



A comprehensive conceptual framework for road safety strategies



B.P. Hughes^{a,*}, A. Anund^{b,c}, T. Falkmer^{a,c,d}

^a School of Occupational Therapy and Social Work, Curtin University, Perth, Australia

^b Swedish Road and Transport Research Institute, 581 95 Linköping, Sweden

^c Rehabilitation Medicine, Department of Medicine and Health Sciences (IMH), Faculty of Health Sciences, Linköping University and Pain and Rehabilitation Centre, UHL, County Council, Linköping, Sweden

^d School of Occupational Therapy, La Trobe University, Melbourne, Australia

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ABSTRACT

Road safety strategies (generally called Strategic Highway Safety Plans in the USA) provide essential guidance for actions to improve road safety, but often lack a conceptual framework that is comprehensive, systems theory based, and underpinned by evidence from research and practice. This paper aims to incorporate all components, policy tools by which they are changed, and the general interactions between them. A framework of nine mutually interacting components that contribute to crashes and ten generic policy tools which can be applied to reduce the outcomes of these crashes was developed and used to assess 58 road safety strategies from 22 countries across 15 years. The work identifies the policy tools that are most and least widely applied to components, highlighting the potential for improvements to any individual road safety strategy, and the potential strengths and weaknesses of road safety strategies in general. The framework also provides guidance for the development of new road safety strategies, identifying potential consequences of policy tool based measures with regard to exposure and risk, useful for both mobility and safety objectives.

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1. Introduction

Road trauma continues to rate as a severe social and economic issue globally, despite recognition of the significance of it and the need to reduce the burden of death, injury and other costs. Contrary to the successes in many western countries, road safety still needs continuing efforts to be maintained and further improved. Worldwide, road crashes are estimated to cost 1.2 million lives each year with possibly as many as 50 million people injured (WHO, 2013). In Europe, nearly 25,700 fatalities were reported in 2014 and more than 200,000 people sustained serious injuries (European Commission, 2015). In the USA more than 30,000 people die and more than a million more are injured in road crashes each year (Evans, 2014). Globally, the number of road traffic deaths has plateaued since 2007, while road safety has been deteriorating in many developing countries (WHO, 2015). The full extent of road trauma's economic and social consequences defies description or estimation, with the average cost to governments alone approximating 3% of Gross Domestic Product, and up to 5% in some cases (WHO, 2015).

Worldwide, road trauma is a leading cause of preventable death and is regarded as a public health issue that has been neglected. It is forecast that road trauma will continue to deteriorate worldwide, imposing an even greater burden on society as a whole (WHO, 2013). However, this burden will fall disproportionately greater on lower income countries. It is estimated that deaths from road crashes globally could rise by around 50% from 2010 to 2020 to 1.9 million per annum (WHO, 2013). Many countries have therefore developed road safety strategies or plans as a response to this human and economic disaster. Some appear to have been successful, for example in the European Union with an 18% reduction in fatalities from road crashes from 2010 to 2014 (European Commission, 2015).

Road safety shares the attributes of many 'wicked' problems with characteristics including a multitude of contributing causes and intersecting external influences, and resistance to resolution (Di Stefano and Macdonald, 2003; Agarwal et al., 2013). Road trauma is a complex and intractable problem which cannot reasonably be reduced by easily implemented, simple solutions without taking account of the multitude of consequences for society, beyond individual types of crashes. As such, road safety may fall into a category of non-routine and non-standard problems not amenable to solution by rational-technical approaches that governments most commonly and comfortably apply (Eliasson and Lundberg, 2012; Albalade et al., 2013).

* Corresponding author at: 5/296 Mill Point Rd, South Perth, WA, Australia.
E-mail address: brett.hughes@transport.wa.gov.au (B.P. Hughes).

Road safety strategy and policy have evolved from focusing on the driver, mainly through enforcement and publicity based on human error being the primary cause. Later on, attention was given to road design standards before it was redirected in the 1970s to the motor vehicle industry to improve vehicle standards (Hakkert and Gitelman, 2014). Conceptual frameworks have been described for certain specific road safety issues, such as for cycling (Schepers et al., 2014) and in occupational safety (Stuckey et al., 2007), but not for the system as a whole for the purposes of road safety strategies. Bliss and Breen (2012) described the evolution of road safety strategy over the past decade, and the alignment with reduced road trauma in selected countries using the most recent approaches. However, there is no assessment of any cause and effect relationship between recent types of strategies (i.e., frameworks and processes) and the desired outcomes. Moreover, while individual strategy actions have a sound basis in theory and evidence it is not evident that the fundamental frameworks of strategies have the same scientific foundation. This leads to the potential that road safety strategies are incomplete or suboptimal.

