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An exposure based study of crash and injury rates in a cohort of transport and recreational cyclists in New South Wales, Australia

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ABSTRACT

This paper examines self-reported prospectively collected data from 2038 adult transport and recreational cyclists from New South Wales (Australia) to determine exposure-based incident crash and injury rates. During 25,971 days of cycling, 198 crashes were reported, comprising approximately equal numbers of falls and collisions. The overall crash rate was 0.290 (95% CI, 0.264–0.319) per 1000 km or 6.06 (95% CI, 5.52–6.65) per 1000 h of travel. The rate of crashes causing any injury (self-treated, or medically attended without overnight hospital stay) was 0.148 (95% CI, 0.133–0.164) per 1000 km or 3.09 (95% CI, 2.79-3.43) per 1000 h of travel. The rate of crashes causing a medically attended injury (without overnight hospital stay) was 0.023 (95% CI, 0.020–0.027) per 1000 km or 0.49 (95% CI, 0.43-0.56) per 1000 h of travel. No injuries requiring an overnight stay in hospital were reported on days meeting the inclusion criteria. After adjustment for exposure in hours, or for the risks associated with different infrastructure utilisation, the rates of crashes and medically attended injuries were found to be greater for females than males, less experienced than more experienced cyclists, and for those who rode mainly for transport rather than mainly for recreation. Comparison of estimated crash and injury rates on different infrastructure types were limited by the small number of events, however findings suggest that the separation of cyclists from motorised traffic is by itself not sufficient to ensure safe cycling.

1. Introduction

Many nations have policies to promote cycling (Pucher et al., 2010) (OECD/International Transport Forum, 2013) because of its recognised benefits in terms of the environment, traffic congestion, social cohesion and health (Bassett et al., 2008; Bauman et al., 2008; Garrard et al., 2012). Indeed, the Australian National Cycling Strategy 2011–2016 aims to double cycling participation within this period (Australian Bicycle Council, 2010). However, cyclists are vulnerable road users and they face real risks of injury. A recent analysis of national data on road vehicle traffic crashes shows that there has been an upward trend in the number of cyclists seriously injured (with high threat to life) in Australia over the period from 2000–2001 to 2008–2009, estimating the average annual rate of increase to be 6.8% (95%CI, 5.9–7.9%). The most significant increases have occurred among adults aged 25 years and older, particularly those in the age group 45–64 years (average annual rate of increase of 14.0% for males, and 14.4% for females) (AIHW, 2012).

Therefore, in countries like Australia, where the modal share for cycling is low, it is imperative that efforts to promote cycling are coupled with evidence-based initiatives to improve cycling safety. The safe system approach to road safety reflects an understanding of the multifactorial nature of transport related injury, which includes consideration of infrastructure, people, vehicles and speeds, as well as their interaction (Australian Transport Council and Australian Transport Safety Bureau, 2011). Its application in the context of cycling safety requires a sound understanding of these factors and their impact on injury risk. Unfortunately, relevant research which may inform the safe system approach has been hampered by at least two significant limitations, that of under-enumeration of cyclist crashes and a lack of exposure-related data (Sikic et al., 2009).

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Information about cycling crashes and injuries has often come from official records, such as police or hospital admissions data. Both of these sources are known to under-enumerate cycling crashes and injuries, and involve a bias toward crashes with more serious injury outcomes (Lujic et al., 2008). Further, hospitalisation data contain limited information about crash causes, while police-reported crash data contain limited information about injury outcomes (Mitchell et al., 2014). Secondly, and perhaps more critically, information about exposure of cyclists (for example, trips, kilometres or hours) is often unavailable (Sikic et al., 2009) or not measured in a comprehensive or standardised manner (OECD/International Transport Forum, 2013). This is particularly significant in the context of cycling promotion activities, as it is difficult to determine the extent to which increases in the numbers of injured cyclists reflect changes in participation rates or actual risk. In addition, limitations in exposure data impact on the determination of the relative safety of various types of infrastructure for cyclists. Thus, with the numerator (number of crashes) and the denominator (measures of exposure) being inadequately measured, the basis on which cyclists' safety and the impact of transport and planning policies can be assessed, is lacking (OECD/International Transport Forum, 2013).

