource allocation analysis, strategy identification, and planning.

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