Exploring the application of the Safe System Approach to cycling

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Abstract

The personal, social and environmental benefits of cycling have been clearly identified (Bauman et al, 2008). However, significant barriers to encouraging more people to cycle are the perceived and real injury risks for cyclists. The Safe System Approach [SSA] has been recently adopted Australia wide as an approach to road safety. However, much of its application has focussed on motor vehicle safety, and there is limited consideration in the context of cycling safety. As a part of the Safer Cycling Study, a prospective cohort study in which a large cohort of cyclists reported on their cycling patterns and experience, all cyclists who experienced a crash were interviewed (n=145). Interviews were structured around the four elements of the SSA: safe road use, safe infrastructure, safe speeds and safer vehicles. These elements also formed the high-level themes of template analysis of cyclists' perceived crash causes and opportunities for prevention. Cyclists perceived factors associated with road use (behaviour) as being the greatest contributor to crashes, partly because of a tendency to blame themselves for crashes which could have been avoided by safer infrastructure. Infrastructure factors were next most frequently reported as crash contributors. Cyclists rarely reported safe vehicles or speed as contributory factors. The majority of opportunities for prevention were also perceived to be around safe road use, and included education for all road users. Improved signage and lighting on existing infrastructure and extension of cyclist infrastructure were also mentioned frequently. Consideration of the four quadrants of the SSA provides a useful framework for improving research, policy and practice relating to cycling safety. Although cyclists may lack specific expertise, their perceptions of crash causation and opportunities for prevention offer specific avenues for creating a safer cycling system.

Keywords: Safe System Approach; cyclist safety; safe road use

1. Introduction

The personal, social and environmental benefits of cycling have been clearly identified (Bauman et al, 2008). Studies have consistently demonstrated a positive relationship between cycling and health, providing 'strong support for the promotion of cycling for public health' (Oja et al, 2011).

The perceived and real injury risks are significant barriers to encouraging more people to cycle. In Australia, there was an increase of 7.5% in age standardised rates of life threatening injury for cyclists from 2000-01 to 2007-08, which was the highest of all road user groups (Henley and Harrison, 2011). Research in Australia has demonstrated that police crash records significantly underestimate the number of cyclist crashes (Lujic et al, 2008). Furthermore, crashes where cyclists are injured may not be captured in hospitalisation data if cyclists receive treatment in emergency departments or with local medical practitioners. Lower European cycling injury rates have been attributed to better cycling infrastructure and education for all road users, reduced speed limits (30km/h) and an expectation on drivers that they are responsible for cyclist safety (Garrard et al, 2010) thus suggesting possibilities for improving cycling safety in Australia.

The Safe Systems Approach [SSA] has been adopted in Australia as an approach to road safety. It emphasises a holistic view of road safety, with shared responsibility for the prevention of crashes (Roadwise, 2011). The SSA has four essential elements for safety promotion: safe road use (behaviour), safe roads and roadsides (infrastructure), safe speeds and safe vehicles (Roadwise, 2011). It aims to reduce the number of crashes by creating a transport system that is more forgiving of human error, keeps crash forces at a survivable level and decreases unsafe road user behaviour as a contributing factor to road crashes (Vicroads, 2012).

To date, application of the SSA within planning documents has focussed on motor vehicles and drivers. For example, although the “National Road Safety Strategy 2011-2020” (Australian Transport Council, 2011) applies the SSA throughout, with minimal specific application to more vulnerable road users, such as cyclists. The “National Cycling Strategy 2011-2016” (Australian Bicycle Council, 2010) does not mention the SSA. The Austroads “Guide to Road Design” (Austroads, 2009) and “Cycling Aspects of Austroads Guides” (Austroads, 2011) state the philosophy and objectives of the SSA approach are relevant to pedestrian and cyclist infrastructure but offer few suggestions as to how to apply SSA principles to promote cyclist safety. The “NSW Bike Plan” (Roads and Traffic Authority, 2010) discusses various aspects of the SSA, but does not apply it overtly as a framework for safety.