There are a limited number of studies which have used travel data from individual participants to calculate exposure-based rates of crashes and injuries for cyclists. These have included studies undertaken in Ottawa-Carleton (Aultman-Hall and Hall, 1998), Toronto (Aultman-Hall and Kaltenecker, 1999), Belgium (de Geus et al., 2012), Portland (Hoffman et al., 2010), New Zealand (Tin Tin et al., 2013) and Tasmania (Palmer et al., 2014). These studies have various limitations. For example, most have been restricted to commuter cycling only (Aultman-Hall and Hall, 1998; Aultman-Hall and Kaltenecker, 1999; de Geus et al., 2012; Hoffman et al., 2010), which may have limited generalizability in countries such as Australia, where cycling is mainly seen as a means of recreation rather than as a form of regular transport (Pucher and Buehler, 2008). Others have been limited by the use of survey methods requiring recall periods from one month (Hoffman et al., 2010), one year (Aultman-Hall and Hall, 1998; Aultman-Hall and Kaltenecker, 1999, Palmer et al., 2014) or more (Aultman-Hall and Hall, 1998; Aultman-Hall and Kaltenecker, 1999; Palmer et al., 2014), introducing potential error into estimations of distance travelled and the recall of crash details. Further, only the studies in Ottawa-Carleton (Aultman-Hall and Hall, 1998) and Toronto (Aultman-Hall and Kaltenecker, 1999) have attempted to account for cycling exposure on different infrastructure, and these have been limited by the aggregation of quite different types of infrastructure (for example, off-road infrastructure combining multi-use paved and unpaved recreational paths, and unofficial short-cut type routes such as paths through fields, schools or parks; and roads including roads with and without bicycle lanes). An understanding of personal and behavioural factors which influence cycling safety should also inform relevant policy, planning and design. However, the effects of gender, experience and age remain unclear in these studies, with no consistent findings across them (Aultman-Hall and Hall, 1998; Aultman-Hall and Kaltenecker, 1999; Hoffman et al., 2010; de Geus et al., 2012; Tin Tin et al., 2013; Palmer et al., 2014). Further, the interplay of personal characteristics with infrastructure type may also be complex. For example, inexperienced cyclists prefer separated infrastructure, but by riding on it may reduce its apparent safety. Such interplay has rarely been considered (but see Aultman-Hall and Hall, 1998; Aultman-Hall and Kaltenecker, 1999).

The Safer Cycling Study was designed to broaden the evidence base to inform policy by providing unique data on the experience of a large cohort of New South Wales (NSW) cyclists, and to collect prospective data on exposure and events to enable a better understanding of the crash and injury experiences of cyclists. This paper aims to address some of the limitations in previous research and includes: cycling exposure both in terms of time and distance, and on various infrastructure types; a broader spectrum of crashes and injuries than are usually captured in administrative databases; and an exploration of the role of personal characteristics in cycling crashes and injuries.

2. Methods

2.1. Study design

The Safer Cycling Study was a study of cyclists from New South Wales (Australia), who were aged 18 years and older, and rode a bicycle at least once per month. The details of the study protocol are provided elsewhere (Poulos et al., 2012). Cyclists were recruited via multiple channels including: the extensive email lists of a state cycling advocacy organisation, social media sites, community cycling events, bike shops, media publicity and word of mouth within the cycling community. Enrolment occurred between March and November 2011. Participants completed a baseline questionnaire, followed by six cycling diaries each of seven consecutive days commencing within weeks 8, 16, 24, 32, 40 and 48 from the date of the baseline questionnaire. Cyclists could enter data via a secure website on a daily basis or keep a record of daily travel on a 7-day version of the diary (downloadable PDF file), and enter their data at the end of the week. Weekly diaries were open for data entry for a period of 14 days. Participants reporting a crash in their diary were telephoned for additional information about crash circumstance and any injuries sustained. To improve the accuracy of recorded distance travelled, four hundred bicycle odometers were distributed to enrolled participants. As the number of odometers was limited by available funding, they were preferentially distributed to those participants who reported not having an odometer on their bike at baseline, and who mainly rode one bike.

2.2. Questionnaires

The baseline questionnaire collected data including demographic characteristics (e.g. age, sex and level of education), self-reported cycling experience (novice, intermediate, experienced, advanced or expert/professional), and self-identification of cyclist type (as a "mainly transport" or "mainly recreational" cyclist). At the start of each reporting week, cyclists were asked to record any crashes and injuries sustained in the intervening period between diaries (that is, between the baseline questionnaire and the first cycling diary completed, or between cycling diaries). These data were collected so as to document the complete experience of cyclists over the period of observation. However, as no exposure data (distance or time) were collected for the period between diaries, these events are excluded from the analysis of incident crash and injury rates determined from the weekly cycling diaries.

Weekly cycling diaries collected daily reports of: distance and minutes spent cycling; the estimated proportion of the time cycling each day on various forms of cycling infrastructure, sealed and unsealed surfaces, and bike types (e.g. road, mountain, hybrid and other); the number, location and characteristics of crashes; and the severity of the most serious crash-related injury sustained on a reporting day. Cyclists contributed daily exposure, crash and crash-related injury data to the study with each diary day reported. Diary days in which cyclists either indicated they did not cycle, or diary days in which cyclists did not enter any data, were assumed to be days of no cycling exposure.