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# The impact of compulsory cycle helmet legislation on cyclist head injuries in New South Wales, Australia

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ABSTRACT

The study aimed to assess the effect of compulsory cycle helmet legislation on cyclist head injuries given the ongoing debate in Australia as to the efficacy of this measure at a population level. We used hospital admissions data from New South Wales, Australia, from a 36 month period centred at the time legislation came into effect. Negative binomial regression of hospital admission counts of head and limb injuries to cyclists were performed to identify differential changes in head and limb injury rates at the time of legislation. Interaction terms were included to allow different trends between injury types and pre- and post-law time periods. To avoid the issue of lack of cyclist exposure data, we assumed equal exposures between head and limb injuries which allowed an arbitrary proxy exposure to be used in the model. As a comparison, analyses were also performed for pedestrian data to identify which of the observed effects were specific to cyclists. In general, the models identified a decreasing trend in injury rates prior to legislation, an increasing trend thereafter and a drop in rates at the time legislation was enacted, all of which were thought to represent background effects in transport safety. Head injury rates decreased significantly more than limb injury rates at the time of legislation among cyclists but not among pedestrians. This additional benefit was attributed to compulsory helmet legislation. Despite numerous data limitations, we identified evidence of a positive effect of compulsory cycle helmet legislation on cyclist head injuries at a population level such that repealing the law cannot be justified.
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## 1. Introduction

There are relatively few countries in the world where some or all cyclists are required by law to wear a helmet. Australia was the first country to introduce such legislation and was later followed by New Zealand (NZ) (Attewell et al., 2001). A number of other countries have subsequently introduced similar laws for some or all of the population including Czech Republic, Slovenia, Spain, Malta (Avenoso and Beckmann, 2005), Finland, Sweden, Iceland, Dubai and Japan. Several jurisdictions in Canada and the US have also introduced compulsory helmet laws for at least a sub-section of the population (Macpherson et al., 2002). Extensive research has been published on the impact of compulsory helmet legislation on cyclist head injuries in these countries; however, in the Australian context the debate appears to be ongoing some 20 years after the law was enacted.

Several reviews on the effect of helmet wearing on individual risk of head injury found helmet wearing to be associated with significant reduction in head, brain and facial injury (Henderson, 1995; Thompson and Patterson, 1998; Attewell et al., 2001). The systematic reviews by Attewell et al. (2001) and Thompson and Patterson (1998) used case-control studies; however, Robinson (2006) has suggested that the many observational studies reporting a protective effect associated with helmet wearing may not accurately reflect what occurs at a population level due to unmeasured factors such as risk compensation (Lardelli-Claret et al., 2003), improper helmet wearing and reduced safety in numbers (Robinson, 2005). In 2004, the Cochrane Collaboration published a review of several case-control studies which also found helmet wearing to be efficacious (Thompson et al., 2004), but this work has received some criticism (Curnow, 2005, 2006, 2007; Robinson, 2007), in part due to the majority of the included studies being the work of the review authors.

A number of studies from NZ, Canada and the US found that the introduction of compulsory helmet wearing corresponded to a decline in head injuries to cyclists (Rivara et al., 1994; Povey et al., 1999; Scuffham et al., 2000; Macpherson et al., 2002). In addition, a recent narrative review by the Cochrane Collaboration

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(Macpherson and Spinks, 2008) based on six non-randomised, controlled before and after studies from Canada and the US found that helmet legislation was associated with both increased helmet usage and reduced head injury rates.

On 1 January 1990, the state of Victoria became the first of the Australian states to introduce compulsory helmet legislation and the remaining states and territories followed suit within two years. Some studies in Victoria found evidence of a positive effect of helmet legislation with one study finding a reduction in the proportion of head injuries among injured cyclists (Cameron et al., 1994), while another found a reduction in the count of cyclist head injuries (Carr et al., 1995), both of which attempted to adjust for changes in cyclist numbers and various background confounders. A decrease in cyclist numbers among those aged under 16, predominantly among teenagers, was observed in the years immediately following the legislation in both Victoria and NSW (Walker, 1990, 1991, 1992; Cameron et al., 1992, 1994; Smith and Milthorpe, 1993). It has been argued that the compulsory wearing of helmets has discouraged cycling to the point that the increased burden of disease associated with reduced physical activity outweighs any reduction in the burden of cyclist head injuries (Robinson, 1996; De Jong, 2010). It has also been suggested that reduced numbers of cyclists on the road increases individual risk as motorists are less aware of or willing to accommodate them (Robinson, 2005; Jacobsen, 2003). While the reduction in numbers of teenaged cyclists has been widely cited in the few years immediately after legislation, the opposite was observed among adults and the estimated overall change in cyclist numbers in NSW was close to zero (Walker, 1990, 1991, 1992; Cameron et al., 1992, 1994; Smith and Milthorpe, 1993). It is unknown whether the reductions or increases were temporary or a permanent phenomenon; however, assessments of the legislation's efficacy must take such fluctuations into consideration. A decline in cyclist numbers was only noted in one of the North American studies (Carpenter and Stehr, 2010).

