



Making sense of safety

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World Health Day

World Health Organization dedicates World Health Day to road safety

M Peden, L Sminkey

Political will and sustained efforts will save lives

Worldwide, nearly 1.2 million people are killed in road traffic crashes every year and about 20 million to 50 million more are injured or disabled. These injuries account for 2.1% of global mortality and 2.6% of all disability-adjusted life years (DALYs) lost. Low income and middle income countries account for about 85% of the deaths and 90% of the DALYs lost annually as a result of road traffic crashes.¹ Projections indicate that these figures will increase over the next 20 years.^{2 3} Without appropriate action, by 2020, road traffic injuries are predicted to be the third leading contributor to the global burden of disease ahead of other health problems such as malaria, tuberculosis, and HIV/AIDS.²

The economic cost of road traffic crashes is enormous. Estimates suggest that they cost low income and middle income countries 1% to 1.5% of their gross national product (GNP) and high income countries 2% of GNP.⁴ A conservative estimate of the global cost has been placed at US\$ 518 billion per year with low income and middle income countries accounting for US\$ 65 billion—more than they receive in development assistance.⁴

But economic costs are just the tip of the iceberg. For everyone killed, injured, or disabled by a road traffic crash there are countless others deeply affected. Many families are driven deeper into poverty by the expenses of prolonged

medical care, loss of a family breadwinner, or the added burden of caring for the disabled.⁵

Traditionally, road safety has been assumed to be the responsibility of the transport sector, and public health has been slow to become involved. But the health sector would greatly benefit from better road traffic injury prevention in terms of fewer hospital admissions and a reduced severity of injuries. It would also be the health sector's gain if more people were to adopt the healthier lifestyle of walking or cycling, without fearing for their safety.

The World Health Organization's annual World Health Day 2004 focused on road safety. The global event was held in Paris. The slogan for the day was "Road Safety is No Accident". At this event the joint World Health Organization/World Bank *World report on road traffic injury prevention* was launched.¹ This report emphasizes the role of public health in the prevention of road traffic injuries. It offers countries six recommendations for action on road safety at a national level. The report and a summary version (in various languages) are downloadable from the internet at www.who.int/violence_injury_prevention/.

The report calls for a "systems approach" to road safety which looks at the system as a whole and also the interaction between the three elements of the system—namely, the

roads, vehicles, and road users in order to identify where there is potential for intervention. In particular the systems approach recognises that humans make mistakes and as such a safe road traffic system is one that accommodates their weaknesses.¹

The report further emphasises that road safety is a shared responsibility between governments, industry, non-governmental organizations and international agencies as well as by many different disciplines such as health professionals, road and motor vehicle designers, law enforcers, educators, and community groups.

The time to act is now. Strong political will and sustained efforts across a range of sectors will save lives.

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Road traffic crashes

Road safety and public health: a US perspective and the global challenge

S Binder, J W Runge

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Together we can save lives and reduce suffering

Road traffic crashes are not just a highway safety problem—they are a public health problem. With over a million people killed each year on the world's roads, and tens of millions more injured, road traffic crashes are a leading cause of death and the ninth leading cause of disability adjusted life years (DALYs) lost worldwide. By 2020, road traffic injuries are projected to become the third leading cause of DALYs. This is all the more tragic because we could prevent so many of these deaths, so many of these injuries, and so much of this suffering.

In the United States, road traffic injuries accounted for more than 42 000 deaths in 2002 and almost three million non-fatal injuries.¹ They are the leading cause of death for people ages 1–34 years and the leading cause of injury related death. The cost of motor vehicle crashes exceeded \$230 billion in 2000.² The United States has the most motor vehicles per capita of any country in the world (765 motor vehicles per 1000 population).³ Therefore, we had to begin addressing the problem of road traffic safety many years ago. What are some of the lessons we have learned? For this commentary, we will focus on just three: the importance of having an agency devoted to road traffic safety; the importance of linking health and transportation sectors; and the usefulness of good data in defining the problem and determining the solutions.

First, in the United States, since 1970 we have had an agency devoted to road traffic safety (the National Highway Traffic Safety Administration, NHTSA)—with a mission that includes setting and enforcing safety performance standards for motor vehicles and investigating defects in motor vehicle equipment, as well as developing interventions based on sound research. This has helped government and industry work together to improve safety.

