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A comprehensive conceptual framework for road safety strategies

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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.

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; Albalate et al., 2013).

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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, 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.

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

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)

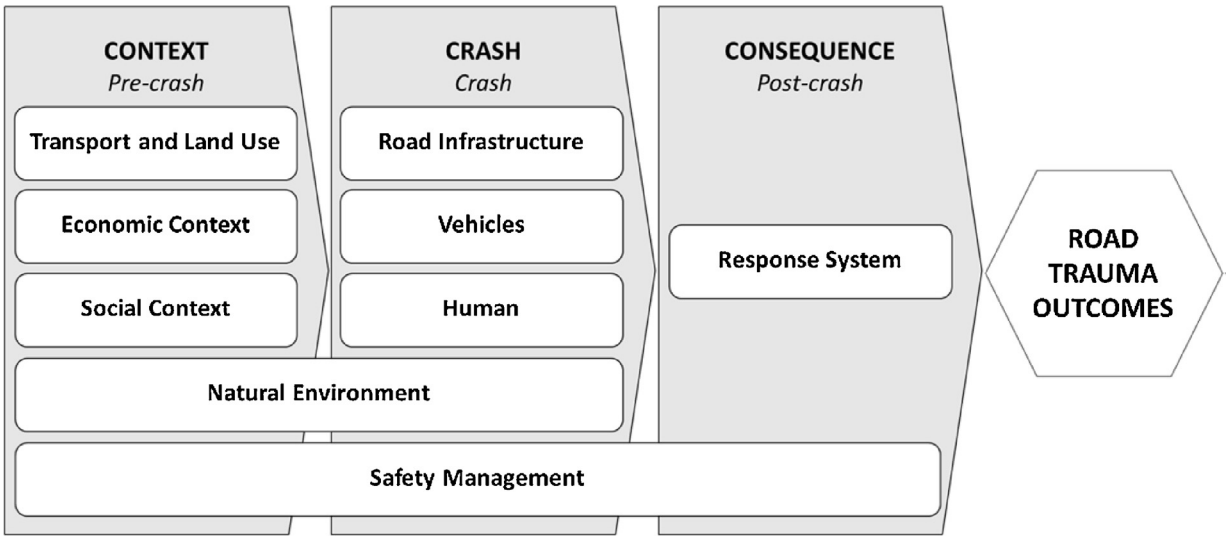

Fig. 2. Road safety phases and components.

describes both components and their interdependencies to achieve the desired outcomes. Unfortunately, common practice in road safety strategies only describes a specific policy tool applied to an individual component and does not take account of systems theory requirements to describe interdependencies between components or policy tools which interact.

More detailed descriptions of road safety components are therefore needed, and underpinned by research (Road Research Laboratory, 1963), crash analysis (Baker and Fricke, 1986) or individual road safety measures (Elvik et al., 2009a). Since these perspectives are different they do not cover all of the components that apply to road safety. Consequently, a comprehensive description covering all of the potentially contributing components is described in Table 1. In doing so the more common, but limited, description of road transport is considerably expanded in terms of breadth to other road infrastructure, the natural environment, the management of road safety and several stages of crash response. In addition, the wider economic, transport, land use and social context were also described.

Haddon's (1972) initial logical framework; human, vehicle and equipment, environment, and the human, machine environment component approach (Wang, 2010) has been strongly reflected in road safety strategies for a long time. Yet, road safety strategies have tended to limit the people involved to the driver, pedestrian or rider, as opposed to other people such as passengers, or those who might otherwise influence the system, such as those who design vehicles, load trucks, set policies or enforce the law. Systems theory requires identification of components that interact to achieve a specified outcome, so it is essential that all contributing components of the system are specified (Perrow, 1984; Rasmussen, 1997; Leveson, 2004, 2009).

Models can describe crashes as a sequence of events over time or a process, such as Haddon's (1972) framework; pre-crash, crash and post-crash phases. In this case, as illustrated in Fig. 2., generally the *context* phase prior to the event would include the Transport and Land Use, Economic, and Social Contexts, the *crash* phase at the time of the time event would include the Road Infrastructure, Vehicles, and Human while the Crash Response occurs in the *consequence* phase after the event. Some aspects of the Natural Environment are constant over time (such as topography) represented in the *context* phase, while others are temporal (such as precipitation and sunlight) represented in the *crash* phase. Safety Management occurs pre-crash but is applied to all three phases; *context, crash* and *consequence*.

Components from other safety domains to be included in road safety strategies have been identified (Yannis et al., 2015), such as public health's concept of determinants (Gordon, 1949; Bonita et al., 2006), control systems inclusion of institutional structures (Bax et al., 2014) and the wider view of the environment beyond the road to encompass social and economic factors (Haddon, 1980). These wider views identify model components not traditionally incorporated in road safety strategies, even though they are all represented in road safety research and practice. The references in Table 1 attest to the legitimacy of all of the individual components, each of which has been independently identified as being a component relevant to road safety.

2.2. Road safety strategy policy tools

Road safety strategy policy tools are activities, generally executed by governments, which aim to reduce road trauma. Policy tools may be described as policy measures, instruments, countermeasures, interventions, actions, responses or other terms. Road safety strategies are a combination of policy tools which are applied, although different road safety strategies describe the policy tools differently, or apply them according to different perspectives, such as whichever are the primary focuses. In addition, an approach to designing safer systems would extend the application of the policy tools to private companies, other organisations and individuals (Leveson, 2004).

Measures for regulating social behaviour have been categorised as detectors (tools for collecting information about target behaviour) and effectors (sanctions or rewards for changing or modifying the behaviour detected) (Durant and Legge, 1993). These approaches rely on the premise that human action (or behaviour) is a component in all aspects of road safety, not only as the road user. For example, road and vehicle designers are responsible for vehicle and road engineering. They, together with road users, respond to the broader natural environment, and the social and economic context components.

The means by which road safety outcomes can be improved have been considered according to different approaches or perspectives. One broad approach to policy instruments has suggested a threefold typology; economic means (carrots), regulations (sticks), and information (sermons), but also noted other broader and more detailed categorisations, listing up to 63 individual tools (Vedung, 2003). Following previous Engineering (or non-interacting), Economic (or utility maximizing, or danger compensation) and Risk

Table 1
Road safety components.

