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System theory and safety models in Swedish, UK, Dutch and Australian road safety strategies

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ABSTRACT

Road safety strategies represent interventions on a complex social technical system level. An understanding of a theoretical basis and description is required for strategies to be structured and developed. Road safety strategies are described as systems, but have not been related to the theory, principles and basis by which systems have been developed and analysed. Recently, road safety strategies, which have been employed for many years in different countries, have moved to a 'vision zero', or 'safe system' style. The aim of this study was to analyse the successful Swedish, United Kingdom and Dutch road safety strategies against the older, and newer, Australian road safety strategies, with respect to their foundations in system theory and safety models. Analysis of the strategies against these foundations could indicate potential improvements. The content of four modern cases of road safety strategy was compared against each other, reviewed against scientific systems theory and reviewed against types of safety model. The strategies contained substantial similarities, but were different in terms of fundamental constructs and principles, with limited theoretical basis. The results indicate that the modern strategies do not include essential aspects of systems theory that describe relationships and interdependencies between key components. The description of these strategies as systems is therefore not well founded and deserves further development.

1. Introduction

Road traffic injury is listed in the top ten major causes of mortality and morbidity worldwide (WHO, 2010). It is estimated that more than 1.2 million people die as a result of road traffic crashes and some 50 million are injured per annum (WHO, 2009). Across the world, road safety strategies are therefore developed, implemented and evaluated against different kinds of road related fatality and injury estimates (Johnston, 2010). It has been pointed out that road safety strategies are all implemented into a social technical system, *"Complex systems cannot be understood by studying parts in isolation. The very essence... lies in the interaction between parts and the overall behaviour that emerges from the interactions..."* (p293). This implies that if a strategy does not consider the system as a whole it is likely to fail (Ottino, 2003). However, the road traffic system is complex (Salmon et al., 2012) and therefore needs to be modelled before it can be understood and properly structured, in order to generate, for example, road safety strategies (Kaposi and Myers, 1994).

Following the introduction of recent road safety strategies, such as the Vision Zero in Sweden (Larsson et al., 2010), the Tomorrow's roads: safer for everyone in the U.K. (Department for Transport, 2000) and Sustainable Safety in the Netherlands (Wegman and Aarts, 2006; Wegman et al., 2008), a subsequent or continuing improvement in road safety has been observed. The number of people killed per capita from 2000 to 2011 has declined by approximately 4.85% per annum in Sweden, the United Kingdom (UK) and the Netherlands during this period, as shown in Fig. 1. A similar reduction has not been observed in Australia, where the number of people killed per capita only decreased by about 3.3% per annum despite *The National Road Safety Strategy: 2001–2010.* As a result, a new *Australian Road Safety Strategy: 2011–2020* has been agreed (Australian Transport Council, 2011), which more closely aligns with the Swedish and Dutch strategies.

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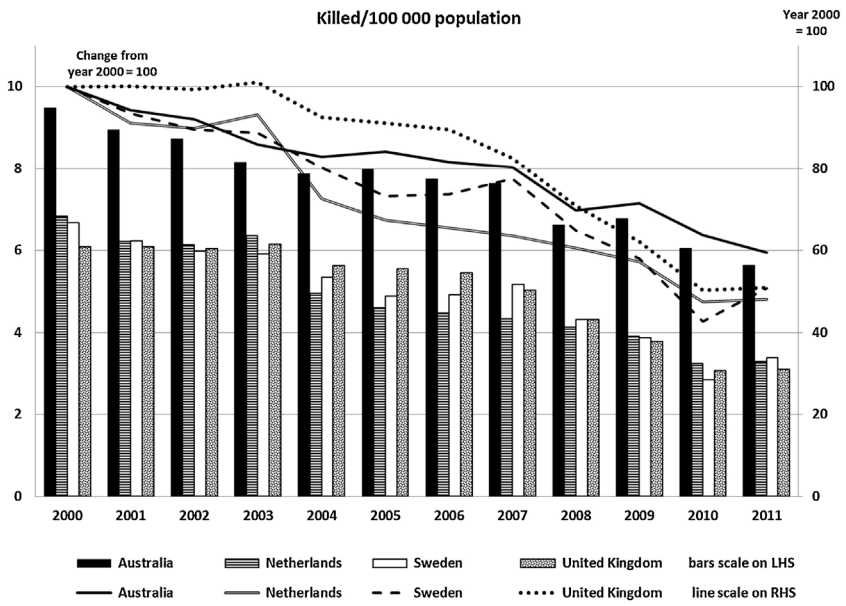