Second, in the United States, road traffic safety is both a public health and a transportation responsibility. Given the enormity of the problem, the tools of any one sector will not solve it alone. This partnership extends from the collection of data about the impact of road traffic

crashes to the research on prevention tools to the implementation of programs. The Centers for Disease Control and Prevention (CDC) in the Department of Health and Human Services and the NHTSA in the Department of Transportation have collaborated for many years at the national level on high priority projects and encourage such partnerships at state and local levels.

Third, high quality data are essential for ensuring that resources are used to achieve maximal benefit. At the national level, surveillance data define the extent of the problem and also can be used to identify specific emerging issues such as the potential impact of airbags on children sitting in the front seats of cars. At the state and local levels, they can identify locations where crashes frequently occur and require interventions. The use of geographic information system technologies has been particularly beneficial in that regard. Special studies have resulted in regulations, standards, laws, and other intervention approaches. For example, intense, short duration, high visibility safety belt enforcement campaigns, coupled with paid media, have resulted in raising safety belt use in the United States. In fact, in 2003 safety belt use increased four percentage points (from 75% to 79%),⁴ reducing societal costs by more than \$3 billion and saving more than 1000 lives.⁵ A non-Federal Task Force on Community Preventive Services, associated with CDC, has been using stringent standards and methods to evaluate interventions for a variety of public health problems, including many related to road traffic safety.⁶ Interventions found to be highly effective include child safety seat laws, primary enforcement of seat belt laws, minimum age drinking laws, community-wide information and enforcement campaigns, and sobriety checkpoints.

Despite the fact that the highest per capita rates of motor vehicle use are in developed countries, 90% of motor vehicle deaths in the world occur in low to middle income countries. The projections of future motor vehicle

deaths as these countries continue to gain vehicles and roads are frightening, making it even more imperative that we mobilize now. The World Health Organization and the World Bank are to be commended for taking a bold step forward in addressing road traffic injuries as a preventable global health problem. Their leadership on this issue has the potential to put road traffic crashes alongside other diseases and illnesses we classify as predictable and preventable.

CDC, NHTSA, and many others actively participated in the development of the *World Report on Road Traffic Injury Prevention*.⁷ The six recommendations in the report center on recognizing the global burden of traffic injuries; documenting the burden through effective surveillance systems; identifying the risk factors; and developing and disseminating effective interventions. These are consistent with our experience in the United States and we believe they will be effective elsewhere as well.

The downward trend in motor vehicle death rates in the United States from 21.7 deaths per 100 million vehicle miles traveled in 1923 to 1.51 in 2002—a 93% reduction¹—occurred despite an increased number of vehicles, drivers, miles traveled, and a growing population. In recent years, other industrialized nations have registered even greater declines. Since 1979, traffic fatalities have declined by 50% in Canada, 46% in Great Britain, 48% in Australia,⁸ and 16% in the United States.¹ These successes only hint at what could be achieved if road traffic safety were made a higher priority globally. World Health Day 7 April 2004 is an important opportunity for all of us in public health and transportation safety to join hands and lend support to one another in our efforts to reduce this global burden. Together, we can save lives and reduce suffering.

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Nosology

What is an injury?

J Langley, R Brenner

A clear definition is needed

Paramount to the study of any disease is the clear definition of the subject of interest. The definition of injury is fraught with challenges and complexities. Importantly, injuries unlike most diseases must be defined simultaneously by the causative event and by the resulting pathology. For example, bruising can occur in the absence of a mechanical insult to the body (for example, in the case of sepsis or a bleeding disorder) and thus, taken alone, cannot be considered an injury. Similarly there are many events, such as car crashes, that result in no pathology, even if “victims” are brought to an emergency department for observation. Thus, the theoretical definition of injury must incorporate both cause and outcome. Equally challenging is the operational definition of injury, for example, which diagnoses, codes, or combination of codes from the *International Classification of Diseases (ICD)*¹ define injury? In this paper we discuss shortcomings in existing theoretical and operational definitions of injury with a view to advancing injury prevention research and practice.

