



Journal of the **Australasian College of Road Safety**

Formerly RoadWise – Australia's First Road Safety Journal



Special Issue: Cycling Safety

Peer-reviewed papers

- Anti-helmet arguments: lies, damned lies and flawed statistics
- A systematic review of methods used to assess mandatory bicycle helmet legislation in New Zealand
- An observational study of conflicts between cyclists and pedestrians in the city centre

Contributed articles

- Cycling safety in Australia
- Key influences on cycling for transport
- Cycling and children
- Safe cycling: all we need is 3, 2, 1 to reach zero
- Road safety and cycling – a view from the handlebars
- Cycling on rural roads

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Cover image

Olympic gold medallist Anna Meares demonstrates her commitment to cycling safety in South Australia in her role as Road Safety Ambassador with the Motor Accident Commission. The Commission's cycling safety initiatives include a "Be Safe Be Seen" campaign which promotes techniques to improve road positioning, defensive riding and visibility. For MAC safe cycling tips and Anna Meares videos, please visit the MAC website:
<http://www.mac.sa.gov.au>

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Messages may be left on voicemail when the office is unattended.

From the President



Dear ACRS members,

The World Day of Remembrance for Road Traffic Victims (WDR) will be observed on the 16th of November this year by an increasing number of countries on every continent around the world. This day is dedicated to remembering the many millions killed or injured in road crashes and their families and

communities, as well as to pay tribute to the dedicated emergency crews, police and medical professionals who daily deal with the traumatic aftermath of road death and injury.

This is an important memorial event for us all to contemplate and helps motivate us in the road safety community to find more solutions to reduce so much unnecessary trauma.

Of course many of us and many in the general community are alive and uninjured because of much of the good road safety work done over the last few decades.

The Hon Barry Cohen, a minister in the Whitlam and Hawke government and a passionate advocate for road safety reminded us in an article in *The Australian* in September 2013 that “Whichever graph you study, it shows there are about 90,000 people alive today who would have been dead without the work of scientists, engineers, road safety lobbyists and politicians who refused to accept the industry’s propaganda that the fault lay with the drivers.” These people probably do not know they were spared and of course it is reasonable to assume that in the same time frame some 2,000,000 have been spared serious injuries.

Last year I circulated a “conversation “paper to encourage a wider debate on improving road safety.

This year our Executive Officer Claire Howe and I prepared what we called a “2014 ACRS Submission to the Road Safety Community’ – Boosting Australia’s Productivity and International Standing Through Road Trauma Reductions.” See link below.

The aim of these is to stimulate a wider and higher level debate on road safety; recognising not only the terrible unnecessary trauma which we must reduce, celebrating our successes, but most importantly moving our actions up a gear or two.

Unfortunately it is now apparent that Australia’s performance in generating road death and injury reductions has not kept pace with world’s best standards. Australia’s performance has not improved to the same degree as many Organization of Economic Cooperation and Development (OECD) countries since the year 2000. Australia’s ranking has therefore been slipping, and we need to commit to measuring our achievements on a global scale if we are to make the progress that our society deserves. While we have many good programs in place, while we are improving our performance; many in the world are doing better. It is as though we are achieving better swimming times than when we went to the last Olympics, only to find that quite a few others have done even better.

We would welcome your comments on the paper. We will be presenting a shorter version at the Australasian Road Safety Research Policing and Education Conference in Melbourne in November - it would help us present a better version if we know your views. Hopefully it will provide a useful background for the update of the National Road Safety Strategy due out later in the year.

<http://acrs.org.au/2014/09/acrs-president-releases-2014-acrs-submission-to-the-road-safety-community/>

*Lauchlan McIntosh AM FACRS
ACRS President*

Diary

12 – 14 November 2014

Australasian Road Safety Research, Policing and Education Conference
Melbourne, Australia
<http://rsrpe2014.com.au>

16 November 2014

World Day of Remembrance for Road Traffic Victims

17 November 2014

Road Safety Management Leadership Program
Monash Conference Centre, Melbourne
<http://www.nrspp.org.au/Events/Details/156>

17 November 2014

AAPA National Workshop Series: Safety at Roadworks
Various dates and capital cities. For further details go to
<http://www.nrspp.org.au/Events/Details/168>

17 – 19 November 2014

1st International Road Federation Asia Regional Congress
Bali Nusa Dua Convention Center
Bali, Indonesia
<http://www.irfnews.org/event/1st-asia-regional-congress>

18 – 19 November 2014

International Cycling Safety Conference (ICSC)
Gothenburg, Sweden
<http://www.icsc2014.eu/>

(continued next page)

28 November 2014

Injury Prevention in Aboriginal and Torres Strait Islander People
Sydney Business School, The Gateway Building
Level 18, 1 Macquarie Place
Sydney – Circular Quay, 9:00am – 4:30pm
To register visit www.aipn.com.au or email
secretariat@aipn.com.au

30 November – 9 December 2014

Fourth Safer Roads by Design: Across Six Continents
Rosen Plaza Hotel, Orlando Florida, United States
<https://www.irfnews.org/event/safer-roads-by-design-across-six-continents-fall/>

11 – 15 January 2015

Transportation Research Board Annual Meeting: Corridors to the Future: Transportation and Technology
Washington DC
<http://www.trb.org/AnnualMeeting2015/AnnualMeeting2015.aspx>

28 January 2015

Engineering Safer Roads
International Road Foundation. This is an online event.
<https://www.irfnews.org/event/engineering-safer-roads/>

28 – 30 January 2015

Women in Safety Leadership Summit
Fraser Suites, Sydney
<http://liquidlearning.com.au/llg08/January/women-in-safety-leadership-summit-2015.html>

24 – 25 March 2015

Australian Road Engineering and Maintenance Conference
Australian Technology Park, Sydney
<http://commstrat.cvent.com/events/10th-australian-road-engineering-maintenance-conference/event-summary-04b050cb7618461896494d1e0d748ae6.aspx>

4 – 7 May 2015

IRF A Regional Conference for Asia and Australasia 2015
<http://www.roads.org.au/conference2015>

4 - 10 May 2015

3rd United Nations Global Road Safety Week: Focussed on Children and Road Safety

29 May 2015

Fatality Free Friday
Details at: <http://www.fatalityfreefriday.com/>

College news

Head Office News

Welcome to Corporate Members

New Bronze Member - Drive to Survive, Sydney

Chapter reports

ACT and Region Chapter

The ACT and Region chapter faces an ambitious program in the next nine months or so. A series of events has been scheduled that involve new partnerships with the ACT Justice and Safety Directorate, the Transport Industry Skills Centre, local government and the ACRS National Office. This is both an exciting and demanding schedule in the time frame.

The program comprises:

- Whose responsibility is it? - Oct 2014 (with MRA as part of Motorcycle week)
- Seminar on ACT Government's response to Vulnerable Road User report - February 2015

- Truck Safety open day with Transport Industry Skills Centre - December 2014
- Communications Seminar (part of ACRS national series of seminars) - February 2015
- Annual Road Safety Seminar (in conjunction with the ACT Government) - May 2015
- Seminar on regional road safety issues with NSW Local Government bodies - date to be determined.

It is hoped the successful completion of the program will demonstrate the Chapter's capacity to produce road safety events for the community and specialist road safety organisations. This hopefully will assist in gaining both financial and membership support from organisations with an ongoing commitment to road safety in the ACT and Region.

On 20 September 2014, the Chapter made a presentation to the Australian Driver Trainers' Association Annual General Meeting in Canberra. The topic addressed was the ACRS road safety initiatives at a local level. The basic questions put to the delegates were how the College could support the driver training industry and what input the ADTA might be able to make to the College and to important road

safety issues through the College. This was demonstrated by examples of activities the College undertakes at the national and chapter level. Delegates were very interested in our programs and in becoming more involved. ADTA asked what moves were under way to establish Chapters in Tasmania and the Northern Territory.

Keith Wheatley

ACRS ACT and Region Chapter Secretary

Victorian Chapter

The Victorian chapter held the first ACRS Effective Road Safety Communications Seminar series on Tuesday 9 September 2014 at the Royal Australasian College of Surgeons, which will then roll out to other states.

The full day seminar was successful, with 80 delegates attending to hear a broad range of speakers including:

- Lauchlan McIntosh, Australasian College of Road Safety
- John Thompson, Mitchell and Partners
- Paul Tierney, 4 Tier Consulting
- Robin Tiffany, Mornington Peninsula Shire

- Tracey Gaudry, Amy Gillett Foundation; and
- Sarah Henderson (TAC), Caroline Rebaque (VicRoads), Laurel Collins (Mitchell and Partners) and Luke Axelby (RACV).

An online evaluation survey was circulated to all delegates during the week following the seminar. Thirty delegates completed the survey, which is a 38% response rate. Responses to the survey were overwhelmingly positive and supportive of the seminar, showing that the event provided a valuable opportunity for participants to hear about the latest developments in road safety communications.

I would like to thank all of our speakers, the Chapter Committee and the National Office for all their hard work in organising the seminar as well as all the delegates for an interactive day. We are very appreciative of the support of the event sponsors - the Royal Australasian College of Surgeons (RACS); the Victorian Transport Accident Commission (TAC); the Royal Automobile Club of Victoria (RACV); and VicRoads which ensured the success of the event as well as accessibility in terms of reduced pricing for attendees.

Melinda Spiteri

Acting Victorian Chapter Chair

Other news

Current research

Urban road design and the risk of injury to cyclists

Brendan Lawrence, Monash University Injury Research Institute

Providing safer roads for cyclists is integral to building a sustainable and inclusive cycling culture. It is also recognised that characterisation of what comprises a safe road environment for cyclists is not yet well-understood and requires more research, including discerning which features of the existing road system present the greatest risk to cyclists.

This current research combines an interest in sustainable transport and travel safety with PhD study into the impacts on cycling at the Monash University Injury Research Institute (MIRI). The aim is to measure the effect of different urban road design features on the risk of injury to cyclists. This research is a key element of a larger cycling

safety study led jointly by Monash University in Melbourne and Curtin University in Perth. The study is sponsored by the Australian Research Council (ARC), and supported by VicRoads, Main Roads Western Australia, TAC, Amy Gillett Foundation, Cycling Promotion Fund and Portland State University. The research findings will be used to develop innovative road design prototypes for evaluation in a cycling simulator (BikeSIM) based at Monash University.

Cyclists are currently being actively recruited into the study, riding with forward and rearward facing video cameras attached to their bicycles over two weeks. This will serve to characterise the type of infrastructure to which cyclists are exposed and to better understand the interplay between road infrastructure and road use. It is expected that preliminary findings of the research and the ARC cycling safety study will be available in 2015.

For more information please contact Brendan Lawrence on brendan.lawrence@monash.edu.

Love Cycling, Go Dutch – Study Tour

Peter Bourke, Cycling Promotion Fund

In September 2014 the Cycling Promotion Fund (CPF), with support from Specialized Aust and Trek Aust partnered with the Dutch Ministry of Economic Affairs to lead a delegation of key Australian transport ‘influencers’ to The Netherlands.

The Cycling Promotion Fund

The Cycling Promotion Fund is an initiative of the bicycle industry in Australia. Since 2000, when the CPF was established, it has undertaken a range of activities to promote cycling as an active transport solution that helps address climate change, improves transport congestion and public health, and makes our cities and urban areas more liveable and productive.

Why invest in a study trip for 10 key Australian transport influencers to the Netherlands to learn about bicycle infrastructure, policies and programs?

Australia, like many countries in the world has a political culture that has yet to embrace cycling as a form of transport and in fact has not acknowledged cycling as a positive intervention to address some of the key issues that affect our standard of living.

The CPF took the opportunity to learn from the results evident in other countries as a demonstration as to what could and should be achieved if there was real commitment from our leaders.

Why the Netherlands?

The Netherlands is a country of 17 million people, with the highest rates of bike usage in the world. Yet it is still in the top 20% of countries in the world for car ownership per capita. The Netherlands was not always the bicycle loving country we see today - it evolved this way through planning and investment following a major public campaign in the 70's. It is a country that has chosen to ensure that an integrated, safe and accessible transport system is the cornerstone of its community. That didn't happen by accident.

The CPF targeted key individuals and organisations that have the ability to influence future investment and the direction of transport policy in local, state and national agendas.

The participants came from a wide variety of key bodies across Australia including:

The Australian Local Government Association; Australasian College of Road Safety; City of Melbourne; City of Port Phillip; City of Sydney; Department of Transport WA; NRMA; RACQ; RMS NSW; and Vicroads.



The delegation to the Netherlands

The schedule included:

- 7 Mayors, Deputy Mayors or Aldermen/Councillors
- 23 regional and city transport executives, planning officials and other government representatives
- 20 transport academics, experts and consultants working with various jurisdictions in the Netherlands
- 49 presentations or guided tours attended
- We travelled by bicycle, boat, bus, foot, taxi and train.

The participants maintained a hectic schedule starting before 8am and experiencing what it took to develop and now maintain an integrated transport system till after 9pm every night, visiting Amsterdam; Arnhem-Nijmegen City Region; Eindhoven; Houten; Rotterdam; Utrecht; and Zwolle.

A critical highlight

The challenge with this trip was an ever present feeling that “this is Europe, and we can't do it in Australia.” Of all the cities we visited on this trip, Rotterdam is the most comparable to a large Australian city. As such, the steps that have been taken to go from an auto-dominated, war-torn, industrial city to a modern Dutch cycling paradise made for interesting and the most often transferable observations.

The biggest parallel between an Australian city and Rotterdam is its modern urban form. Unlike many Dutch city centres, Rotterdam is not defined by narrow, ancient alleyways, backstreets and quaint plazas.

In 1940, German bombs flattened Rotterdam and destroyed all but a few of its buildings. In addition to social scars, those bombs forever changed the cityscape. Only a handful of buildings survived and the city was completely rebuilt in the 1950s. The city was marching forward in a “modern”

style that they thought would assure economic prosperity; and from a transportation perspective that meant the construction of massive motorways where cars would have top priority.

Not only was Rotterdam designed and built for automobiles, it became central to the economic prosperity for the country, home to Europe's largest port and the third busiest in the world (receiving over 36,000 ships annually, Botany in Sydney berthed 1,600 in 2012).

Like other Dutch cities, Rotterdam's citizens rallied against an all-out embrace of automobiles. However Rotterdam had wide roads and a cultural connection to driving. Because auto use remained convenient and encouraged (policy-wise), bicycle use has 'only' achieved a mode share that is about 20%.

What was learnt?

The outcomes of the trip were varied for each participant. Knowledge was gained on infrastructure design, political lobbying and economic modelling, but for many it was more about reinforcement than what was learnt, and the networks developed in Australia.

A clear awareness was gained of the effectiveness of a transport network that has at its core a priority that is fit for purpose.

The Netherlands has a sensational network of quality highways that promote the movement of goods and people by motorised vehicles. Upon entering built up and residential areas, speed limits drop and the focus on moving people through public transport, walking and riding becomes much more evident.



A bicycle tunnel in Amsterdam (open, attractive and welcoming)

What's next?

The CPF has always focussed on achieving the long-term benefits of an environment that supports and promotes greater numbers of people riding bikes, and this trip was an investment in the people that can make this change.

The trip has allowed us to develop the foundations for a network of people that understand the positive impact of an integrated transport system on communities and economies.

For some, the critical outcome was also an understanding that it is not cars v bikes, it is reinforcing the position that it is about an integrated transport system.

The NRMA and RACQ, as leading automobile associations, are critical influencers in the future design of transport infrastructure, especially for bicycles. This trip has helped us identify the common ground we can work on and ensure we build alliances and strong lines of communication – not trenches!

The CPF will continue to invest further in the individuals and organisations that can influence investment in cycling infrastructure, policy and programs in the future. We will be looking to utilise our networks to lead further study tours in coming years, and look forward to members of the Australasian College of Road Safety joining us.

The benefits of developing networks of support cannot be overstated and are critical to the future of utility cycling and all cycling in Australia.

Be Safe Be Seen - South Australia

*Michelle Prak,
Corporate Communications and Policy Manager
Motor Accident Commission*

The Motor Accident Commission (MAC) manages South Australia's road safety communications program and cycling safety is a major focus.

There have been five cyclist fatalities in South Australia this year (to 16 September 2014) and an average four cyclist deaths per year for the past five years.

MAC's cycling safety initiatives include a "Be Safe Be Seen" campaign which promotes techniques to improve road positioning, defensive riding and visibility. Olympic gold medallist Anna Meares is campaign ambassador. The 'Be Safe, Be Seen' message is also shared during the popular Santos Tour Down Under, where MAC is the Stage 6 naming rights partner.

Through Bike SA, MAC funds the delivery of rider safety education sessions to workplaces in the Adelaide CBD. These one-hour sessions conducted during lunch breaks provide cycling safety education for riders of any level of experience.



MAC General Manager Road Safety Michael Cornish said the partnership with Bike SA had seen more than 3,000 people attend 140 presentations in its first year.

“MAC also advocates the use of front and rear bicycle lights, day and night, to improve rider visibility,” Mr Cornish said. “To help encourage use of these lights, MAC distributed quality lights free to Bike SA session participants.”

For MAC safe cycling tips and Anna Meares videos, please visit the MAC website: <http://www.mac.sa.gov.au>

VicRoads Cycling Road Rules Review

*Rachel Carlisle, Senior Policy Officer,
Road User Access and Mobility, VicRoads*

VicRoads is currently conducting a cycling related road rules review. The review consists of an analysis of cycling crash statistics, consideration of the latest research on cycling related road rules and road safety legislation, in-depth interviews with key stakeholders and community interest groups to gauge their views, and two surveys - one for road users and the other for council officers.

The online public survey was designed to gain a better understanding of Victorian road users' current knowledge of the cycling road rules, and to seek opinions on a range

of issues relating to cycling. Almost 11,000 Victorians participated in the public survey.

Responses provide insights into the views of cyclists, drivers, pedestrians and motorcyclists in relation to cycling. Initial analysis of survey respondents reveals that 72 per cent of respondents are male and 28 per cent female; and 84 per cent of respondents live in the city and suburban areas, compared with 16 per cent of respondents from regional areas.

The survey was designed to elicit opinions and measure knowledge on a wide range of issues and therefore asked questions on both current and hypothetical road rules. Until the results of the review are known there is no plan to make any changes to current cycling road rules, including those related to traffic signals. If, as part of the review, there is strong justification for a road rule change, further consultation would be undertaken to help fully understand the impact of any proposed change.

It is expected that the review will be completed by the beginning of 2015. Further details are available on the VicRoads web site vicroads.vic.gov.au

Bicycle safety in NSW

Transport for NSW developed and released the Cycling Safety Action Plan, following an increase in the number of bicycle riders killed in 2013, which focuses on fostering safer road user interactions. The plan has been developed by key stakeholders across the road community including the NSW Police Force, Bicycle NSW, the Amy Gillett Foundation, NRMA Motoring and Services and NSW Local Government.

Some of the key highlights from the plan include:

- The development of a targeted cycling infrastructure safety improvements program
- A trial of vehicle activated road signs to advise drivers when cyclists are approaching in targeted areas
- To investigate systems to improve compliance with road rules.

An initiative from the plan has been the partnership with the Amy Gillett Foundation and the development of the *It's a Two Way Street* campaign.

The campaign includes drive and ride rules for bicycle riders and motorists explaining road rules, behaviours and actions to educate both drivers and riders on safer road use together.

The campaign will reach all road users in NSW through roadside billboards, print, radio, social media and a pocket Z-card guide.

Copies of the Z-cards can be collected from any Trek dealer throughout NSW as well as NRMA Motoring & Services auto repair stores and holiday parks and through the Transport for NSW distribution warehouse.

Further details on the *It's a Two-Way Street* campaign can be found at: www.amygillet.org.au/itsatwowaystreet.

Road Ribbon for Road Safety

The *Road Ribbon for Road Safety* campaign is a community-based initiative which allows individuals to directly contribute to raising awareness about the importance of road safety, including over the festive holiday period.

The campaign urges people to take care on the roads and promotes the *Road Ribbon for Road Safety* message to friends, family and colleagues to help reduce road trauma. Individuals are encouraged to wear a road ribbon to help raise awareness of road safety in Western Australia.

The 2014 campaign will commence on Sunday 16 November 2014 to align with the World Health Organisation's World Day of Remembrance for Road Traffic Victims and will run through until Monday 5 January 2015.

Local Governments, police, government agencies, commercial businesses and not-for-profit organisations as well as individuals across the state are encouraged to join in.

WALGA's RoadWise Program has developed a range of resources to help organisations with participation in the campaign: <http://www.roadwise.asn.au/road-ribbon-for-road-safety.aspx>

Cycling – Resources for your State or Territory

Each State and Territory has a range of information on cycling available which covers rules, safety and the latest campaigns, events, planning and projects in your local area.

ACT

<http://www.act.gov.au/browse/topics/sport-and-recreation/cycling>

NSW

<http://www.rms.nsw.gov.au/roads/using-roads/bicycles/cycling-research.html>

NT

<http://www.transport.nt.gov.au/activetransport/cycling>

QLD

<http://www.tmr.qld.gov.au/Travel-and-transport/Cycling.aspx>

TAS

http://www.transport.tas.gov.au/passenger/cycling_and_walking

VIC

<http://www.transport.vic.gov.au/projects/cycling/cycling-projects>

WA

<http://www.transport.wa.gov.au/activetransport/24022.asp>

New Zealand

<http://www.nzta.govt.nz/traffic/ways/bike/>

**World Day of Remembrance
for road traffic victims**

**16th
November
2014**

Theme for 2014
From Global Remembrance to Global Action across the Decade
Speed kills – design out speeding
Let's make 2011-2020 a Decade to remember!

This theme relates to the call in Pillar 3 of the Global Plan for the Decade of Action for **Safer Vehicles** - for vehicles with improved vehicle safety & crash avoidance technologies and with high levels of occupant & vulnerable road user protection; for consumer information about safety performance of motor vehicles and minimum crash test standards, among others.

Peer-reviewed papers

Anti-helmet arguments: lies, damned lies and flawed statistics

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Abstract

Bicycle helmets are designed to mitigate head injury during a collision. In the early 1990's, Australia and New Zealand mandated helmet wearing for cyclists in an effort to increase helmet usage. Since that time, helmets and helmet laws have been portrayed as a failure in the peer-reviewed literature, by the media and various advocacy groups. Many of these criticisms claim helmets are ineffective, helmet laws deter cycling, helmet wearing increases the risk of an accident, no evidence helmet laws reduce head injuries at a population level, and helmet laws result in a net health reduction. This paper reviews the data and methods used to support these arguments and shows they are statistically flawed. When the majority of evidence against helmets or mandatory helmet legislation (MHL) is carefully scrutinised it appears overstated, misleading or invalid. Moreover, much of the statistical analysis has been conducted by people with known affiliations with anti-helmet or anti-MHL organisations.

Keywords

Bicycle helmets, Bicycle helmet legislation, Statistical errors

Introduction

Use of the helmet is the most controversial topic in all issues discussed in cycling. Media discussions about cycling safety often devolve into a debate about helmets [77]. To date, a substantial body of research has been published both in favour and against bicycle helmet use and mandatory helmet legislation (MHL). It is important to note there are two distinct but related debates with regards to bicycle helmets. One is centred on the helmet itself and its effectiveness in a crash. The other debate focuses on whether governments should mandate their use. It is

not uncommon for an individual to favour helmet use but oppose government mandated use of helmets.

Research evidence supportive of helmet use notes a protective effect in mitigating head injuries while research opposed argues helmet use increases the likelihood of rotational head injuries, increases risky behaviour and is associated with closer motor vehicle overtaking. Research evidence supportive of MHL notes declines in bicycle related head injury coinciding with an increase in helmet wearing at the time of the law. On the other hand, research opposed to MHL argues declines in head injury are due to less cycling as MHL is a cycling deterrent and also claims there is an absence of population-level evidence demonstrating a benefit. MHL opponents further argue the combination of deterred cycling, increased risk per cyclist due to fewer cyclists and risk compensation leads to a negative health benefit. Note that this final argument is dependent on the other arguments holding true.

This manuscript will demonstrate the primary arguments against helmet use and/or MHL are statistically flawed. In turn, we will discuss the arguments (1) helmets are ineffective, (2) helmet laws deter cycling, (3) helmet wearing increases the risk of a crash, (4) no evidence helmet laws reduce head injuries at a population level and (5) helmet laws result in a net health reduction. These are the core arguments found on anti-helmet advocacy websites (Bicycle Helmet Research Foundation, <http://www.cyclehelmets.org/>; Cyclists rights Action Group, <http://crag.asn.au/>; Helmet Freedom, <http://helmetfreedom.org/>; Freestyle Cyclists, <http://www.freestylecyclists.org/>; Transport and Health Study Group, <http://www.transportandhealth.org.uk/>) and even cycling organisations (Bicycle NSW, <http://bicyclensw.org.au/advocacy/>; European Cyclists' Federation, <http://www.ecf.com/>).

