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## The frequency of single-bicycle crashes (SBCs) in countries with varying bicycle mode shares

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### ABSTRACT

In order to encourage cycling, we need to reduce the hazards that cyclists face. Single-bicycle crashes or 'bicycle-only crashes' are falls and obstacle collisions in which only one cyclist is involved. Between 60 and 95% of cyclists admitted to hospital or treated at an emergency department are victims of single-bicycle crashes. As proportion of the total number of traffic casualties the share exceeds 20% in most countries with medium to high levels of cycling. This paper discusses the prevalence of the problem and describes measures that may both reduce the risks and make cycling a more attractive transport choice at the same time.

**Keywords:** Cycling, Road safety, Single-bicycle crashes, Bicycle-only crashes.

## 1 INTRODUCTION

Single-bicycle crashes (SBCs) or ‘bicycle-only crashes’ are a leading cause of serious transport related injuries [1-3]. The number of fatalities due to SBCs is relatively low [4], but the health burden is high because of the high number of serious and minor injuries that they cause, and the discouraging effect they have on injured cyclists [5]. SBCs and contributory factors such as ice on the road during wintertime may also discourage cycling [6]. This paper concentrates on the occurrence of the most serious non-fatal injuries. The share of SBCs victims in the total number of bicycle casualties (hereafter referred to as ‘the share’) is determined using studies from different countries.

## 2 FIGURES ON SINGLE-BICYCLE CRASHES

Only a small proportion of SBCs are recorded in official road crash statistics and so SBCs have remained a hidden safety issue [7-9]. SBCs are recorded in hospital data using the International Classification of Diseases (ICD) 10 codes V17 (collision with fixed and stationary objects) and V18 non-collision incident. The figures we found in peer-reviewed journals or grey literature for casualties admitted to hospital or treated at an emergency department are based on ICD or questionnaires among these casualties. For hospitalized casualties, it was in most cases also possible to estimate the share of SBC victims in the total number of road traffic casualties. Other figures are based on questionnaire studies and in two cases insurance companies [10, 11].

### *Data selection*

For purposes of comparability the categories of injury of ‘unknown’ or ‘unspecified’ causes that are reported in some studies are excluded in the estimated proportions in Table 1. Some studies only reported the share of bicycle injuries in crashes with no motor vehicles, which include bicycle-bicycle and bicycle-pedestrian crashes. Based on other studies, [1, 3, 12-15] we estimate that 90% of all victims in cycle crashes not involving a motorised vehicle are victims of SBCs not involving pedestrians or other cyclists.

### *Results*

Table 1 reveals that the share of SBCs varies between 60 and 95% for casualties admitted to hospital or treated at an emergency department and this is not much different for minor injuries. The share in the *total* number of hospitalized road crash casualties (the right column in Table 1) ranges from only a few percent in jurisdictions with low levels of cycling such as Iran and the US to 41% in the Netherlands. However, in both countries with low and high bicycle usage, the majority of injuries among cyclists are incurred in SBCs.

**Table 1.** Share of SBCs in the total number of bicycle crash and road crash casualties per country.

Single-bicycle crash casualties:	Share (%) of all		Source
	cyclist victims	travel and transport victims	
<i>Hospitalized</i>			
Netherlands (2005-2009)	74	41	Reurings and Bos [16]
Denmark (2011)	74	33	Statistics Denmark [17]
Belgium, Flanders and Brussels (2003-2007)	87	30	Dhondt, et al. [18]
England (2011-2012)	80	23	Benington [1]
Sweden (1998-2005)	75	23	Larsson [19]
Finland (1985-1986)	65	22	Olkkonen, et al. [20]
Australia (2008-2009)	63	9	Henley and Harrison [15]
France, Rhône county (1996-2008)	65	9	Amoros, et al. [3]
Iran (2003)	62	3	Karkhaneh, et al. [21]
New Zealand (2011)	78	-	Ministry of Transport [22]
Canada, Ontario (2002-2003)	74	-	Simpson [23]
<i>Treated at an emergency care department</i>			
Netherlands (2005-2009)	78		Consumer Safety Institute [13]
England, Cambridge (2003)	69		Davidson [24]
Germany, Göttingen (2007-2008)	60		Ellwein [25]
Sweden (2003-2006)	72		Thulin and Niska [14]
Finland (1985-1986)	79		Olkkonen, et al. [20]
Norway (2001-2002)	82		Hansen, et al. [26]
France, Rhône county (1996-2008)	71		Amoros, et al. [3]
USA, Seattle (1992-1996)	76		Rivara, et al. [27]
USA, California, New York, and North Carolina	63		Stutts and Hunter [28]
Hong Kong, Shatin, New Territories (2006)	88		Yeung, et al. [29]
Turkey, Central Anatolian Region (2005-2008)	95		Özkan, et al. [30]
United Arab Emirates (2001-2003)	84		Eid, et al. [31]
<i>Wide range of injury severities (mostly minor)</i>			
Austria, Wien (commuters; 2000-2005)	66		Risser [10]
Switzerland (2006-2010)	81		UVG [11]
Germany, Saxony (> 60 years of age; 2009)	66		Hagemeister and Tegen-Klebingat [32]
Norway (2012)	74		Fyhri, et al. [33]
Australia, Queensland (off-road excluded; 2009)	73		Heesch, et al. [34]
Belgium (2008-2009)	79		De Geus, et al. [35]
Ghana (based on only 38 rural crashes; around 1997)	98		Mock, et al. [36]
Hong Kong (2010)	74		Loo and Tsui [9]; Transport Department, 2011

### 3 CAUSES OF SINGLE-BICYCLE CRASHES

SBC mechanisms are related to infrastructure, cyclist behaviour, bicycle defects, and external forces such as bad weather. The two most frequent SBC types are related to infrastructure (including bad surfaces) and cyclist behaviour. Ice and snow cause significant problems where they occur [2, 6]. Between 10% and 26% of all SBCs occur on ice/snow, which is a high proportion given the fact fewer people cycle in bad weather [37]. Tram rails and drain covers also become slippery when wet: skidding on wet roads is a common SBC type. Cyclists may lose balance due to road surface irregularities such as potholes.