THEORETICAL DEFINITIONS

The theoretical definition of injury is problematic since there is no basic scientific distinction between disease and injury. In some cases the etiologic agents are identical, for example the result of the brief exposure to toxic gas is often called injury whereas eventual pulmonary effect of chronic exposures to low concentrations of the same gas may be called disease.² Many of the public health orientated injury texts consider that the “energy definition” best describes the causes and pathologies of interest, namely “injury” refers to damage to the body produced by

energy exchanges that have relatively sudden discernible effects.³ In contrast, “disease” tends to be used for pathologies such as cancer which manifest themselves over longer periods after first exposure to their causes. While this seems to be a reasonable starting point, a number of issues remain. These issues are perhaps best explored through specific examples. First, what is meant by “damage to the body”. If damage to the body refers to tissue damage, strict adherence to the theoretical definition would lead to the exclusion of many events that are routinely classified as injuries. For example, ingestion of a foreign body, such as a coin, often results in no tissue damage and foreign bodies can be removed from other orifices such as the nose or ear, without damage to the surrounding tissues. Similarly, a sexual assault which results in no tissue damage but from which the victim experiences severe depression, will only be covered by the theoretical definition if the scope of bodily damage is broadened to include psychological damage. There would seem to be a case for such harm to be included in a theoretical definition given that significant numbers of those in injury research and practice consider this a legitimate area of concern for the field. Moreover, in New Zealand (population 4 million) at least, the agency, Accident Compensation Corporation, which has the primary mandate for injury prevention, rehabilitation, and compensation, compensates victims who suffer such harm. In the 2000/2001 financial year 267 people were compensated for psychological injury at a total cost \$NZ2 659 000.

Second, consider also the meaning of “energy exchange”. Clearly a surgical incision is the result of intentional transfer of mechanical energy and this

transfer results in tissue damage, yet, traditionally surgical incisions are not included in counts of intentional injuries. Perhaps, when the benefits of the purposely intended injury are thought to outweigh the costs, the theoretical definition is not applicable. But that approach is inconsistent with our approach for counting injury due to the lawful use of force (for example, police), where presumably the benefits are also thought to outweigh the costs of using such force. In this case, however, provision is made in ICD to code injuries due to this cause (E970-978: legal intervention).

Most injury prevention experts expand the theoretical definition of injury to include not only bodily damage caused by transfers of energy but also damage caused by the absence of energy.³ While this serves us well by bringing injuries due to a number of causes (for example, drowning, hypothermia, and asphyxia) under the broad umbrella of the theoretical definition, it also obscures the boundaries as it could be argued that the final pathway for death of any etiology is ultimately an absence of energy.

Finally, the notion that an injury must have “sudden discernible effects” leads to the exclusion of tissue damage due to chronic low energy exposures (for example, carpal tunnel syndrome) but as Robertson has pointed out some have modified the energy definition to include such cases.³

The development of the theoretical “energy” definition of injury by Haddon represented a significant advance in our thinking and provided a useful basis on which to consider injury control measures.⁴ One of its major strengths is the inclusion of both cause and outcome in the definition. However, as the field of injury prevention has advanced it is clear that there is now a need to refine the concepts outlined in this theoretical definition.

OPERATIONAL DEFINITIONS

Arguably the most common operational definitions of injury, although rarely directly stated as such by most authors, are all those pathologies included in the “Injury and Poisoning” chapter (XVII) of the ninth revision of the ICD or all those events coded to ICD

Supplementary External Causes of Injury and Poisoning (commonly referred to as E codes).¹ The former chapter includes all those pathologies most scientists and members of the public would describe as injury (for example, fracture, dislocation, open wound). The latter includes all those mechanisms or events which “cause” injury (for example, motor vehicle traffic crash, fall, sharp objects).

Consider first the chapter on injury and poisoning. The title of the chapter alone raises interesting issues. Many injury researchers and practitioners would consider poisoning to be one of a range of pathologies which operationally define injury. That being the case why is the chapter named in this manner?

The chapter makes provision for “Effects of foreign bodies entering through orifice” (930–939) yet these classifications do not directly describe pathology and as we have already mentioned many such events do not result in discernable damage to the body (for example, young child sticks a small toy up his nose). In other words there is no injury. Even allowing for the possibility that injury may have occurred, this range of codes is anomalous as it is inconsistent with ICD’s approach to other injuries. For example ICD does not have a grouping of codes for “effects of motor vehicle crashes”. Rather ICD require the actual pathology to be coded.

The chapter also includes: “Certain adverse effects not elsewhere classified” (995) and “Complications of surgical and medical care, not classified elsewhere” (996–999). Some have argued that these are “medical injuries” and should be excluded from the operational definition of injury. The justification given is that the aetiology is different than other injuries and that these types of injuries require different means of prevention.⁵ As has been argued elsewhere,⁶ neither argument is sufficient grounds for exclusion. Rather the decision should be based on whether the injuries meet an accepted theoretical definition of injury. While some would in fact appear not to meet the theoretical “energy” definition, such as 996.0 “Mechanical complication of cardiac device, implant and graft” others almost certainly do, for example 998.2: “Accidental puncture or laceration during a procedure”. Importantly, the inclusion or exclusion of “medical” injuries has dramatic effects on estimates of incidence. For example, in New Zealand in 1998 there were 67 428 public hospital discharges which had injury (800–999) as the primary diagnosis,⁶ and 17% of these were in the range 995–999.