Helmets are ineffective

There is substantial biomechanical evidence using test dummies that helmet use will lessen the kinetic energy to the head when struck in a collision [for example, see McIntosh, Lai and Schilter, [61]. Randomised controlled trials are not ethically possible to assess the potential association between helmet wearing and head injury; therefore, most human subjects' research on helmet efficacy comes from observational studies. There have been many case-control studies that assess the association between helmet wearing and head injury and, to date, there has been a Cochrane review [96], a meta-analysis [5] and three versions of a re-analysis of the meta-analysis [37, 38]. In each case, the odds of a head injury were significantly diminished for cyclists wearing helmets versus those that did not.

Curnow [26, 27] suggested helmets exacerbate rotational injuries; the more serious being diffuse axonal injury (DAI). Although Curnow only hypothesised the DAI/helmet link unsupported by any real world or experimental evidence, some have taken this as fact [11, 13, 42, 94, 82, 83, 14]. There is, however, no existing evidence to support the DAI hypothesis. McIntosh, Lai and Schilter [61] found, when testing oblique impacts on dummies to simulate head rotation, helmet wearing did not increase angular acceleration, a result unresponsive of Curnow's hypothesis. In a study by Dinh et al. [34], using trauma registry data from seven Sydney area hospitals over one calendar year, 110 cyclists were identified and none were diagnosed with DAI regardless of helmet wearing. Walter et al. [110], using linked police and hospitalisation data in New South Wales (NSW) from 2001-2009, reported at most 12 possible DAI cases out of 6,745 cyclists in a motor vehicle collision. Seven of the twelve cyclists were unhelmeted. These results suggest the incidence of DAI among cyclists appears to be rare and unrelated to helmet wearing. Additionally, computer simulated studies of bicycle crashes found no evidence helmets increased the likelihood of neck injury among adults [63] nor was there evidence helmets increased the severity of brain or neck injury in children [62].

In addition to head injuries, Elvik [37] performed separate analyses by combining head, face and neck injuries. The results from a random effects model adjusting for potential publication bias estimate a small, slightly significant benefit to helmet wearing to protect the head, face or neck (OR: 0.85, 95% CI: 0.74-0.98). However, due to data and analytic errors, Elvik published a full length corrigendum to this article reporting a slightly different estimate (OR: 0.82, 95% CI: 0.72-0.93). More errors were found in Elvik's correction [22], which led to a correction of the corrigendum [38]. The current version estimates a substantially larger overall benefit of helmet wearing (OR: 0.67, 95% CI: 0.56-0.82) to protect the head, neck and face. With regards to head injury alone, which helmets are

designed to mitigate, Elvik [38] estimates an even greater reduction in the odds (OR: 0.50, 95% CI: 0.39-0.65).

Additionally, Elvik [37, 38] reported an increasing time trend for odds ratio estimates of helmet efficacy and suggested his summary estimate, OR=0.50, fit the trend "remarkably well." However, it is unclear if a time trend truly exists as more recent studies have estimated substantial reductions in head injury associated with helmet wearing that do not follow this pattern. Dinh et al [33] estimate an odds ratio of 0.19 (95% CI: 0.06-0.59) for intracranial bleeding or skull fractures, Amoros et al [4] report an odds ratio of 0.34 (95% CI: 0.15-0.65) for serious head injuries (AIS3+) in urban areas, Dinh et al [34] estimate an odds ratio of 0.18 for head injuries in a trauma registry (95% CI: 0.07-0.48) and Bambach et al [9] report an odds ratio of 0.26 (95% CI: 0.15-0.45) comparing severe versus possible minor head injury (survival risk ratio ≤ 0.854). In a technical report cited by Elvik [38] but not included in his meta-analysis, Amoros et al. [3] report an odds ratio of 0.29 (95% CI: 0.13-0.56) for serious head injuries (AIS3+).

Helmet laws deter cycling

Using NSW and Victorian data, Robinson [85] concluded the impact of MHL in Australia was to reduce cycling numbers and not reduce head injuries. Some recent researchers have taken MHL as a cycling deterrent as fact and present no supportive evidence [83, 90]. It should be noted, however, that Robinson omits important, relevant data and other information from her analyses.

When describing cycling count data in NSW for children (< 16 years), Robinson [85] states

"Comparable figures were not available for adults"

and, in a related paper, Robinson [88] states

"all available long and short term data show cycling is less popular than would have been expected without helmet laws."

Cycling count data for adults does, in fact, exist for NSW before and after MHL. Additionally, Robinson [85] omits NSW cycling counts for children from October 1990 in her analysis.

Prior to MHL in NSW, the Roads and Traffic Authority commissioned a series of helmet wearing surveys with data collected at road intersections and recreation areas for all ages as well as school gates for children only [106, 107, 108, 92]. Note counts were not taken at recreation areas in the 1990 report. The counts of adult cyclists from these reports are summarised in Table 1. MHL became effective for NSW adults on 1 January 1991.

Comparing the October 1990 and April 1991 counts, there was a 7% increase in adult cycling counts at road intersections spurred by a large increase in Sydney (+22%) but a decline in rural areas (-10%). Thereafter, counts at road intersections declined; however, counts in recreational areas increased substantially from the second to fourth surveys (+141%) and the absolute decrease in road intersection counts was smaller than the absolute increase in counts at recreation areas. In their summary of the effect of helmet legislation on bicycle ridership, Smith and Milthorpe [93] found “*no drop in adult ridership following legislation*”.

With regards to children cycling, Smith and Milthorpe [93] noted a decline but concluded

“The unevenness in the change in ridership – up at some sites, down in others – makes it difficult to draw conclusions about trends.”

Table 1. Counts of adult cyclists in NSW from RTA surveys (*adult recreation cycling not separated by location)

Location	Oct 90	April 91*	April 92	April 93
Road Intersections				
Sydney	2730	3332	2796	2591
Rural	2388	2146	1933	1436
Subtotal	5118	5478	4729	4027
Recreation Areas				
Sydney	n/a	n/a	911	1345
Rural	n/a	n/a	545	1293
Subtotal	n/a	1095	1456	2638
Total	n/a	6573	6185	6665

It may be argued that cycling counts in October are not comparable to those in April. However, these two months have similar weather patterns for Sydney in terms of average high temperature (22.1° C vs. 22.4° C) and average number of rainy days (8.0 vs 9.0) according to the Bureau of Meteorology [17]. They do differ in terms of rainfall (77.1mm vs. 127.2mm); however, this would contribute to a decline in post-MHL adult cycling since weather is often cited as a cycling deterrent. Additionally, Olivier et al. [74] found no significant difference in cycling related head injury hospitalisations between those months in the pre-MHL period for adults.

Caution should be taken when interpreting statistical results using this survey data whether supportive or opposed to helmet legislation. There is only one pre-law observation making it impossible to control for existing trends. Smith and Milthorpe [92] note the surveys were

designed to estimate helmet wearing in NSW and not to estimate cycling exposure. A recent article found that direct observation of cyclists could lead to biased trend estimates if precipitation, temperature and day of the week are not taken into account in the analysis [51]. Also, over a forty-eight month period, data was only collected over four months (akin to an 8.3% response rate). However, the use of the NSW helmet use surveys only support Robinson’s conclusions when the data and its limitations are not considered in full.

A series of Victorian cycling surveys found results similar to those in NSW. Cameron et al. [18] report a 3% drop in young children (aged 5-11 years), a 43% decrease in older children (aged 12-17 years) and a 44% increase in adult cycling comparing surveys from 1987/88 and 1991. The authors conclude for all ages “*bicycle use was higher during the post-law years than it was in 1987-88*”.

Marshall and White [59], in a report assessing the South Australian (SA) MHL, give estimated changes in cycling exposure. This work is cited by Robinson [88]; however, she does not mention survey results of cycling exposure. Using data from approximately 3000 households before (1990) and after (1993) helmet legislation, the authors found no significant declines in cycling exposure regardless of age, gender or level of urbanisation. Marshall and White [59] also report a 2.9% increase in counts of cyclists into Adelaide following MHL. Another survey of helmet wearing among SA schoolchildren did note a 38.1% decline of cycling to school from observational surveys of helmet wearing in 1988 and 1994. This is inconsistent with the other SA surveys; however, the authors note only 20% of those aged 15 years of age or younger reported cycling to school.

There is evidence cycling was declining prior to helmet legislation in Australia and New Zealand (NZ). The mode share for cycling in Australian metropolitan areas peaked at approximately 8-9% in the early 1940’s [8]. Since that time, travel by private vehicle steadily increased, plateauing just under 90% mode share while active transport modes (i.e., cycling, walking and public transport) steadily declined during that period. With regards to New Zealand, Tin Tin, Woodward and Ameratunga [95] noted commuting by bicycle was in decline since 1986, eight years prior to the NZ helmet law.

In Ontario, Canada, Macpherson, Parkin and To [56] reported no declines in children cycling (5-14 years) after the introduction of helmet legislation. In another Canadian study, Dennis et al. [32] found no evidence of declines in cycling in provinces that introduced helmet legislation.

Current opinions in Australia regarding bicycle helmets suggest it is a minor issue with more important concerns regarding cycling. Recent surveys list helmet wearing as

the 10th and 13th most common barrier to cycling among current and non-cyclists respectively [29]. This survey allowed for multiple responses making it difficult to ascertain the primary deterrent to cycling; however, helmet wearing comprised approximately 4% of all responses. In a survey of Australian women regarding encouraging women to cycle more, 4.1% gave the repeal of the helmet law as their main response [30]. In both surveys, the lack of cycling infrastructure and safety concerns were much more common responses.

Rissel and Wen [84] report significantly more people would cycle without helmet legislation. However, Olivier et al. [69] note the authors misinterpreted their statistical results by confusing between group comparisons with prevalence estimates. Their results actually indicated most Australians would not cycle more. Further, since Rissel and Wen's survey only concerned helmets as a cycling deterrent, it is unclear if those indicating they would cycle more without helmet legislation would not be further deterred due to other, more often cited factors such as lack of cycling infrastructure or concerns regarding safety.

Although the evidence is weak or mixed with regards to the argument helmet legislation deters cycling, this hypothesis cannot be fully rejected. However, it is important to note this is not a phenomenon unique to countries with such legislation. Cycling has decreased 17% in Denmark from 1990 to 2008 [28] and there was a decrease in on-road cycling of 19% in the United Kingdom from 1989/90 to 1997/98 [100].

It has been argued that increasing the number of cyclists will lower the number of cycling injuries per cyclist [48]. This is often called the *safety in numbers* (SiN) effect and is a variation of Smeed's Law. Robinson [87], using her estimates of the deterrent effects of MHL, further hypothesised helmet legislation could increase the number of injuries per cyclist. The mathematical representation of SiN for cyclists is

$$\frac{I}{C} \propto C^{-0.6} \quad (1)$$

where I represents the number of injuries and C is the amount of cycling.

As noted above, very little cycling exposure data exists at the time of helmet legislation in the early 1990's. Yearly estimates of cycling participation does exist beginning in 2001 as part of the Participation in Exercise, Recreation and Sport (ERASS) surveys from the Australian Bureau of Statistics [6].

Equation (1) can be reformulated as

$$I = I_0 \left(\frac{C}{C_0} \right)^{0.4} \quad (2)$$

where I_0 and C_0 are initial values for injuries and amount of cycling respectively. Using NSW hospitalisation data [73], Figure 1 gives actual and expected head and arm injuries for 2001-2010 using equation (2) and 2001 injury and cycling participants as initial values.

The results are not supportive of SiN as the observed injuries differ substantially from expected (chi-square test, $p < 0.001$ in each case). Additionally, using the counts of head/arm injuries and ERASS cycling estimates, the exponent is estimated to be 0.94 (95% CI: 0.59-1.30). Therefore, this data suggest a proportional change in cycling is associated with a similar change in the proportion of cycling-related injury and is not supportive of the SiN effect for cycling.

Although the counts of observed and expected injuries diverge immediately, they seem to converge after 2006. In fact, observed head injuries are less than expected by 2010. This change coincides with increased cycling expenditures in NSW [66] suggesting segregated cycling infrastructure and helmet legislation, not safety in numbers, are major causal factors in cycling safety. In other words, the safety in numbers effect may be a consequence of an existing safe cycling environment. Other authors [10] have further questioned the use of SiN in determining transportation policy due to the lack of supportive evidence.

The increase in cycling injuries is also consistent with increased cycling per person (measured in either time or distance). The ERASS surveys estimate a 45% increase in Australians cycling from 2001 to 2010, although these are participation rates and not actual amounts of cycling [6, 7]. However, this would indicate the amount of cycling (not just participation) can increase in jurisdictions with helmet legislation which runs counter to most arguments against helmet legislation. In fact, a key assumption by de Jong [31] is the kilometres cycled per person can only decrease with helmet legislation.

Helmet wearing increases the risk of a crash

Robinson [85, 88] suggested a cyclist's perception of risk is modified when wearing a helmet and, as a consequence, will exhibit riskier behaviour when wearing a helmet. This is often termed risk compensation or risk homeostasis. In a criticism of a Cochrane Review assessing the protective effect of bicycle helmets [96], Adams and Hillman [2] argue in favour of risk compensation. Adams [1] has made similar arguments around seat belts in motor vehicles. However, there is scant evidence to support this theory.

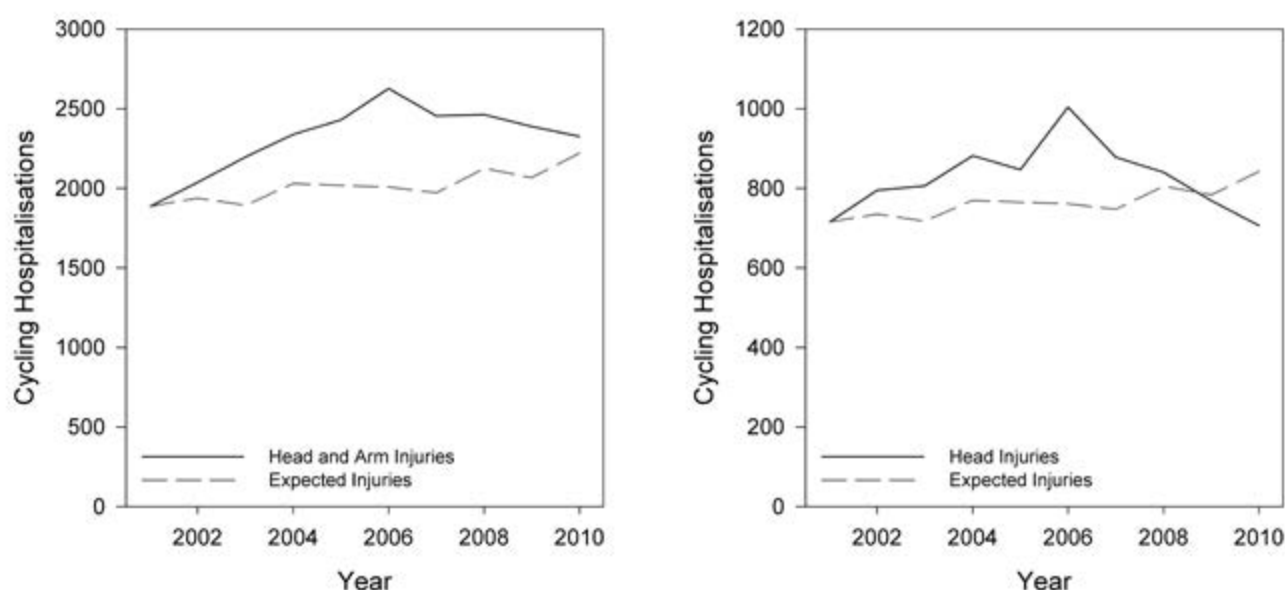


Figure 1. Actual and expected NSW cycling hospitalisations (2001-2010) for (a) head and arm injuries and (b) head only

A series of Norwegian studies, in an effort to measure risk compensation for helmet wearing, recruited cyclists who either usually wear or not wear helmets. Their primary outcome was average speed while wearing or not wearing a helmet and a measure of psychophysiological relaxation. For usual helmet wearers, Phillips, Fyhri and Sagberg [76] report lower cycling speeds and increased heart rate variability when not wearing a helmet. No significant differences were found for non-helmet users. A plot of this relationship is given in Fyhri and Phillips [41] which has been reproduced below in the left panel of Figure 2. The authors urge caution regarding helmet legislation in light of their results.

These results, and particularly their figure, are misleading as it conveys a temporal ordering that does not exist. This figure gives the impression a cyclist who usually wears a helmet will increase speed when wearing a helmet. The correct temporal ordering here is the reverse for usual helmet wearers and the correct ordering is given in the right panel of Figure 2. When plotted correctly, their results demonstrate a decrease in cycling speed when a cyclist moves from their usual condition (helmet use or non-use) to the treatment condition (non-use or helmet use). This is also true for their psychological relaxation results, i.e., declines in both groups when subjected to the treatment condition. Further, it is unclear if increased speed is a valid measure of risk compensation for bicycle helmet use. Through the use of computer simulation of bicycle crashes, helmet use was found to increase in protection as cycling speed increased thereby negating any potential effect of risk compensation [62, 63].

More importantly, helmet promotion and helmet legislation have a clear temporal ordering: usual non-wearers are urged or mandated to put on a helmet. In this situation, the authors report no significant changes in speed or psychological relaxation when a non-user wears a helmet, so their results do not support risk compensation theory as it relates to helmet promotion or legislation. On the other hand, results from case-control studies give evidence non-helmet users in a crash were more likely to exhibit illegal behaviour [52, 9].

One of the NSW helmet wearing surveys [107] examined whether helmet legislation may have influenced levels of compliance with other regulations governing the use of bicycles on the road. The data estimated a decrease in certain illegal behaviour by NSW adults including riding on the wrong part of the road or riding on the footpath following MHL. There was also no evidence that dangerous riding behaviour, such as doubling, riding 'no hands' or 'no feet' or riding more than three abreast, increased after the law. The report concluded that "the evidence available provides no support for the risk hypothesis."

Thompson, Thompson and Rivara [97] have called for a systematic review of the evidence surrounding bicycle helmets and risk compensation. In their view, the "empirical evidence to support the risk compensation theory is limited if not absent." In a response, Adams and Hillman [2] argue such a review would be difficult due to the "tens of thousands of articles that have a bearing on risk compensation". A search using the phrase "risk compensation" turned up 147 articles on Medline, 322 articles on Scopus and 343 articles on Web of Science (14 August 2014). The number of articles reduced dramatically when the phrase "bicycle helmet" was added to the search

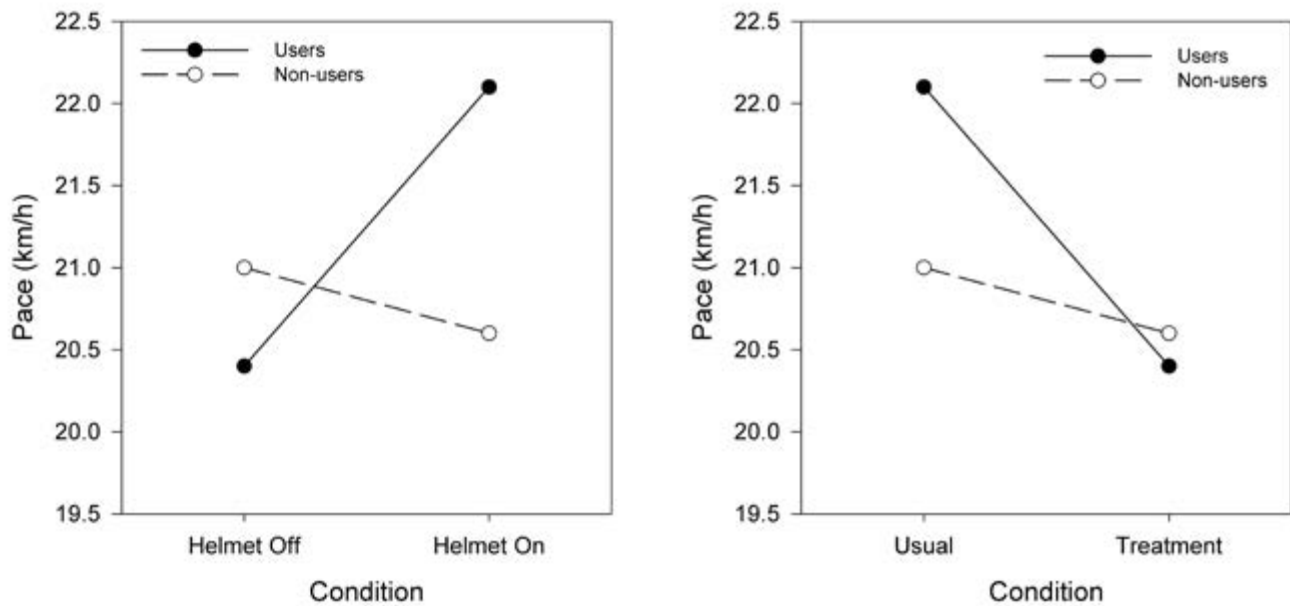


Figure 2. Cycling speed with and without helmet wearing for regular helmet users and non-users with (a) incorrect and (b) correct temporal ordering (source: Fyhri & Phillips [41])

– one for Medline, nine for Scopus and six for Web of Science. Note that four of the nine Scopus articles are opinion pieces co-authored by Adams or Hillman.

In a study of driver behaviour towards cyclists, Walker [103] reported significantly less overtaking distance when wearing a helmet versus not. Although not an example of classical risk compensation, the implication is the cyclist's environment is riskier when wearing a helmet.

It is known that lateral forces are increased as a result of air turbulence when vehicles get nearer a cyclist. This is often the basis for the one metre rule, or similar three foot rule in the US, for safe overtaking [55]. Further, on his website, Walker [104] supports the categorisation of his data using the one metre rule stating “this is perhaps the clearest way to illustrate the effect of helmet wearing.” However, using data available on his website, Olivier and Walter [72] demonstrated the association between helmet wearing and unsafe passing distances ($< 1\text{m}$) is non-significant ($\text{OR}=1.3$, $p=0.182$) and this effect is reduced when adjusted for vehicle size, city of occurrence and distance to the kerb ($\text{aOR}=1.1$, $p=0.540$). This result is not due to lack of statistical power since the sample size of the original study was based on 98% power. Walker, Garrard and Jowitt [105] found no evidence overtaking distance was associated with helmet wearing in a follow-up study.

No evidence helmet laws reduce head injuries at a population level

Although helmet use has been shown to be beneficial in a cycling crash, Robinson [88] and Rissel [82] argue a population level effect has not been detected for

jurisdictions with helmet legislation. Both authors cite a study by Hendrie et al. [47] using Western Australian (WA) data to support their arguments, yet each fail to note the paper found a significant decline in the ratio of cycling to pedestrian head injury at the time of the WA helmet law.

Comparing head and arm injury hospitalisations in NSW, Voukelatos and Rissel [101] concluded helmet legislation did not lead to a greater reduction in head injuries beyond an overall declining trend in cycling injuries. However, serious data issues were identified in this study [21] and the article was later retracted by the journal [44]. Subsequently, however, the results from the retracted paper have been used as evidence against helmet legislation [82]. Additionally, Gillham [42] uses the incorrect data reported by Voukelatos and Rissel [101] as the basis for arguing against conclusions drawn from subsequent analyses by Walter et al. [109] using the same source data while also hosting the original, retracted article (<http://www.cycle-helmets.com/rissel.pdf>).

Mindell, Wardlaw and Franklin [65] combined figures found in Walter et al. [109] and state “it is difficult to discern any particular reduction in head injuries to cyclists (black) compared with pedestrians (grey), although the data are rather “noisy”.” Their plot is given in Figure 3. Note that these plots do not correspond to the actual data. In fact, the time series of head/arm and head/leg ratios for cyclists and pedestrians respectively do not overlap at all and exhibit differing amounts of variability or “noise”.

The correct plots are given in Figure 4. To reproduce the plots in Mindell, Wardlaw and Franklin [65], the height and variability of each time series would need to

be adjusted producing time series that are ultimately no longer comparable. This is a clear case of manipulating the presentation of data to lend support to an existing policy in opposition to helmet legislation [98].

Relative to the other time series plots, there would appear to be less variability (i.e., “noise”) in the head/arm ratio for cyclists and the head/leg ratio for pedestrians. By contrast, there is more “noise” in the comparison between cycling head and leg injuries. This suggests cycling arm and pedestrian leg injuries are better comparators with their respective primary outcomes (i.e., head injury). With regards to cycling injury, this is supported numerically as the within-month correlation is higher comparing cycling head injuries to arm injuries as opposed to leg injuries [110]. Further, Figure 5 gives a plot of the head/arm injury ratio and the estimated counterfactual, i.e., the trend without the effect of the helmet law. This plot demonstrates a clear level shift in the head/arm ratio for cyclists after the helmet law as 89% (16/18) of monthly ratios are below the counterfactual.