Component	Subcomponent Description	Example Reference
Transport and Land Use Context	Transport alternatives, other modes, company operations	Andersson (1994), Stuckey et al. (2007), Elvik et al. (2009b), Stradling (2011), Shan and Xi (2014), Bouaoun et al. (2015), Moeinaddini et al. (2015)
	Spatial arrangement, co-location	Henning-Hager (1986), Ossenbruggen et al. (2001), Flahaut (2004), Cho et al. (2009)
	Accessibility—remoteness, location, service levels	Brodsky (1983), Maio (1992), Cheffins (2007), Palamara et al. (2013), Thekdi and Lambert (2015)
	Transport integration	Whitelegg (1983)
Economic Context	Economics, finance, funding	Forjuoh (2003), Chen (2005), Garg (2005), Kopits and Cropper (2005), Elvik (2006), Paulozzi (2007), Traynor (2008, 2009), Chi (2011), Rangel et al. (2013)
	Population, employment structure	Partyka (1984), Wagenaar (1984), Hakim et al. (1991), Noland and Oh (2005), Krüger (2013), Stipdonk et al. (2013)
	Environment, energy, climate change	Schulte and Chun (2009), Chi (2011)
	Legal—regulation, liability, privacy, insurance, courts, corrections	Kenkel (1993), Blows (2003), Elvik (2006), Dionne (2011), Eriksson and Bjørnskau (2012)
Social Context	Politics and government	Køltzow (1993), Timpka et al. (2009), Belin et al. (2011), Bliss and Breen (2012), Hyder et al. (2012)
	Law—role and response	Gaygisiz (2010), Kim et al. (2011), Mullen et al. (2014), Smith et al. (2014)
	Social norms, nurture, background, traditions, rituals	Dobson et al. (1999), Bianchi and Summala (2004), Iversen (2004), Rosenbloom et al. (2009), Fries (2012)
	Ethnic practices	Chung (1990), Rasanathan (2008), Boufous (2010), Steinbach (2011)
	Spiritual beliefs	Forjuoh (2003), Melinder (2007), Yang et al. (2008), Akanbi et al. (2009), Kayani et al. (2011)
	Literacy, intellect, education	Forjuoh (2003), Borrell et al. (2005), Emerson et al. (2012)
	Employment—practices, demands, restrictions	Mitchell (2004), Stuckey et al. (2007), Clarke (2009)
	Activities, travel purposes	Wilks et al. (1999), Elias et al. (2010), Rosselló and Saenz-De-Miera (2011), Møller and Haustein (2013)
Natural Environment	Daylight, dawn, dusk, night, sun	Road Research Laboratory (1963), Limpert (1978), Baker and Fricke (1986), Elvik et al. (2009a), Eriksson and Bjørnskau (2012)
	Weather and atmospheric conditions—rain, fog, snow, smoke, wind, temperature	Road Research Laboratory (1963), Limpert (1978), Baker and Fricke (1986), Fridstrøm et al. (1995), Khan et al. (2014)
	Adjacent environment—topography, trees, grass, water	Road Research Laboratory (1963), Limpert (1978), Baker and Fricke (1986), Elvik et al. (2009a), Zou et al. (2014)
	Wildlife	Wentz et al. (2001), May et al. (2011), Shiftan et al. (2012)
Human	Driver, passenger, witness, acquaintance, occupant, road workers	Road Research Laboratory (1963), Limpert (1978), Baker and Fricke (1986)
	Age and sex	Road Research Laboratory (1963), Baker and Fricke (1986), Elvik et al. (2009a)
	Impairment—alcohol, drugs, medicines, carbon monoxide, drowsiness, sleep, disablement (seizures, pain, blackouts, disabilities), fatigue	Road Research Laboratory (1963), Limpert (1978), Baker and Fricke (1986), Elvik et al. (2009a)
	Driving process*—strategy, tactics, perception, alertness, reaction, attention, distraction, error correction, response to incidents and conditions	Road Research Laboratory (1963), Limpert (1978), Baker and Fricke (1986), Elvik et al. (2009a), Chan and Singhal (2015)
	Abilities—physical, vision, hearing, mental state, injury, illness, disability, health	Road Research Laboratory (1963), Baker and Fricke (1986), Wijesuriya et al. (2007), Elvik et al. (2009a)
	Capability—natural, learned, skill, intelligence, education, experience	Road Research Laboratory (1963), Baker and Fricke (1986), Elvik et al. (2009a)
	Attitude, motivation, demeanour, emotion, psychological state, behaviour	Road Research Laboratory (1963), Baker and Fricke (1986), Wijesuriya et al. (2007)
	Time (day, week, month, season), type of trip	Road Research Laboratory (1963), Baker and Fricke (1986), Eriksson and Bjørnskau (2012)
	Capability—licence, restrictions	Road Research Laboratory (1963), Limpert (1978), Baker and Fricke (1986)
	Helmets, clothing and other protection	Road Research Laboratory (1963), Limpert (1978), Baker and Fricke (1986), Elvik et al. (2009a)
	Clothing—visibility, protection, interference	Gowens (2003), De Rome (2011), Khan et al. (2014)
Vehicles	Type- car, truck, trailer, motorcycle, bicycle, bus, farm machinery, other	Road Research Laboratory (1963), Limpert (1978), Baker and Fricke (1986), Elvik et al. (2009a), Bouaoun et al. (2015)
	Design*—standards, maintenance, damage, modifications, inspections	Road Research Laboratory (1963), Limpert (1978), Baker and Fricke (1986), Elvik et al. (2009a)
	Wheels and tyres*—size, type, tread, pressure, condition, chains	Road Research Laboratory (1963), Limpert (1978), Baker and Fricke (1986), Elvik et al. (2009a)
	Brakes*	Road Research Laboratory (1963), Limpert (1978), Baker and Fricke (1986), Elvik et al. (2009a)
	Controls*—steering, pedals, levers, switches	Road Research Laboratory (1963), Limpert (1978), Baker and Fricke (1986), Elvik et al. (2009a)
	Body type* and mass	Road Research Laboratory (1963), Limpert (1978), Baker and Fricke (1986), Elvik et al. (2009a)

Table 1 (*Continued*)