It should be noted that there are conditions which fall outside the 800–999 range but which some would classify as injury. These include musculoskeletal conditions related to the knee and back (717, 718, 724) and certain conditions of the eye (366.2). Some have argued that most of these conditions are chronic and should thus be excluded from an operational definition of injury, presumably on the basis that the theoretical definition of injury should be confined to pathologies that occur suddenly. Assuming one accepts this argument, it raises an interesting question. Are we to assume, for example, that all strains and sprains coded in the range 840–848 have occurred acutely? Given that there are no guidelines in this respect we feel such an assumption would be unwise. In 1999 at the International Collaborative Effort on Injury Statistics meeting in Washington, Pickett sought to identify all injury codes outside chapter XVII.⁷ Various recommendations for dealing with these were discussed at the meeting but no consensus was reached.

The ICD injury and poisoning codes do not include psychological injury. Such harm presumably could be covered by the ICD codes for over mental health outcomes (mental disorders 290–319). In New Zealand cases with psychological injury could potentially be identified by ascertaining injury events using external cause codes and then searching for accompanying codes indicative of a relevant mental disorder. This is possible in New Zealand because hospital discharges for injury events are routinely assigned external cause of injury codes, even if there is no apparent tissue damage. However, external cause codes are not routinely assigned in many other countries and, even when they are assigned, it is not clear that coders routinely document psychological consequences of injury.

The US Injury Surveillance Workgroup of the State and Territorial Injury Prevention Directors Association (STIPDA) have grappled with the above problems and have recently produced the inclusion/exclusion criteria for identification of injuries from hospital discharge data.⁸ A number of issues are worthy of note. First, no explanation is given for the exclusions/inclusions. For example, late effects of injuries, poisonings, toxic effects, and other external causes (905–909) are included. This contrasts with the coding practice in New Zealand where the following explanation is given: “Late effects of injury and poisoning (ICD codes 905–909) are no longer entered as principal diagnosis; preference is given to the residual conditions, with the late effects entered

as a secondary diagnosis” (P8).⁹ The approach adopted in New Zealand would appear consistent with the instructions in ICD-9 (P501), although it must be said that those instructions are difficult to interpret.¹ Second, with the exception child maltreatment syndrome (995.5), most “medical injuries” have been excluded. Third, the working group acknowledges that there may be codes outside the 800–999 range which qualify as injury but until such stage as a consensus can be reached on these codes, they recommend exclusion of these pathologies from injury counts.

Consider now, the supplementary classification of external causes of injury and poisoning. Reliance on external cause of injury codes to operationally define injuries, has led to other problems. Most importantly, these codes can be used to describe events that result in little or no injury. This occurs most often when a person seeks medical care following an event (for example, a car crash or a fall), but when the event resulted in no injury. Recent work in New Zealand has shown that 26% of all persons discharged from a public hospital, and whose record was assigned an E code, did not have a diagnostic code within the injury and poisoning range (800–999).⁷ In ICD-10 the equivalent chapter is now titled “Injury and poisoning and certain other consequences of external causes”.¹⁰ This is more descriptive of what has always been included in the chapter.

Consider the case of drowning as an example of the definitional confusion which arises from the failure to distinguish the pathology of interest from external causes which may result in that pathology. Typically the term drowning is used to refer to deaths due to asphyxia in liquid. Non-fatal injury outcomes arising from similar processes are often referred to as near drownings. The difficulty here is that the concept of near drownings includes everything from losing your footing in the surf and temporarily losing control of the situation with no detectable pathology right through to major neurological damage as a result of asphyxia. In the latter case should we not be coding the actual pathology—the injury to the brain? In the former case why are we counting these cases if there is no damage namely we do not after all code “near lacerations or near burns”.