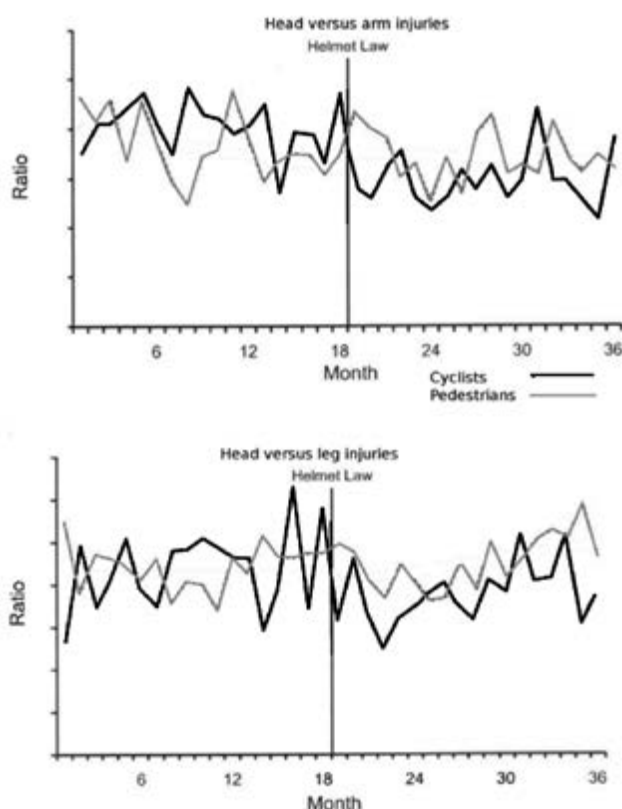


Figure 3. Time series of the ratio of head to limb injuries for bicycle and pedestrian related hospitalisation in NSW
(source: Mindell et al. [65])

Although graphical displays of data are an efficient method for presenting a study’s results, they can also be misleading as demonstrated above. Additionally, a determination that data is “noisy” should be assessed objectively by comparing an observed effect to an estimate of variance, sometimes

called the “signal” to “noise” ratio. Importantly, Ramsay et al. [80], in a systematic review of studies using interrupted time series designs, found over 40% of studies in which the data was not analysed or analysed inappropriately, the original conclusions were reversed when appropriate statistical methods were used.

A numerical analysis of the NSW hospitalisation data for cycling and pedestrian head injuries is given in Table 2. Walter et al. [110] validated the fit of their model through inspection of the deviance residuals which included checking for residual autocorrelation. Furthermore, this study meets all the quality criteria for interrupted time series designs proposed by Ramsay et al. [80]. Additional resources for properly assessing population-based interventions through interrupted time series designs are Wagner et al. [102], Shadish, Cook and Campbell [91] and French and Heagerty [40].

Table 2: Ratio of head to limb injury hospitalisations in NSW for cyclists and pedestrians immediately before and after mandatory helmet legislation (source: Walter et al., [110])

	Pre-Law	Post-Law	% Change	p-value
Head/Arm				
Cyclists	1.075	0.779	-27.5	0.03
Pedestrians	1.579	1.756	+11.2	0.41
Head/Leg				
Cyclists	2.164	1.493	-31.0	0.03
Pedestrians	0.896	0.804	-10.2	0.38

Note that the p-values given are substantially lower when the within-month correlation between head and limb injuries is part of the model or the most parsimonious model is chosen [110]. For each type of ratio, there is a significant change with the helmet law for cyclists but not for pedestrians. In fact, there is an estimated increase in the head/arm ratio for pedestrians while there is a substantial decrease for cyclists. These results point to a small amount of “noise” relative to “signal” in the NSW hospitalisation data for cycling head injuries around the helmet law.

There is a drawback of strictly analysing the ratio of one injury to another. Specifically, the ratio between them may vary over time, yet it will be unclear whether it is due to changes in one or both. A more appropriate analysis, and perhaps time series plot, would be to estimate them as part of a joint model. Separate time series plots of cycling head and arm injury hospitalisations in NSW for the eighteen month period around the helmet law and the following two decades are given in Figure 6.

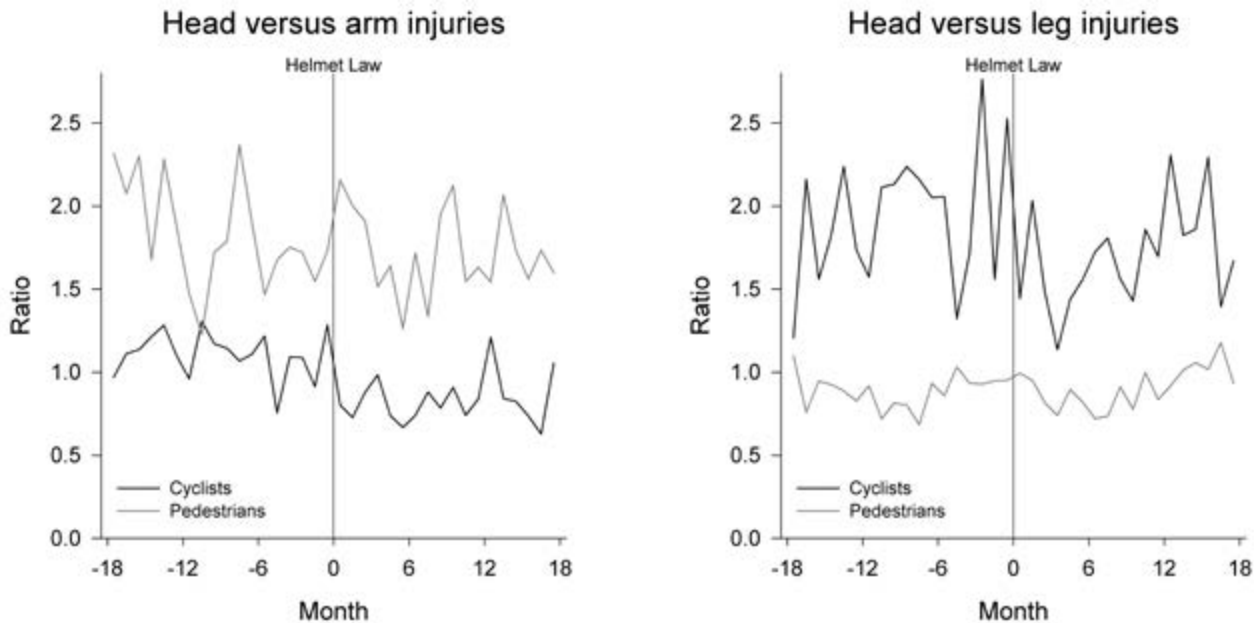


Figure 4. Time series of the ratio of head to limb injuries for bicycle and pedestrian related hospitalisation in NSW (source: NSW Department of Health)

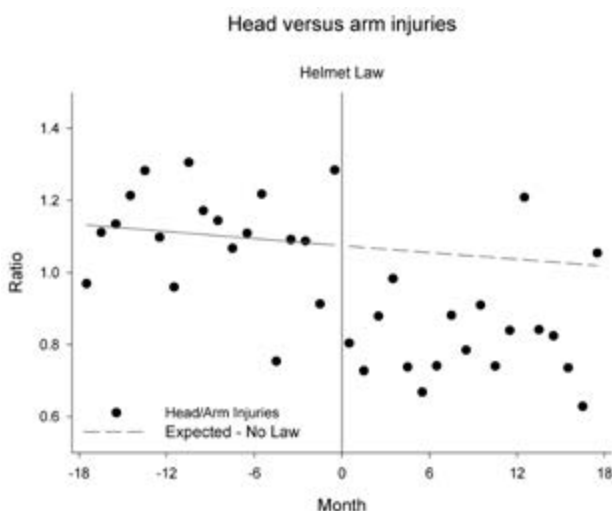


Figure 5. Time series of the ratio of head to arm bicycle injury hospitalisations in NSW and the expected ratio without the helmet law (source: NSW Department of Health)

In the eighteen month period before the helmet law, the head injury rate is consistently higher than the arm injury rate while the opposite holds in the subsequent eighteen month period. There is a clear divergence between these injury rates over the next twenty years using yearly aggregated data.

In a review of New Zealand data found in Tin Tin, Woodward and Ameratunga [95], Clarke [23] argues the NZ helmet law is associated with an increased injury risk of 20-32%. This conclusion comes from comparing overall injuries per million hours cycling in the periods 1988-1991 and 2003-2007. The NZ helmet law was effective from 1

January 1994 and Clarke's comparison ignores intermediate injury data for 1996-1999 and estimates of helmet wearing. There is a 17% decline in overall cycling injury comparing 1988-1991 with 1996-1999 data as well as a 53% decline in serious cycling injury (AIS: 3+). This time period also corresponds to an increase in helmet wearing (see Figure 7).

Although helmet use is a targeted intervention (i.e., a helmet will only protect the head), Clarke did not analyse head injuries separately and instead combined all cycling related injury [112]. Missing from Clarke's study was a 67% decline in serious traumatic brain injury (TBI) comparing 1988-1991 and 1996-1999 data. Further, when contrasted with increases in helmet wearing, there is a decline in both injuries overall and serious TBI alone. While there is an increase in overall cycling injury comparing 1996-1999 and 2003-2007 data, there is only a slight increase in TBI. During this period, estimates of helmet wearing in NZ have remained steady indicating any changes in the injury trends are unrelated to helmet wearing.

Helmet legislation has also been shown to be beneficial in other jurisdictions. This includes reductions in cycling head injury or fatality for children under 18 years in Alberta, Canada [50], children under 16 years in Ontario, Canada [113], Canadian children aged 5-19 years in provinces with helmet legislation [57], children under 16 years in the US [43, 64], children 17 years or under in California [54], male children under the age of 15 in Sweden [16] and cyclists in Spain [53]. A Cochrane Review has also found helmet legislation to be beneficial at decreasing cycling head injury rates [58].

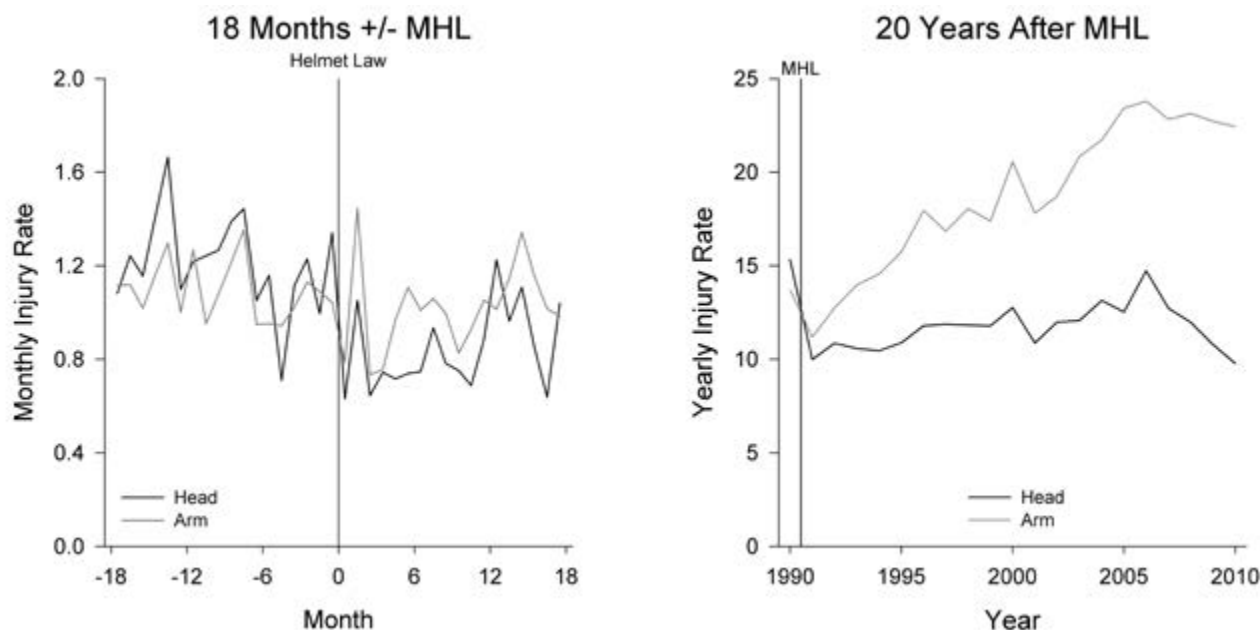


Figure 6. Cyclist head and arm injury hospitalisations in NSW during (a) the 36 month period around the helmet law and (b) 20 years post-MHL (source: NSW Department of Health)

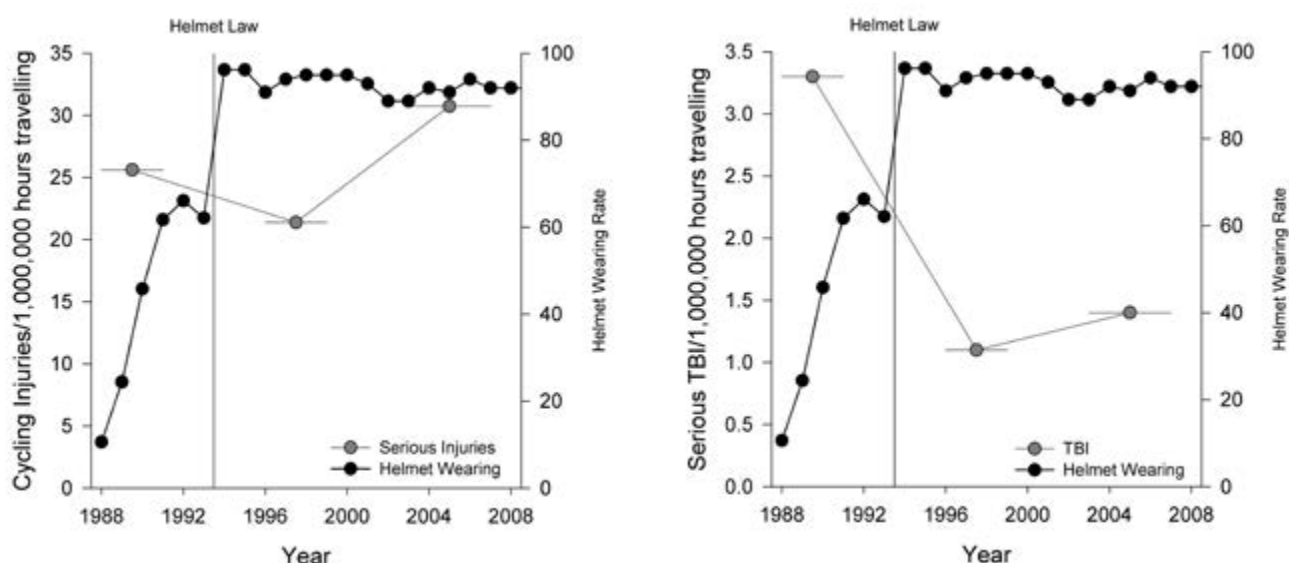


Figure 7. Overall cycling-related injuries and serious traumatic brain injury (TBI) per one million hours travelling and estimated helmet wearing rates in New Zealand (source: Tin Tin et al., [95], New Zealand Ministry of Transport, [67])

Helmet laws result in a net health reduction

It is often argued the deterrent effects of MHL, and subsequent increase in injury risk per cyclist through safety in numbers, leads to a net reduction in health. In a study regarding the health impact of MHL, de Jong [31] concludes MHL is only overall beneficial under “relatively extreme assumptions”.

Among de Jong’s assumptions is helmet legislation can only lead to declines in cycling. As support for this assumption,

de Jong notes, without citation, motorcyclists do not like helmets, so it is “safe to assume the same is true for bicyclists”. He also points to Robinson [85, 88, 89] as the “main statistical studies” on the subject. As demonstrated above, there is no evidence adult cycling diminished with helmet legislation in NSW, South Australia or Victoria and the safety in numbers hypothesis is not supported using available NSW data. There is also little evidence helmet use increases the risk of DAI or an increase in risky behaviour. Therefore, the belief that helmet legislation will not lead to less cycling or helmet use will not increase the risk of

injury are reasonable assumptions. Under those conditions, de Jong's model will always demonstrate a net benefit to helmet legislation.

With regards to Australia, de Jong used model parameters based on data from other nations. So, it is unclear if any of his results are applicable to cycling in Australia. Additionally, Newbold [68] found a benefit to helmet legislation using de Jong's model using parameters relevant to the United States. In an unrelated assessment, Elvik and colleagues [36] found a positive cost-benefit ratio for helmet legislation under most scenarios.

Discussion

In this paper, we discuss common arguments against the use of bicycle helmet use and adoption of a government mandated helmet law. As demonstrated, these arguments are not supported by available data (DAI hypothesis, safety in numbers); rely on the omission of key data (deterrent effects of legislation, lack of population level effects); or the misrepresentation of data (risk compensation, lack of population level effects). The hypothesis that helmet legislation leads to a net health disbenefit, or the related obesity link (for example, see Rissel, [82]), is dependent on these arguments and is therefore not supported by available evidence.

This is not the first paper critical of methods used in anti-helmet arguments. Other work not cited above has pointed to common fallacies in the literature portraying bicycle helmets or helmet laws negatively [25, 46, 45, 81, 70, 15, 99, 19, 78, 75].

Many of the authors arguing against helmets cited in this paper belong to anti-helmet advocacy groups. Adams, Curnow, Franklin, Gillham, Hillman, Robinson and Wardlaw are members of the Bicycle Helmet Research Foundation [12]. Curnow and Gillham also maintain their own websites dedicated to anti-helmet advocacy [24, 42]. Mindell is vice-chair of the Transport and Health Study Group whose objectives include "To promote a more balanced approach to cycle safety and oppose cycle helmet legislation" [98]. The THSG is affiliated with a new Elsevier journal with Mindell as editor-in-chief with Rissel and Wardlaw as members of the editorial board [49]. Additionally, Rissel has participated in anti-helmet protests [20].

Quite often arguments against helmet legislation are framed as an all-or-nothing safety intervention strategy that is in direct competition with creating segregated cycling infrastructure. In other words, it is believed a government will support one but not both. To wit, Ian Walker in a recent New York Times article states "Any solution to bicyclist safety should focus on preventing collisions from taking place, not seeking to minimize the damage after a

collision has occurred" [35]. This strategy runs counter to the safe system approach supported by government and safety advocacy groups, where personal protection is seen as a critical component of the whole system to reducing vulnerable road user (cyclist and motorcyclist) injuries. There is also little support for focussing on injury avoidance alone in the injury record. In NSW from 1991 to 2010, only 12% and 23% of bicycle related head injury hospitalisations for children and adults respectively involve a motor vehicle. The goal of the safe system approach, on the other hand, would be to minimise the risk of a crash (crash avoidance) and to minimise the risk of injury when a crash occurs (personal protection), i.e., a holistic approach is used to reduce road trauma.

There are other anti-helmet arguments we have not addressed. A Straw Man is often posited that helmet use is not mandated for pedestrians, so it should not be applied to cyclists. This argument has appeal on the surface; however, a similar argument could be made regarding seat belt legislation. A similarly structured argument might be "seat belts are not required for cyclists who are often injured falling off a bicycle, so it should not apply to drivers or passengers." Another argument is that helmet legislation impedes personal freedoms [81]. In a democratic society, this is a valid argument for an individual. However, helmet legislation would be valid for a democratic society with support from the majority. An estimated 94% of Australians support helmet legislation [39]. Consideration should also be given in jurisdictions with government funded health care as the cost of cycling injuries is shared by all tax payers. Olivier et al. [71] point out that presently more than 700 head injury hospitalisations are currently being avoided with the associated reduced health burden cost saving on the order of around a third of a billion dollars saved each year by taxpayers.

This paper does not suggest research in favour of helmets is not without flaws. For example, Robinson [86] was critical of Povey et al. [79] for not fitting time trends in their assessment of the New Zealand helmet law. Povey et al. fit the log of the ratio of head injuries to limb fractures with estimates of helmet wearing for years 1990-1996. Observations taken over time can exhibit serial dependence and failure to account for this interdependence can lead to invalid inferences. The model used by Povey et al. assumes independence, serial or otherwise. Fitting time trends is an indirect method for accounting for serial dependence and there are more direct statistical methods for this purpose, for example, autocorrelated regression or autoregressive integrated moving average models (see, for example, McDowall et al. [60]). At issue with the Povey et al. analysis is whether their model assumptions were justified, specifically serially independent observations. Neither Povey et al. [79] nor Robinson [86] assessed serial dependence in the NZ data and there are other

methodological issues in much of the research assessing the NZ law [111]. Importantly, the Durbin-Watson statistic for this data is 1.8 indicating an independence assumption is reasonable and, therefore, the results of the Povey et al. [79] analysis are valid. So, Robinson's concerns were reasonable, although her specific criticism was not.

Conclusion

While there is much conflicting evidence related to helmets and MHL efficacy, when brought under statistical scrutiny the majority of evidence against helmets or MHL appears overstated, misleading or invalid. Moreover, much of it has been conducted by people with known affiliations with anti-helmet or anti-MHL organisations. Ultimately, this body of work distorts our understanding of the mechanisms by which helmet wearing protects the heads of cyclists and the factors related to the success or failure of helmet legislation. Future research should exercise caution regarding the validity of the anti-helmet arguments discussed in this paper unless, of course, they are supported by robust data and analyses from the peer-reviewed literature. We further caution against the use of advocacy groups, such as those listed above, as a resource for shaping road safety policy.

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References

- Adams, J. (2007). Seat belt laws: Repeal them? *Significance*, 4, 86-89. <http://dx.doi.org/10.1111/j.1740-9713.2007.00236.x>.
- Adams, J. & Hillman, M. (2001). The risk compensation theory and bicycle helmets. *Injury Prevention*, 7, 89-91.
- Amoros, E., Chiron, M., Ndiaye, A. & Laumon, B. (2009). *Cyclistes Victimes d'Accidents (CVA) Partie 2: Études cas-témoins. Effet du casque sur les blessures à la tête, à la face et au cou*. Available at: http://www.invs.sante.fr/publications/2010/cyclistes_victimes_accidents/rapport%20cyclistes_victimes_accidents_cas_temoins.pdf
- Amoros, E., Chiron, M., Martin, J.L., Thelot, B. & Laumon, B. (2012). Bicycle helmet wearing and the risk of head, face, and neck injury: a French case control study based on a road trauma registry. *Injury Prevention*, 18, 27-32.
- Attewell, R.G., Glase, K. & McFadden, M. (2001). Bicycle helmet efficacy: a meta-analysis. *Accident Analysis and Prevention*, 33, 345-352.
- Australian Bureau of Statistics. (2001). Participation in Exercise, Recreation and Sport 2001. ABS, Canberra. Available at: http://www.ausport.gov.au/_data/assets/pdf_file/0007/148777/ERASS_2001.pdf.
- Australian Bureau of Statistics. (2010). Participation in Exercise, Recreation and Sport 2010. ABS, Canberra. Available at: http://www.ausport.gov.au/_data/assets/pdf_file/0018/436122/ERASS_Report_2010.PDF
- Australian Department of Infrastructure and Transport. (2012). Walking, Riding and Access to Public Transport: Draft Report For Discussion – October 2012. Available at: http://www.infrastructure.gov.au/infrastructure/pab/urbanpolicy/files/ACTIVE_TRAVEL_DISCUSSION.pdf
- Bambach, M.R., Mitchell, R.J., Grzebieta, R.H. & Olivier, J. (2013). The effectiveness of helmets in bicycle collisions with motor vehicles: A case-control study. *Accident Analysis and Prevention*, 53, 78-88.
- Bhatia, R. & Wier, M. (2011). "Safety in Numbers" re-examined: can we make valid or practical inferences from available evidence? *Accident Analysis and Prevention*, 43, 235-240.
- BHRF. (2003). Cycle helmets and rotational injuries. Bicycle Helmet Research Foundation. Available at: <http://www.cyclehelmets.org/1039.html>. (accessed 19.07.13)
- BHRF. (2013). Patrons and Editorial Board. Bicycle Helmet Research Foundation. Available at: <http://www.cyclehelmets.org/1121.html>. (accessed 26.07.13)
- Bicycle Australia. (2010). Bicycle Helmets. Available at: <http://bicycleaustralia.org/helmets.php>. (accessed 19.07.13)
- Bicycle NSW. (2013). Bicycle Helmets. Available at: <http://bicyclensw.org.au/advocacy/positions/legal/helmets/>. (accessed 19.07.13)
- Biegler, P. & Johnson, M. (2013) In defence of mandatory bicycle helmet legislation: response to Hooper and Spicer. *Journal of Medical Ethics*. <http://dx.doi.org/10.1136/medethics-2013-101476>
- Bonander, C., Nilson, F. & Andersson, R. The effect of the Swedish bicycle helmet law for children: An interrupted time series study. *Journal of Safety Research*, in press.
- Bureau of Meteorology. (2013). Summary statistics for Sydney (Observatory Hill). Available at: http://www.bom.gov.au/climate/averages/tables/cw_066062.shtml. (accessed 19.07.13)
- Cameron, M., Newstead, S., Vulcan, P. & Finch, C. (1994). Effects of the compulsory bicycle helmet law in Victoria during its first three years. *Proceedings of 1994 Pedestrian and Bicyclist Safety and Travel Workshop*, Melbourne, Australia, ed. Adreassen, D. & Rose, G, 165-176.
- Cameron, P.A., McDermott, F. & Rosenfeld, J.V. (2013). Head injury prevention for bicyclists – helmets make a difference. *MJA*, 199, 522-523.
- Chadwick, V. (2012). Protesting cyclists to make Merri, their hair blowin' in the wind. *The Courier*. Available at: <http://www.thecourier.com.au/story/361766/protesting-cyclists-to-make-merri-their-hair-blowin-in-the-wind/?cs=12>. (accessed 15.08.14)
- Churches, T. (2010). Data and graphing errors in the Voukelatos and Rissel paper. *Journal of the Australasian College of Road Safety*, 21, 62-64.
- Churches, T. (2013). The benefits of reproducible research: a public health example. Available at: <https://github.com/timchurches/meta-analyses/blob/master/benefits-of-reproducible-research/benefits-of-reproducible-research.md>. (accessed 19.07.13)