Consistent application of the SSA to cycling should offer improvements to cycling safety, yet currently there is little information regarding the impact of infrastructure, vehicle, speed or behavioural factors, and their interactions, on cyclists. Moreover, the success of the SSA is likely to be limited in the absence of its widespread application by all levels of government and to all road users. Discussion and debate on what a safe system may look like should be encouraged (Transport Research Centre, 2008). This research aims to assess whether the SSA can be usefully applied to a set of self-reported cycling crashes to classify crash contributors.

2. Methods

2.1. Overall study design

The Safer Cycling Study is a prospective cohort study of cyclists aged 18 years and over, who live in New South Wales, and who usually bicycle at least once a month (Poulos et al, 2011). Over 2000 cyclists were recruited between March and November 2011. Data are collected via web-based online questionnaires. At enrolment, participants completed a baseline questionnaire, which included demographic, attitudinal and behavioural data. In the 12 months following enrolment, cyclists are surveyed on six occasions (weeks 8, 16, 24, 32, 40 and 48 from the week of the enrolment survey). In these survey weeks, cyclists are asked to provide daily reports of: distance travelled; time, location and duration of trips; infrastructure used; crashes, and crash-related injuries. Based on the definitions of Reynolds et al (2009), crashes are defined as collisions (“an event in which the bicycle hits or is hit by an object, person or animal regardless of fault”) or falls (“an event not caused by a collision where the bicycle and/or bike rider lands on the ground”).

2.2. Qualitative data collection

All participants reporting a crash during at least one survey week between May 2011 and March 2012 were contacted and invited to participate in a semi-structured telephone interview regarding the circumstances surrounding each crash. Cyclists were asked about causal factors based on the four key elements central to the SSA, without limit to the number of factors that could be identified.

2.3. Analysis

Qualitative data were analysed using ‘template analysis’ (King and Horrocks, 2010), which involves developing a coding template composed of hierarchically arranged codes, representing themes identified through multiple readings of interview transcripts (King, 2005). The SSA key elements provided the first level categories for template analysis of the data. Initial templates were developed based in review of a small subsample. These templates were refined after all research team members coded 20 interviews each and met to reach consensus, and as coding proceeded.

3. Results

3.1. Sample characteristics

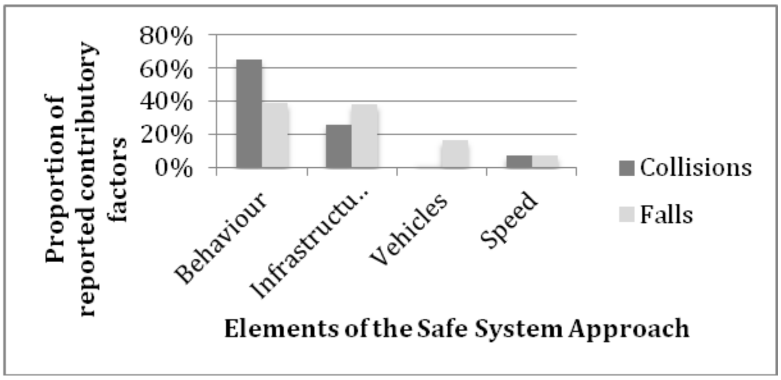
One hundred and thirty six cyclists reported 145 crashes between May 2011 and March 2012. The average age of the cyclists was 43 (sd +/- 9.6) years; 72% (n=98) of cyclists were male and 28% (n=38) were female. Only 1.5% of cyclists (n=2) classified themselves as novices with the remainder rating themselves as being intermediate 18.5%, (n=25), experienced 49%, (n=66), advanced 27%, (n=37) or expert/professional 4% (n=6) of cyclists. On average, over the last 12 months, cyclists spent 51% of their time on roads, 17% on shared paths, 15% on bicycle lanes, 9% on bicycle only paths, 5% on the pedestrian footpaths, and 3% on other infrastructure.

Of the 145 crashes reported, 78 were falls and 67 were collisions. Sixty five crashes (34 falls and 31 collisions) required medical attention by a GP or at hospital. No reported injuries required the cyclist to stay in hospital overnight. Three collisions but no falls, were reported to the police.

3.2. Factors contributing to crashes

Cyclists identified a total of 276 factors as contributing to the reported crashes, with between 1 and 3 factors being identified per crash. Figure 1 shows the proportion of these factors falling into each of the four SSA key elements.