Following the lead of Victoria, the state of New South Wales (NSW) introduced mandatory helmet wearing for cyclists in 1991 at separate times for adults and children: 1 January for those aged 16 and over and 1 July for children aged less than 16. There is scant research into the effect of this legislation in NSW, and certainly no rigorous analyses of population level data. A recent study suggested that any decrease in cyclist head injury in NSW around the time of the law coming into effect was due largely to general improvements in road safety rather than to helmet legislation (Voukelatos and Rissel, 2010); however, the conclusions were undermined by data accuracy issues and has subsequently been retracted (Churches, 2010; Australasian College of Road Safety (ACRS), 2011).

An ideal assessment of the impact of helmet legislation on head injuries among cyclists would require individual level population wide data on cycling exposure and helmet wearing. The lack of such data is a fundamental impediment to generating accurate population level rates of cyclist head injuries and examining their trends in light of compulsory helmet legislation. Previous studies have attempted to deal with this issue by investigating the ratio of head injuries to limb injuries. Povey et al. (1999) analysed the ratio of head injuries to limb fractures among cyclists and non-cyclists, treating limb fractures as a proxy for head injury exposure by assuming that limb fractures were constantly proportional to cyclist exposure. A similar study treats non-head injuries as the proxy by assuming these counts are proportional to person-time exposure (Scuffham et al., 2000). In a NSW based study, Voukelatos and Rissel (2010) used the ratio of head injuries to all arm injuries as a means of avoiding the need for cyclist exposure data. They used the ratio as an indicator of factors which differentially impact one type of injury, but not the other, and they assumed that general fluctuations in cyclist numbers did not affect the ratio. This is an important assumption given the observed reduction in numbers of children cycling in NSW in the years immediately following the introduction of legislation.

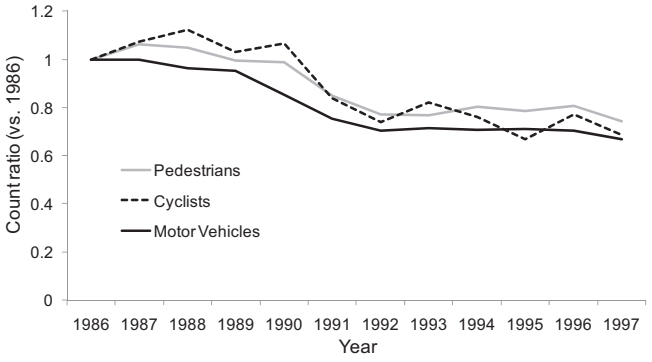


**Fig. 1.** Annual road casualties for pedestrians, cyclists and motor vehicle occupants: NSW 1986–1997.
Source: (RTA, 2008).

The main focus of this study was to examine trends in the rate of hospitalised head injuries relative to arm injuries among cyclists, focusing in particular on the change in this trend around the time that helmet legislation was introduced. Without exposure data, we assumed the exposures for head and arm injury rates were equal and hence cancelled when we took the relative risk of head to arm injuries. In addition to assuming the equality of rate exposures, our approach also assumed that rates of limb injuries over time would not be affected by helmet legislation and hence any decrease in the ratio around the time of legislation could be attributed to a reduction in head injuries due to mandatory helmet wearing. This assumption implies that helmet legislation is the only factor that could differentially affect head and arm injury rates; however, it is possible that other factors may have such an effect. Road safety improvements, such as the introduction of speed cameras in NSW in 1991 (Australian Transport Safety Bureau, 2004), would be expected to modify vehicle speeds and hence the biomechanics of cyclist traffic accidents, potentially resulting in a differential change to the risk of head and arm injuries. However, the majority of cyclist traffic injuries occur at less than 50 km/h (Simms and Wood, 2009) and hence speed modifying interventions would not be expected to have a marked differential effect on head and arm injury rates. There is no clear evidence of other factors which may affect injury rates differentially.

Many hospitalised cycling accidents occur on roads. Multiple factors influence general safety on NSW roads including enforcement of speed and alcohol limits for motorists as well as campaigns designed to improve the behaviour of road users. Potentially driven by such broader measures, counts of road accidents for pedestrians, motorists and cyclists showed a marked decline approximately between 1989 and 1992 (Fig. 1). In this study, we endeavoured to identify improvements in cyclist head injury rates in NSW in addition to the concurrent trends at the time that compulsory helmet legislation came into effect.

## 2. Methods

### 2.1. Data and case definition

The Traffic Accident Database System (TADS) is administered by the NSW Roads and Traffic Authority (RTA) and records all traffic accidents occurring in NSW where a person was killed or injured or where at least one vehicle was towed away (RTA, 2003). Data are available from 1986 onwards. TADS records road user category, including pedal cyclists, for each person involved in an accident,

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