23. Clarke, C. (2012). Evaluation of New Zealand's bicycle helmet law. *New Zealand Medical Journal*, 125, 60-69.
24. CRAG. (2013). Cyclists Rights Action Group. Available at: <http://crag.asn.au/>. (accessed 26.07.13)
25. Cummings, P., Rivara, F.P., Thompson, D.C. & Thompson, R.S. (2006). Misconceptions regarding case-control studies of bicycle helmets and head injury. *Accident Analysis and Prevention*, 38, 636-643.
26. Curnow, W.J. (2003). The efficacy of bicycle helmets against brain injury. *Accident Analysis and Prevention*, 35, 287-292.
27. Curnow, W.J. (2007). Bicycle helmets and brain injury. *Accident Analysis and Prevention*, 39, 433-436.
28. Cycling Embassy of Denmark. (2010). Bicycle statistics from Denmark. Available at: <http://www.cycling-embassy.dk/wp-content/uploads/2010/03/Bicycle-statistics-from-Denmark.pdf> (accessed 15.08.14)
29. Cycling Promotion Fund. (2011). Riding a Bike for Transport: 2011 Survey Findings. Available at: http://www.cyclingpromotion.com.au/images/stories/MediaReleaseDocs/CyclingPromotionFund_Riding_a_Bike_for_Transport_Survey_Report_2011.pdf
30. Cycling Promotion Fund. (2013). Women and cycling survey 2013. Available at: <http://www.heartfoundation.org.au/news-media/Media-Releases-2013/Documents/CPF%20-%20Women%20and%20Cycling%20Survey%202013.pdf>
31. de Jong, P. (2012). The health impact of mandatory bicycle helmet laws. *Risk Analysis*, 32, 782-790.
32. Dennis, J., Potter, B., Ramsay, T. & Zarychanski, R. (2010). The effects of provincial bicycle helmet legislation on helmet use and bicycle ridership in Canada. *Injury Prevention*, 16, 219-224.
33. Dinh, M.M., Roncal, S., Green, T.C., Leonard, E., Stack, A., Byrne, C. & Petchell, J. (2010). Trends in head injuries and helmet use in cyclists at an inner-city major trauma centre, 1991–2010. *MJA*, 193, 619-620.
34. Dinh, M.M., Curtis, K. & Ivers, R. (2013). The effectiveness of helmets in reducing head injuries and hospital treatment costs: a multicentre study. *MJA*, 198, 416-417.
35. Egan, S. (2013). Bike Sharing Can Mean Safer Biking. *New York Times*. Available at: http://well.blogs.nytimes.com/2013/06/13/bike-sharing-can-mean-safer-biking/?_r=0. (accessed 15.08.14)
36. Elvik, R., Høy, A., Vaa, T. & Sørensen, M. (2009). *The Handbook of Road Safety Measures*, 2nd Edition. Emerald, Bingley, UK.
37. Elvik, R. (2011). Publication bias and time-trend bias in meta-analysis of bicycle helmet efficacy: a re-analysis of Attewell, Glase and McFadden, 2001. *Accident Analysis and Prevention*, 43, 1245–1251. <http://dx.doi.org/10.1016/j.aap.2011.01.007>
38. Elvik, R. (2013). Corrigendum to: "Publication bias and time-trend bias in meta-analysis of bicycle helmet efficacy: A re-analysis of Attewell, Glase and McFadden, 2001". *Accident Analysis and Prevention*, 60, 245-253. <http://dx.doi.org/10.1016/j.aap.2012.12.003>
39. Essential Vision. (2012). Essential Report. Available from http://essentialvision.com.au/documents/essential_report_120430.pdf. (accessed 02.07.12).
40. French, B. & Heagerty, P.J. (2008). Analysis of longitudinal data to evaluate a policy change. *Statistics in Medicine*, 27, 5005-5025.
41. Fyhri, A. & Phillips, R.O. (2013). Emotional reactions to cycle helmet use. *Accident Analysis and Prevention*, 50, 59-63.
42. Gillham, C. (2011). Mandatory bicycle helmet law in Western Australia. Available at: <http://www.cycle-helmets.com/>. (accessed 19.07.13)
43. Grant, D. & Rutner, S.M. (2004). The Effect of Bicycle Helmet Legislation on Bicycling Fatalities. *Journal of Policy Analysis and Management*, 23, 595-611.
44. Grzebieta, R. (2011). Retraction of the Voukelatos and Rissel paper on bicycle helmet legislation and injury. *Journal of the Australasian College of Road Safety*, 22, 39.
45. Hagel, B., McPherson, A., Rivara, F.P. & Pless, B. (2006). Arguments against helmet legislation are flawed. *BMJ*, 332, 725-726.
46. Hagel, B.E. & Pless, I.B. (2006). A critical examination of arguments against bicycle helmet use and legislation. *Accident Analysis and Prevention*, 38, 277-278.
47. Hendrie, D., Legge, M., Rosman, D. & Kirov, C. (1999). An economic evaluation of the mandatory bicycle helmet legislation in Western Australia. Conference on Road Safety, Perth, Western Australia, November 26.
48. Jacobsen, P.L. (2003). Safety in numbers: more walkers and bicyclists, safer walking and bicycling. *Injury Prevention*, 9, 205-209.
49. *Journal of Transport & Health*. (2013). Editorial Board. Available at: <http://www.journals.elsevier.com/journal-of-transport-and-health/editorial-board/>. (accessed 26.07.13)
50. Karkhaneh, M., Rowe, B.H., Saunders, L.D., Voaklander, D.C. & Hagel, B.E. (2013). Trends in head injuries associated with mandatory bicycle helmet legislation targeting children and adolescents. *Accident Analysis and Prevention*, 59, 206-212.
51. Kraemer, J.D., Zaccaro, H.N., Roffenbender, J.S., Baig, S.A., Graves, M.E., Hauler, K.J., Hussain, A.N. & Mulroy, F.E. Assessing the potential for bias in direct observation of adult commuter cycling and helmet use. *Injury Prevention*, in press.
52. Lardelli-Claret, P., de Dios Luna-del-Castillo, J., Jiménez-Moleón, J.J., García-Martín, M., Bueno-Cavanillas, A. & Gálvez-Vargas, R. (2003a) Risk compensation theory and voluntary helmet use by cyclists in Spain. *Injury Prevention*, 9, 128-132.
53. Lardelli Claret, P., de Dios Luna del Castillo, J., Jiménez-Moleón, J.J., García-Martín, M., Bueno-Cavanillas, A. & Gálvez-Vargas, R. (2003b). Valoración del efecto del uso de casco en los ciclistas sobre el riesgo de sufrir lesiones craneales y de morir en España, entre 1990 y 1999. *Medicina Clínica*, 120, 85-88.
54. Lee, B.H.-Y., Schofer, J.L. & Koppelman, F.S. (2005). Bicycle safety helmet legislation and bicycle-related non-fatal injuries in California. *Accident Analysis and Prevention*, 37, 93-102.

55. Love, D.C., Breaud, A., Burns, S., Margulies, J., Romano, M. & Lawrence, R. (2012). Is the three-foot bicycle passing law working in Baltimore, Maryland? *Accident Analysis & Prevention*, 48, 451-456.
56. Macpherson, A.K., Parkin, P.C. & To, T.M. (2001). Mandatory helmet legislation and children's exposure to cycling. *Injury Prevention*, 7, 228-230.
57. Macpherson, A.K., To, T.M., Macarthur, C., Chipman, M.L., Wright, J.G., Parkin, P.C. (2002). Impact of mandatory helmet legislation on bicycle-related head injuries in children: a population-based study. *Pediatrics*, 110, e60.
58. Macpherson, A. & Spinks, A. (2008). Bicycle helmet legislation for the uptake of helmet use and prevention of head injuries. *Cochrane Review*, Issue 3. Art. No.: CD005401.
59. Marshall, J. & White, M. (1994). Evaluation of the compulsory helmet wearing legislation for bicyclists in South Australia. South Australian Department of Transport, Walkerville, SA.
60. McDowall, D., McCleary, R., Meidinger, E.E. & Hay, R.A. (1980). *Interrupted time series analysis*. Sage, London.
61. McIntosh, A.S., Lai, A. & Schilter, E. (2013). Bicycle Helmets: Head Impact Dynamics in Helmeted and Unhelmeted Oblique Impact Tests. *Traffic Injury Prevention*, 14, 501-508.
62. McNally, D.S. & Rosenberg, N.M. (2013). MADYMO simulation of children in cycle accidents: A novel approach in risk assessment. *Accident Analysis and Prevention*, 59, 469-478.
63. McNally, D.S. & Whitehead, S. (2013). A computational simulation study of the influence of helmet wearing on head injury risk in adult cyclists. *Accident Analysis and Prevention*, 60, 15-23.
64. Meehan, W.P., Lee, L.K., Fischer, C.M. & Mannix, R.C. (2013). Bicycle Helmet Laws Are Associated with a Lower Fatality Rate from Bicycle-Motor Vehicle Collisions. *The Journal of Pediatrics*, 163, 726-729.
65. Mindell, J., Wardlaw, M. & Franklin, J. (2011). Cycling: health and safety study for HotM2. Transport and Health Study Group. Available at: http://www.transportandhealth.org.uk/wp-content/uploads/2011/10/THSG-seminar_Cycling-safety.pptx. (accessed 15.08.14)
66. Montoya, D. (2010). Cycling and Transport Policy in NSW, Briefing Paper No. 8/2010, NSW Parliamentary Library Research Service, ISBN 978-0-7313-1869-8.
67. New Zealand Ministry of Transport. (2012). Cycle helmet use survey 2012. Available at: <http://www.transport.govt.nz/research/roadsafety-surveys/cyclehelmetusesurvey2012/> (accessed: 15.08.14)
68. Newbold, S.C. (2012). Examining the Health-Risk Tradeoffs of Mandatory Bicycle Helmet Laws. *Risk Analysis*, 32, 791-798.
69. Olivier, J., Churches, T., McIntosh, A. & Grzebieta, R. (2012a). Response to Rissel and Wen. *Health Promotion Journal of Australia*, 23, 76.
70. Olivier, J., Hayen, A., Walter, S., Churches, T. & Grzebieta, R. (2012b). Cycling rates are up, despite creaky knees. *ABC Environment*. Available at: <http://www.abc.net.au/environment/articles/2012/07/18/3546884.htm>. (accessed 15.08.14)
71. Olivier, J., Walter, S.R. & Grzebieta R.G., (2012c). Bike helmet critics not using their heads, *Opinion*, Sydney Morning Herald, October 3, 2012.
72. Olivier, J. & Walter, S.R. (2013). Bicycle helmet wearing is not associated with close motor vehicle passing: A re-analysis of Walker, 2007. *PLOS ONE*, 8(9): e75424. doi:10.1371/journal.pone.0075424.
73. Olivier, J., Walter, S.R., & Grzebieta, R.H. (2013). Long-term bicycle related head injury trends for New South Wales, Australia following mandatory helmet legislation. *Accident Analysis and Prevention*, 50, 1128-1134. <http://dx.doi.org/10.1016/j.aap.2012.09.003>.
74. Olivier, J., Wang, J.J.J., Walter, S. & Grzebieta, R. (2013). On the use of empirical Bayes for comparative interrupted time series with an application to mandatory helmet legislation. *Proceedings of the 2013 Australasian Road Safety Research, Policing & Education Conference*.
75. Olivier, J. (2014). The apparent ineffectiveness of bicycle helmets: A case of selective citation. *Gaceta Sanitaria*, 28, 254-255.
76. Phillips, R.O., Fyhri, A. & Sagberg, F. (2011). Risk compensation and bicycle helmets. *Risk Analysis*, 31, 1187-1195.
77. Piper, T.A., Willcox, S.J., Bonfiglioli, C., Emilsen, A. & Martin, P. (2011). Science, media and the public: the framing of the bicycle helmet legislation debate in Australia: a newspaper content analysis. *Ejournalist: Refereed Media Journal*, ISSN:1444-741X. Available from <http://ejournalist.com.au/v11n2/Piper%20et%20al.pdf> (accessed 15.08.12).
78. Pless, I.B. (2014) Bicycle injuries and injury prevention. *Chronic Diseases and Injuries in Canada*, 34, 71-73.
79. Povey, L.J., Frith, W.J., Graham, P.G. (1999). Cycle helmet effectiveness in New Zealand. *Accident Analysis and Prevention*, 31, 763-770.
80. Ramsay, C.R., Matowe, L., Grilli, R., Grimshaw, J.M. & Thomas, R.E. (2003). Interrupted time series designs in health technology assessment: Lessons from two systematic reviews of behavior change strategies. *International Journal of Technology Assessment in Health Care*, 19, 613-623.
81. Rechnitzer, G., McIntosh, A. & Grzebieta, R. (2012). Response to "Australia's Helmet Law Disaster". *Institute of Public Affairs Review*, 64, 63.
82. Rissel, C. (2012a). The impact of compulsory cycle helmet legislation on cyclist head injuries in New South Wales, Australia: A rejoinder. *Accident Analysis and Prevention*, 45, 107-109.
83. Rissel, C. (2012b). Wrong Headed Laws. *MJA InSight*. Available at: <https://www.mja.com.au/insight/2012/15/chris-rissel-wrong-headed-laws> (accessed 11.09.12).
84. Rissel, C. & Wen, L.M. (2012). The possible effect on frequency of cycling if mandatory bicycle helmet legislation was repealed in Sydney, Australia: a cross sectional survey. *Health Promotion Journal of Australia*, 22, 178-183.
85. Robinson, D.L. (1996). Head injuries and bicycle helmet laws. *Accident Analysis and Prevention*, 28, 463-475.
86. Robinson, D.L. (2001). Changes in head injury with the New Zealand bicycle helmet law. *Accident Analysis and Prevention*, 33, 687-691.

87. Robinson, D.L. (2005). Safety in numbers in Australia: more walkers and bicyclists, safer walking and bicycling. *Health Promotion Journal of Australia*, 16, 47-51.
88. Robinson, D.L. (2006). No clear evidence from countries that have enforced the wearing of helmets. *BMJ*, 332, 722-725.
89. Robinson, D.L. (2007). Bicycle helmet legislation: Can we reach a consensus? *Accident Analysis and Prevention*, 39, 86-93. <http://dx.doi.org/10.1016/j.aap.2006.06.007>.
90. Rojas-Rueda, D., Cole-Hunter, T. & Nieuwenhuijsen, M. (2013). Bicycle helmet law in urban areas. Is it good for public health? *Gaceta Sanitaria*, 27, 282. <http://dx.doi.org/10.1016/j.gaceta.2012.08.005>
91. Shadish, W.R., Cook, T.D. & Campbell, D.T. (2002). Experimental and quasi-experimental designs for generalized causal inference. Wadsworth, Belmont, CA, USA.
92. Smith, N. & Milthorpe, F. (1993). An observational survey of law compliance and helmet wearing by bicyclists in New South Wales – 1993. NSW Roads and Traffic Authority, Rosebery, NSW. Available at: http://www.bicycleinfo.nsw.gov.au/tools_and_resources/cycling_research.html.
93. Smith, N.C., Milthorpe, F.W. (1994). Bicycle helmet wearing in New South Wales after legislative mandate. *Proceedings of 1994 Pedestrian and Bicyclist Safety and Travel Workshop*, Melbourne, Australia, ed. Adreassen, D. & Rose, G, 153-164.
94. Stewart, M. (2012). The Myth of the Bicycle Helmet. Available at: <http://www.risksense.org/2012/06/14/the-myth-of-the-bicycle-helmet/>. (accessed 19.07.13)
95. Tin Tin, S., Woodward, A. & Ameratunga, S. (2010). Injuries to pedal cyclists on New Zealand roads, 1988-2007. *BMC Public Health*, 10, 655.
96. Thompson, D.C., Rivara, F. & Thompson, R. (1999). Helmets for preventing head and facial injuries in bicyclists. *Cochrane Review*, Issue 4. Art. No.: CD001855.
97. Thompson, D.C., Thompson, R.S. & Rivara, F.P. (2001). Risk compensation theory should be subject to systematic reviews of the scientific evidence. *Injury Prevention*, 7, 86-88.
98. THSG. (2013). Further policy objectives. Available at: http://www.transportandhealth.org.uk/?page_id=113. (accessed 26.07.13)
99. Trégouët, P. Helmets or not? (2013) Use science correctly. *Journal of Medical Ethics*. <http://dx.doi.org/10.1136/medethics-2013-101521>
100. United Kingdom Department of Transport. (1999). Road Accidents Great Britain 1998: The Casualty Report.
101. Voukelatos, A. & Rissel, C. (2010). The effects of bicycle helmet legislation on cycling related injury: the ratio of head to arm injuries over time. *Journal of the Australasian College of Road Safety*, 21, 50-55.
102. Wagner, A.K., Soumerai, S.B., Zhang, F. & Ross-Degnan, D. (2002). Segmented regression analysis of interrupted time series studies in medication use research. *Journal of Clinical Pharmacy and Therapeutics*, 27, 299-309.
103. Walker, I. (2007). Drivers overtaking bicyclists: Objective data on the effects of riding position, helmet use, vehicle type and apparent gender. *Accident Analysis and Prevention*, 39, 417-425.
104. Walker, I., (2012). Bicycle overtaking studies. Available at: drianwalker.com/overtaking (accessed 01.08.12).
105. Walker, I., Garrard, I. & Jowitt, F. (2014). The influence of a bicycle commuter's appearance on drivers' overtaking proximities: an on-road test of bicyclist stereotypes, high-visibility clothing and safety aids in the United Kingdom. *Accident Analysis and Prevention*, 64, 69-77.
106. Walker, M. (1990). Law Compliance Among Cyclists in New South Wales. NSW Roads and Traffic Authority, Rosebery, NSW. Available at: http://www.bicycleinfo.nsw.gov.au/tools_and_resources/cycling_research.html.
107. Walker, M. (1991). Law Compliance Among Cyclists in New South Wales, April 1991. NSW Roads and Traffic Authority, Rosebery, NSW. Available at: http://www.bicycleinfo.nsw.gov.au/tools_and_resources/cycling_research.html.
108. Walker, M. (1992). Law Compliance Among Cyclists in New South Wales, April 1992: A Third Survey. NSW Roads and Traffic Authority, Rosebery, NSW. Available at: http://www.bicycleinfo.nsw.gov.au/tools_and_resources/cycling_research.html.
109. Walter, S.R., Olivier, J., Churches, T., & Grzebeita, R. (2011). The impact of compulsory cycle helmet legislation on cyclist head injuries in New South Wales, Australia. *Accident Analysis and Prevention*, 43, 2064-2071. <http://dx.doi.org/10.1016/j.aap.2011.05.029>.
110. Walter, S.R., Olivier, J., Churches, T. & Grzebieta, R. (2013). The impact of compulsory helmet legislation on cyclist head injuries in New South Wales, Australia: A response. *Accident Analysis and Prevention*, 52, 204-209. <http://dx.doi.org/10.1016/j.aap.2012.11.028>.
111. Wang, J.J.J., Grzebieta, R., Walter, S. & Olivier, J. (2013). An evaluation of the methods used to assess the effectiveness of mandatory bicycle helmet legislation in New Zealand. *Proceedings of the 2013 Australasian College of Road Safety Conference*.
112. Wang, J., Olivier, J. & Grzebieta, R. (2014). Response to 'Evaluation of New Zealand's bicycle helmet law' article. *The New Zealand Medical Journal*, 127, 106-108.
113. Wesson, D.E., Stephens, D., Lam, K., Parsons, D., Spence, L. & Parkin, P.C. (2008). Trends in pediatric and adult bicycling deaths before and after passage of a bicycle helmet law. *Pediatrics*, 122, 605-610.

A systematic review of methods used to assess mandatory bicycle helmet legislation in New Zealand

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Abstract

Background: Mandatory helmet legislation (MHL) for cyclists became effective in New Zealand (NZ) on 1 January 1994. Assessments of the NZ MHL have led to conflicting conclusions regarding its effectiveness at reducing cycling head injury and risk of fatality. These studies also differ in their use of analytic approaches and data sources.

Objectives: The aim of this paper is to systematically review all studies that assess the NZ MHL in accordance with quality criteria for assessing population-based interventions.

Data Sources: A search of Medline, Scopus and Web of Science for peer-reviewed articles from 1994 to 9 September 2014 was conducted.

Study Selection: Documents were independently extracted by two reviewers and limited to original articles in peer-reviewed journals that assessed the NZ MHL in terms of cycling head injury.

Results: The results from three of the four included studies indicated a positive effect of MHL for increasing helmet wearing and reducing head injuries. However, the findings of these studies must be interpreted within the context of methodological limitations.

Conclusion: We believe more high quality evaluations are needed to provide evidence for an objective assessment of MHL in NZ.

Keywords

Bicycle helmet legislation, New Zealand, Systematic review, Quality criteria

Introduction

Helmet use was made mandatory in New Zealand (NZ) for cyclists of all ages on 1 January 1994. The law applies to on road cycling where a road is defined to include: a) a street; b) a motorway; c) a beach; d) a place to which the public have access; e) all bridges, culverts, ferries, and fords forming part of a road or street or motorway or a place

referred to in d); and f) all sites at which vehicles may be weighted for the purposes of the Act or any other enactment (New Zealand Land Transport (Road User) Rule 2004).

Although the impetus for helmet legislation is to reduce cycling head injury, there is no direct causal link. Instead, helmet legislation acts to increase helmet usage among cyclists and, given the hypothesised protective effect of helmets, should lead to a decrease in cycling head injury. A diagram of this hypothetical relationship is given in Figure 1.

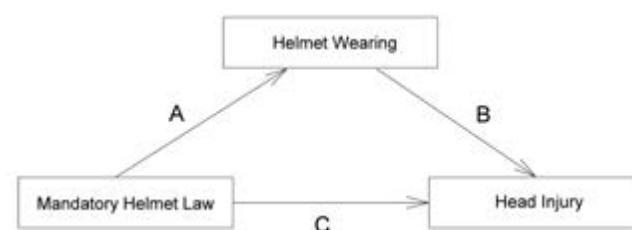


Figure 1. Diagram of the relationship between helmet legislation, helmet wearing and cycling head injury

Given the relationship between these variables, an assessment of helmet legislation can take on many forms. This can include assessing the association (A) between the law and helmet wearing, (B) between helmet wearing and head injury, or (C) between the law and head injury. The analysis of an intervention, such as analyses (A) and (C), is best analysed as an interrupted time series [24]. Because of the inter-relationship between these analyses, we believe a full assessment of the effects of helmet legislation to reduce head injury requires assessing all three associations.

Much of the literature assessing helmet legislation has focused on one type of analysis. Rodgers [18] assessed the effect of helmet legislation on the uptake of bicycle helmet use among children less than 16 years of age in US states. Povey, Frith and Graham [14] assessed the relationship between changes in helmet wearing and cycling head injury in NZ using data before and after helmet legislation. Cameron et al. [3] assessed changes in cycling head injury following helmet legislation in Victoria.

Helmet wearing has consistently been shown to be effective in case-control studies; however, there are conflicting results when assessed at a population level [1, 25, 20].

Therefore, it is important to assess the quality of studies, as high quality evaluations are necessary to provide solid evidence supporting or opposing the intervention which, in turn, has profound implications for future decision-making by governments.

The aim of this paper is to perform a systematic review against quality criteria for peer-reviewed manuscripts assessing the effect of the NZ helmet law on cycling head injuries. We chose to focus on NZ due to the abundance of relevant data (over five years of pre-helmet law hospitalisation data and yearly helmet wearing estimates from 1986-2012). Also, none of the NZ studies met inclusion criteria of a Cochrane Review [9] and therefore none were assessed against quality criteria.

Methods

Potential studies were selected through searches on Medline, Scopus, and Web of Science on 9 September 2014. Google Scholar was not chosen due to its inability to search within titles and abstracts only. The search terms were “helmet” and “New Zealand” for articles published from 1994 onwards. The search terms were intentionally broad in scope in an effort to avoid omitting relevant studies. Articles were excluded if they were duplicates, were commentaries or did not assess the impact of the New Zealand bicycle helmet law.

Those studies meeting the selection criteria were then independently assessed against quality criteria (see Appendix) by two of the authors (JW and JO) in accordance with PRISMA guidelines [12]. Compliance with each criterion was either “Yes”, “No”, “Partial”, “Unclear” or “Not applicable”. The assessments are shown in Table A1. Disagreements regarding criteria were discussed and all disagreements were resolved.

Quality criteria were adapted from Downs and Black [5], Ramsay et al. [15] and Macpherson and Spinks [9]. The criteria fall under the broad categories of Study Design, Reporting, Internal Validity and Interrupted Time Series (ITS) Design. Detailed information regarding specifics of scoring is given below.