Whilst there are many possible approaches to road safety, some recent road safety strategies have evolved to be described as systems approaches (Hughes et al., 2015a), essentially based on principles that refer to aspects of system theory (Perrow, 1984; Rasmussen, 1997; Leveson, 2004, 2009). Contemporary road safety strategies are consistent with some of the key principles of systems theory, although they also include aspects that are inconsistent with it (Salmon and Lenné, 2015). The various styles of modern road safety strategies include many components (such as drivers and vehicles), and their individual characteristics (such as age) which contribute to the consequences of road crashes. They also include the policy tools (such as programs and projects) to change the components, in order to reduce road trauma. At the same time, there are differences between the content of road safety strategies and how they are described. Individual strategies may not include actions to address all of the issues that may contribute to road safety. Therefore, a comprehensive conceptual framework has the potential to guide the development of road safety strategies to ensure they are complete, effective and efficient.

The widespread use of frameworks in road safety and elsewhere in safety management generally, such as those described by Haddon (1980), Road Research Laboratory (1963), Limpert (1978) and Baker and Fricke (1986) is an inherent indication of their value and applicability for practitioners in road safety. Therefore, the objective of this paper is to present a framework for road safety strategies that is further developed based on systems theory and underpinned by evidence from research and practice. The framework is comprehensive, incorporating all components, policy tools by which they are changed, and the general interactions between them. It addresses:

1. Components of the road safety system that comprise the constituent parts which alone, or in combination, cause road crashes.
2. Policy tools by which these components may be affected, in order to improve road safety and reduce road trauma.
3. Recent road safety strategies with regard to components and policy tools being applied.
4. Possible potential for improving road safety strategies.

It should be noted that it is not sufficient in itself to ensure that effective and efficient road safety strategies are developed; they must also be properly implemented and evaluated. Strategy development requires a sound process to ensure that all actors who contribute to development or implementation the strategy are recognised, including individual people, government agencies, companies, industry associations, interest groups and others who can make a contribution to improving road safety. This paper,

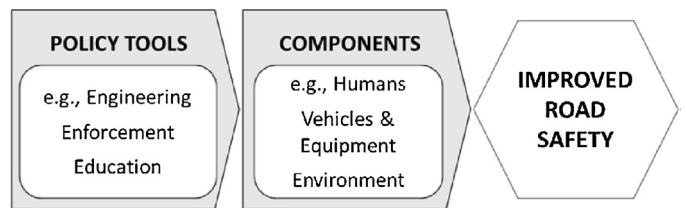


Fig. 1. Applying policy tools to components to achieve outcomes.

however, does not go beyond the description of a comprehensive framework to further describe the participants in road safety strategies, how it should be developed in order to be efficient and effective, or the subsequent evaluation.

Policy tools, such as engineering, enforcement and education (Nader, 1965; Booth, 1980), have previously been applied to components of the road safety system, such as humans, vehicles and equipment, and environment (Haddon, 1972). Road safety strategies describe policy tools applied to individual components to improve road safety. Therefore, the underlying rationale in this paper, derived from these approaches and consistent with systems theory, is that a comprehensive suite of policy tools have the potential to be applied to all relevant components in order to reduce road trauma, as illustrated in Fig. 1.

2. Method

This paper builds on two basic concepts recognised in the literature; the nature of models used for safety strategy and road safety policy tools. Firstly, there are several types of models that could be applied to road safety strategy, and each of them can incorporate different details (Yannis et al., 2015). Secondly, there are numerous policy tools that can be applied to improve road safety (Elvik et al., 2009a).

The conceptual framework provides a comprehensive description of the components that contribute to crashes, and the policy tools by which they can be influenced. The conceptual framework also provides the opportunity to consider all of the possible policy tools that could be applied to any of the relevant components in the development of road safety strategies. In doing so, it increases the likelihood that all valuable actions are included for all components and it reduces the risk that any valuable actions are omitted. However, it does not mean that a road safety strategy necessarily must include all policy tools or target all components.

The conceptual framework is applied to assess 58 road safety strategies, mostly at the national or state level, to determine the degree to which they apply policy tools and target components. This approach highlights the potential for improvements to any individual road safety strategy, considers the potential strengths and weaknesses of road safety strategies and provides guidance for the development of road safety strategies in general, potentially improving road safety outcomes.

2.1. Components of road safety

Given the variety of types of road safety strategy and the large number of components that they comprise of, the first task is to identify and describe all components. Haddon (1980) famously described a logical system, the Haddon matrix, for the prevention of road trauma according to a sequence of events in three phases (pre-crash, crash and post-crash) and four types of factors (human, vehicles and equipment, physical environment and roadway, and socio-economic environment). However, the matrix does not describe how these factors interact. In contrast, systems theory (Perrow, 1984; Rasmussen, 1997; Leveson, 2004, 2009)

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