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Bicycling crash characteristics: An in-depth crash investigation study

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ABSTRACT

The aim of this study was to describe the crash characteristics and patient outcomes of a sample of patients admitted to hospital following bicycle crashes. Injured cyclists were recruited from the two major trauma services for the state of Victoria, Australia. Enrolled cyclists completed a structured interview, and injury details and patient outcomes were extracted from the Victorian State Trauma Registry (VSTR) and the Victorian Orthopaedic Trauma Outcomes Registry (VOTOR). 186 cyclists consented to participate in the study. Crashes commonly occurred during daylight hours and in clear weather conditions. Two-thirds of crashes occurred on-road (69%) and were a combination of single cyclist-only events (56%) and multi-vehicle crashes (44%). Of the multi-vehicle crashes, a motor vehicle was the most common impact partner (72%) and distinct pre-crash directional interactions were observed between the cyclist and motor vehicle. Nearly a quarter of on-road crashes occurred when the cyclist was in a marked bicycle lane. Of the 31% of crashes that were not on-road, 28 (15%) occurred on bicycle paths and 29 (16%) occurred in other locations. Crashes on bicycle paths commonly occurred on shared bicycle and pedestrian paths (83%) and did not involve another person or vehicle. Other crash locations included mountain bike trails (39%), BMX parks (21%) and footpaths (18%). While differences in impact partners and crash characteristics were observed between crashes occurring on-road, on bicycle paths and in other locations, injury patterns and severity were similar. Most cyclists had returned to work at 6 months post-injury, however only a third of participants reported a complete functional recovery. Further research is required to develop targeted countermeasures to address the risk factors identified in this study.

1. Introduction

Cycling is an alternative mode of transport to motor vehicles that has numerous health and economic benefits (Oja et al., 2011; Grabow et al., 2012). In line with this, cycling-specific strategies have been developed by government agencies and cycling committees with the aim of increasing cycling participation both in Australia (Australian Bicycle Council, 2010; Victorian Government, 2012) and internationally (German Federal Ministry of Transport Building and Urban Development, 2012; United Kingdom Department of Transport, 2014). Specifically, the Australian National Cycling Strategy aimed to double cycling participation between 2011 and 2016 (Australian Bicycle Council, 2010). Whilst acknowledging the health, environmental and economic benefits of cycling, cyclists are considered vulnerable road users and safety concerns remain a barrier to increased participation (Winters et al., 2011).

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Previous studies have shown that serious injury rates among cyclists have increased (Sikic et al., 2009; Henley and Harrison, 2012), highlighting the need to identify cyclist, route and crash factors associated with crashes in order to inform targeted interventions to reduce the likelihood of injury. For on-road cycling crashes, cycling on streets where cars are parked has been associated with increased crash risk, while on-road bicycle infrastructure, such as marked bicycle lanes, and lower motor vehicle speeds have been associated with reduced crash risk (Reynolds et al., 2009; Teschke et al., 2012; Cripton et al., 2015). When compared to on-road cycling crashes, those occurring on bicycle paths that are separated from traffic more commonly result from a fall than a collision, and are more likely to involve a pedestrian or cyclist, or be single bicycle-only events (De Rome et al., 2014; Teschke et al., 2014). Given the differences in infrastructure and crash characteristics between crash locations, it is likely that interventions targeting risk factors specific to each locale will be most effective. In order to inform the design of such interventions, this study aimed to describe the crash characteristics and injury outcomes of a sample of cyclists admitted to hospital following bicycle crashes with a specific focus of crashes occurring on-road, on bicycle paths and in other locations.

2. Methods

2.1. Study design

Cycling-related trauma patients were prospectively recruited from two hospitals in Melbourne, Australia. The hospitals, The Alfred Hospital and the Royal Melbourne Hospital, are the two adult major trauma services (Level 1 trauma centre equivalent) for the state of Victoria. These trauma centres definitively manage more than 80% of cycling-related major trauma each year. Recruitment occurred between 1 January 2013 and 31 December 2013. This study forms a component of a wider study investigating safer cycling in the urban road environment; the protocol for which has previously been published (Stevenson et al., 2014).

2.2. Ethics approval

Ethics approval for the study was obtained from the human research ethics committees at The Alfred Hospital and Royal Melbourne Hospital, and the Monash University Human Research Ethics Committee (MUHREC).