CONCLUSIONS

Some have suggested that discussions about what is and what is not an injury is an esoteric exercise of interest only to nosologists and theorists. Using the New Zealand experience, however, this paper has demonstrated that estimates

of the incidence of injury can vary substantially depending on one's operational definition of injury. This has important implications for determining priorities, developing indicators for monitoring trends, and undertaking international comparisons. Commonly accepted theoretical and operational definitions of what is an injury are in need of revision. Ideally this should take place in an international context and by consensus. The International Collaborative effort on Injury Statistics represents an excellent international forum through which to progress this.

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Safety

Making sense of safety

P Nilsen, D S Hudson, A Kullberg, T Timpka, R Ekman, K Lindqvist

Beyond injury prevention

The concept of “safety” can have many different meanings. The *Concise Oxford Dictionary* defines it as “freedom from danger and risks”, while the *Merriam-Webster Dictionary* describes safety as “the condition of being safe from undergoing or causing hurt, injury, or loss”. According to etymologist Douglas Harper, the word safe first came into use in the English language around 1280, derived from the Old French *sauf*, which in turn stemmed from the Latin *salvus*, meaning “un-injured, healthy, safe”. The Latin word is related to the concepts of *salus* (“good health”), *saluber* (“healthful”), and *solidus* (“solid”), all derived from the Proto-Indo-European base word *solwos*, meaning “whole”.¹ Thus, at its root, the concept of safety revolves around wholeness and health.

Injury prevention researchers have defined safety as “a state or situation characterised by adequate control of physical, material, or moral threats”, which “contributes to a perception

of being sheltered from danger” (Andersson and Svanström, as quoted in Welander *et al*, page 12²). Safety is commonly viewed through the lens of specific injury domains: for some researchers in the injury prevention field, safety has come to mean the prevention of crime and violence; for others, a reduction in motor vehicle deaths or a feeling of being out of danger rather than being in a positive state of human growth and development.³

Due to the multitude of views on the definition of safety, a collaborative effort was launched in 1996 by two World Health Organisation (WHO) Collaborating Centers on Safety Promotion and Injury Prevention, sponsored by the Ministry of Health, Quebec, Canada, and Karolinska Institute, Stockholm, Sweden, to develop international consensus on the conceptual and operational aspects of safety and safety promotion.² A document was published in 1998 entitled *Safety and Safety*

Promotion: Conceptual and Operational Aspects. The authors of the document stated that a shared definition of safety would result in improved cooperation between researchers and community program workers within the safety promotion discipline, stimulating the development of initiatives that would improve the wellbeing of the population.³

TWO DIMENSIONS OF SAFETY

A key point of the WHO's definition of safety is that it has two dimensions: an objective dimension, which can be seen as behavioural and environmental factors measured against *external* criteria, and a subjective dimension, which can be variously defined as the individual's *internal* feelings or perceptions of being safe (which can be aggregated to the macrolevel, to represent the community's subjective safety perception). Hence, for the researchers who contributed to the WHO report, safety is more than merely “non-injury”.

In the injury prevention domain, safety is rarely, if ever, operationalised in a manner that is consistent with WHO's broad definition of the concept. Indeed, most injury prevention interventions and programs are designed and implemented with the overall objective to reduce injury rates; injury incidence is seen as the primary focus of program interest and success is overwhelmingly defined as a reduction in injuries.^{4–6} Thus, safety is typically defined and measured more by its absence than its presence.

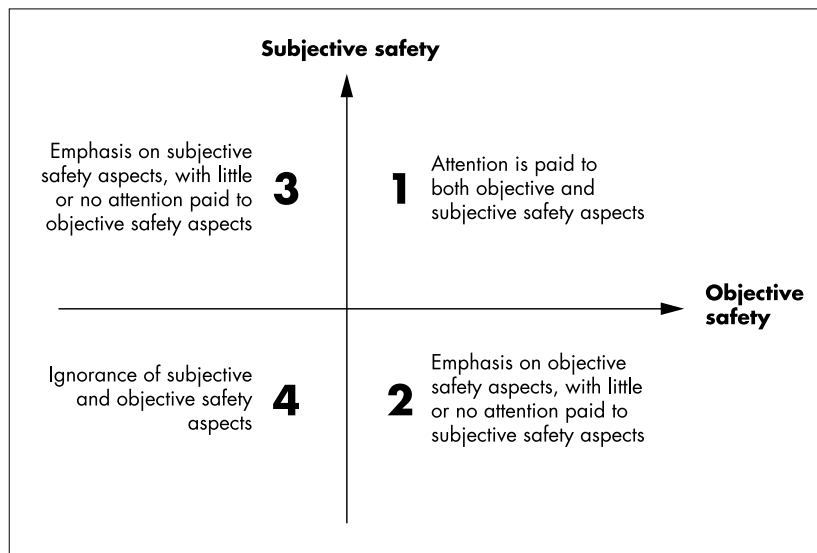


Figure 1 Approaches to defining and operationalising safety concepts.