Figure 1 Proportion of factors cyclists reported as contributing to their crashes in each SSA element



For collisions, behavioural factors were most frequently identified as a contributory factor, followed by infrastructure factors. For falls, behavioural factors and infrastructure factors were reported in almost equal proportions, followed by vehicle factors. For both falls and collisions, less than 10% of the reported contributory factors were categorised as relating to speed of a motor vehicle or bicycle.

Contributory factors related to behaviour and infrastructure are explored further in Figures 2 and 3, with Figure 2 identifying the specific road user whose behaviour was reported to have contributed the crash, and Figure 3 identifying specific infrastructure issues.

Figure 2 Proportion of behavioural factors categorised as relating to motor vehicle drivers, cyclists themselves, other cyclists, pedestrians, animals or other road users (collisions n=90, falls n=62)

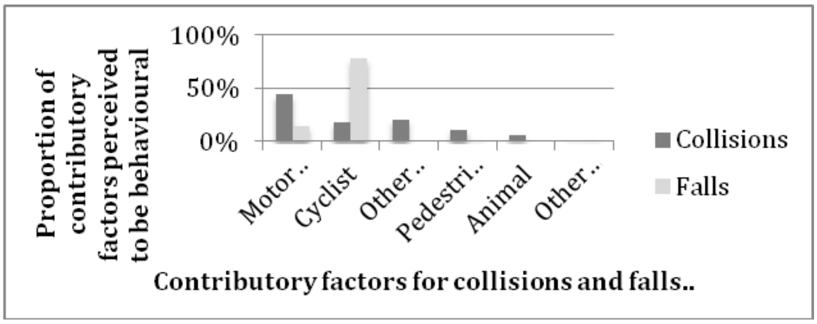
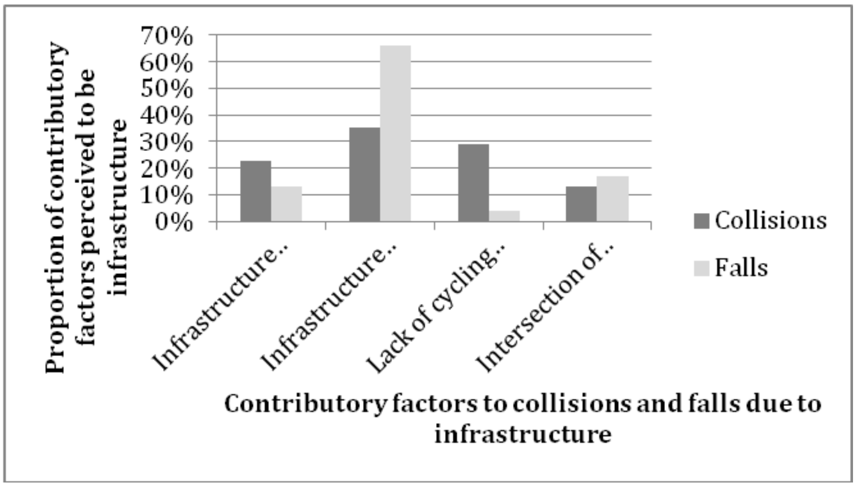


Figure 3 Proportion of falls (n=53) and collisions (n=31) perceived to be due to infrastructure maintenance, infrastructure design, lack of cycling infrastructure, or intersection of infrastructure



Tables 1 and 2 indicate the range of behaviours that cyclists reported having contributed to collisions and falls, respectively. For collisions, the most commonly reported contributory behavioural factor was motor vehicle driver inattention followed by inattention of other cyclists, the cyclist's own inattention, and pedestrian inattention. For falls, the most commonly reported contributory behavioural factor was the cyclist's own behaviour, with the single most frequently reported factor being failure to either unclip from cleats in time or of having insufficient experience in using cleats, followed by cyclist inattention and failing to adjust cycling behaviour to the conditions.