Component	Subcomponent Description	Example Reference
	Seat belts, child restraints and other protection	Road Research Laboratory (1963), Limpert (1978), Baker and Fricke (1986), Elvik et al. (2009a)
	Lights*—external, internal, type, performance, colour, reflectors	Road Research Laboratory (1963), Limpert (1978), Baker and Fricke (1986), Elvik et al. (2009a)
	Cargo—type, characteristics, mass, strength, shape, hazardous	Road Research Laboratory (1963), Limpert (1978), Baker and Fricke (1986), Elvik et al. (2009a)
	Structure*—frame, doors, panels, safety features, crashworthiness, fittings, mirrors, mountings, flammability	Road Research Laboratory (1963), Limpert (1978), Baker and Fricke (1986), Elvik et al. (2009a)
	Suspension	Limpert (1978), ElMadany and Abduljabbar (1989), Elvik et al. (2009a)
	Engine, transmission, fuel type	Limpert (1978), Baker and Fricke (1986), Elvik et al. (2009a)
	Instruments	Road Research Laboratory (1963), Baker and Fricke (1986), Elvik et al. (2009a)
	Electrical components and circuits	Limpert (1978), Baker and Fricke (1986)
	Colour	Baker and Fricke (1986), Lardelli-Claret et al. (2002), Newstead and D'Elia (2010)
	Glass—colour, type	Road Research Laboratory (1963), Baker and Fricke (1986), Elvik et al. (2009a)
	Movement—speed, direction, angle, acceleration, coasting, deceleration, turning, overtaking, reversing, force, vibration	Road Research Laboratory (1963), Limpert (1978), Baker and Fricke (1986), Elvik et al. (2009a)
	Liquids and fluids	Radlinski et al. (1971), Treat and Joscelyn (1973), Baker and Fricke (1986), Lee (1998)
	Type of impact—speed, angle, physical dimensions	Baker and Fricke (1986), Elvik et al. (2009a), Candappa et al. (2015)
	Active safety and other technology—antilock brakes, electronic stability control, adaptive cruise control, speed control, etc.	Limpert (1978), Elvik et al. (2009), Jermakian (2012)
Note 1: *Generally applicable to motor vehicles, but may be applied to others		
Road Infrastructure	Surface—friction, colour, smoothness, cracks, edges, shoulders, unsealed, pothole, concrete asphalt, seal, manhole, drain, repair, cycle facility, drainage, grit, spills, footpaths—wet, dry, snow, ice, other	Road Research Laboratory (1963), Limpert (1978), Baker and Fricke (1986)
	Geometry—alignment geometry, curve, crest, dip, gradient, level, lanes, crossfall, physical dimensions, dual carriageway, passing lane, shoulder, median	Road Research Laboratory (1963), Limpert (1978), Baker and Fricke (1986), Elvik et al. (2009a)
	Signs, regulatory, advisory, pavement marking, signal, manned, speed limits, active/passive, reflectors, colour, illumination, reflectivity, access control, street design, bus lanes, roadworks	Road Research Laboratory (1963), Limpert (1978), Baker and Fricke (1986), Elvik et al. (2009a)
	Lighting—roadway, features and adjacent	Road Research Laboratory (1963), Baker and Fricke (1986), Elvik et al. (2009a), Wanvik (2009), Jackett and Frith (2013)
	Obstacles—pylons, gutter, kerb, culvert, bridge, pole, other street furniture, safety barrier, tunnel, building, overpass, tree, bus facilities	Road Research Laboratory (1963), Limpert (1978), Baker and Fricke (1986), Elvik et al. (2009a)
	Intersection type—intersection, junction, roundabout, grade separation, merge, railway crossing, crosswalk or crossing point, angled, pedestrian crossing, island	Road Research Laboratory (1963), Baker and Fricke (1986), Elvik et al. (2009a)
	Road type—Freeway, highway, city street, residential, rural, bridge, tunnel	Road Research Laboratory (1963), Baker and Fricke (1986), Elvik et al. (2009a)
	Miscellaneous—driveway, midblock, parked cars, stopped buses, lighting, glare, road debris, previous collision, landslides, work zones, tram/light rail	Road Research Laboratory (1963), Baker and Fricke (1986), Elvik et al. (2009a)
	Traffic volume, type, interaction	Ceder and Livneh (1982), Baker and Fricke (1986), Golob et al. (2004), Elvik et al. (2009a)
	Safety devices—guardrail, barrier, rest stop, fence, service area, route guidance, landslide protection	Lee and Mannering (2002), Elvik et al. (2009a), La Torre et al. (2012), Zou et al. (2014)
	Maintenance	Tighe et al. (2000), Elvik et al. (2009a), Usman et al. (2012), Agarwal et al. (2013)
Crash Response	Emergency & rescue services	Brodsky (1983), Wilmink et al. (1996), Sánchez-Mangas et al. (2010)
	Crash reporting and incident management	Golob et al. (1987), Giuliano (1989), Allred (2004), Lee and Fazio (2005)
	Heath treatment—first aid, emergency treatment, injury treatment	Coats (2002), Khorasani-Zavareh et al. (2009), Sánchez-Mangas et al. (2010), Adelborg et al. (2011)
	Rehabilitation, permanent care & adaptation	Clarke (1995), Piccinelli (1999), Ameratunga et al. (2004), Fitzharris et al. (2007), Tournier et al. (2014)

Table 1 (*Continued*)

Component	Subcomponent Description	Example Reference
Safety Management	Risk management—identification, assessment, countermeasures, revision	Bluff (2003), Bubbico et al. (2006), Dawson et al. (2014), Fernández-Muñiz et al. (2014), Jamroz et al. (2014)
	Information—research, data, investigations, benchmarking	Bluff (2003), Chapelon and Lassarre (2010), Papadimitriou and Yannis (2013)
	Capability—skills, knowledge, experience, of all participants	Bluff (2003), Bliss and Breen (2012), Jähi et al. (2012)
	Capacity—financial, human, system, technology	Bliss and Breen (2012), Jähi et al. (2012)
	Systems—processes, structures, procedures, standards	Bluff (2003), Crackel and Small (2010), Jamroz et al. (2014), Mooren et al. (2014)
	Integration—collaboration, coherence, synergy, co-ordination, optimisation	Niskanen (1994), Bluff (2003), Bliss and Breen (2012), Hyder et al. (2012), Canoquena (2013)
	Implementation—policy, planning, design, installation, maintenance, monitoring, revision	Bluff (2003), Hyder et al. (2012), Bliss and Breen (2012), Jähi et al. (2012)
	Communication—content, contact, medium	Niskanen (1994), Bluff (2003), Belin et al. (2011), Hyder et al. (2012)
	Culture—attitudes, beliefs, values, commitment	Niskanen (1994), Bluff (2003), Wills et al. (2006), Fries (2012), Canoquena (2013), Atchley et al. (2014)

Note 2: The examples in this Table may not be comprehensive—i.e., not all subcomponents within the description may be exemplified.

homeostasis approaches, Evans (1985) developed a theory that policy tools were applied to improve road safety outcomes, but are affected by human behaviour responding to the results of applying the tools. Leveson (2009) alternatively described five levels of control mechanisms that generally can be applied to improve safety in systems: physical, operational, managerial, organizational, and manufacturing-based.