The reduction of objective injury related measures, such as fewer falls or assaults, does not necessarily lead to a proportional increase in subjective safety, and vice versa.³ Studies have demonstrated a lack of correlation between subjective and objective safety—for example, between citizens' perceptions of crime versus official crime statistics from police departments,⁷ between public anxiety about the wellbeing of children versus the statistical likelihood of their being kidnapped by non-custodial adults,⁸ or between risk perceptions versus involvement in accidents in the offshore oil industry.⁹

The approaches that community safety researchers and program personnel use to define and operationalise safety concepts can be illustrated by a figure depicting four quadrants (fig 1). Quadrant 1 is the optimal state, where both subjective and objective aspects of safety are taken into account when designing and implementing injury prevention interventions. Traditional injury prevention programs are "located" in quadrant 2. Such programs focus on objective macrolevel parameters (that is, injury rates), with little or no regard of the subjective dimension. Quadrant 3 denotes a situation in which objective surveillance and epidemiological injury data are ignored in favour of reliance on subjective safety assessments. Quadrant 4, meanwhile, is characterised by uninformed guesses regarding subjective and objective safety goals, which result in *ad hoc* safety initiatives.

To date, most community based injury prevention programs can be defined as operating primarily in quadrant 2:

they are predominantly based on assessments of objective safety and demonstrate success through injury rate reductions. What is often lacking in these types of programs are data that demonstrate an increase in subjective safety that can be linked to the programs or interventions, as measured within the target population.

The goal of community based safety promotion should be to move intervention and research efforts towards quadrant 1, which requires an increased emphasis on providing services that affect not only the elimination of injuries, but also increase individual and group perceptions of feeling safe. A philosophical migration from the reliance on objective safety aspects toward a more comprehensive approach could be said to signify a shift in perspective from defining and measuring safety by its absence to its presence. Most importantly, the migration from quadrant 2 to quadrant 1 would move research and practice from defining itself as merely "injury prevention" to an expanded discipline of "safety promotion".

RATIONALE FOR INCREASED EMPHASIS ON SUBJECTIVE SAFETY ASPECTS

The case for a research and program shift among community safety professionals, from a reliance on objective injury reduction interventions (quadrant 2) toward an increased emphasis on perceptions of subjective safety (quadrant 1), rests on a number of arguments.

Subjective safety turns the focus of community injury prevention from the

program providers to the program recipients. Subjective safety assessments, by necessity, involve community participation because the programs are responding to the citizens' self defined needs, which increase the chances of achieving community support. Hayes *et al* argue that much of what the population perceives as barriers to their safety are well founded, even though these barriers may not be measurable with commonly used injury surveillance methods.¹⁰ Community participation and influence make programs more effective because services are generated from "within" people.¹¹ The "principle of participation" states that large scale behavioural change requires the people heavily affected by a problem to be involved in defining the problem, planning and instituting steps to resolve the problem, and establishing structures to ensure that the desired change is maintained.¹²

Basing program priorities around the community's safety perceptions will also foster an increased community ownership of safety promotion efforts. Target populations who have a sense of responsibility for and control over programs promoting change will continue to support them after the initial organisation effort.¹³ Both the "principle of participation" and the "principle of ownership" follow the same basic premise: change is more likely to be permanent when the people it affects are involved in initiating and promoting it.¹⁴ Increased community participation and ownership does not mean that all injury prevention programs must be grassroots efforts that *only* build from citizens' concerns. We are not calling for a shift away from scientifically based programs to promote safety. Certainly, safety interventions need to be implemented if epidemiological data identify problems of sufficient magnitude to warrant attention.