2.3. Inclusion criteria

Patients were invited to participate if they met all of the following criteria: emergency admission to The Alfred or Royal Melbourne Hospital for >24 h; admitted for management of a cycling-related injury; and eligible for registration on the Victorian State Trauma Registry (VSTR) or the Victorian Orthopaedic Trauma Outcomes Registry (VOTOR). Eligible patients were identified from the daily trauma service lists and liaison with the Trauma Coordinator or nursing staff at each site. Patients were excluded if they were riding a motorised vehicle, or if the patient's condition resulted in the treating nurse or doctor advising the researchers not to contact the patient. As the study required direct interview of patients about their crash circumstances, patients who were unable to consent to participate in the study due to pre-existing conditions, or due to the injuries sustained, were excluded. Patients with a language other than English, where a suitable interpreter could not be found, and those who could not recall the injury event were also excluded.

2.4. Interview

Enrolled injured cyclists completed a structured interview during their hospital stay. Where patients were discharged prior to contact with the study investigators, telephone contact was made to invite the patient to take part and documentation was then mailed to the patient. A trained research nurse conducted the structured interview with the cyclist and the interview included questions about demographic details, a precise description of the crash circumstances, potential risk factors identified from the literature, and the events leading to the crash. Incident types were classified according to the Definitions for Classifying Accidents (DCA) (VicRoads, 2013). Self-reported accident sites were coded as on-road (occurring on a road way), bicycle paths (shared with pedestrians or dedicated for cyclists) or others (e.g. mountain bike trail, BMX track, velodrome, footpath). Self-reported pre-impact speed was stratified by those travelling ≤30 km/h and those travelling >30 km/h. An on-road bicycle lane was defined as a marked lane on a road that was exclusively identified for cycling use. A detailed list of data collected from the structured interviews has previously been reported (Biegler et al., 2012) and is contained within Appendix A.

2.5. VSTR and VOTOR data linkage

Data from the structured interview were linked with data collected by the Victorian State Trauma Registry (VSTR) and Victorian Orthopaedic Trauma Outcomes Registry (VOTOR). The VSTR is a population-based registry that collects data about all hospitalised major trauma patients in Victoria (Cameron et al., 2004). A case is included in VSTR if any of the following criteria are met: (1) death due to injury; (2) an injury severity score (ISS) >12 as determined by the Abbreviated Injury Scale (AIS) (2005 version 2008 update); (3) admission to an intensive care unit (ICU) for more than 24 h and requiring mechanical ventilation for at least part of their ICU stay; and (4) urgent surgery. The VSTR collects pre-hospital, acute care and long term outcomes data for all registered patients. All survivors to discharge are followed-up by telephone interview at 6, 12 and 24-months post-injury to collect functional, health-related quality of life, pain and work-related disability outcomes (Gabbe et al., 2010).

VOTOR is a sentinel site registry collecting data about all adult (>15 years) orthopaedic trauma patients with a length of stay >24 h, and admitted to The Alfred, Royal Melbourne Hospital, University Hospital Geelong and The Northern Hospital. All VOTOR patients are followed-up by telephone interview at 6 and 12-months post-injury using the same methodology as the VSTR patients (Edwards et al., 2006; Gabbe et al., 2010).

Data extracted from the VSTR and VOTOR for this study included additional demographic information, the Injury Severity Score (ISS) (Baker et al., 1974), in-hospital outcomes (e.g. hospital length of stay) and post-discharge follow-up data to 12-months post-injury. Injuries were coded using the International Classification of Diseases 10th Revision – Australian modification (ICD-10-AM). The focus of the injury analysis was on those most commonly observed: head injuries, spinal injuries and fractures. Head injuries were defined as any intracranial injury, including concussion. Spinal injuries were defined as fractures, dislocations, sprain and strain of joints and ligaments, and injury of nerves or spinal cord. Pelvic fractures included fractures to the sacrum, coccyx, ilium, acetabulum, pubis or ischium. Functional recovery was quantified using the Glasgow Outcome Scale-Extended (GOS-E), with a GOS-E score of 8 (upper good recovery) representing return to pre-injury function (Wilson et al., 1998). The GOS-E is recommended for use in trauma populations (Sleat et al., 2011; Williamson et al., 2011). Return to work (yes/no), defined as returning to work in any capacity or role,