Elvik (2003) investigated a broad range of measures used in road safety and found 132 potential road safety tools for Norway, applicable to many individual components of the road safety system, but without a categorized general system. Tools that focus on the road network as a whole, including institutional management functions, which achieve road safety outcomes have been described (Bliss and Breen, 2012).

Road safety strategies investigated in the present paper revealed hundreds of individual activities, typically according to the categories of target groups, safe systems approaches, and traditional descriptions described above. However, it is not evident that a single taxonomy is complete, since some policies or components exist outside the known categorizations. Consequently, despite the years of research, investigation and policy development, there is no categorization covering all policy tools applicable to road safety strategies. To the best of our knowledge, broad descriptions do not describe the complexity that is required when developing road safety strategies, but descriptions available currently are incomplete.

The current paper adopted a taxonomy based on three categories; Incentives, Disincentives and Influence, as shown in Fig. 3. Table 2 describes these categories of all road safety strategy policy tools, particularly in accordance with Vedung (2003), and detailed descriptions of policy tools in general use or for road safety, such as described by Elvik (2003) and others.

As shown in Table 2, road safety strategies suggested a strong emphasis on Disincentives (regulation, enforcement and penalties), Influence (ensuring driver competency) and Incentives (funding and investment to improve roads). Experience from other domains suggests a lack of a general classification of policy tools, but also a lack of comprehensive identification of available policy tools. Other domains focus on tools related to financial, cultural and tools to improve system objectives. This has led to the classification and sub-classifications of policy tools described in Table 2, in which all of the individual policy tools were represented in road safety research and practice.

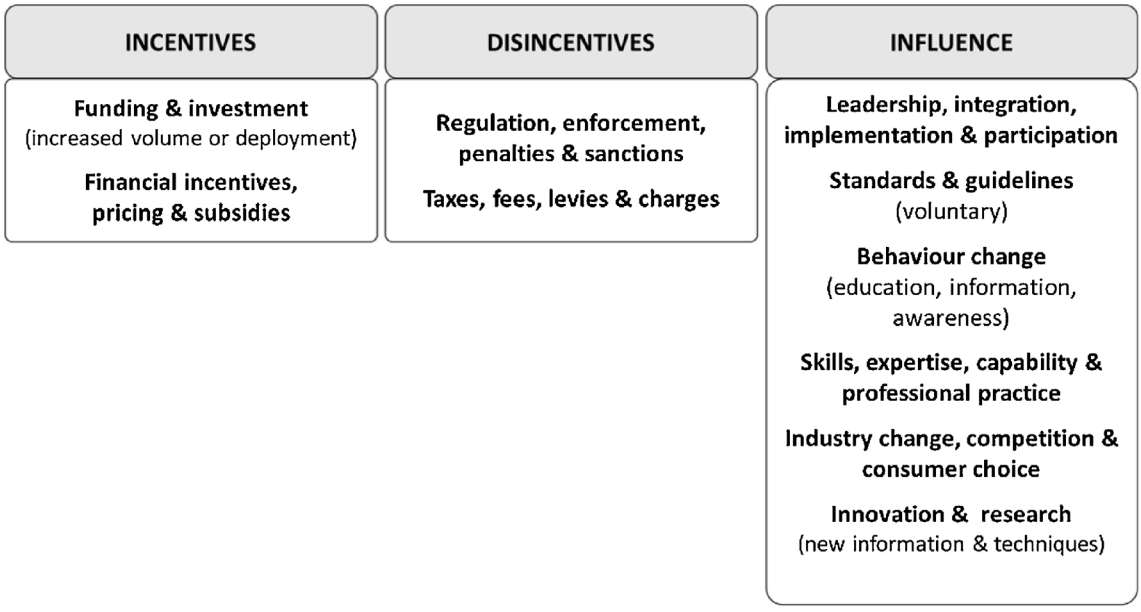

Fig. 3. Categories of policy tools.

Table 2
Policy tools.

Policy Tool	Description	Example reference
Funding and investment	Application of finances to increase the amount of facilities, services, assets, product or level of deployment	ETSC (1999), Lambert et al. (2003), Mock et al. (2005), Hyder and Aggarwal (2009), Odeck (2010), Eliasson and Lundberg (2012), Agarwal et al. (2013), Albalate et al. (2013), Bax et al. (2014), Nguyen-Hoang and Yeung (2014), Yannis et al. (2015)
Includes:	Purchasing of vehicles, tools, systems and equipment, infrastructure investment, services delivery, deployment of staff, engineering production, maintenance and product delivery	
Financial incentives, pricing and subsidies	Voluntary monetary or in-kind payments, costs and rewards to encourage desired behaviour or practice. Financial transfers and cross subsidies	Wilde and Murdoch (1982), Boyer and Dionne (1987), Koornstra and Christensen (1991), Thompson et al. (1993), Gregersen et al. (1996), Wesemann (2000), Elvik (2010), Grayson and Helman (2011), Mooren et al. (2014)
Includes:	Disincentives or penalties for poor behavers and inducements or rewards for good behavers Taxes and charges which provide road safety benefits (e.g., alcohol excise) Discounts for insurance and registration, payments to service providers	
Regulation, enforcement, penalties and sanctions	Activities to develop and apply a legislative authority	Lee (1998), Bagard (2004), Macpherson and Spinks (2008), Mehmood (2010), Wilson et al. (2010), Dionne (2011), Langford and Koppel (2011), Sze et al. (2011), Albalate et al. (2013)
Includes:	Legislation, rules, orders, enforcement, penalties, sanctions, mandatory application of standards	
Taxes, fees, levies and charges	Financial charges applied to discourage undesirable behaviour or practice	Dionne (1987), Wesemann (2000), Blows (2003), Linnakangas (2003), Thomas (2003), Elvik (2006), Boyer and Shiftan et al. (2012), Rangel et al. (2013)
Includes:	Payments for costs incurred, fees to encourage behaviour change, levies to fund policy tools	
Leadership, integration, implementation and participation	Desktop, office, personal and relational activities regarding the planning and delivery of policies, programs and projects to optimise safety outcomes. Excludes actual delivery of a policy	Hakim et al. (1991), Wegman et al. (1995), Elvik (2003), May et al. (2008), Holló (2010), Larsson et al. (2010), Belin et al. (2011), May et al. (2011), Jähi et al. (2012), Agarwal et al. (2013), Canoquena (2013), Papadimitriou and Yannis (2013), Bax et al. (2014), Thekdi and Lambert (2015)
Includes:	Leadership: advocacy, campaigning, general background information, strategic planning, development, assessment, selection of effective and efficient policies, programs and projects, outcomes monitoring Integration: coordination, optimisation, information exchange, output management Implementation: planning, programming, timing, impact assessment Participation: dialogue with stakeholders, negotiation, agreements, engagement	
Behaviour change	Activities which encourage people to behave more safely Separate from, but may be linked to incentives, pricing, subsidies and regulatory mechanisms	Henning-Hager (1986), Gregersen et al. (1996), Bianchi and Summala (2004), Delaney et al. (2004), Bertelli (2008), May et al. (2008), Grayson and Helman (2011)
Includes:	Education, information, awareness, rational encouragement, individualised information, mass campaigns	
Skills, expertise, capability and professional practice	Development of personal capacity, competency and fitness to undertake a task Development of professional skills and practice	Baas et al. (2000), Arnold and Hartley (2001), Di Stefano and Macdonald (2003), Washington et al. (2011), ISO (2012), Beanland et al. (2013), Martin et al. (2013)
Includes:	Training, experience, knowledge, skilling Medical, physical and intellectual fitness for duty	
Standards and guidelines	Voluntary application of written authoritative agreements or references with respect to design and practice Formal and informal standards and guidelines for good practice. May be recommended, desirable or minimum	Haworth et al. (2000), FHA (2006), Crackel and Small (2010), Lamptey et al. (2010), Marshall and Garrick (2011), ISO (2012), Kafka (2012)
Industry change, competition and consumer choice	Application of strategic advantage to provide a market advantage. Influences in markets which result in a desired outcome	Haworth et al. (2000), Koppel et al. (2008), ITF (2011), Thompson et al. (2011), Atchley et al. (2014), Fernández-Muñiz et al. (2014), Rangel and Vassallo (2015)
Includes:	Performance enhancement, lower costs, improved service, provision of market information (price, performance or quantity)	
Innovation and research	Investigation and development of new information with respect to behaviour, practice, product or operations and initial deployment to prove and refine applicability	Wentz et al. (2001), Elvik et al. (2009b), Chapelon and Lassarre (2010), Hinchcliff et al. (2010), Johnston (2010), Schulze and Koßmann (2010), Weijermars and Wesemann (2013), Shen et al. (2015)
Includes:	Basic and applied research, pilots, trials, evaluations, new general and specific information, continuous improvement	