Study Design

The quality criteria for study design consist of assessing the three pairwise associations of helmet legislation, helmet wearing and head injury. This corresponds to relationships A, B and C in Figure 1. A “Yes” is given when there is a formal analysis of the association and “Partial” is given if there is only a description of the association.

Reporting

The quality criteria for reporting are assessed against whether the manuscript included the study hypothesis, main

outcomes and interventions, main findings, estimates of random variability, p-values and potential adverse impacts of the intervention.

Internal Validity

Both randomisation of pre- and post-intervention time periods and blinding are infeasible for population-level intervention studies. It has been argued that internal validity can be maintained by including cases and controls from the same population and over the same period of time [9]. A potential threat to internal validity is the reliability of compliance with the intervention. Therefore, a discussion of changes in the helmet wearing rate with the helmet law is required as a measure of compliance. Adjustment for confounding is also essential in an assessment to address potential biases. It is, however, unclear what type of adjustment would be sufficient or most appropriate to address potential confounding. Other issues related to internal validity include using appropriate statistical tests, and accurate and valid outcome measures.

(Interrupted) Time Series Design

Interrupted time series (ITS) designs broadly encompass analytic approaches to assess interventions using time series data. The criteria given have been adapted from Ramsay et al. [15]. Not every analysis will follow an ITS design, e.g. assessing changes in helmet wearing and head injury over time. In those instances, a study will be assessed in accordance with the quality criteria related to time series designs.

It is required the data cover at least 80% of the total number of participants in the study. For the assessment of helmet legislation using hospitalisation data, this translates to no more than 20% of the data that can be missing around the effective date of the law. Specific to ITS designs, the authors need to state a rational explanation for the shape of the intervention effect. This may come in the form of an abrupt or gradual change in the time series or whether the hypothesised effect is immediate or delayed.

Serial correlation often occurs in observations taken over time and p-values are underestimated for models that assume independence when serial correlation exists. It is therefore important for models to explicitly account for serial correlation (e.g. autoregressive integrated moving average (ARIMA) or structural time series models) or to check for residual correlation for models that do not (e.g. linear or generalised linear regression).

Other criteria in this area include justifying the number and level of data aggregation and using a concurrent comparison group.

Results

A flow chart for studies included for quality assessment is given in Figure 2 [12]. The three search engines identified 149 potential articles for inclusion of which 62 duplicate records were removed and 79 articles were excluded by a title and abstract search according to the selection criteria. These papers were excluded as they were unrelated to cycling (59%), did not focus on New Zealand (25%), did not assess helmet legislation (6%) or were commentaries (9%).

Of the eight remaining papers, two papers were cost-benefit analyses and did not directly assess changes in helmet wearing or head injury [7, 22]. Two papers were excluded as they were commentaries of other studies [16, 17].

In total, four studies met selection criteria [14, 21, 13, 4]. A brief description of each study is given as follows:

Povey, Frith & Graham (1999)

The effect of changes in cycle helmet wearing on head injuries was assessed using hospitalisation data between 1990 and 1996, and separately for motor vehicle and non-motor vehicle crashes. Estimates of helmet wearing rates were obtained from national surveys conducted by the Land Transport Safety Authority. Injury data was obtained from the New Zealand Health Information Service and cases were identified by ICD-9-CM (1990-1994) and ICD-9-CM-A (1995-1996). Injury counts were aggregated by year. Non-motor vehicle injury data was further broken down into three age groups: primary school age (5-12 years), secondary school age (13-18 years) and adult (age 19 and above). The number of limb fractures provided a measure of exposure to the risk of cycling injuries and was used as a comparative control group.

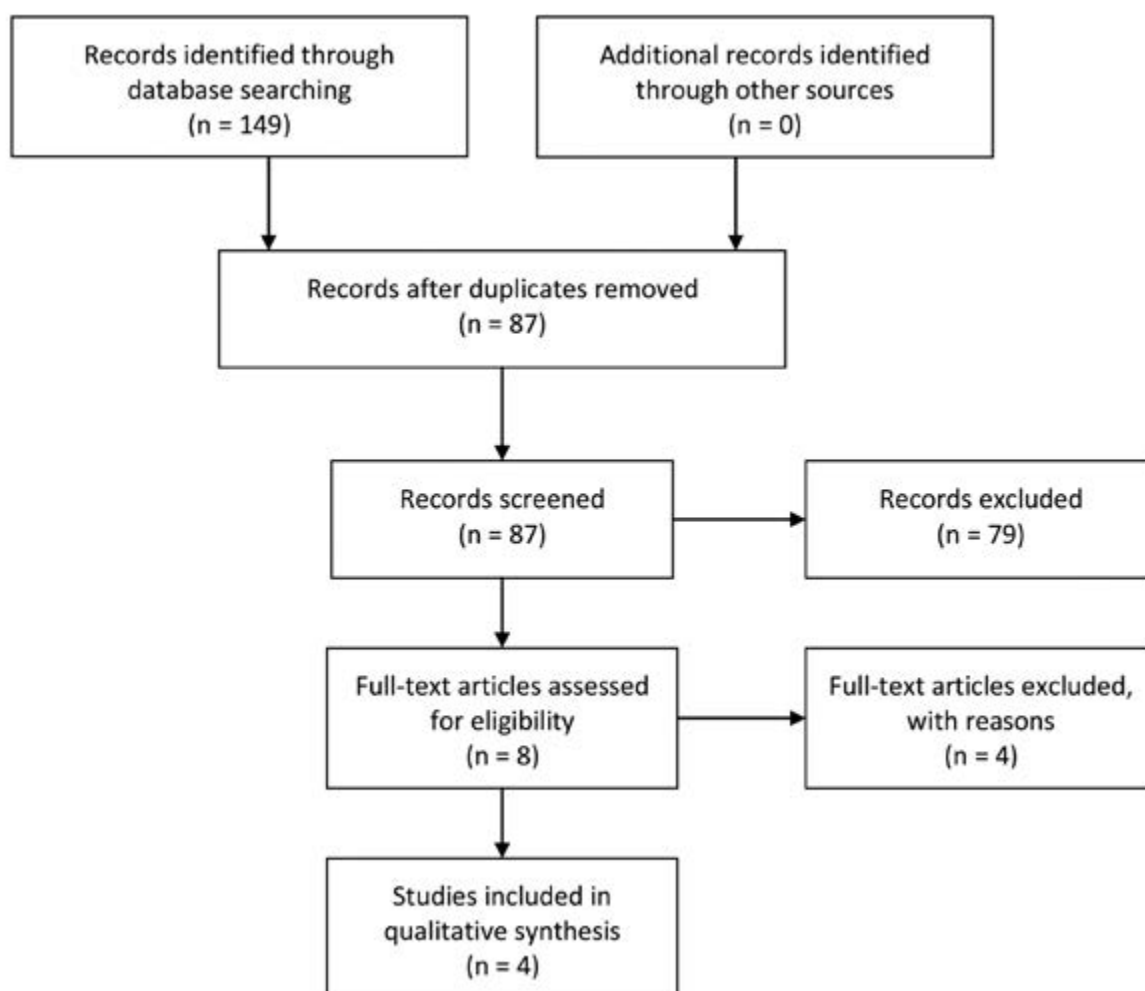


Figure 2: Flow diagram of selection of articles considered for inclusion

Scuffham et al. (2000)

The effect of changes in helmet wearing and the helmet law on serious head injury to cyclists was assessed for motor vehicle and non-motor vehicle crashes between 1988 and 1996. Hospitalisation data were obtained from the New Zealand Health Information Service. Injury data were aggregated into quarterly intervals centred on the months of the helmet surveys and intervening months. Age was categorised by primary school children (5-12 years), secondary school children (13-18) and adults (19+ years). Head injury data was disaggregated into fractures, intracranial injuries and lacerations defined by ICD-9-CM codes. A negative binomial regression model was used with head injury count as the outcome and the helmet wearing rate as an explanatory variable. All injured non-cyclists admitted to hospital were used as a comparison group. The number of cyclists admitted without a head injury was used as an offset.

Moyes (2007)

The impact of helmet law and safety campaigns was assessed on bicycle injuries in children in the Bay of Plenty. Data consisted of all bicycle injuries to children that presented at the Whakatane Hospital Emergency Department in the periods 1982-1986 and July 1998-December 2005. Comparisons were made on an average yearly rate per 100,000 population between the two time periods. There was no assessment of the association between helmet law and helmet wearing, or between helmet wearing and cycling head injury. No concurrent comparison group was used in the analysis.

Clarke (2012)

A review of publicly available data and analyses was performed to assess the impact of the NZ helmet law in terms of cycling activity levels, safety, health, law enforcement, accident compensation, and environmental and civil liberties issues. The exposure data came from the Land Transport Safety Authority and the ongoing New Zealand Household Travel Surveys. Fatality data was obtained from the Ministry of Transport and injury data was sourced from Tin Tin, Woodward and Ameratunga [23]. However, cycling head injuries were not presented in the study apart from other cycling injuries. There was no assessment of the association between the helmet law and helmet wearing, between helmet wearing and cycling head injury, or between the helmet law and cycling head injury. Pedestrian fatality numbers were used as a comparison group.

A more detailed discussion of these studies with regards to quality criteria follows.

Study design

None of the included studies formally assessed all of the three potential associations. Scuffham et al. [21] fully met two criteria and received a partial mark for a descriptive assessment of helmet legislation and changes in helmet wearing. On the other hand, Clarke [4] did not assess any of the possible associations.

Reporting

Reporting was in general adequate for all included studies, except for criterion six on providing estimates of the random variability in the outcome. Only one study [14] provided estimates of random variability for all the main outcomes.

Internal Validity

Two studies adjusted for exposure time [13, 4]. One study Clarke, [4] did not use any statistical tests and Moyes [13] used a t-test to compare two proportions. The use of the t-test is not justified for proportions although it gives similar results to the chi-square test for large sample sizes.

Adequate adjustment for confounding was also limited in these studies. Moyes [13] and Clarke [4] did not explicitly adjust for confounding while Povey, Frith and Graham [14] and Scuffham et al. [21] adjusted for confounding by comparing changes in head injuries with other injuries. Povey, Frith and Graham [14] used limb fractures to account for any variations in the level of cycling risk over time and possible changes to the cycling environment. On the other hand, Scuffham et al. [21] used injured non-cyclist admission counts to control for changes in the probability of being admitted to hospital with a head injury. However, it is unclear to what extent such strategies account for potential confounders, so these studies were given “Partial” marks against this criterion.

(Interrupted) Time Series Designs

The performance of the included studies was quite poor against this set of criteria. For two studies [13, 4], it was only evident from the publication they met one of seven quality criteria in this area. Povey, Frith and Graham [14] does not mention checking whether model assumptions were reasonable, therefore it is unclear whether the data was analysed using appropriate time series regression methods. None of the included studies state explicitly the anticipated effect of the intervention.

An overall score was given to each article by a weighted sum with “Yes” responses given a full mark and “Partial” responses a half mark. The highest mark, 16 for Scuffham et al. [21], was twice that of the lowest, eight for Clarke [4].

Discussion

A 2008 Cochrane Review considered the effect of mandatory helmet legislation [9]. Three New Zealand studies were considered [14, 21, 13] and none met inclusion criteria of the Cochrane Review. In our review of the New Zealand helmet law, we identified and included four studies that met our inclusion criteria.

The included studies differ in their methodological approaches in analysing data as well as the main findings. Three of the studies reported a significant protective effect of helmet legislation on bicycle related head injuries. In particular, Povey, Frith and Graham [14] estimated 24%, 32% and 28% reductions in head injuries in non-motor vehicle crashes for primary school, secondary school and adult age groups, respectively. For motor vehicle crashes, the estimated percentage reduction was 20% over all age groups. Scuffham et al. [21] concluded the helmet law led to a 19% reduction in head injury to cyclists over its first three years. Moyes [13] noted a substantial decrease in head injuries comparing two time periods twelve years apart, despite an overall increase in total injuries.

Clarke [4] concluded that following the helmet law, cycling usage reduced by 51% and cyclist's risk of injury increased. Furthermore, Clarke attributed 53 premature deaths per year to the New Zealand helmet law. This study met the fewest of the quality criteria and we have previously discussed the weaknesses of this study [26].

Our review found a discrepancy in the identification of injury in Povey, Frith and Graham [14] and Scuffham et al. [21]. When NZ converted from ICD9-CM to ICD9-CM-A, the primary diagnosis no longer represented the most serious condition. Therefore, Povey, Frith and Graham [14] examined all available diagnosis codes for the identification of head injury cases. However, Scuffham et al. [21] chose only the primary diagnosis for identifying head injuries. The authors examined the effect of using multiple diagnoses to identify head injuries and found the use of primary diagnosis only would have at most overestimated the effect of helmet wearing by 3.5%.

Robinson [16] was excluded from this review as it was a critique of Povey, Frith and Graham [14] and was not a direct assessment of the NZ helmet law. Robinson [16] argued the large increase in helmet wearing associated with the helmet law did not result in any obvious change in head injuries over and above existing trends; therefore, trends were the most likely cause for the observed reduction in head injury. Since it is a commentary of a study included in this review, it is perhaps relevant to assess Robinson [16] against quality criteria with the view to identify possible improvements over the original paper. Povey, Frith and Graham [14] did not fully meet quality criteria on eight

items and, in each instance, Robinson [16] received an identical or lower mark.

Because the focus of this paper was on cycling injury, two cost-benefit assessments of the helmet law were not included. These assessments are, in part, dependent on estimates of the effect helmet legislation has on cycling injury. Therefore, the quality of the assessment of helmet legislation on cycling injury directly affects the validity of these cost-benefit analyses.

There are methodological limitations of the included studies. Despite the abundance of the NZ data relevant to assessing the helmet law, which includes yearly estimates of helmet wearing from 1986 to 2012 [11], none of the studies assessed all three potential associations to obtain a complete picture of the inter-relationships between helmet legislation (the intervention), helmet wearing (direct consequence of the intervention) and head injury (target outcome of the intervention). To account for possible confounding factors such as changes in cycling exposure, some of the studies included a comparison control group. However, sound methodologies needed to evaluate the adequacy of any attempted adjustment for confounding are still lacking. Justification for choosing a particular comparison group over others remains qualitative.

The Wikipedia page on Bicycle Helmets in New Zealand [27] was also reviewed as the online encyclopaedia is often used as a resource by the media and general public. The Povey, Frith and Graham paper [14] is incorrectly referenced as a NZ Ministry of Transport technical report (it appeared in the peer-reviewed journal *Accident Analysis and Prevention*). The webpage makes no reference to Scuffham et al. [21] or Moyes [13].

The Wikipedia page lists other studies not included in our review as none are indexed by Medline, Scopus or Web of Science. These other studies include a press release for a Massey University cycling campaign [10, 19], commentaries from anti-helmet websites [6, 2], a submission to the NZ coroner [8], and an assessment of cycling injury in New Zealand but not an assessment of helmet legislation [23].

As with Macpherson and Spinks [9], limitations of our review are related to the small number of studies meeting the inclusion criteria. Only one of the included studies argued against helmet legislation. Other papers that provided arguments against the helmet law were excluded from this review as they are mainly commentaries and thus did not meet the inclusion criteria. Half of the included studies failed to use appropriate statistical tests to analyse data and thus there is little evidence to provide support for or against helmet legislation in New Zealand.

Conclusion

The results of this review show that more methodologically sound evaluations with rigorous statistical methods for data analysis are urgently needed to assess the impact of helmet legislation on cycling head injuries in New Zealand. In line with the Cochrane review [9], we believe the quality criteria listed in this review are necessary for a high quality evaluation of helmet legislation.

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References

1. Attewell, R.G., Glase, K. & McFadden, M. (2001). Bicycle helmet efficacy: a meta-analysis. *Accident Analysis and Prevention*, 33, 345–352.
2. Bicycle Helmet Research Foundation. (2014). How helmet promotion and laws affect cycle use. Available at: <http://www.cyclehelmets.org/1020.html> (accessed: 24.09.14)
3. Cameron, M.H., Vulcan, P.A., Finch, C.F. & Newstead, S.V. (1994). Mandatory bicycle helmet use following a decade of helmet promotion in Victoria, Australia – An evaluation. *Accident Analysis and Prevention*, 26, 325–337.
4. Clarke, C. (2012). Evaluation of New Zealand's bicycle helmet law. *New Zealand Medical Journal*, 125, 60–69.
5. Downs, S.H. & Black, N. (1998). The feasibility of creating a checklist for the assessment of the methodological quality both of randomised and non-randomised studies of health care interventions. *Journal of Epidemiology & Community Health*, 52, 377–384.
6. Gillham, C. (2014). Mandatory bicycle helmet law in New Zealand. Available at: http://www.cycle-helmets.com/zealand_helmets.html (accessed: 24.09.14)
7. Hansen, P. & Scuffham, P.A. (1995). The cost-effectiveness of compulsory bicycle helmets in New Zealand, *Australian Journal of Public Health*, 19, 450–454.
8. Koorey, G.F. (2013). New Zealand Chief Coroner's Inquiry into Cycling Deaths – Evidence. Available at: <http://can.org.nz/system/files/CoronerInquest-Notes-GKoorey-v2.4-Jun2013.pdf> (accessed: 02.06.14)
9. Macpherson, A. & Spinks, A. (2008). Bicycle helmet legislation for the uptake of helmet use and prevention of head injuries. *Cochrane Review*, Issue 3. Art. No.: CD005401.
10. Massey University. (2007). Cycling campaign praised. Available at: <http://www.massey.ac.nz/massey/about-massey/news/article.cfm?mnarticle=cycling-campaign-praised-15-10-2007> (accessed: 25.09.14)
11. Ministry of Transport. (2012). Cycle helmet use 2012. Available from: <http://www.transport.govt.nz/assets/Import/Documents/Cycle-helmet-survey-results-2012.pdf> (accessed: 02.06.14)
12. Moher, D., Liberati, A., Tetzlaff, J., Altman, D.G. & The PRISMA Group. (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. *PLoS Med*, 6(6): e1000097.
13. Moyes, S.A. (2007). Changing pattern of bicycle injury in the Bay of Plenty, New Zealand. *Journal of Paediatrics and Child Health*, 43, 486–488.
14. Povey, L.J., Frith, W.J., Graham, P.G. (1999). Cycle helmet effectiveness in New Zealand. *Accident Analysis and Prevention*, 31, 763–770.
15. Ramsay, C.R., Matowe, L., Grilli, R., Grimshaw, J.M. & Thomas, R.E. (2003). Interrupted time series designs in health technology assessment: Lessons from two systematic reviews of behavior change strategies. *International Journal of Technology Assessment in Health Care*, 19, 613–623.
16. Robinson, D.L. (2001). Changes in head injury with the New Zealand bicycle helmet law. *Accident Analysis and Prevention*, 33, 687–691.
17. Robinson, D.L. (2006). No clear evidence from countries that have enforced the wearing of helmets. *BMJ*, 332, 722–725.
18. Rodgers, G.B. (2002). Effects of state helmet laws on bicycle helmet use by children and adolescents. *Injury Prevention*, 8, 42–46.
19. Scoop. (2006). Dump harmful helmet law, say cyclists. Available at: <http://www.scoop.co.nz/stories/GE0612/S00058.htm> (accessed: 24.09.14)
20. Scuffham, P. & Langley, J.D. (1997). Trends in cycle injury in New Zealand under voluntary helmet use. *Accident Analysis & Prevention*, 29, 1–9.
21. Scuffham, P., Alsop, J., Cryer, C. & Langley, J.D. (2000). Head injuries to bicyclists and the New Zealand bicycle helmet law. *Accident Analysis and Prevention*, 32, 565–573.
22. Taylor, M. & Scuffham, P. (2002). New Zealand bicycle helmet law - do the costs outweigh the benefits? *Injury Prevention*, 8, 317–320.
23. Tin Tin, S., Woodward, A. & Ameratunga, S. (2010). Injuries to pedal cyclists on New Zealand roads, 1988–2007. *BMC Public Health*, 10, 655.
24. Wagner, A.K., Soumerai, S.B., Zhang, F. & Ross-Degnan, D. (2002). Segmented regression analysis of interrupted time series studies in medication use research. *Journal of Clinical Pharmacy and Therapeutics* 27, 299–309.
25. Walter, S.R., Olivier, J., Churches, T., & Grzebieta, R. (2011). The impact of compulsory cycle helmet legislation on cyclist head injuries in New South Wales, Australia. *Accident Analysis and Prevention*, 43, 2064–2071.
26. Wang, J., Olivier, J. & Grzebieta, R. (2014). Response to 'Evaluation of New Zealand's bicycle helmet law' article. *The New Zealand Medical Journal*, 127, 106–108.
27. Wikipedia. (2014). Bicycle helmets in New Zealand. Available at: http://en.wikipedia.org/wiki/Bicycle_helmets_in_New_Zealand (accessed: 24.09.14)

Appendix

Quality criteria (Adapted from: Downs and Black, 1998; Ramsay et al., 2003; Macpherson and Spinks, 2008)

Study Design

- A. Was helmet legislation and helmet wearing association assessed?
- B. Was helmet wearing and cycling head injury association assessed?
- C. Was helmet legislation and cycling head injury association assessed?

Reporting

1. Is the hypothesis/aim/objective of the study clearly described?
2. Are the main outcomes to be measured clearly described in the Introduction or Methods section?
3. Are the characteristics of the patients included in the study clearly described?
4. Are the interventions of interest clearly described?
5. Are main findings of the study clearly described?
6. Does the study provide estimates of the random variability in the data for the main outcomes?
7. Have all important adverse events that may be a consequence of the intervention been reported?

8. Have actual probability values been reported for the main outcomes except where the probability value is less than 0.001?

Internal validity

9. In trials and cohort studies, do the analyses adjust for different lengths of follow-up of patients, or in case-control studies, is the time period between the intervention and outcome the same for cases and control?
10. Were the statistical tests used to assess the main outcome appropriate?
11. Was compliance with the intervention/s reliable?
12. Were the main outcome measures used accurate (valid and reliable)?
13. Was there adequate adjustment for confounding in the analyses from which the main findings were drawn?

(Interrupted) time series design

14. Were there no more than 20% of data missing?
15. Was the shape of intervention determined a priori?
16. Was the number and level of aggregation of data points justified?
17. Were data analysed using appropriate time series methods?
18. Were model assumptions checked and verified?
19. Was a concurrent comparison group used?

Table A1. Methodological quality of included studies

Criteria	Povey et al. (1999)	Scuffham et al. (2000)	Moyes (2007)	Clarke (2012)	*Robinson (2001)
Study Design					
A	Partial	Partial	No	No	Partial
B	Yes	Yes	No	No	Partial
C	No	Yes	Yes	No	No
Reporting					
1	Yes	Yes	Yes	Yes	Yes
2	Yes	Yes	Yes	No	Yes
3	Yes	Yes	Yes	Yes	Yes
4	Yes	Yes	Partial	Yes	Yes
5	Yes	Yes	Yes	Yes	Yes
6	Yes	Partial	No	No	No
7	Yes	No	Yes	Yes	Partial
8	Partial	Yes	Partial	No	No

Criteria	Povey et al. (1999)	Scuffham et al. (2000)	Moyes (2007)	Clarke (2012)	*Robinson (2001)
Internal validity					
9	No	No	Yes	Yes	No
10	Yes	Yes	No	No	No
11	Yes	Yes	Unclear	No	Yes
12	Yes	Yes	Yes	Yes	Yes
13	Partial	Partial	No	No	No
ITS design					
14	Yes	Yes	No	No	No
15	NA	No	NA	NA	No
16	Yes	Yes	Partial	No	No
17	Unclear	Unclear	No	No	No
18	No	Partial	No	No	No
19	Yes	Yes	Partial	Yes	Yes
Overall Score	15.5	16	10	8	9.5

NA=Not Applicable; Overall score is weighted sum of yes (full) and partial (half) marks

*Did not meet inclusion criteria, score is given as a comparison to Povey, Frith & Graham [14]

An observational study of conflicts between cyclists and pedestrians in the city centre

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Abstract

City centres have large volumes of pedestrians and motorised traffic and increases in walking and cycling could potentially lead to more pedestrians and cyclists being injured. In this study, observers recorded cyclist characteristics, number of pedestrians within 1m and 5m radius and type of conflict (none, pedestrian, vehicle) for 1,971 cyclists in 2010 and 2,551 cyclists in 2012 at six locations in the Brisbane Central Business District. Only 1.7% of cyclists were involved in conflicts with a motor vehicle or pedestrian and no collisions were observed. Increased odds of a pedestrian-cyclist conflict was associated with: male riders, riders not wearing correctly fastened helmets, riding on the footpath, higher pedestrian density (within 1m but not within 5m), morning peak and 2-4 pm (compared with 4-6 pm), two-way roads, roads with more lanes, higher speed limits, and yellow marked bicycle symbols on the road.

Keywords

Active travel, Bike share, Traffic conflicts, Cyclist, Pedestrian, Public bicycle.