Fig. 1. Recent history of road safety outcomes in four countries. LHS = left hand scale, RHS = right hand scale. The *x*-axis represents the years 2000 to 2011. The curves represent normative data across the four countries.

'Models' are simplified descriptions or representations to assist understanding. They create a mental picture, facilitate questioning, establishing rules, checking, evaluation, analysis, identifying and assessing countermeasures and communication (Kjellén, 2000; Hughes et al., 2014). Many different types of model have been applied to identifying and managing risks, but not all of them have been applied to road safety (Hughes et al., 2014).

Systems concepts are highly influential in various diverse domains to improve safety, although the term 'system' is widely, but inconsistently used (Waterson, 2009), and it has not been thoroughly or widely applied to road safety (Salmon et al., 2012). Systems are operating entities comprising discrete components which transform input to output for a purpose (Hughes et al., 2014). According to systems theory, systems exist when there are interdependent, but related components achieving a valued pre-set objective, purpose or function. System theory has been thoroughly and scientifically developed over a long time to explore complex processes of transforming input to output for a purpose (Von Bertalanffy, 1968; Perrow, 1984; Leveson, 2004, 2011; Waterson, 2009; Wilson, 2014a,b). Safety in complex operations and situations including aviation, rail transport, nuclear power and health (Waterson, 2009) and aerospace, production industry, water supplies, and the military (Leveson, 2011) has benefited from application of systems theory and techniques.

This study investigates the basis of five road safety strategies based on systems theory and safety models. While Larsson et al. (2010) describes the Vision Zero as based on system theory, they claim that there are very few references of systems theory being applied to other road safety strategies. Furthermore, they describe road safety strategies to be simplistic and limited and therefore inconsistent with system theory. Whether this is true or not needs to be scrutinised. However, road safety strategies have previously been compared by Koornstra et al. (2002) who found both considerable differences and substantial similarities between successful strategies.

1.1. Swedish, UK, Dutch and Australian road safety strategies

The key components of the Swedish, UK, Dutch and two Australian Road Safety Strategies analysed in this paper are summarised in Table 1. The strategies are widely different in the way they are presented and the additional material included as road safety, transport or institutional background or for implementation. The Swedish Vision Zero uses points for 'long-term guideline and traffic safety structure', although there are multiple descriptions of Vision Zero which differ (Ministry of Transport and Communications, 1997; Tingvall and Haworth, 1999; Tingvall and Lie, 2001; Wegman et al., undated; Larsson et al., 2010). The UK strategy is based on main themes, while the Dutch focus on five principles with three 'Risk factors' and the Australian Road Safety Strategy uses 'key cornerstones' and 'guiding principles'. In the present study, we have regarded all of them to be 'Key Components', according to system theory, as described below.

The aim of this study was to analyse the Swedish, UK and Dutch road safety strategies against old and new versions of the Australian road safety strategy, with respect to their foundations in system theory and safety models.

2. Methods

With a starting point in system theory and safety models and the connection between those, a review of the five identified road safety strategies was carried out, as illustrated in Fig. 2.

2.1. System theory

Several terms are used in discussions about systems including system, systems theory, systems approaches and systematic processes (Hughes et al., 2014). System theory describes that systems exist when there are interdependent but related components achieving a valued pre-set objective (or purpose or function) (Von Bertalanffy, 1968; Perrow, 1984; Leveson, 2004, 2011). Systems may be supported further by principles, and based on theories and information applicable to the situation (such as road safety or organisations). Consequently, the fundamental constructs of system theory are: Key Components, Relationships, Objectives and Interdependency, in addition to principles and theoretical basis.

Fig. 2. A model of the design of the present study.