3. Result and analysis of road safety strategies

Identification of the components and policy tools is potentially useful for developing and assessing road safety strategies. Based on the components and policy tools identified, a matrix was constructed and used to analyze both the components and policy tools identified and described in 58 road safety strategies from 22 countries dated from 2000 to 2015, as shown in Table 3, in which each cell represents at least one policy tool targeting one component. The count in each cell represents the number of strategies which include at least one policy tool for that component, with a percentage comparing to the total number of strategies. Many strategies include several policy tools in certain cells, such as regulation of drivers for licences, speeding and acceptable blood alcohol levels. Each cell was shaded to highlight the levels of effort road strategies generally according to quartiles (black—more than 75%

Table 3
Component and policy tool analysis of road safety strategies.

Policy Tool: / Component affected:	INCENTIVES				DISINCENTIVES				INFLUENCE												*Total number of strategies with Component*	
	Funding & investment		Financial incentives, pricing & subsidies		Regulation, enforcement, penalties & sanctions		Taxes, fees, levies & charges		Leadership, integration, implementation & participation		Behaviour change		Skills, expertise, capability & professional practice		Standards, guidelines		Industry change, competition & consumer choice		Innovation & research			
Transport and Land Use Context	12	21%	1	2%	2	3%	0	0%	33	57%	25	43%	5	9%	20	34%	3	5%	10	17%	*41*	71%
Economic Context	2	3%	1	2%	4	7%	0	0%	5	9%	10	17%	8	14%	3	5%	5	9%	5	9%	*18*	31%
Social Context	1	2%	1	2%	6	10%	1	2%	17	29%	27	47%	15	26%	5	9%	3	5%	6	10%	*33*	57%
Natural Environment	7	12%	0	0%	2	3%	0	0%	2	3%	1	2%	2	3%	8	14%	0	0%	5	9%	*16*	28%
Road Infrastructure	57	98%	3	5%	23	40%	0	0%	53	91%	26	45%	27	47%	47	81%	8	14%	50	86%	*58*	100 %
Vehicles	29	50%	7	12%	38	66%	0	0%	41	71%	35	60%	18	31%	35	60%	24	41%	45	78%	*53*	91%
Human	29	50%	4	7%	53	91%	4	7%	50	86%	56	97%	50	86%	22	38%	14	24%	45	78%	*57*	98%
Response System	17	29%	2	3%	2	3%	0	0%	19	33%	11	19%	20	34%	9	16%	3	5%	18	31%	*32*	55%
Safety Management	21	36%	2	3%	26	45%	0	0%	54	93%	39	67%	30	52%	18	31%	6	10%	41	71%	*56*	97%
Total number of strategies with Policy Tool	*56*	*97%*	*16*	*28%*	*55*	*95%*	*3*	*5%*	*56*	*97%*	*56*	*97%*	*54*	*93%*	*55*	*95%*	*32*	*55%*	*54*	*93%*		

Note: The count in each cell represents the number of strategies which include at least one policy tool for that component, with a percentage comparing to the total number of strategies.

Note: The count in each cell represents the number of strategies which include at least one policy tool for that component, with a percentage comparing to the total number of strategies.

of strategies, dark grey—between 50% and 75% of strategies, light grey—between 25% and 49% of strategies, and no shading—less than 25% of all strategies).

The matrix in Table 3 displays the emphasis of road safety strategies, with more than 90% of strategies focusing on road infrastructure, vehicles, human and safety management. More than 50% of strategies also included some actions regarding the social context, transport and land use context or response system, but 25% or less of the road safety strategies engaged in changing the economic context, the natural environment, or the social context. More than 90% of the strategies analyzed included a leadership approach, integration, implementation, participation, funding, investment, regulation, enforcement, behaviour change, skills, expertise and capability, innovation, research, standards and guidelines. Other policy tools including financial incentives, pricing, subsidies, industry change, competition and consumer choice were less commonly used, while taxes, fees and charges were only identified in three strategies.

The individual strategies are noted in Appendix A, together with the number of components affected and policy tools employed. These are illustrated in Fig. 4. for all strategies across time. The analysis indicates that road safety strategies have been increasing in complexity over the past 15 years as illustrated by the trend lines shaded. More policy tools are being applied to more components. A few recent strategies either affect all components and/or employ all types of policy tools.