Table 1 Number of reports of behavioural factors contributing to collisions

	Behavioural factors reported for collisions	**# of reports**
Motor vehicle driver behaviour (including bus and taxi drivers)	Driver inattention (e.g. failing to look out for cyclists before performing a manoeuvre)	28
	Driver aggression	4
	Drivers not following or knowing the road rules	2
Cyclist's own behaviour	Cyclist inattention	10
	Cyclist poor judgement	3
	Cyclists disobeying the road rules	1
	Cyclist fatigue	2
Other cyclists	Apparent inattention	13
	Apparent disobedience of road rules	1
	Aggressive behaviour	1

Pedestrians	Inattention	5
	Aggression	2
	Appearing not to know road/ path rules	1
	Animal crossing the path of a cyclist	5

Table 2 Number of reports of behavioural factors contributing to falls

	Behavioural factors reported for falls	# of reports
Cyclist's own behaviour	Cyclist inattention	13
	Failing to adjust cycling behaviour to conditions	6
	Cyclist's poor judgment (e.g. poor judgement of another's speed or position)	2
	Cyclist distracted by something	2
	Failure to either unclip from cleats in time or of having insufficient experience in using cleats	16
	Disobeying or poor knowledge of the road rules	3
	Carelessness or recklessness	3
	Cyclist impaired by alcohol	2
Motor vehicle drivers	Not looking out for cyclists/ travelling too close	4
	Apparent disobedience of the road rules	1
	Apparent aggressive behaviour or deliberately trying to cause a crash	3
Pedestrians	Apparent poor knowledge of road rules	1
	Construction workers not taking account of cyclist.	1

Tables 3 and 4 indicate the range of infrastructure factors reported as having contributed to collisions and falls, respectively.

Table 3 Number of reports of infrastructure factors contributing to collisions

	Infrastructure factors identified for collisions	# of reports
Infrastructure design issues	Ridge on shared path	1
	Bike lane ending when it enters a roundabout or poor cycle path marking on the roundabout	3
	Tight bend in a shared path or path too narrow	2
	Oncoming path users obscured	1
	Bike path in dog leash-free area	1
	Parking spaces in inappropriate places for major cycling route	1
	Many vehicle entry/ exit points along shared path	1
	Slippery paint on road	1
Lack of cycling infrastructure	Poor linkage of cycling infrastructure	4
	Cycling infrastructure coming to an abrupt end	3
	Lack of cycling infrastructure in busy traffic areas	2
Intersection of infrastructure	e.g. moving from a road onto a driveway or going from a paved surface to an uneven surface	4
Poor maintenance	e.g. overgrown vegetation; loose gravel; uneven surfaces and potholes in the road or path	7

Table 4 Number of reports of infrastructure factors contributing to falls

	Infrastructure factors identified for falls	# of reports
Infrastructure design issues	Slippery surfaces (e.g. wet weather making surface of paint-markings slippery, road fixtures being slippery)	19
	Poor layout of infrastructure (e.g. bike lanes ending at roundabout, tight bends, bollards/barriers)	8
	Poor lighting or signage	3
	Bicycle inappropriate grates in the roadway	3
	Train tracks on the road	2
Intersection of infrastructure	e.g. moving from a road onto a driveway or going from a paved surface to an uneven surface	9
Poor maintenance	Loose gravel on route	3
	Uneven surface	1
	Other maintenance problems (e.g. mud on the path)	3

For collisions, the most commonly reported contributory infrastructure factor was infrastructure design issues, followed by lack of cycling infrastructure and poor infrastructure maintenance. Infrastructure design issues were also the most commonly reported contributory infrastructure factor for falls, with slippery surfaces being the single most frequently reported factor, followed by poor lay out of existing infrastructure and poor lighting or signage.

4. Discussion

Effective design, implementation and management of facilities for vulnerable road users must be informed by good quality data on the circumstances surrounding injury (Chong et al 2010). However, there has been little research about the circumstances surrounding bicycle crashes which have not resulted in serious injury. The application of the SSA to cyclists' self-reports of their crashes in this study highlights the importance of factors relating to user behaviour and infrastructure, and potentially identifies particular aspects for remediation.

4.1. Behaviour

Participants perceived factors associated with behaviour such as driver and cyclist inattention; apparent disobedience or lack of knowledge of the road rules; and poor judgment, as being the most frequent contributors to crashes, both collisions and falls.