Introduction

Many jurisdictions around the world promote walking and cycling for health and transport reasons. Both walking and cycling are especially suited to short distance trips, and many trips in city centres are short trips. However, city centres have large volumes of pedestrians and motorised traffic and increases in walking and cycling could potentially lead to more pedestrians and cyclists being injured. Much previous research has focused on the high severity of injuries often incurred when motor vehicles collide with pedestrians and cyclists but there is increasing concern from pedestrians about the threats they perceive from cyclists. European studies [1, 2] have reported that elderly pedestrians consider cyclists riding on the footpath to be a hazard and a Japanese study [3] has shown that

the elderly and young children rate scenes of pedestrian and bicycle conflicts as more risky than do university students. Ratings of risk appeared to be influenced by physical separation, not speed, with high ratings when bicycles were less than 0.75 metres from the pedestrian, dropping to low ratings when the bicycles were more than 1.5 metres away. Analyses of potential energy transfer also support this concern. Grzebieta, McIntosh [4] point out that the ratio of kinetic energy between an adult cyclist and a 50th percentile pedestrian walking at 5 km/h is similar to that between a 1.5 tonne car in a 50 km/h zone and an adult cyclist riding at 30 km/h in the same direction [4]. A German study [5] cited national statistics showing that fatal pedestrian-bicycle collisions were rare outcomes but that the cyclist was considered to be at fault in about two-thirds of all pedestrian-bicycle collisions. The authors reported detailed reconstructions of three fatal pedestrian-bicycle collisions which involved teenaged riders on mountain bikes colliding with frail, elderly pedestrians.

Despite these concerns, there is little objective data available regarding the prevalence of injury to pedestrians resulting from collisions with cyclists. Australian hospital data for the 2008-2009 financial year show that 40 pedestrians were coded as having been injured in a traffic accident (either on the footpath or on the road) where the counterpart was a pedal cyclist [6], corresponding to 1.5% of all hospitalised pedestrians. In the same period, 33 cyclists were hospitalised as a result of a traffic accident where the counterpart was a pedestrian or animal, corresponding to 0.6% of all hospitalised pedal cyclists. Chong, Poulos [7] compared the frequency and severity of injuries arising from bicycle-motor vehicle and bicycle-pedestrian collisions in NSW over a five-year period. Most cyclists admitted to hospital were male and injured in collisions with motor vehicles ($n=784$). Among females aged 65 and older, there were less than five cyclists admitted to hospital resulting from a collision with a pedestrian or animal, less than five cyclists admitted as a result of a motor vehicle collision and 20 admitted following a collision with a cyclist. The corresponding figures for males aged 65 and older were less than 5, 13 and 46. Of the 163 pedestrians hospitalised resulting from collisions with cyclists, 72 resulted from a non-traffic accident and 48 were unspecified. The severity of injury was greater for people aged 65 and older, regardless of whether they were a pedestrian in a collision with a cyclist or a cyclist in a collision with a pedestrian or a motor vehicle [7].

Cycling on the footpath is one way of separating cyclists from motor vehicle traffic, and is permitted throughout Queensland, Tasmania and the Australian Capital Territory for adults and children unless otherwise signed. In other jurisdictions, adults are only permitted to ride on the footpath if accompanying a child aged 12 years or less.

Cycling on footpaths arguably allows cyclists a safer option in locations where the rider perceives the road and traffic conditions to be too dangerous. Prohibiting cycling on the footpath appears to be based on concerns about cyclists posing a threat to pedestrians on footpaths, and the potential to increase conflict between cyclists and motor vehicles at driveways and intersections.

One of the few studies of cyclist-pedestrian crashes where location of cycling was known [8] examined admitted patients records of eight Victorian hospitals. During the period 1 April to 20 December 1986, only two pedestrians were injured as a result of a collision with a cyclist on a footpath (and two potential additional cases where actual location of the collision could not be determined). While the study found that pedestrians sustaining serious injuries as a result of a collision with cyclists on the footpath is a relatively small problem, there was no way of determining the likelihood of pedestrians sustaining non-serious injuries that do not require hospitalisation or determining the reduction in pedestrian amenity from permitting cycling on footpaths.

A more recent survey of more than 2,500 Queensland adult cyclists [9] reported that about 5% of the distance ridden occurred on the footpath and about 5% of self-reported cyclist injury crashes occurred on footpaths. The majority of footpath crashes (approximately 70%) were single-vehicle crashes (involving only the bicycle), with less than 10% involving pedestrians. Of all the self-reported pedestrian-cyclist crashes, the largest number occurred on bike paths (including shared paths), representing 18% of bike path crashes and 68% of pedestrian-cyclist crashes. The number of pedestrian-cyclist crashes on footpaths was similar to the number on urban roads. Footpath crashes (like bike path and off-road crashes) resulted in less serious injuries to cyclists than crashes on urban roads. The lower frequency and severity of footpath crashes is consistent with the finding of Kiyota, Vandebona [3] that the average speed of cyclists on the footpath dropped from about 12 km/h when there were no pedestrians present to about half that value when there were six pedestrians within 20 metres of the bicycle.

Several studies have attempted to characterise the extent and nature of pedestrian-cyclist interactions. Early observational research examined bicycle-pedestrian interactions on footpaths in Victoria, where adults are not permitted to ride on the footpath unless accompanying a child [10]. Pedestrians were more likely to encounter cyclists travelling on footpaths adjacent to arterial roads and in shopping precincts, with the majority of the cyclists on the footpaths being adolescents.

Most traffic conflict studies in the recent years have analysed safety by looking at conflicts between vehicles [e.g. 11-14]. Some studies have examined the traffic

conflicts between vehicles and bicycles [e.g. 15] and vehicles and pedestrians [e.g. 16]. However, relatively little attention has been given into understanding the conflicts between cyclists and pedestrians. An Australian study [17] used observational data to identify conflicts between pedestrians and bicyclists on 10 shared paths in three cities in New South Wales but the sites were mostly parks and shared paths on bridges. Similarly, Hatfield and Prabhakaran [18] also focused their observations on shared paths. To address the lack of empirical data regarding pedestrian-cyclist conflicts, this paper uses observational data collected in the Brisbane city centre in 2010 and in 2012 to explore the prevalence of pedestrian-cyclist conflicts and the factors associated with their occurrence in a busy area.

Method

Data collection

Observations were conducted on Monday to Thursday of the first week of October in 2010 and 2012, during the hours of 7-9am, 9-11am, 2-4pm, and 4-6pm to capture commuter cycling trips, as well as the short trips that are the target of the Brisbane bicycle hire scheme (CityCycle). The observation periods occurred during the school term and did not include any public holidays. The data collected during 2010 occurred during the first week CityCycle bicycles were available for hire, however relatively few docking stations and bicycles were operational. Data collection was repeated in 2012 to measure whether there was any increase in cycling due to the introduction of CityCycle. One observation period was rescheduled to the same time and day of the following week due to rain (Thursday 4-6pm, 2012). The project received approval from the Queensland University of Technology Human Research Ethics Committee (approval no. 1000000937).

Six mid-block CBD observations sites were chosen: Ann Street outside Central Railway Station, Eagle Street opposite Riparian Plaza, Adelaide Street outside City Hall, George Street between Ann and Turbot Streets, William Street outside the Old Treasury Building and Albert Street between Margaret and Mary Streets. All sites are near CityCycle docking stations, and considered to be routes to key destinations in the city. The selection of sites included locations with varying geometric features: different footpath widths, the presence or absence of on-road bicycle facilities, one-way and two-way traffic, and a range of pedestrian volumes (summarised in Table 1).

Table 1. Characteristics of observation sites

Sites	Traffic direction	No. of traffic lanes	On-road Bicycle Markings	Pedestrian Volume
Adelaide St	Two-way	2	Bicycle Awareness Zone markings	High
Albert St	Two-way	3	None	Medium
Ann St	One-way	4	None	Medium
Eagle St*	Two-way	5	None	Low
George St	One-way	4	Bicycle Awareness Zone markings	Low
William St	Two-way	5	None	Low

*Location shifted 150m north between 2010 and 2012, as pedestrian traffic lights were installed at the 2010 location. All other locations remained the same.

Traffic conflicts data have traditionally been collected by human observers who identify and rate conflicts by observing road users' movements and range of evasive actions taken, until the recent developments in automated video analysis techniques [e.g. 19, 20]. As discussed earlier, most traffic conflicts studies have looked at vehicle-vehicle, vehicle-bicycle, and vehicle-pedestrian conflicts. A probable reason why none have looked at the conflicts between pedestrians and cyclists using the automated video analysis techniques is that identifying and tracking movements of pedestrians and cyclists in high density areas (e.g. footpaths, city centres) could be more difficult and resource-intensive than tracking vehicles or bicycles on roadways and intersections. Furthermore, because of overlapping pixels among pedestrians walking in close proximity in a city centre, it is likely to have a significant amount of errors in the tracked trajectories of the pedestrians. Therefore, the field-observer method of conflict data collection was adopted in the current study. A simple form was developed for recording observations (see Figure 1). The variables collected for each observed cyclist included: apparent gender, apparent age (child, adolescent, adult), helmet use; and location of cyclist (road or footpath). The number of pedestrians within a five metre radius was estimated as a measure of pedestrian density and the number of pedestrians within one metre of the cyclist was counted as an indicator of potential for collision. Any conflict between cyclists and motor vehicles or pedestrians was also noted.

Observers received training prior to conducting observations to maximise consistency between observers. At each site an unmarked reference line perpendicular

to the roadway and footpath between two identifiable points on buildings was identified by the researchers and demonstrated to the observers. The observers were instructed to record all bicycles (and the presence of pedestrians) at the moment the rider crossed this line. This approach was taken to simplify the task for the observers because cyclists can easily move between the road and footpath, and the presence of pedestrians could change. The observers stood away from this unmarked line and so their presence did not impede or alter the path taken by cyclists or pedestrians.

Conflict was defined as: “where a collision would be imminent unless one or more road users did not undertake an evasive manoeuvre”. An evasive manoeuvre, such as hard braking or swerving (as an isolated action, or accompanied by shouting, bell ringing or horn honking), may have been taken by the rider or by another road user. However, only evasive manoeuvres by the cyclist were recorded. The definition of a conflict was deliberately simplified, given the potential for high bicycle traffic in some locations and the potential for large groups of cyclists to pass the observation point together, and observers were not asked to describe the conflict. Observers recorded only those cyclists who were riding at the time, with no records made of people walking bicycles.

Analysis methods

To examine the usage patterns of bicycles in the city area and to understand the factors influencing the safety in bicycle-pedestrian interactions, a two stage analysis approach was undertaken in this study. First, a descriptive analysis of observational data on bicycle usage and potential conflicts involving pedestrians was conducted in order to understand the general characteristics of bicycle usage and how these are associated with conflict occurrence. Chi-square tests were conducted to determine any difference in the patterns of data between 2010 and 2012. Second, a regression model was formulated to examine the factors influencing the occurrence of conflicts involving bicyclists and pedestrians. Each observed bicyclist in the dataset could have two possible outcomes: not involved in a conflict, and involved in a conflict with a pedestrian. These outcomes can be well formulated as a binary logistic model by using the binary outcomes conflict (=1) and no-conflict (=0) as the response variable. To account for potential correlations among observations within each observation location, a random effects binary logistic model formulation (where the conflict observations are nested within the observation locations) is also considered. A set of explanatory variables (see Table 5) describing the characteristics of the bicyclists, locations of observation, and time of observation was included in the model.

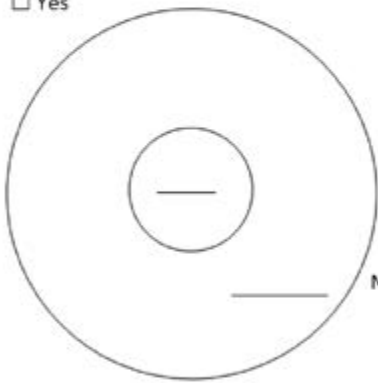
Recorder sheet			
Date: 11/10/2012			
Location: William St			
Apparent Gender	☐ Male	☐ Female	
Apparent Age	☐ Child (<13)	☐ Adolescent (13-17)	☐ Adult (>17)
Helmet Use	☐ Yes	☐ No	☐ On but not fastened
Location	☐ Footpath	☐ Marked Bicycle Lane	☐ Traffic Lane
Bicycle Hire Scheme bicycle	☐ Yes		
			
Conflict	☐ None	☐ Pedestrian	☐ Vehicle
Evasive manoeuvre by cyclist	☐ None	☐ Swerving	☐ Hard braking ☐ Other
Collision	☐ None	☐ Yes	

Figure 1. Bicycle observation data collection form

To identify the subset of explanatory variables which yield the most parsimonious model, a backward elimination procedure was employed to eliminate the non-significant variables one by one so that the Akaike Information Criteria (AIC) was minimised. Significance of the explanatory variables was examined by using the z-test. To evaluate if the model had sufficient explanatory power, likelihood ratio statistics (G^2) was computed.

Results

Descriptive statistics

A total of 1,992 cyclists were observed in 2010, and 2,552 cyclists were observed in 2012. Data from incomplete observer records was excluded, leaving 1,971 complete observations in 2010 and 2,551 in 2012. A summary of the observations is presented in Table 2. The majority of observed cyclists were adults (97.7%) and male (84.6%) with almost equal shares in the 2010 and 2012. Most riders were wearing helmets appropriately (97.8%, note that helmet usage is compulsory in Queensland), and travelled on the roadway (77.2%). Only a small proportion of cyclists (3.1%) were observed using CityCycle bikes, which means most riders (96.3%) were riding their own bikes. Tuesday had the highest number of observed riders. The majority of riders were observed travelling during the morning and afternoon peak hours (7-9am: 35.8%, 4-6pm: 39.5%), although approximately a quarter of observations were made outside the peak hours.

Among the 1032 cyclists observed riding on the footpath, 24.4% had one or more pedestrians within 1 metre and an additional 303 cyclists had one or more pedestrians within 1-5 metres. However, the majority of bicycles (98.3%) were not involved in conflicts with pedestrians or motor vehicles. There were 48 observed conflicts between pedestrians and bicyclists and 27 conflicts between pedestrians and vehicles. As expected, cyclists riding on the footpath were more likely to experience a conflict with a pedestrian, while those travelling on the road were more likely to experience a conflict with a vehicle ($\chi^2 = 92.732$, $p < 0.01$) (see Table 3). When comparing 2010 and 2012, there were no significant differences in age, gender, use of helmets, involvement in conflicts, or time of day bicycles were ridden. A greater proportion of cyclists were observed travelling on the footpath in 2012 than in 2010 ($\chi^2 = 77.066$, $p < 0.01$). A greater proportion of cyclists used public hire bicycles in 2012 ($\chi^2 = 44.432$, $p < 0.01$).

In order to focus on conflicts between pedestrians and bicyclists, the dataset for calibration of the regression model excluded the 27 observations where a pedestrian was involved in a conflict with a vehicle. Before estimating the model parameters, conflicts rates in the observation sites were examined first (see Table 4). Overall, 1.1% of all observations resulted in conflicts between pedestrians

and cyclists. The Ann Street site had the highest rate of conflicts (2.2%) among all sites; whilst it had the second lowest number of observed cyclists ($n=543$). In contrast, Adelaide Street had the lowest rate of conflicts (0.4%), despite having the highest number of observed cyclists ($n=1139$). The second lowest rate of conflicts (0.6%) was seen in George Street, which also had the lowest number of observed cyclists ($n=512$). William Street and Albert Street had similar conflict rates and numbers of observed cyclists.

Regression model estimates

Before estimating the regression model parameters, correlations among explanatory variables were examined first. Categorical variables of 'Observation site id' was attempted to be included in the Binary Logistic model, but these variables were correlated with other explanatory variables. For example, Ann Street was correlated with speed limit and traffic direction variables, average width of footpath was correlated with William Street and George Street, number of lanes was correlated with William Street, and presence of taxi stand was correlated with Eagle Street. Because of these correlations, the 'Observation site id' variable was not included in the model. Traffic direction and presence of taxi stands variables were also correlated, so the later was removed from the model.

The parameters of the formulated binary logistic model (BLM) were derived using the maximum likelihood estimation method in the software STATA 11.2. Estimation results of the random effects binary logistic model (REBLM) yielded an Intraclass Correlation Coefficient (ICC) value close to zero (with a p-value of 1.0 in a Likelihood-ratio test of the null hypothesis: $ICC=0$). The ICC value suggested that the REBLM is not superior to the BLM in the case of modelling the current dataset, i.e., there are no significant within-observation-location correlations available in the observed cyclist data. The parameter estimates of the BLM, odds ratios (O.R.), and their statistical significance, are presented in Table 5. The best-fitted model had an AIC value of 400.4. The likelihood ratio statistics value of 160.9 (14 df) was well above the critical value for significance at the 1% significance level, implying that the model had sufficient explanatory power. The estimation results of the model parameters are discussed in the subsequent paragraphs.

No significant statistical evidence was found to support the argument that the probability of conflict increased from 2010 to 2012, although the number of bicyclists observed in 2012 was 29.4% greater than in 2010. This result implies that despite the increase in bicycle use, the safety of pedestrians and cyclists has not worsened.

Conflicts were likely to be significantly higher during the periods 7-9am (O.R. = 4.2) and 2-4 pm (O.R. = 5.7), compared to the period 4-6 pm. The corresponding result for the 9-11 am period was statistically non-significant.

Table 2. General characteristics of cyclists observed

Variable		2010 (n=1971)	2012 (n=2551)	Total (n=4522)
Gender	Male	1683 (85.4%)	2144 (84.0%)	3827 (84.6%)
	Female	288 (14.6%)	407 (16.0%)	695 (15.4%)
Age	Adult	1928 (97.8%)	2493 (97.7%)	4421 (97.7%)
	Child (up to 17yrs)	43 (2.2%)	58 (2.3%)	101 (2.2%)
Helmet use	Wearing a helmet	1925 (97.7%)	2497 (97.9%)	4422 (97.8%)
	Helmet on, but not fastened	25 (1.3%)	30 (1.2%)	55 (1.2%)
	Not wearing a helmet	21 (1.1%)	24 (0.9%)	45 (1.0%)
Riding location choice	Riding on road	1541 (78.2%)	1949 (76.4%)	3491 (77.2%)
	Riding on footpath	430 (21.8%)	602 (23.6%)	1032 (22.8%)
Public or private bicycle	Private bicycle	1947 (98.8%)	2437 (95.5%)	4384 (96.3%)
	CityCycle bicycle	24 (1.2%)	114 (4.5%)	138 (3.1%)
Day of week	Monday	374 (19.0%)	674 (26.4%)	1048 (23.2%)
	Tuesday	587 (29.8%)	675 (26.5%)	1262 (27.9%)
	Wednesday	510 (25.9%)	601 (23.6%)	1111 (24.5%)
	Thursday	500 (25.4%)	601 (23.6%)	1101 (24.3%)
Time of day	7-9am	659 (33.4%)	958 (37.6%)	1617 (35.8%)
	9-10am	216 (11.0%)	245 (9.6%)	461 (10.2%)
	2-4pm	309 (15.7%)	349 (13.7%)	658 (14.6%)
	4-6pm	787 (39.9%)	999 (39.2%)	1786 (39.5%)
Observation site	Adelaide St	402 (20.4%)	742 (29.1%)	1144 (25.3%)
	Albert St	376 (19.1%)	440 (17.2%)	816 (18.0%)
	Ann St	285 (14.5%)	265 (10.4%)	550 (12.2%)
	Eagle St	332 (16.8%)	452 (17.7%)	784 (17.3%)
	George St	259 (13.1%)	253 (9.9%)	512 (11.3%)
	William St	317 (16.1%)	399 (15.6%)	716 (15.8%)
Observed conflict	No conflict	1938 (98.3%)	2509 (98.4%)	4444 (98.3%)
	Conflict with pedestrian	21 (1.1%)	27 (1.1%)	48 (1.1%)
	Conflict with vehicle	12 (0.6%)	15 (0.6%)	27 (0.6%)

Table 3. Bicycle conflict according to riding location

	Riding on footpath (n= 1032)	Riding on road (n=3490)
No Conflict	993 (96.2%)	3454 (99.0%)
Conflict with pedestrian	38 (3.7%)	10 (0.3%)
Conflict with vehicle	1 (0.1%)	26 (0.7%)

Table 4. Pedestrian-cyclist conflicts by observation sites

Site	No. of conflicts	No. of non-conflicts	Total no. of obs.	% conflicts
Adelaide St	5	1,134	1,139	0.44
Albert St	11	795	806	1.36
Ann St	12	531	543	2.21
Eagle St	7	774	781	0.90
George St	3	509	512	0.59
William St	10	704	714	1.40
	48	4,447	4,495	1.07

While age of the cyclist was not associated with their likelihood of being involved in a conflict, female riders were found to be less likely (62% lower odds) to be involved in a conflict than male riders (significant at 94% confidence level). Those cyclists who wore helmets appropriately had 62% lower odds to be involved in a conflict than those who either did not wear a helmet or wore it inappropriately (e.g. not fastened). The likelihood of conflict involvement did not differ significantly among the riders who rode private bicycles and those who rode CityCycle bicycles.

Conflicts were more likely to occur on two-way roads than on one-way roads (O.R. = 12.8) and if the road had a higher number of lanes (O.R. = 1.6). Compared to locations with no bicycle marking, conflict occurrence was more likely in locations with yellow painted bicycle marking (207% higher odds) and less likely in bicycle lanes (79% lower odds). As expected, bicyclists riding on the footpath had 6.6 times higher odds of being involved in conflicts than those riding on the road. Results for riding in a marked bicycle lane, average width of footpath, and presence of bus stops in close proximity of observation location were statistically non-significant.

Posted speed limit of the road had the highest effect on conflict probability. The odds of a conflict were 16.4 times higher in a road with 60 km/h limit, compared to one with 40 km/h. Only the Ann Street location has a 60 km/h limit while the rest have 40 km/h limits.

Higher pedestrian density in close proximity to bicycles (number of pedestrians in one metre) increased the probability of conflict occurrence. The odds of conflict increased by 79% for a one-unit increase in pedestrian

density. However, pedestrian density in a larger area around bicyclists (i.e. five metres) was not found to significantly influence conflict probability.

Discussion

This study sought to examine the prevalence of pedestrian-cyclist conflicts and the factors associated with their occurrence in a busy area. The results demonstrated that a quarter of the cyclists riding on the footpath had one or more pedestrians within 1 metre and an additional quarter of the cyclists had one or more pedestrians within 1-5 metres. However, less than 2% of cyclists were involved in conflict, either with a motor vehicle or pedestrian and none of the observed conflicts resulted in a collision. Cyclists were more likely to be involved in conflict with a pedestrian (48 observed conflicts) than with motor vehicles (27 observed conflicts). The number of conflicts with motor vehicles observed in this study may be limited due to the fact that all observation locations were mid-block, and did not include junctions. The presence of bus stops, and the average width of footpath in the Brisbane CBD, had no effect on the risk of conflict between a bicycle rider and a pedestrian. Riding in a marked bicycle lane was also found to have had no effect, although this may be a residual effect of only one location having a marked bicycle lane.

Increased odds of a pedestrian-cyclist conflict was associated with: male riders, riders not wearing correctly fastened helmets, riding on the footpath, higher pedestrian density (within 1m but not within 5m), morning peak and 2-4 pm (compared with 4-6 pm), two-way roads, roads with more lanes, higher speed limits, and yellow marked bicycle symbols on the road.

Table 5. Explanatory variables and estimates of regression model

Explanatory variables	Categories	Beta	O.R.	p-value
Year	0: 2010, 1: 2012	-		
Time of day				
	7-9am	1.444	4.238	0.002
	9-11am	0.635	1.887	0.335
	2-4 pm	1.739	5.694	<0.001
	4-6pm	Ref		
Age	0: Adult, 1: Young	-		
Gender	0: Male, 1: Female	-0.957	0.384	0.060
Helmet use	0: No, 1: Yes	-0.965	0.381	0.057
Bicycle Hire Scheme	0: No, 1: Yes	-		
Location of riding				
	Marked bicycle lane	-0.335	0.716	0.760
	Traffic lane	Ref		
	Footpath	1.884	6.580	<0.001
Bicycle Marking				
	Yellow painted bicycle marking	1.120	3.065	0.010
	Bicycle lane	-1.574	0.207	0.040
	No bicycle marking	Ref		
Traffic direction	0: one way, 1: two way	2.552	12.831	0.001
Presence of bus stops	0: no, 1: Yes, within 150 m	-		
Presence of taxi stops	0: no, 1: Yes, within 150 m	Cor.		
Speed limit of road	0: 40 km/h, 1: 60 km/h	2.796	16.384	<0.001
Observation site id	1 to 6 as categorical variable	Cor.		
No of ped. in 1 m	Continuous variable	0.582	1.790	<0.001
No of ped. in 5 m	Continuous variable	0.106	1.112	0.110
Total number of lanes	Continuous variable	0.471	1.601	0.008
Average footpath width	Continuous variable	-		
Constant		-10.649		<0.001
Model statistics				
No. of observations		4495		
LL(null)		-265.6		
LL(model)		-185.2		
<i>df</i>		15		
AIC		400.4		
G ²		160.9	14 <i>df</i>	<0.001

- Non-significant variable, not present in the most parsimonious model; Ref: Reference category;

Cor.: Variable was correlated with another variable, so was removed from model.