4. Discussion

Road safety strategies provide essential guidance for actions to improve road safety, but lack a conceptual framework that is comprehensive, systems theory based, and underpinned by evidence from research and practice. A framework based on 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. Looking into 58 road safety strategies from 22 countries across 15 years for completeness, found they were narrowly focused and could be improved by extending both the policy tools and the components to which they are applied.

The use of components and policy tools is based on systems theory (Perrow, 1984; Rasmussen, 1997; Leveson, 2004, 2009) and other fundamental principles (Vedung, 2003; Elvik et al., 2009a; Bliss and Breen, 2012), but the descriptions presented are more than a speculative invention, since they are all evident in road safety research and practice. Policy tools and the components to which they are applied have therefore been robustly proven over time to be appropriate for inclusion. The comprehensive conceptual framework is a thorough illustration of the complexity of road safety previously recognized (WHO, 2013), but not previously described.

The presented framework extends the common three components (humans, vehicles and roads) to nine key components, and by expanding them, resulting in 74 individual subcomponents, all of which have been described as affecting road safety, but

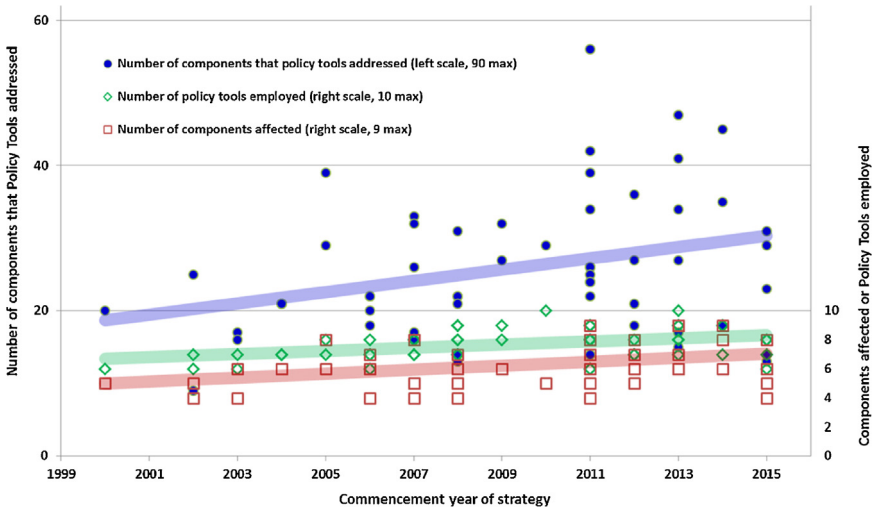

Fig. 4. Components affected and Policy Tools employed in individual road safety strategies over time.

not commonly included in road safety strategies. Secondly, the framework identified describes ten policy tools applicable to improve road safety, some more commonly applied than others (Hughes et al., 2015b).

Policy tools for improving road safety have not previously been comprehensively described or categorized. The traditional strong emphasis on enforcement, ensuring driver competency and improving roads was therefore extended to include financial, cultural and other tools to improve system objectives, all of which have been employed in road safety, but not commonly included in road safety strategies.

The components and policy tools demonstrate that road safety is complex and subject to many determinants, themselves influenced by other policy tools. The framework matrix of components and policy tools might be used to develop road safety strategies. The framework is consistent with the conclusion that "*the application of systems thinking and methods affords the opportunity to take a far more holistic approach to road safety*" (Salmon and Lenné, 2015; p247).

The analysis of road safety strategies' policy tools and components found that a narrow range of policy tools were applied to a few components. Vehicles, human (the driver in this case) and roads were most commonly targeted with strategic approaches, integration, implementation, participation, funding, investment, regulation, behaviour change, skills, expertise and capability, innovation and research. Standards and guidelines were used to a lesser extent, but other policy tools including financial incentives, pricing & subsidies were rarely used. Very few of the road safety strategies analyzed engaged in changing the economic system, transport and land use, or the social system. While this assessment does not demonstrate any strategy as inadequate, neither is it obvious that a strategy has been developed to ensure that it is complete. The framework includes policy tools and components which are described in other safety domains.

Road safety strategies in the USA (or Strategic Highway Safety Plans—SHSP's) are guided by Federal Law and guidance material including *A Champion's Guide to Saving Lives—Guidance to Supplement SAFETEA-LU Requirements* (FHA, 2006). Consequently, SHSP's are required to follow a collaborative process and develop a strategy with goals that comply with the template format. Development of the strategy is required to focus on "*key emphasis areas*" (FHA, 2006, p8) (e.g., occupant protection, pedestrians, intersections, roadway departure, impaired or distracted driving, data management, motorcycles, etc.). The Guidance suggests use of the four 'E's' (Engineering, Education, Enforcement and Emergency Medical Services). Consequently, road safety strategies in the USA could be more limited in scope than strategies that have less rigidity and a wider guidance structure. Such strategies could be less likely to include economic policy tools, such as incentives or taxation, and not take account of the wider social, economic, transport and urban form contexts, since there is no guidance on such policy tools and components. Conversely, road safety strategies from other jurisdictions do not clearly demonstrate collaboration with other relevant agencies or organizations, the application of a thorough process or a robust and comprehensive structure of policy tools, components, or the most important topics of focus. The differences suggest that there is potential to investigate whether variations in the types of strategies affects the efficiency or effectiveness of achieving strategy outcomes.

The breadth or detail of policy tools applied to improve individual components do not describe the effectiveness of any strategy, as a whole, to achieve the outcomes intended. It is possible for a strategy to employ a narrow range of policy tools across a few components if the tools are effective and sufficient resources are applied to substantially improve the components. It is possible that the effectiveness of any strategy has as much to do with the resources applied in its implementation, as it has to do with the level of sophistication of any strategy. That is, the success of recent road safety has been dependent on the level effort (such as the amount of enforcement as an example) rather than the quality of the strategy itself.

The analysis indicates that road safety strategies have been constantly increasing in complexity over the past 15 years, and some recent strategies include hundreds of individual actions, see Fig. 4. Where the focus of a strategy is limited (e.g., due to the agency span of responsibility like Police departments) or scope of interest is limited (like heavy vehicles alone), it can reasonably be expected that the road safety strategy will be simpler. Again, complexity does not necessarily indicate that the strategies are becoming more effective. However, it is known that road safety has been improving over the same period in many of the countries represented. Further work could assess the effectiveness of road safety strategies, such as whether more comprehensive strategies are more effective than simpler strategies, the levels of resourcing applied to execute the strategy and the effectiveness of management of implementation. One way to progress this might be to build on the knowledge about successful strategies (Hughes et al.,

2015a), which identified similarities and differences between road safety strategies in countries which had improved road safety.