Participants perceived motor vehicle driver behaviour to be a contributory factor in nearly half of behavioural factors identified for collisions, particularly driver inattention (e.g. not looking out for cyclists before performing a manoeuvre or failing to look properly before changing lanes). Other research has found that drivers were at fault in the majority of collision and near-collision events for commuter trips and this was attributed to a lack of awareness by drivers (Johnson et al, 2010). Drivers' lane change behaviour or being seemingly unaware of the presence of the cyclist, has been found to be involved in a majority of events (Johnson et al, 2010). In order to reduce the number of events such as these, adequate overtaking distances are required to ensure cyclists have a safer clearance space on the roads (Johnson et al, 2010). Johnson also suggested that drivers be made aware of their requirement to indicate for at least 5 seconds prior to changing course, which would give cyclists time to adjust their line of travel (Johnson et al, 2010). Several reports from our participants indicated that driver lack of knowledge, failure to follow the road rules and driver aggression contributed to their collision. Poor levels of road rule knowledge and lack of understanding among drivers has been found to be significantly associated with poor attitudes towards cyclists (Rissel et al, 2002; Benz, 2010).

Cyclist inattention (their own or another's) was frequently reported as a contributory factor in both collisions and falls. In many instances, cyclists accepted some responsibility for the crash where they stated behaviour was a contributory factor. These results indicate that cyclists are often willing to admit responsibility, somewhat allaying concerns about misreporting. Schramm et al (2009) identified cyclist error as being a contributory factor in their examination of police data of predominantly nonfatal cyclist crashes. Furthermore, the Australian Transport Safety Bureau (2006) found that in over 60 per cent of national cyclist fatality crashes, the cyclist was at fault.

It appears both motorists and cyclists would benefit from increased knowledge of traffic laws and adoption of a more tolerant attitude (Sharpe et al, 2011). Benz (2010) suggests that in order to make the roads safer, the quality and skills of car drivers need to be improved. De Geus (2012) believes actions taken should contain both 'soft' (communication/ education) and 'hard' (enforcement) methods. Cyclists may also benefit from education or training on how to ride more defensively around cars; being more vigilant of drivers who may lack awareness of cyclists; and increasing their conspicuity by wearing reflective clothing and using front and rear lights (Johnson et al, 2010). Despite this, in Australia local councils are unlikely to be the source of behaviour modification interventions. Of the total expenditure by councils on bicycle related programs in 2009-2010, only 2% was for education/ promotion campaigns (ABC, 2012).

There were 5 reports of inattention and 2 reports of aggression by pedestrians. This suggests that understanding the dynamic relationship between these two vulnerable road user groups is also of importance and requires attention in the SSA. Chong et al (2010) suggest the speed limit for shared bicycle–pedestrian pathways should be set at 10km/h for cyclists. They suggest that if the number of shared pathways for cyclists and pedestrians increases then there may be more potential for collision and injury (Chong et al, 2010). Road safety initiatives and policies therefore need to be developed with consideration of the different user groups and the implications these policies have for each (Johnson, 2011)

4.2. Infrastructure

Infrastructure factors are perceived by participants to be the next most important contributory factor to crashes. Bike specific facilities have been consistently shown to provide improved safety for cyclists compared to on-road cycling with traffic (Reynolds et al, 2009). Infrastructure modifications are advantageous as they don't require action by the users in order to achieve widespread benefits (Reynolds et al, 2009). The most common elements in local government bicycle strategies are infrastructure (96% of respondents) and bikeway signage (75% of respondents) (ABC, 2012). However, in 2009-2010 only 4% of the total expenditure by councils on bicycle related programs was for maintenance (ABC, 2012). Cycling maintenance programs should be better integrated into other planning and construction processes and the standard of cycling infrastructure, including maintenance, should be improved to best practice international standards (ABC, 2012).

In some cases where the description of the crash suggested that infrastructure contributed to the crash, the cyclist did not identify infrastructure as a contributing factor – instead taking responsibility for the crash themselves. For example, a participant who slipped when turning on a wet grid reported that it was, "just bad luck". A central tenet of the SSA is that roads and roadsides should accommodate user errors. This is often missed by policy documents that address cycling safety, which tend to focus on improving cyclists' skills. Whilst this is a commendable aim, it is critically important that roads and roadsides be acknowledged as an important contributor to cyclist crashes and relevant initiatives be adopted. If there were no slippery metal grids then no cyclists would crash because of them.