While more bicycles were observed during the afternoon peak hours (4-6pm), the likelihood of a rider being involved in a conflict with a pedestrian was higher during the morning peak hours (7-9am) and the afternoon non-peak hours (2-4 pm) than in the afternoon peak hours. Surprisingly, the likelihood of conflicts during the afternoon non-peak hours was more than that of the morning peak hours as well.

The finding that cyclists had six-fold higher odds of being involved in a conflict with a pedestrian when riding on the footpath was expected given previous research [1, 2]. However, it is important to note that while the odds of a conflict were increased, no collisions were observed for more than 500 cyclists riding within five metres of pedestrians on the footpath.

No statistically significant relationships were found between the likelihood of conflicts and type of bikes used (private or hired). In addition, no evidence was found that the likelihood of conflicts between the years 2010 and 2012 differs, despite having more observed riders in the later year when the bike hire scheme was more mature than it was in 2010. Collectively, all these findings imply that the safety of pedestrians and cyclists has not worsened even after increase in bicycle usage. Furthermore, these findings indeed carry a positive message towards the safe use of public bikes.

Female riders and those who wear helmets appropriately had lower odds of being involved in conflicts. Perhaps, male riders are faster than females and are taking more risks when riding. Appropriate use of helmets might also indicate that these riders are more safety conscious than those who either do not wear a helmet or wear it inappropriately. The lower likelihood of being involved in conflicts, therefore, might be resulted from their higher safety consciousness.

There was a 29.4% increase in observed cyclists from 2010 to 2012 which occurred without a significant change (increase or decrease) to bicycle route facility provisions (either on-road or off-road) in the Brisbane Central Business District. Not only is this increase heartening to transport and health agencies who are promoting active travel, it is also reassuring that the research found that this increase in cyclist numbers was not associated with any significant increase in the likelihood of cyclist-pedestrian conflicts.

This study has a number of limitations. The range of sites was restricted which made it difficult to clearly identify effects of variables such as speed limit, pavement width and whether there was one-way or two-way travel. Given that data collection occurred mid-week within school term, there were few adolescent or child riders who earlier studies [8] suggest may have had a greater likelihood of conflicts with pedestrians. While the use of trained observers allowed

for flexibility and minimised privacy restrictions, limited data on the nature of the observed conflicts was able to be collected. Future studies using video analytics promise to provide more detailed information on the trajectories of the conflicting cyclists and pedestrians and potential factors contributing to conflicts.

In conclusion, the current study has demonstrated a large increase in cyclists in the centre of Brisbane, more than 20% of whom are riding on the footpath. While riding on the footpath increases the odds of a pedestrian-cyclist conflict, it remains low and factors associated with the danger from motor vehicles contribute to these odds. This suggests that the footpath is playing an important role as bicycle infrastructure in the centre of the city where motor vehicle density is high. Yet the current research and the published literature demonstrate challenges associated with male, risk-taking and young riders interacting with (especially) older pedestrians. Safer infrastructure and lower speed limits have an important role in encouraging cyclists to ride on the road and thus minimise risks and inconvenience to pedestrians and cyclists.

References

1. Bernhoft I, Carstensen G. Preferences and behaviour of pedestrians and cyclists by age and gender. *Transportation Research Part F* 2008; 11:83-95.
2. Wennburg H, Ståhl A, Hydén C. Older pedestrians' perceptions of the outdoor environment in a year-round perspective. *European Journal of Ageing* 2009; 6(4):277-90.
3. Kiyota M, Vandebona U, Katafuchi N, Inoue S. Bicycle and pedestrian traffic conflicts on shared pavements. In *Velomondidal 2000*, Amsterdam, 2000.
4. Grzebieta RH, McIntosh AM, Chong S. Pedestrian-Cyclist Collisions: Issues and Risk. In *Australasian College of Road Safety Conference*, Melbourne, Australia, 2011.
5. Graw M, König HG. Fatal pedestrian-bicycle collisions. *Forensic Science International* 2002; 126(3):241-7.
6. Henley G, Harrison JE. Serious injury due to land transport, Australia 2008-2009. Canberra: Australian Institute of Health and Welfare, 2012.
7. Chong S, Poulos R, Olivier J, Watson W, Grzebieta R. Relative injury severity among vulnerable non-motorised road users: Comparative analysis of injury arising from bicycle-motor vehicle and bicycle-pedestrian collisions. *Accident Analysis & Prevention* 2010; 42(1):290-6.
8. Drummond AE. Pedestrian casualties resulting from collisions with cyclists on footpaths (Report No. 8). Melbourne: Monash University Accident Research Centre, 1989.
9. Haworth N, Schramm A. Adults cycling on the footpath: What do the data show? In *Australian Road Safety Research, Education and Policing Conference*, Perth, 2011.
10. Drummond AE, Gee FM. The risk of bicyclist accident involvement (Report No. 2). Melbourne: Monash University Accident Research Centre, 1988.

11. Autey J, Sayed T, Zaki MH. Safety evaluation of right-turn smart channels using automated traffic conflict analysis. *Accident Analysis & Prevention* 2012; 45:120-30.
12. Saunier N, Sayed T, Ismail K. Large scale automated analysis of vehicle interactions and collisions. *Transportation Research Record* 2010; 2147:42-50.
13. Saunier N, Sayed T. Probabilistic framework for the automated analysis of the exposure to the road collision. *Transportation Research Record* 2008; 2083:96-104.
14. St-Aubin P, Miranda-Moreno L, Saunier N. An automated surrogate safety analysis at protected highway ramps using cross-sectional and before-after video data. *Transportation Research Part C* 2013; 36:284-95.
15. Sayed T, Zaki MH, Autey J. Automated safety diagnosis of vehicle-bicycle interactions using computer vision analysis. *Safety Science* 2013; 59:163-72.
16. Ismail K, Sayed T, Saunier N, Lim C. Automated analysis of pedestrian-vehicle conflicts using video data. *Transportation Research Record* 2009; 20140:44-54.
17. NSW Roads and Traffic Authority. Study of bicyclist and pedestrian safety on shared paths. Surry Hills: Taverner Research, 2009.
18. Hatfield J, Prabhakaran P. An investigation of behaviour and attitudes relevant to the user safety of pedestrian/cyclist shared paths. In: 2013 Australasian College of Road Safety Conference, Adelaide, 2013.
19. Zaki MH, Sayed T. A framework for automated road-users classification using movement trajectories. *Transportation Research Part C* 2013; 33:50-73.
20. Saunier N, Sayed T. Automated analysis of road safety with video data. *Transportation Research Record* 2007; 2019:57-64.

Contributed articles

Cycling safety in Australia

by Tony Arnold

Executive Officer, Australian Bicycle Council

The humble bicycle is making a comeback around the world; with governments recognising the many benefits that encouraging transport cycling has for individuals and society. Many of these benefits are well-recognised such as improved health, air quality and congestion. Many are less well-recognised such as providing socially-equitable access to transport and improving road safety for vulnerable road users.

In an effort to saturate cities with bicycles and mainstream transport cycling, hundreds of major cities across the globe have launched bike-share schemes including New York, London, Paris, Barcelona, Montreal, Mexico City, Stockholm, Milan, Helsinki, Lyon and Australia's Melbourne and Brisbane.

This worldwide trend has little to do with spandex-clad bodies engaging in sports cycling and more to do with ordinary people just getting from A to B. Governments are looking to mainstream cycling and are using imagery that is very different to the hardened, helmeted, sweaty bodies of past cycling promotion efforts. Today's bicyclists are everyday people in everyday clothes making everyday trips.



Today's bicyclists are everyday people in everyday clothes making everyday trips

The Australian National Cycling Strategy

The primary goal of the National Cycling Strategy 2011-2016 is to double cycling participation over the life of the strategy.

This goal recognises the significant benefits that are realised by both individuals and society by increasing participation in active travel.

The economic benefit of cycling has been calculated

in Australia at \$1.43 per kilometre cycled per person [1] which equates to a \$14.30 benefit for every two-way commute of 20 minutes each way.

The goal of doubling cycling participation has the potential to improve the safety of riders through an effect known as "Smeed's Law" or "safety in numbers." This effect states

that the safety of the cycling environment correlates to the number of people riding bikes.

This relationship may be due to a number of possible factors such as:

- The increasing number of riders making bicycles more visible and resulting in an increased driver awareness of bicycles on the road.
- Existing riders feeling an increased social pressure from the growing number of cycling peers to behave in a more predictable and law-abiding fashion.
- More infrastructure being built to accommodate the increasing number of riders.
- New riders that are attracted by safer infrastructure will tend to be more risk-averse and more likely to ride conservatively.

Even if we ignore the “safety in numbers” effect, the public health benefits of cycling outweigh the safety risks. This is why governments have been increasingly keen to promote cycling and, more widely, active travel.

Cycling fatalities in 2013

The number of cycling fatalities in 2013 was the highest in 15 years at 50 fatalities with the outlook for 2014 being even worse with 30 deaths in the first six months. Men were over-represented in comparison to women even after accounting for their higher participation rates. Riders over 30 years of age were also disproportionately over-represented. This result is largely due to the fact that young riders, particularly very young riders, are less exposed to motor vehicle traffic as they tend to ride more on footpaths or on fully-separated facilities.

Cycling participation

Last year, 8.5 million Australians rode a bicycle, with 3.8 million people riding in a given week. [2] Younger people tended to ride more than older people with 44% of children between the ages of 2 and 9 year having ridden in the past week. Men tended to ride more than women by a factor of around 2 to 1. Participation in recreational cycling was significantly higher than participation in transport cycling (to work, shops, university, school etc).

While the level of cycling for transport is very low in Australia (as in the US and UK) at around 1% of trips, there is enormous potential to increase this number. The high participation rates in nations such as the Netherlands, Denmark and Germany have shown that it is possible to have up to one third of trips made by bicycle.

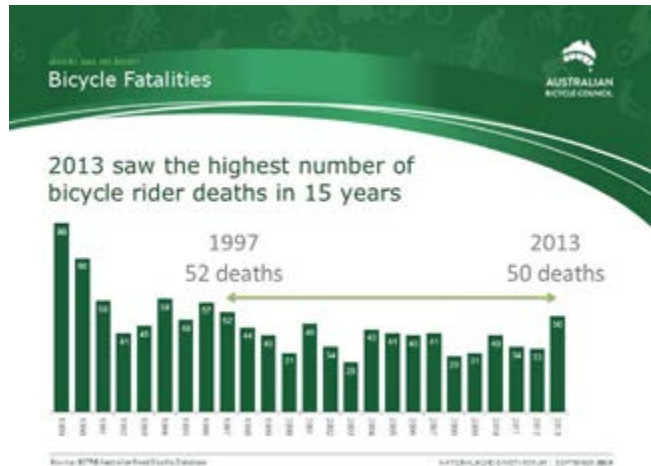


Figure 1. Bicycle rider deaths



Figure 2. Road fatalities by user

Barriers to increasing cycling participation

A 2011 study [3] found that concerns about safety top the list of barriers to cycling for transport with the top four reasons from a list of twenty given for not riding for transport being:

- Unsafe road conditions
- Speed/volume of traffic.
- Don't feel safe riding.
- Lack of bicycle lanes/trails.

While a recent study [4] found that walking accounted for ten times as many serious head injuries as cycling, walking is seen as very safe while cycling is perceived as a risky activity. There are several potential reasons for this, including:

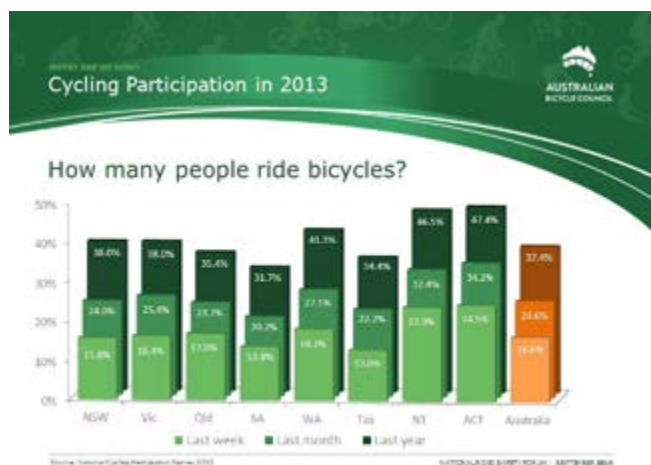


Figure 3. Bicycle usage

- Pedestrians have almost ubiquitous access to infrastructure that is separate from motor vehicles while bicycle users are in close physical proximity to motor vehicles for a large proportion of their journeys.
- Government communications strategies that target bicycle users focus heavily on safety issues and equipment.
- The prominence of bicycle accidents in the media.
- The mainstream participation in walking and driving results in an acceptance of these activities and the risks they entail. In contrast, riding a bicycle, particularly for transport, is less common.

The perception that riding a bicycle is dangerous slows growth in cycling participation. Failing to reduce the barriers to cycling participation will further consign Australia to low population activity levels which contribute to Australia's expanding waistlines and increased health care costs. It is therefore critical that interventions to improve the objective safety of cycling in Australia are carefully designed to also improve the subjective safety and reverse the perception that cycling is dangerous.

Improving cycling safety using the Safe Systems Approach

Safe roads and infrastructure

More than 75% of the cycling fatalities that occurred in 2013 involved a second vehicle. The dangers that motor vehicles present to vulnerable road users not only present a risk to those who currently ride bicycles; they present a strong deterrent to those contemplating transport cycling.

Building a network of bicycle facilities that provide separation from motor vehicle traffic will improve actual safety by minimising the risks faced by bicycle users.

By building these facilities, we will also see a significant improvement in the perceived safety of cycling and therefore an increase in cycling participation.

Safe speeds

Low speed limits are an essential part of the Safe Systems approach which aims to create an environment that is tolerant to human error and designed to minimise forces on the human body. Australia has been moving towards lower speed limits with initiatives such as 40 km/h limits in school zones and the lowering of the standard residential speed limit from 60 to 50 km/h. More recently, several cities in Australia have moved towards 40 km/h as a standard speed for CBD areas, although there are still challenges to overcome in getting this accepted by all parts of the community.

Bicycle users typically travel at around 20 to 30 km/h and can mix well with motor vehicle traffic travelling at around 30 km/h on low-volume streets. The current standard speed limit of 50 km/h in many areas is too high to allow for the comfortable and safe sharing of roads between bicycles and motor vehicles. In many parts of Europe, they have taken the sensible move to create 30 km/h speed zones in residential areas and high pedestrian activity areas.

By lowering speed limits, shared traffic environments will be objectively safer for bicycle users and will, importantly, feel much safer. Again, it is the feeling of improved safety that will contribute to an uptake in cycling.

Safe vehicles

It is important that bicycle users are riding safe bicycles. This can be achieved through community engagement activities that focus on encouraging cycling while also offering services such as free bike check-ups. If a bicycle is missing a bell, it is cheap and easy for government programs to supply and fit a bell to ensure compliance with the law while also encouraging the rider to keep riding.

Safe people

There is a perception in Australia that bicycle users are rule-breakers who act irresponsibly and are partly to blame for any accidents they are involved in just by being on the roads. This perception can be seen in the sporadic calls by members of the public for the registration of bicycles so that they can be identified. The perception is that bicycle users present a significant danger to others and that they need to be "held accountable".

The common misconception that bicycle users are disproportionately responsible for accidents was refuted in a recent study that looked at the Police records of accidents that resulted in the hospitalisation of bicycle users. The study found that "in 79% of cases the driver of the (motor) vehicle was deemed to be at fault for the crash".

The actual danger presented to other road users by bicycles is insignificant next to the very real threat that motor vehicles present both to other motor vehicle occupants and, even more so, vulnerable road users. Basic physics dictates that the speed, mass and rigidity of a motor vehicle presents a potentially-lethal danger to vulnerable road users. Risk factors such as speeding, fatigue and the growing problem of distracted driving further compromise the safety of vulnerable road users.

In order to keep pedestrians and bicycle users safe on our streets, it is important that the behaviour of drivers is regulated and that the legitimacy of cycling as a mode of transport is maintained. The regulation of driver behaviour can be done through policing but can be even more effectively achieved through the appropriate design of roads and the built environment.

The legitimacy of cycling can be achieved through the normalisation and mainstreaming of bicycle transport. Increasing cycling participation has a big role to play in the normalisation of cycling. When every person is good friends with a person who rides regularly, there will be a reduction in the “cars vs bicycles” narrative that plays out regularly in the media.

Efforts to improve the behaviour of bicycle users should focus on improving their skill levels from a young age. It is in these early years where good habits are formed and

where confidence and competence can best be established. Bicycle education not only improves actual safety by building skills, it also builds confidence that can help overcome the barriers to cycling and lead to a lifetime of healthy activity.

References

1. Queensland Dept. Transport and Main Roads (Prepared by SKM and PWC), Benefits of Inclusion of active transport in infrastructure projects, 2011.
2. Austroads, National Cycling Participation Survey, 2013.
3. Heart Foundation, Cycling Promotion Fund, Riding a bike for transport, 2011.
4. S. Suhood, Profile of CTP Claims Involving Pedestrians, 2013.

About the Australian Bicycle Council (ABC)

The role of Australian Bicycle Council is to coordinate and oversee the implementation of the National Cycling Strategy. The ABC reports annually on the implementation of the Australian National Cycling Strategy to the Transport and Infrastructure Council, through Austroads and the Transport and Infrastructure Senior Officials' Committee (TISOC).

Key influences on cycling for transport

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Introduction

Over recent years, the health, transport and environment sectors have been increasingly focused on the promotion of transport cycling. From a health perspective, transport cycling is recognised as a beneficial form of physical activity as it can be easily integrated into daily living, is done at an intensity that confers health benefits, and is associated with reductions in mortality and morbidity [1]. From a safety perspective, the risk of a serious cycling injury decreases as cycling increases [2] as having more cyclists on roads increases motor vehicle drivers' awareness of cyclists and in turn makes cycling safer.

Whereas cycling for recreation is the fourth most commonly reported physical activity among Australian

adults [3], transport cycling is an underutilised travel mode. Approximately 1.3% of journeys to work in Australia are made by bicycle [4]. This low prevalence is mirrored in the UK and the US, but not in some European countries like the Netherlands and Denmark, where over 18% and 26%, respectively, of all journeys are made by bicycle [5].

In the past decade, concerted efforts have been made by Australian state and local governments to increase cycling rates [6]. Notably, Melbourne, Sydney and Brisbane have implemented policies, increased bicycle commuting infrastructure, and offered information and promotion programs to encourage commuter cycling [6,7]. Governments have also developed comprehensive long-term plans for guiding future cycling strategies, using lessons learned from around the world in developing

successful cycling policy and promotion [6,7]. Changes in transport cycling rates in inner cities since these efforts have been implemented are encouraging. In Sydney, census data indicate an 83% increase in the number of people using a bicycle for commuting between 2001 and 2011 [8]. Counts of bicycles being ridden along major cycling commuter routes indicate increases in weekday morning cycling trips in Brisbane (63% increase from 2004 to 2010) [7] and in Melbourne (a 43% increase from 2006 to 2008) [9]. However, bicycle mode share to work has changed little: for example, between 2001 and 2011, it decreased slightly from 1.6% to 1.3% in Brisbane [10,11].

Researchers have been investigating factors that may be contributing to low rates of cycling for transport, to inform future policy and programming to encourage transport cycling. The aim of this paper is to overview our work to date in this area of research in Queensland.

Cycling in Queensland Study

The first study was a survey of cyclists in Queensland, undertaken to understand their attitudes about, and experiences with, cycling. Respondents were members, aged ≥ 18 years, of Bicycle Queensland (BQ), a statewide non-profit organisation that promotes cycling and advocates for better cycling facilities and improved safety (see bq.edu.au). As reported elsewhere [12], 2356 individuals (47% response rate) completed the survey.

The data from the survey were used in part to examine factors that may be influencing decisions to cycle for transport. An initial examination of the data revealed that transport cyclists tended to be male, young to early mid-aged (aged 18-44 years), and of a higher socio-economic position (in full-time jobs and educated at a tertiary level) [13]. In addition to these demographic characteristics that were associated with the behaviour, certain constraints were reported by high proportions ($>40\%$) of both transport and recreation-only cyclists that limited the appeal of transport cycling. These included concern with cycling in traffic and aggression from motorists [14]. Alarming, of the transport cyclists, 76% reported harassment from motor vehicle drivers; mainly driving too close, shouting abuse, and making obscene gestures/sexual harassment [15]. Not surprising then, respondents preferred to cycle off-road [14]. The cyclists were also concerned with cycling in rainy or stormy weather, cycling to places that lack a safe place to store bicycles and inhaling fumes from motor vehicles [14]. These factors led the cyclists to perceive that the built, natural and social environments for cycling were unsafe for transport cycling.

Cyclists were also asked to describe in their own words what would motivate them to cycle for transport (more) [16]. The most often mentioned motivators fell within the theme 'improving the built environment', which included

calls for building more and 'better' bikeways; improving safety for cyclists at intersections, at pinch points and on overpasses/underpasses; better maintenance of roads and paths used by cyclists; and moving bikeways away from parked cars. Improving the convenience of cycling was the second most important theme that emerged, with cyclists reporting that greater connectivity among bikeways, more direct safe routes to destinations, and better linkages with public transport would make cycling a more convenient and safe mode of transport. These qualitative data therefore further suggest that safety of the built and social environment for cycling is paramount to increasing transport cycling, and add that safe paths must make getting to destinations of interest convenient as well, to increase rates of transport cycling.

Further analysis indicated gender differences in transport cycling [14]. More women reported certain constraints to transport cycling, which included lack of time for transport cycling, the inability to put a bicycle on public transport, the decrease in daylight hours during winter, the presence of hills, their lack of fitness and their lack of confidence in bicycle maintenance and bicycle skills. Thus, the women in the study perceived additional constraints to transport cycling that need to be addressed in order to increase their participation in transport cycling.

Together these findings indicate that only certain populations are choosing to cycle for transport in Queensland; namely young, highly educated men. The main constraint to transport cycling is the perception that the environment is unsafe for transport cycling; a finding supporting other research in Australia and other low-cycling countries. To encourage cycling for transport in Queensland then, the findings suggest that the environment needs to improve: most importantly, bicycle infrastructure and end of trip facilities that support short, safe and direct trips to regularly-travelled destinations are needed.

HABITAT study

The next series of analyses is using data from a representative sample of Brisbane residents to understand the factors influencing cycling for transport in the general population. The data are being collected for HABITAT (**H**ow **A**reas in **B**risbane **I**nfluence **h**eal**T**h and **a**c**T**ivity), a multilevel longitudinal study of physical activity, sedentary behaviour, and health in Brisbane adults aged 40–65 years [17]. The primary aim of HABITAT is to examine patterns of change in physical activity, sedentary behaviour, active transport and health between 2007 and 2018 and to assess the relative contributions of environmental, social, psychological and socio-demographic factors to these changes. Both survey data from residents and objective measures of the built environment are being collected. Further details about the HABITAT study are available at <http://www.habitat.qut.edu.au/>.

In the first analysis [18], survey data from 2007 were used to examine whether individual characteristics and perceptions were associated with cycling for transport. As shown in the Cycling in Queensland Study, socio-demographic characteristics were associated with transport cycling, with males, younger residents (aged 40-44 years), and those in a high socio-economic position (household income $\geq$ \$130,000) more likely to cycle for transport. Age and gender data pooled from the 2007, 2009 and 2011 surveys from HABITAT show a large difference between men and women in the percentage who cycled for transport and also show decreases in transport cycling behaviour as age increases for both men and women (see Figure 1).

Also of interest here is that perceptions of less supportive neighbourhoods were associated with a lower likelihood of cycling for transport. Such neighbourhoods were ones that had the most crime; had many streets with cul-de-sacs (so fewer direct routes to destinations); were lacking in nearby recreational facilities (e.g., bike path, public park, public swimming pool) or had few nearby transport destinations (e.g., supermarket, post office, cafe/restaurant, bus stop, ferry terminal, train station). These findings suggest that developers and planners should consider addressing these features of the built environment in future developments and the revitalisation of older developments, as doing so could encourage transport cycling [18].

Currently, analyses are underway to examine the influence of objectively-measured built environment factors on

transport cycling. These analyses are using Geographic Information Systems (GIS) layers that were compiled for the neighbourhoods of the Brisbane residents participating in HABITAT. When complete, the analyses will indicate whether connectivity, residential density, land use mix, hilliness, aesthetics, bicycle path lengths, street lighting, and distances to key destinations are associated with transport cycling. Future analyses are planned to more closely examine interactions between the built environment and individual characteristics and perceptions that influence transport cycling behaviour. It is expected that this work will inform developers, planners, and policy makers on key attributes of neighbourhoods that encourage cycling for transport and thus should be considered in future developments in urban areas that aim to create sustainable, liveable neighbourhoods.

Conclusions

What is clear to date is that few women and older populations are cycling for transport in Brisbane and Queensland more generally. This is likely linked to perceptions of a hostile environment for cycling. To truly increase the numbers of people cycling for transport will require its uptake by these populations, and this will demand that policy and programs be put in place that transform the current culture into a transport cycling culture where these groups feel safe to cycle for everyday transport to their local shops, recreational areas, and to work.