While each of the components and policy tools is described, some overlaps remain. For instance, an action to encourage parents to talk with their children about the risks of alcohol and other drugs (in the *Washington State Strategic Highway Safety Plan 2013·Target Zero*) aims at changing behaviour for young road users, by changing the social norms, perhaps with better parental expertise. In this case the action crosses both Human and the Social Context components, as well as the behaviour change and capabilities policy tools.

This paper highlights the potential to assess the strengths and weaknesses of road safety strategies, individually and collectively. It also provides clear guidance for the development of road safety strategies generally by providing a description of the full range of components of road safety and the policy tools by which they can be affected. It appears there are opportunities for road safety strategies to target components currently ignored, and apply policy tools not yet commonly applied.

The widespread use of frameworks for road safety management in the past indicates their utility, so it is the authors' expectation that the framework presented here can be applied to determine how much value it can add in improving road safety strategies. Therefore, future research should investigate whether use of the framework results in improvements to road safety outcomes, especially compared with existing strategies. In the same way, an index or scoring system could be devised from the framework, in addition to other relevant factors (such as participants or process) and compared with the results of the strategy to determine best practice for widespread use.

Another element, sometimes included in road safety strategies, is the anticipated future level of road trauma outcomes, which is a complex topic also worth further investigation. Some strategies anticipate or forecast the expected results of successful implementation, while others propose a visionary outcome, such as zero deaths or serious injurious, which may not be achievable within the term of the strategy. The strategies themselves should be evaluated for their efficiency and effectiveness, as opposed to the more common situation where individual actions are evaluated in isolation. Furthermore, essential factors for a successful road safety strategy, such as the involvement of all actors, should also be investigated to ensure the frameworks or processes themselves are valid. The framework could be used to investigate the relationship between how a program 'scores' according to the conceptual framework and how much it succeeded in improving safety.

While this paper has described a comprehensive component—policy tool framework for road safety strategy development, analysis, research or beyond in practice, further work is required to apply it and assess its utility. The framework can provide a prompt to potential road safety policy tools and which components they can be applied to, that otherwise might be overlooked. It is, however, not expected that all the policy tools will be included in any road safety strategy or all components will be targeted for intervention. The framework might also be used to ensure that useful policies have been included. Furthermore, the framework has the potential to guide road safety research, analysis and routine investigations in similar ways. Finally, given the generic approach, it is possible that the framework can be adapted for use in similar ways in other domains including industrial, mining and occupational safety.

Strategies for road safety are applicable to particular user groups (such as heavy vehicles), subordinate jurisdictions (such as States within countries or cities), advocacy or coordinating organizations (such as the United Nations, or automobile associations), individual industries (such as tourism or mining), particular commodities (such as hazardous goods, or individual companies for workplace road safety as part of occupational safety). Further work could explore the adaptation, implementation and utility of the framework to these domains. The strategies investigated were from developed countries, so strategies from other jurisdictions may be different. It is expected that the initiatives which have proven successful in developed countries can be successfully applied in developing countries that are subject to different social and economic contexts. Even in developing countries, it remains to learn whether the traditional policies and emerging opportunities, particularly offered by electronic information and communication technologies, will continue to result in reducing road trauma. Given the challenges of complexity, context and scale, perhaps different road safety frameworks will be required to recognize additional factors contributing to safety and to employ policy tools not yet applied. Given the challenges that road safety presents in developing countries, further work could be to consider differences between developing and developed countries, particularly in terms of the underlying social, economic, land use and transport contexts. A limitation here is the knowledge of the effect the stakeholders involved putting the policies into place to affect the described components. A complementary control system approach describing a hierarchy of actors and organizations has recently been developed for road safety (Salmon et al., 2015) based on more general systems theory (Rasmussen, 1997), which could be applied to the proposed framework as a complementary approach. Consistent with systems theory, further research could investigate the relationships between individual actors with the policy tools and subcomponents in the framework, which offers the potential to increase the efficiency and effectiveness of road safety strategies.

The components, policy tools and hierarchy of stakeholders (actors and organizations) clearly demonstrate the complexity in addressing road safety. It highlights that simplistic approaches to a narrow range of components, from a few actors, has at least the potential to be inadequate. It is a signal to road safety strategists that they are likely to need to move beyond the span of their own control into fields where they do not have direct responsibility. Furthermore, they are likely to need to employ policy tools which are beyond their direct authority. These move beyond the focus and activity of traditional road safety strategies will therefore require road safety strategists to start exerting influence indirectly and more widely, rather than relying on exercising on their own authority directly.

The proposed comprehensive framework for road safety strategies might be applied by road safety practitioners, and subsequently evaluated for utility. Application could take several forms, such as using the framework in its 'blank' form to identify potential policy tools which could potentially be applied to subcomponents to be targeted. The framework might also be used to review past strategies to identify which policy tools and subcomponents have not previously been applied. Researchers might use the framework as a guide to identify complementary or confounding factors which may be influencing individual policy tools or subcomponent being investigated. Finally, the framework might be used to further guide comparison, assessment and contrast of road safety strategies, extending the assessments in this paper.

The authors expect the framework contributes to holistic thinking, innovation, and a comprehensive strategy involving a range of coordinated and interrelated responses required for road safety (Eliasson and Lundberg, 2012). The results of this paper support what is stated by Salmon and Lenné (2015) p247 that "*adopting systems thinking approaches in road safety research and practice has the potential to aid the design and operation of safer road transport systems and to facilitate new reductions in road trauma*".

Appendix A. Summary of road safety strategies and framework analysis.