Focusing on the need to improve an overall sense of safety will help individuals and communities to become more empowered and will make the interventionist more of a collaborator with local communities. Although many community based injury prevention programs are labelled bottom-up or grassroots initiatives, they tend to be expert driven with limited involvement by community members in implementing interventions or evaluating outcomes.¹⁵ The expected rewards of expanded community participation and empowerment include better penetration of communities with more acceptable and culturally relevant messages, and greater sustainability of intervention activities and effects.^{16 17}

Assessing subjective safety aspects of target populations will ensure improved

local adaptation of interventions. Studies have demonstrated the importance of tailoring programs to meet the current needs of individuals and communities.^{5 18 19} Forde stresses that programs need to be adapted to each community, taking into account its real life, as well as its subjective, judgment about situations affecting it; subjective perceptions cannot be overruled or valued as somehow being worth less than objective data.⁷ Purtscher notes that the "epidemiological situation" of a community does not necessarily reflect the individuals' or the community's subjective perception of safety.²⁰ More accurate assessments of the needs and priorities increase the likelihood of implementing relevant and appropriate programs.²¹

The framing of injury problems often requires more attention to social aspects of injury, not just changes in injury rates, if community support is desired. Laflamme questions whether injury occurrence is a suitable indicator for action, because people react to perceived changes in safety, rather than real changes in objective safety.¹⁷ This implies that community perception of problems that result in injuries can be altered, without actually altering the number of injuries they cause. The theory of risk compensation states that individuals' behaviour change in response to changes in *perceived* injury risk, which means that an increased safety level will not automatically result in reduced injury rates.²² Risk compensation mechanisms underscore the importance of addressing perceived safety, while at the same time pointing to the need for broader constructs of safety.

When a broader view of community safety is enacted, programs will be assessed differently: a project that failed to reduce injury rates, but achieved a higher level of subjective safety, could still be regarded as successful if a yardstick other than injury incidence is employed. Christoffel and Gallagher stress that success should not be defined solely by injury rates,²³ while Klassen *et al* believe that there is a range of outcomes and benefits *other* than injury frequency that could attest to success in injury prevention.⁵

THE WAY AHEAD

Numerous methodologies can be employed in gathering information

about subjective safety perceptions, including traditional surveys, panel studies, interviews with key informants and focus groups, convenience samples, "piggybacking" on studies being conducted by other organisations, and secondary analysis of existing data sets. The measurement of subjective health has become an important strategy for health promoters and is integral to the planning and evaluation of health promotion.^{24 25} We see no reason why it should not be possible to construct reliable, sensitive, and valid subjective safety measurement instruments in the near future.

Once safety measurement data can be captured and analysed, broader based safety promotion programs and research are possible, using a mixture of new data gathering methods as well as old, using subjective measures of safety alongside the objective. It is important to emphasise, however, that a shift of perspective to account for the subjective dimension of safety is not a departure from the traditional scientific approach of defining the problem through quantitative data. Indeed, our central point is that the two perspectives can, and *should*, exist as partners in every safety enhancing effort.

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Carbon monoxide poisoning

To make further progress against carbon monoxide poisoning, focus on motor vehicles

B J Strife, L Paulozzi

Modification of motor vehicles may help prevent deaths from carbon monoxide

Motor vehicle crashes are well publicized in the US, where they kill over 40 000 people each year. It is less well known that motor vehicles can also be lethal while standing still. In most such cases, the motor vehicle may be a convenient way to commit suicide. In other cases the death is wholly unintended. Modification of motor vehicles may help prevent some of these deaths.

The best known measure taken to date to address risks from motor vehicle exhaust was intended to reduce chronic exposure to air pollutants rather than acute poisonings. The US introduced catalytic converters in 1975 to improve ambient air quality by reducing the amount of carbon monoxide (CO) and other pollutants emitted by the average automobile. This change apparently also reduced deaths from acute motor vehicle carbon monoxide (MVCO) poisoning, both intentional and unintentional.¹

Catalytic converters, however, do not remove all CO from exhaust. Motor vehicles emit toxic levels of CO when their emission controls malfunction or after cold starts,² and the engine can be "fooled" into putting out more CO when the vehicle is running in a tightly enclosed space.³ Emission controls therefore have not eliminated the MVCO poisoning problem, even though essentially all American cars now have them. In 1998, the most recent year for which deaths traceable to MVCO are available in the US,⁴ the US motor vehicle fleet caused 1561 MVCO deaths, which accounted for 72% of the 2160 CO deaths from all sources combined (table 1). MVCO deaths are also a current problem in other countries with similar automobile emission controls. For example, there were 294 MVCO deaths in the UK in 2000,⁵ 534 in Australia in 1998,⁶ and 276 in Canada in 1999 (Statistics Canada, personal communication, 10 July 2003).