Cyclists also collide with obstacles on the road (e.g. bollards to prevent cars from using bicycle tracks) or next to the road (e.g. lighting poles). Collision with kerbs at too acute an angle and loss of balance when traversing surfaces at different heights (e.g. of the verge and the roadway) is reported as causing a significant proportion of incidents and injuries. [38]. Schepers and den Brinker [39] found that improving the visibility of obstacles and the course of bicycle tracks and lanes may help to reduce the risk of these crash types.

The most frequent cyclist-related SBC type among older cyclists is falling while mounting or dismounting [32]. More common in other age groups is a fall due to forces on the front wheel, e.g. baggage hitting the front wheel. Older cyclists and cyclists under the influence of alcohol are over-involved in severe and fatal SBCs [2, 40, 41]. Schepers [41] found fewer cyclists are involved in a severe SBCs in Dutch municipalities with a high amount of cycling, which may be due to improved skills of cyclists as amount of cycling increases and/or safer infrastructure. Other cyclist-related incidents are caused by riding behaviour, e.g. abrupt steering manoeuvres, braking mistakes, and poor or risky riding behaviour such as stunting [38]. According to Bjørnskau [37] 20% of the single bicycle crashes in Norway occurred as the bicyclist slammed on the brakes and plunged over the handlebars. Some of these victims are attempting to avoid a collision with another road or path user.

#### **4 PREVENTIVE MEASURES**

##### *Infrastructure design*

The results of a number of Dutch studies on SBCs and infrastructure are included in the 2011 Fietsberaad publication<sup>1</sup> that makes recommendations about road surface quality, the width of bicycle facilities, minimising the height difference between the road and shoulder surface, improving the visibility of the road's course (e.g. edge lines), the design of obstacles (their necessity and visibility), and the advantages of avoiding materials in the road surface that become slippery when wet such as tram rails, etc.

##### *Winter maintenance*

Snow and ice on the road are a dominant cause of SBCs in Nordic countries such as Sweden and Finland, but also Germany, Belgium and the UK [1, 35]. Given the health burden due to SBCs and to enable cycling during the winter [6], authorities need to give priority to bicycle tracks (especially main routes) in their winter maintenances policies. Cyclists may skid on grit that it is left on the road. Routines to sweep it up early in the spring are a solution or sweeping snow of the road in combination with scattering salt [42]. Maintenance is also needed during other seasons, for instance to sweep leaves of the road during the autumn.

##### *Training*

Studies suggest that as skill level increases, rate of SBC's decreases [41]. Helping cyclists achieve cycling skills may improve their confidence and ability. Some training programmes specifically address SBC hazards. For instance, the UK's National Standard for Cycle Training<sup>2</sup>, 'Bikeability', requires cyclists to master and demonstrate effective bike handling, safe riding strategy and hazard awareness.

Reduced muscle strength, flexibility, and reaction time in the elderly makes mounting and dismounting more difficult. Physical training may improve condition and prevent the crashes at low speed in which the elderly are typically involved. Also, people with physical problems may

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<sup>1</sup>[http://www.fietsberaad.nl/library/repository/bestanden/Fietberaadpublicatie%2019a\\_printversie.pdf](http://www.fietsberaad.nl/library/repository/bestanden/Fietberaadpublicatie%2019a_printversie.pdf)

<sup>2</sup><https://www.gov.uk/the-national-standard-for-cycle-training>

decide to choose other transport modes during adverse conditions such as bad weather and darkness, or at days when they feel tired [32].

#### *Bicycle measures*

A small proportion of SBC's may be prevented by installing panniers on the luggage carrier [32]. Bicycle-spoke injuries can be prevented by adequate spoke-guards of adequate size and strength. Regular coat-guards provide insufficient protection [43]. The UK's National Standard for Cycle Training requires cyclists to demonstrate basic competence in checking that a bicycle is mechanically fit to ride by checking tyres, brakes, the chain, a helmet that fits, etc. before riding. Design standards are a means to improve bicycles, for example the European bicycle-seat standards aim to improve child passenger safety.

## **5 DISCUSSION**

The high numbers of cyclists incurring minor or even serious injuries in SBCs cause a significant health burden, both directly (through injury and intangible costs such as absence of work and productivity loss) and indirectly (by discouraging more active and sustainable travel choices). We therefore recommend taking preventive measures focusing on infrastructure, cyclist behaviour and use of safe bicycles when promoting cycling and cycle safety. Infrastructure designed to prevent SBCs is probably also inclusive, i.e. enabling cycling under all circumstances (e.g. by winter maintenance) and for all groups of people including the elderly. Addressing causes of SBCs will make cycling a more pleasurable and attractive transport option. Understanding of the causes is growing, but more research is required, especially into the causes of injury for children under 18 years of age. Also, the measures suggested in crash studies need to be evaluated in before-after studies.

SBCs are also frequent in low-income countries. Non-fatal crashes may not be their first priority, but addressing SBCs is possible by building facilities of an adequate quality which fits into a broader strategy for road transport. Pedestrians and cyclists in low income countries are often unable to buy a motor vehicle and willing to switch to a motor vehicle as their income increases. Building facilities may help reduce the bicycle's "poverty" image and support its use (independent or in combination with public transport) which is beneficial from an economical and environmental perspective [44].

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