Title	Period of the strategy or date	Authority	Number of components affected (9 max)	Number of policy tools employed (10 max)	Number of component—policy tools used (90 max, % of 90)	
Safe Roads for Development: A policy framework for safe infrastructure on major road transport networks	Not stated	World Bank Global Road Safety Facility	3	5	10	11.1%
Every Accident Is One Too Many	2000	Danish Ministry of Transport for the Danish Road Safety Commission	5	6	20	22.2%
Road Safety in Norway: Strategy	2002–2011	Ministry of Transport and Communications	4	6	9	10%
Northern Ireland Road Safety Strategy	2002–2012	Department of the Environment Road Safety Branch	5	7	25	27.8%
The South Australian Road Safety Strategy	2003–2010	Transport SA	6	7	17	18.9%
National Heavy Vehicle Safety Strategy	2003–2010	Australian Transport Council	4	6	16	17.8%
National Road Safety Strategy of the Czech Republic	2004–2010	Ministry of Transport of the Czech Republic	6	7	21	23.3%
Queensland Road Safety Action Plan: safe4life & Queensland Road Safety Strategy	2004–2011	Queensland Department of Transport and Main Roads	6	7	21	23.3%
Via sicura – Federal Action Programme for Greater Road Safety	2005	Federal Roads Authority FEDRO (Switzerland)	8	8	39	43.3%
AASHTO Strategic Highway Safety Plan (2004 update)	2005	AASHTO—USA	6	7	29	32.2%
Safe Traffic: Vision Zero on the Move & "Vision Zero" from concept to action	2006	Swedish Road Administration	6	8	20	22.2%
National Road Safety Strategy	2006	Transport Department (South Africa)	4	7	22	24.4%
Safer Roads: A Territory Imperative	2006	Northern Territory Government	6	7	22	24.4%
Strategic Plan: New Ideas for a Nation on the Move	2006–2011	Department of Transportation (USA)	7	6	18	20.0%
White Paper on Traffic Safety in Japan	2007	International Association of Traffic and Safety Sciences	4	7	16	17.8%
Strategic Framework for Road Safety & Tomorrow's roads—safer for everyone	2007 & 2011	Department for Transport (United Kingdom)	8	8	33	36.7%
Road Safety Strategy	2007–2012	Road Safety Authority (Ireland)	5	8	26	28.9%
Our Safety Our Future, Tasmanian Road Safety Strategy and Action Plan	2007–2016	Department of Infrastructure, Energy and Resources	5	8	17	18.9%
Strategic Highway Safety Plan: Target Zero (SHSP)	2007–2030	State of Washington, Office of the Governor	8	7	32	35.6%
Towards Zero Deaths	2008	The American Traffic Safety Services Association	5	7	13	14.4%
UNECE Transport Review: Road Safety	2008	United Nations	4	7	14	15.6%
National Road Safety Strategy	2008–2015	Autoridade Nacional de SegurançaRodoviária (ANSR—National Road Safety Authority, Portugal)	6	9	31	34.4%
Victoria's Road Safety Strategy: Arrive Alive	2008–2017	Victoria Police, Victoria, Transport Accident Commission, Department of Justice	7	8	22	24.4%
Road Safety Strategic Plan, From, for and by everyone	2008–2020	Minister of Transport, Public Works and Water Management (Netherlands)	5	8	22	24.4%
Towards Zero – Road Safety Strategy	2008–2020	Road Safety Council Western Australia	6	9	21	23.3%

Austrian Road Safety Program (2009ed)	2009	Federal Ministry for Transport, Innovation and Technology	6	9	32	35.6%
Scotland's Road Safety Framework	2009–2020	The Scottish Government	6	8	27	30%
Safer Journeys NZ Road Safety Strategy and Action Plan	2010–2020	National Road Safety Committee New Zealand and Ministry of Transport	5	10	29	32.2%
Road Safety Programme	2011	Federal Ministry of Transport, Building and Urban Development (Germany)	8	8	24	26.7%
Kentucky Strategic Highway Safety Plan	2011–2014	Kentucky Transportation Cabinet, Office of Highway Safety	6	8	26	28.9%
Canada's Road Safety Strategy 2015	2011-2015	Canadian Council of Motor Transport Administrators	4	6	14	15.6%
Road Safety Plan	2011–2015	Stirling Council (Scotland)	8	6	26	28.9%
Austrian Road Safety Programme	2011–2020	Ministry for Transport, Innovation and Technology	9	9	56	62.2%
Road Safety Strategy 2011–20 & ACT Road Safety Action Plan 2011–2013	2011–2020	ACT Government	7	8	34	37.8%
South Australia's Road Safety Strategy 2020: Towards Zero Together	2011–2020	Road Safety Advisory Council (South Australia)	7	8	25	27.8%
National Road Safety Strategy	2011–2020	Australian Transport Council	5	9	24	26.7%
National Road Safety Programme	2011–2020	Republic of Croatia	8	8	39	43.3%
Spanish Road Safety Estrategy	2011–2020	Traffic General Directorate	7	9	42	46.7%
Development of a Strategic Plan for the improvement of road safety	2011–2020	Hellenic Republic, Ministry of Infrastructure, Transport and Networks	6	8	22	24.4%
Policy Document Road Safety: working together as one	2012	Ministry of Infrastructure and the Environment (Netherlands)	7	8	36	40.0%
Strategic Highway Safety Plan	2012	Florida Department of Transportation	5	7	21	23.3%
Strategic Highway Safety Plan	2012–2016	State of Nebraska	6	7	18	20.0%
Strategic Highway Safety Plan	2012–2016	Commonwealth of Virginia, Department of Transportation	8	7	27	30.0%
State Strategic Highway Safety Plan 2013 • Target Zero	2013	State of Washington	9	10	47	52.2%
Traffic Safety Plan	2013–2015	Office of Traffic Safety, Alberta Government	9	8	41	45.6%
Strategic Highway Safety Plan	2013–2017	Massachusetts Department of Transportation	6	7	17	18.9%
Every Accident is one too many – a shared responsibility. National Action Plan	2013–2020	Danish Road Safety Commission	6	9	27	30.0%
National Road Safety Programme	2013–2020	National Road Safety Council, Ministry of Infrastructure and Development (Poland)	7	9	34	37.8%
Road Safety Strategy	2013–2020	Road Safety Authority (Ireland)	9	9	47	52.2%
Victoria's Road Safety Strategy	2013–2020	Victoria Government agencies	6	8	15	16.7%
Road Safety Strategy Final Technical Report	2014	City of London	6	7	18	20.0%
Strategic Highway Safety Plan	2014–2016	Wisconsin Department of Transportation	8	9	35	38.9%
National Plan of Action for Road Traffic Safety	2014–2017	Norwegian Government	9	9	45	50.0%
Road Safety Strategy	2015	Bermuda Police Service	4	6	13	14.4%
Alaska Highway Safety Plan	2015	Alaska Highway Safety Office	6	8	23	25.6%

California Highway Safety Plan	2015	California Office of Traffic Safety	6	8	29	32.2%
Road Safety Strategy: Toward Zero Tolerance	2015	Transportation and Infrastructure Renewal (Prince Edward Island)	5	8	14	15.6%
A Safe Systems Approach to Road Safety in Bristol: A 21st Century Approach	2015–2024	Bristol City Council	8	7	31	34.4%

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