In addition to deaths from MVCO, there are probably many thousands of

non-fatal MVCO poisonings. One study has estimated the total number of emergency department visits for CO poisoning in the US annually as 43 000.⁷ The proportion of these visits caused by motor vehicle exhaust is not known, but it is probably a large share given the contribution of motor vehicles to overall CO mortality. Most people who attempt suicide do not seek care when their attempt is unsuccessful,⁸ so emergency department visits probably represent an underestimate of at least the self inflicted morbidity associated with MVCO.

Over 90% of people who kill themselves with motor vehicle exhaust are found inside the passenger cabin of a car or truck.⁹ Similarly, in an unpublished review of 58 non-fatal emergency department visits due to MVCO captured in an emergency department surveillance system in the US, described elsewhere,¹⁰ we found that 71% of the victims were poisoned while inside a motor vehicle, and an additional 23% were poisoned in an enclosed space such as a garage housing a running motor vehicle. Very few incidents involved scenarios where the exhaust had been channeled into an enclosed space that did not contain the motor vehicle.

Given these circumstances, putting carbon monoxide detectors like those used in private homes inside cars would seem like a logical precaution.¹¹ However, the literature shows that alcohol consumption is a consistent

contributing factor in fatal CO poisoning,^{7 11} and a detector that sounds an alarm when levels of CO are dangerously high may have limited effect when a person is inebriated. And it will probably have no effect when that person intends to die and has taken precautions against discovery.

A better approach might be a CO detector in motor vehicles that sounds an alarm and then slows the engine to a stop, allowing the accumulated CO to dissipate. Such an alarm should preferentially measure the cabin air rather than the air outside the motor vehicle. It should be difficult to tamper with and inexpensive to install. Such devices were actually recommended by the US Centers for Disease Control in 1990 to prevent adolescent MVCO suicides.¹² Technical details for such detectors for automobile passenger compartments were sketched out in a 1991 report from the Carnegie-Mellon Research Institute to the US National Highway Traffic Safety Administration (NHTSA),¹³ and results of field tests with such devices have been published more recently.¹⁴ The Carnegie-Mellon report recommended the development of such devices and calculated that they could be mass produced for less than \$12 apiece. If this estimate is correct, the cost of this technology is lower than that of some other required automobile safety features that are designed to prevent smaller numbers of deaths. Tire pressure monitoring systems, for example, cost approximately \$48 per vehicle.¹⁵ NHTSA has recently required such systems for American automobiles. NHTSA estimated that such systems could prevent approximately 124 deaths annually,¹⁵ many fewer than the 1500 MVCO deaths that might be prevented by MVCO detectors.

Depriving suicidal people of the tools they need or prefer to use to end their lives, an approach known as "means reduction", is not foolproof, because suicidal people may simply substitute an alternative means to kill themselves. As a result, it is argued, the MVCO suicide rate may decline, but the total suicide rate may remain the same.

Table 1 Deaths due to carbon monoxide (CO) poisoning by source of CO and manner of death, US, 1998

Manner of death	No (%) motor vehicle source*	No from all sources†
Unintentional	190 (48)	396
Suicide	1329 (79)	1690
Undetermined intent	42 (57)	74
Total	1561 (72)	2160

*Deaths with underlying causes of ICD9 E868.2 (unintentional), E952.0 (suicide), and E982.0 (undetermined).

†Deaths with underlying causes of ICD9 E868.2, E868.3, E868.8, E868.9 (unintentional); E952.0, E952.1 (suicide); and E982.0, E982.1 (undetermined).

However, survivors of deliberate MVCO poisoning report that they had acted impulsively—two thirds reported spending less than 24 hours planning the act—and chose the method in part because of its availability.¹⁶ All such persons may not turn to alternative means once the impulse to kill themselves has passed. This may be why the total suicide rate in Britain declined after the substitution of natural gas for coal gas, which has high concentrations of CO.¹⁷ It may also be why the introduction of catalytic converters, at least in Britain, has been given credit for at least some of the decline in *total* suicide rates for men since that change.¹⁸ Similar reductions in total suicide mortality have been correlated with efforts to control the availability of the pesticide paraquat in Samoa.¹⁹ So MVCO detectors may in fact prevent some suicides. In any case, the use of such technology may be justifiable if only because it may help prevent the 190 annual unintentional deaths from MVCO in the US.

Making modifications to motor vehicles such as CO monitors will require collaboration with automobile manufacturers. Manufacturers may be willing to work with public health agencies to come up with a low cost solution to this problem. They may in fact be able to suggest solutions other than CO monitors. We therefore urge that government agencies in any countries that experience MVCO fatalities work with domestic automobile manufacturers to address this problem.

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