4.3. Vehicles

Vehicle factors were less commonly reported as contributory factors towards crashes. For falls, there were five reports of bicycle failure such as gears jamming, chain falling off and brake failure. Making cyclists aware of the importance of regularly having their bike serviced and encouraging attendance at a bicycle maintenance course may help to prevent some of these crashes happening. There were 16 cases of clip-in pedals contributing to a crash. Participants reported being unable to clip out of their pedals quickly enough when slowing down to make a turn or approaching traffic lights. Patel (2004) reported on three cases studies of cyclists presenting to hospital with major soft tissue injuries due to being unable to release their feet in time when they lost control of their bikes. He highlighted the fact that, 'in cycling, major injuries can be caused by the cycle itself. Proper information is needed to allow cyclists to use clip-in pedals safely and effectively'.

No participants identified the influence of motor vehicle design in cycling crashes. This may be because the injuries sustained were relatively minor. Wegman and Zhang (2010) have suggested that the addition of adequate protection around a lorry, crash-friendly car fronts or side under-run protection on heavy goods vehicles could help to reduce the number of overall casualties.

4.4. Speeds

In this study, participants rarely perceived speed of surrounding traffic to be a contributory factor in crashes, which probably reflects an underestimation of the importance of speed. Garrard (2008) suggests that reduced motor vehicle speed would undoubtedly mean improved cyclist safety and more people prepared to travel by bicycle.

4.5. Limitations

It is likely the sample of cyclists is fairly representative of the general cycling population in NSW, though not perfectly so. A broad sampling strategy was used in the recruitment of the participants. Participants were recruited via Bicycle NSW and various community bicycle events (both of which involve a broad range of cyclists), with media publicity about the study reaching the general population as well. Over 2000 cyclists were recruited over a period of 9 months. The only clear systematic bias is towards people who can comfortably access the internet (probably fairly small). There is probably also self-selection of people who are sufficiently motivated to participate in such a study (e.g. have an interest in making cycling safer). It is not possible to compare characteristics of the sample with those of the general cycling population, because the characteristics of the general cycling population are not known.

Participants were asked to report all crashes that they experienced in their six survey weeks over the year and we have no reason to believe that they did otherwise. Participants who experienced more than one crash may have been less inclined to report a second crash, knowing that they would be asked in detail about it. However, this is likely to be a very small proportion of the sample.

We have relied on cyclists' self-reports of their crashes because this offers a broader and deeper insight into cycle crashes than can be obtained via other methods. Recall bias is likely to be limited because of the short time-frame in which cyclists reported, and were interviewed concerning their crashes. Reporting biases were minimised by the assurance of anonymity. Concerns that cyclists may have fabricated or distorted their reports to "get something done for cyclists" are somewhat allayed by the finding that cyclists often took responsibility for their own crashes.

4.6. Strengths

The methodology employed in this study allowed investigation of a far broader range of cyclist crashes than appear in hospital or police records, which have hitherto been the focus of research conducted in Australia. Particularly, single-vehicle bicycle crashes (which account for most falls), which have a lower potential for serious injury (Wegman and Zhang, 2010), are rarely reported in official statistics and therefore little is known about them (Elvik and Mysen, 1999, Heesch et al, 2011; Wegman and Zhang, 2010). None of the reported crashes in this study required overnight hospital admission and only 3 crashes were reported to police. Thus, this study provides data that is likely to be more representative of the experiences of the general population of cyclists, rather than representing only the ‘tip of the iceberg’. Semi-structured interviews provided participants with the opportunity for clarification, explanation and elaboration of responses to the survey. This allows for a far more detailed examination of crash circumstances than the limited quantitative data collection offered by police and hospital records.

5. Conclusions

The SSA offers a useful framework from which to analyse bike crashes and consider countermeasures for cycling safety. It represents a paradigm shift away from focussing on the behaviour of road users, toward developing a system that can accommodate user error through safer infrastructure, safer vehicles, and safer speeds. Whilst the SSA is reflected in many road safety policy documents, policy documents relevant to cycling safety continue to focus on the cyclist. Although it is appropriate that relevant policy documents aim to improve cyclist (and motorist) knowledge and behaviour, it is critical that they also consider the other elements of the SSA. Application of the SSA in cycling safety policy documents would encourage a broader range of strategies to promote safer cycling.

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