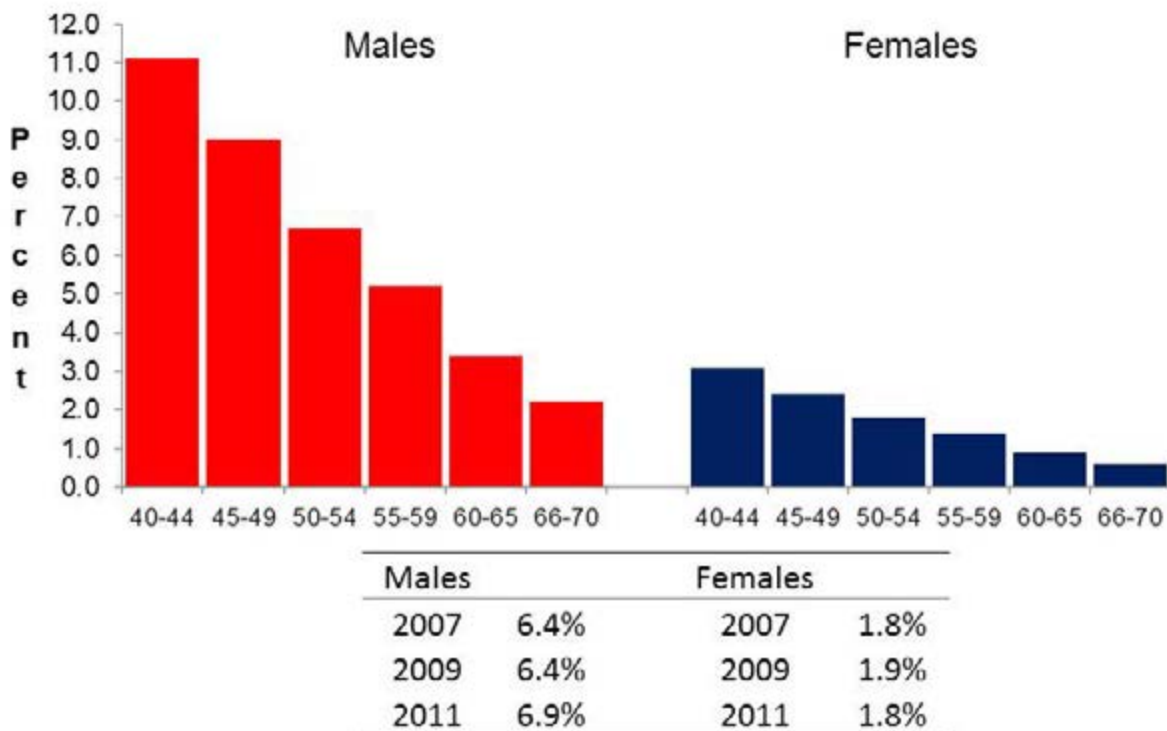


Figure 1. Percent of the sample who reported cycling for transport in the previous week: 2007-2011

References

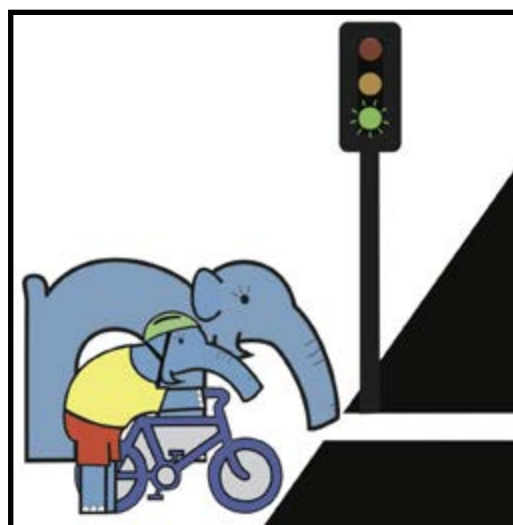
1. Oja P, Titze S, Bauman A, De Geus B, Krenn P, Reger-Nash B, et al. Health benefits of cycling: a systematic review. *Scandinavian Journal of Medicine & Science in Sports* 2011;21(4):496-509.
2. Jacobsen PL, Rutter H. Cycling safety. In: Pucher J, Buehler R, editors. *City cycling*. Cambridge, MA: MIT Press, 2012.
3. Australian Sports Commission. Participation in exercise, recreation, and sport: Annual Report 2010. Canberra: Australian Sports Commission, 2011.
4. Australian Bicycle Council. Australian Census 2011 travel to work by bicycle only. Sydney: Australian Bicycle Council, 2013.
5. Pucher J, Buehler R. Promoting cycling for daily travel: conclusions and lessons from across the globe. In: Pucher J, Buehler R, editors. *City cycling*. Cambridge, MA: MIT Press, 2012.
6. Buehler R, Pucher J. Big city cycling in Europe, North American and Australia. In: Pucher J, Buehler R, editors. *City cycling*. Cambridge, MA: MIT Press, 2012.
7. Brisbane City Council. Brisbane active transport strategy, 2012-2026. Brisbane: Brisbane City Council, 2011.
8. Rissel C, Munro C, Bauman A. Assessing cycling participation in Australia. *Sports* 2013;1:1-9.
9. City of Melbourne. Melbourne bicycle account: Cycling Census 2007. Melbourne: Melbourne City Council, 2013.
10. Cridland M. Cycling - why it matters. In *Asia-Pacific Cycling Congress*, Gold Coast, 2013.
11. Zander A, Rissel C, Bauman A. Cycling to work in Sydney: analysis of journey to work Census data from 2001 to 2011. Camperdown: Prevention Research Collaboration, The University of Sydney, 2012.
12. Heesch KC, Garrard J, Sahlqvist S. Incidence, severity and correlates of bicycling injuries in a sample of cyclists in Queensland, Australia. *Accident Analysis and Prevention* 2011;43(6):2085-92.
13. Sahlqvist SL, Heesch KC. Characteristics of utility cyclists in Queensland, Australia: an examination of the associations between individual, social, and environmental factors and utility cycling. *Journal of Physical Activity & Health* 2012;9(6):818-28.
14. Heesch KC, Sahlqvist S, Garrard J. Gender differences in recreational and transport cycling: a cross-sectional mixed-methods comparison of cycling patterns, motivators, and constraints. *International Journal of Behavioral Nutrition & Physical Activity* 2012;9:106.
15. Heesch KC, Sahlqvist S, Garrard J. Cyclists' experiences of harassment from motorists: findings from a survey of cyclists in Queensland, Australia. *Preventive Medicine* 2011;53(6):417-20.
16. Heesch KC, Sahlqvist S. Key influences on motivations for utility cycling (cycling for transport to and from places). *Health Promotion Journal of Australia* 2013;24(3):227-33.
17. Burton NW, Haynes M, Wilson LA, Giles-Corti B, Oldenburg BF, Brown WJ, et al. HABITAT: a longitudinal multilevel study of physical activity change in mid-aged adults. *BMC Public Health* 2009;9:76.
18. Heesch KC, Giles-Corti B, Turrell G. Cycling for transport and recreation: associations with socio-economic position, environmental perceptions, and psychological disposition. *Preventive Medicine* 2014;63:29-35.

Cycling and children

by Eric Chalmers
CEO, Kidsafe ACT

There are many good reasons to encourage children to cycle more, in part because of the great need to improve the level of physical activity and to reduce the health impacts of obesity in the community. Whilst we are encouraging children and adults to cycle more, there are a number of things we need to keep in mind.

Children are not small adults. They perceive danger and react quite differently to adults. Their perception of distance is not as developed and they tend to focus their vision quite tightly. They often assume that if they can see you, you can see them and have little understanding of the distances involved in stopping or changing direction in a moving vehicle or of the force of impact of being hit by a large vehicle.



Children observe a lot. Adults need to do what we expect children to do. For example, if we expect children to wear helmets, we need to do the same.

Adults need to ensure the environment in which we are asking children to ride is safe – e.g. riding to and from school. We cannot assume that they will be able to assess and address risk as adults do. If adults are going to encourage children to ride to school then we need to make sure the paths they take and the built environment around them are safe.

Other children do not make the environment safer. Younger children need to be under the supervision of an adult or someone who can exercise an adult's responsibilities effectively.

On the other hand there is safety in numbers, in more than one sense. One or two children riding along a footpath may not be seen, whereas 500 children walking and riding to a school will be noticed and will impact on the reaction and behaviour of vehicles' drivers nearby.

Kidsafe has access to good examples of programs from a variety of countries that have addressed some of these key issues. Riding a cycle is a great, healthy pastime. However, we as adults need to make sure we provide a safe environment in which children can enjoy riding. It is an important safety issue.

Safe cycling: all we need is 3, 2, 1 to reach zero

by Marilyn Johnson

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When it comes to riding bikes, Australia is not a world leader. While Australian champions such as Anna Meares, Cadel Evans and Ritchie Porte are leading world cycling, at home we have a long way to go for everyone to feel safe to choose to travel by bike. Creating a safe cycling environment in Australia is the mission of the Amy Gillett Foundation (AGF), Australia's national cycling safety organisation.

Amy Gillett Foundation

The AGF was created out of tragedy, the death of Amy Gillett, who was hit by an out of control motorist while cycling with her Australian National Cycling team mates in Germany. Since our inception we have been a catalyst for change, focused on what should be, rather than what is. That's why we have set ambitious aims and outcomes.



Our Mission: Safe cycling in Australia

Our Vision: Zero bike rider fatalities

The core values of the AGF honour Amy and her passion for life and sport, and focus on the change needed to keep bike riders safe:

- **Human:** a person is represented by every road trauma statistic. The AGF was created out of the tragedy of Amy Gillett's death and it connects us with the need to drive change.
- **Balanced perspective:** we look for the causes behind crashes and use that knowledge to drive our activity.
- **Safety is our priority:** safety sits above our love of cycling. Sometimes the right words to make people safe might not be the same words that promote cycling.
- **Shared respect:** we are positive about the future and believe that road users can use the road more harmoniously with shared respect for each other.
- **Collaborative:** the causes of crashes can be multi-faceted and the solutions are too. We work together with road, safety and concerned organisations to create safe solutions.
- **We are not – civil disobedience or protest:** we believe there are better ways to engage road users, the community and the decision makers to achieve safer cycling.

To achieve a safe cycling environment in Australia for everyone who wants to ride a bike, the AGF approach is structured into just three steps – 3, 2, 1 – to reach our goal of zero bike rider fatalities by 2020.

- 3 Take action on 3 critical factors
- 2 Work 2gether for safe bike riding
- 1 a metre matters
- 0 zero bike rider deaths in Australia from 2020

3: Take action on 3 critical factors

The action needed on three critical factors is based on the Safe System approach that underpins road safety in Australia.

Safe people

Under the pillar of Safe people, there are six key actions needed to improve the safety of bike riders:

- **18% of the road safety communication budget**

Bike riders make up 18% of all serious injuries on Australian roads [1]. A commitment to bike rider safety needs to acknowledge the magnitude of crashes involving riders that lead to not only death, but serious injury.

- **Mandatory cycling content in the driver licence process**

Currently, in every jurisdiction it is possible to become fully licensed without having to answer a single question about sharing the road with bike riders, interacting with cycling infrastructure or having to demonstrate skills that show an awareness of bike riders and an ability to interact safely. Mandatory cycling-related knowledge tests, skills assessment and cycling training as part of the driver licence process will contribute to an intergenerational shift in Australian drivers who will safely share the road with bike riders.

- **Mandatory bike skills training**

Bike skills training is necessary for all children throughout primary and secondary school and forms an essential component in road safety traffic education. Ongoing federal funding is needed to support AustCycle training programs to provide national coverage for all Australian children. Cycling is a fundamental life skill that will have an immediate impact on students' safety as road users, their future experiences as drivers and create an intergenerational shift to Australian drivers who safely share the road with bike riders. School-based delivery of cycling skills training would meet the cycling component of driver education. There also needs to be opportunities available for new and returning adult riders to increase their skills.

Further, individuals who have been involved in a cycling-related driving infringement should be required to complete a cycling skills training course that would contribute to real behaviour change.

- **Police investigation of all reported bike rider-vehicle serious injury crashes**

Currently all bike rider fatality crashes are reported to police. However, not all bike rider crashes are reported to police at the time of the event, or if they are reported post-event many bike riders report that police failed to take direct action and did not investigate the crash. Greater police action is required to follow up all reported bike rider serious injury crashes.

- **Review, improve and enforce rules for bike rider safety**

Many of the model Australian Road Rules, and the state rules, do not provide maximum protection for bike riders. The road rules are written largely from the perspective of the driver and often cannot be directly translated for bike riders or seem to exclude bike riders. Greater review of the road rules is needed to ensure bike riders are protected. Further, active police enforcement of existing rules is essential to create lasting behaviour change (e.g. fining all drivers and passengers who open vehicle doors and cause a hazard to another road user, particularly in crashes with bike rider injury outcomes).

- **Improve legal and regulatory protection for bike riders**

While bike riders are legal road users, there are many loopholes that mean they're not fully protected road users. For example, in Victoria, in the event of a bike rider crashing into the back of a parked car – even if they were forced into the crash to avoid being hit by a moving vehicle – they are not covered by the Transport Accident Commission (state government-owned organisation that pays for treatment and benefits for people injured in road crashes). More comprehensive legal and regulatory protection is needed for bike riders.

Safe roads and safe speeds

Safe roads and safe speeds are inextricably linked. We have considered both Safe System pillars together.

- **Reduce speeds**

Lowering speed limits is one of the most effective ways to improve safety for bike riders on the road, particularly in areas with high volumes of cycling traffic. Speed modelling has clearly demonstrated that 30km/h is the maximum speed tolerance for injury for an unprotected person on the road, see figure 1 [12, 4]. The current National Road Safety Strategy 2011-2020 highlights that the chances of surviving a crash between a pedestrian and a car rapidly decrease at speeds over 30kph. Yet Australian speed limits are set with human tolerances survivable only by vehicle occupants, including the default urban speed limit of 50kph.

Local streets, where almost every bike ride will begin, are a hostile speed environment for bike riders.

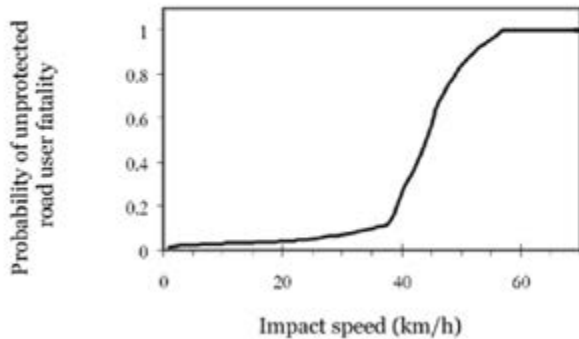


Figure 1. Relationships between probability of an unprotected road user fatality and impact speed. Adapted from Corben et al [4]

The AGF supports trials of lower, human safe, speeds including:

- In residential streets to promote liveability, safety, active trips and safe cycling. A reduction to 40km/h would realise some safety benefits however the greatest safety benefits would be realised at 30km/h;
- 40 km/h limits on arterial roads in areas of high pedestrian and/or bike rider activity (such as strip shopping centres); and
- 50 km/h limits on collector streets where on-road cycle lanes are provided.

- **Minimum spend for cycling facilities (federal, state and local)**

Ongoing, dedicated funding to reshape our roads to include bikes is fundamental to improving bike rider safety. As the responsibility for roads is spread across all levels of government, funding to improve the amenity of the roads for all users also needs to be met by all levels of government.

- **Targeted action to reduce bike rider black spot road sections and reduce all bike rider crash types**

Dedicated attention is needed to address sections of road that have been identified as high crash risk areas for bike riders as well as broader measures that reduce all bike rider crash types. In Australia, when cycling infrastructure is built, it is built to the standards set by the Austroads guidelines. Yet these guidelines do not reflect the world's best practice and lock us into road designs that follow old ways of thinking, failing to encourage innovative and creative solutions. Examples need to be adopted from world's best practice including the Dutch CROW Design manual for bicycle traffic (2007) cycling within the five

widely known main requirements for bicycle-friendly infrastructure: cohesion, directness, safety, comfort and attractiveness.

- **Benchmark guidelines for bike friendly towns and communities**

Benchmark guidelines that incorporate all elements of urban planning and integration of land users is urgently needed to help Australian towns and communities create safe spaces for people to ride bikes. In addition to guidelines, model cycling communities are needed in Australia to provide examples of safe cycling to local towns and communities. Cycling demonstration towns overseas have successfully created local examples of cycling friendly towns (e.g. six towns in the UK, New Plymouth and Hastings, New Zealand).

Safe vehicles

There are a wide range of vehicle and bicycle features, both active and passive, that could be enhanced to improve bike rider safety.

- **Safer motor vehicles**

There are a wide range of features that could be actively promoted through vehicle design standards, for example: pedestrian and bicycle rider detection technology; pedestrian and bicycle rider friendly crumple zones; driver's side door opening warning devices to prevent "dooring" incidents; automated braking technology including ABS and EAB; rear view cameras (in particular to prevent crashes with bicycle riders and pedestrians when backing out of driveways and parking bays); restrictions on window tinting, especially after-market tinting that reduces the driver's ability to see peripherally and other road-users' ability to make eye contact or observe the visual field of the driver; vehicle design to minimise drivers' blind spots, and; removal of front end modifications (e.g. bull bars).

- **Safer bicycles**

Bike riders also have a responsibility to maintain a safe and legally compliant bicycle including: regular servicing (e.g. brakes, tyres, steering, lights); appropriate bicycle style and fit according to riders' experience levels, and; conspicuity features (e.g. day time lights).

2: Work 2gether for safer bike riding

Communication, collaboration, cooperation and coordination across federal, state and local government, businesses and the community is needed to create safe cycling. We welcome collaboration from everyone who can help us achieve safe bike riding in Australia.

The AGF works together with corporate partners to promote safe cycling, including Toll, Wiggle, Subaru and Europcar.

These partners provide unique opportunities to promote safe cycling messages (see Figure 2).

The AGF also holds a range of public participation bike rides nationally including Amy's Ride Victoria, Amy's Ride South Australia, Amy's Big Canberra Bike Ride, Amy's Gran Fondo and the Amy's Share the Road Tour. With a focus on safe riding, the events create an opportunity to reinforce key safety messages to bike riders about their safe behaviour and responsibilities on the road.

The AGF has also worked closely with partners to develop and disseminate cycling safety messages. Every year state governments, local governments and community groups spend their small allocation of road safety funding on designing and redesigning public awareness messages about cycling and bike rider safety. The result is often a mishmash of messages that fail to cut through all the other messaging to reach the community and affect any change in behaviour. We need to be smarter about how we engage the public about road safety. We need a coordinated approach that stops reinventing the wheel. In bike rider safety, the AGF has taken a leadership role in developing a smarter, more coordinated approach.

Cycle Safe Communities is a free public AGF platform that provides cycling safety messages. Cycle Safe Communities contains ready-to-use campaign materials, available online, that bring to life cycling safety messages in the community. Each item has been identified to assist in the promotion and education of important safety messages for all road users, and can be developed and expanded to include other materials and resources. This community platform enables

consistent messaging to be adopted and embedded in the Australian community.

Resources include high resolution artwork, messages for print use, radio community service announcements and a series of animations are currently in development. Examples of campaigns that are currently available include *a metre matters* and *It's a two-way street*. The *It's a two way street* campaign was originally funded and developed in collaboration with the New South Wales Government, who generously made all the artwork and messaging available free of charge via the AGF's Cycle Safe Communities. This means that Australians can develop their own bike rider safety campaigns without the expensive costs of creating artwork. It also enables the roll out of consistent messaging across Australia, which will help raise public awareness for the need to improve bike rider safety.

On 1 October 2014, the Tasmanian Government's Department of State Growth launched an adapted version of the *It's a two-way street* campaign, using key messaging from the road safety initiative. Utilising existing artwork and messaging allowed the Department of State Growth to spend a greater proportion of their budget on delivering the message, rather than developing it.

The AGF has developed a wide range of other collaborative projects, including *Sharing Roads and Paths* (Victoria), and is also contributing to the South Australia Citizens' Cycling Jury; an innovative initiative of the South Australian Government to engage the public in complex, 'wicked' problems.



Figure 2. Examples of safe cycling messaging with AGF partners (Toll, Europcar)

However, a lack of comprehensive data – including data on bike rider crashes [11, 6] – is one of the most significant gaps in road safety research going forward. This gap does not only affect those researching road safety, but also hampers the efforts of everyone working in the field of public health. Together with public health and injury prevention colleagues, the road safety community can contribute to address the gaps in nonfatal road trauma data. There are two main data issues that directly impact cycling safety evidence: injury data and cycling exposure data.

Injury data

There is a growing awareness that the focus of all road safety efforts must be extended beyond reducing fatality crashes to also reduce injury crashes. Further, the contributing factors in a fatality crash may not be the same as those of an injury crash and therefore different action is needed. However, to understand the issue and to monitor the impact of any efforts made, it is essential that we understand the magnitude of the issue.

Two key components of injury data urgently needed in Australia are:

- A nationally agreed definition of injury outcome: currently the definitions vary across jurisdictions and this limits meaningful national comparisons
- The availability of injury data/a central database for injury data: the current delays in publicly-available analysis of injury data significantly decreases its relevance for monitoring road safety impacts.

To create effective and efficient databases of injury data requires cooperation within the road safety community and with other sectors including public health and all levels of government.

Cycling exposure data

The second major data gap is cycling exposure data. This fundamental denominator data is essential to understanding the context of cycling safety. Currently it is not possible to determine if the increase in bike rider fatality and serious injury crashes is a function of increased riders, increased cycle trips or a decrease in cycling safety.

Cycling exposure, or cycling travel data includes cycling participation but extends this to include details of how people use their bicycles, for example: how often people ride their bicycle (trip frequency), destinations they ride to or trip purpose (e.g. local shops, fitness/training), route choice (including on-road, off-road, bike lanes etc.), distance travelled (kilometres) and trip time (can be disaggregated to on-road, off-road). It is likely that existing cycling participation data has significantly under-represented the current level of people using bicycles in

Australia as binary data fails to provide the context for bicycle use for all cyclists and typically children are also excluded.

1. a metre matters



The campaign *a metre matters* was launched in 2009 and is the AGF's longest running campaign. It started as a public education/awareness campaign and in 2013 became a push for legislative change following a finding in a Brisbane court that the driver responsible for the death of 22-year-old bike rider Richard Pollett was not guilty [10].

The push for legislative change is the AGF's commitment to ensuring that people who are riding bikes are safe. While cycling infrastructure is constantly increasing, we are a long way from a European style segregated cycling network and almost all bike riders will at some time need to travel on the road with moving motor vehicles. This amendment to our road rules will help keep bike riders safe while we wait for the physical environment to catch up with more infrastructure and lower speeds.

For bike riders to have safe space on the road, drivers need to allow a safe passing distance when overtaking. A motor vehicle hitting a bike rider from behind while travelling in the same direction is the most common crash type that results in a bicycle rider being killed [2]. Insufficient overtaking distance is also a major contributing factor in serious injury crashes, near-crashes and contributes to bike riders feeling unsafe on our roads [3, 8, 9].

The most important road rule to provide protection for bicycle riders and improve their safety is the amendment of the road rules to legislate a minimum passing distance when overtaking bike riders that must be observed by all drivers. The introduction of specific distances is a great start to behaviour change and increasing road user awareness and mutual respect between bicycle riders and drivers on the roads. The specific distances are:

- 1 metre – in speed zones up to and including 60km/h
- 1.5 metre – in speed zones over 60km/h.

Queensland has shown leadership in this space with a two-year trial of the road rule amendments which started 7 April 2014. In addition, on 25 September 2014, the Australian Capital Territory Government announced that it will also trial the road rule amendments to replicate the Queensland trial.

It is essential the trial is appropriately evaluated to ensure that an accurate evidence base is generated that successfully captures any change in bike rider-vehicle crashes, but also the changes in subjective safety. For many people, sharing the road with moving motor vehicles is a barrier that stops them riding a bike. Fear of moving vehicles and driver behaviour is often cited as the single biggest barrier to cycling in Australia [3, 7]. Changes in subjective feelings of safety that may encourage more people to ride their bike must be included in the evaluation of all trials.

The AGF has compiled a comprehensive report that includes the background and evidence for the minimum overtaking distance. The full reference report can be accessed here: www.amygillet.org.au/minimum-overtaking-distance

0: zero bike rider fatalities by 2020

All the action of the AGF – the 3, 2, 1 – leads to this final aim: for Australia to be bike rider fatality free from 2020.

Currently we are tracking in the wrong direction. In 2013, there were 50 bike riders killed in Australia and as at the first week of October, bike rider deaths for 2014 was trending towards 48 deaths.

At the AGF, we will continue to work for the safety of everyone who chooses to ride a bike. We invite and welcome collaboration from everyone who can help us achieve safe cycling in Australia.

References

1. AIHW, G. Henley and J. Harrison (2012). "Serious injury due to land transport, Australia 2008-09. Injury research and statistics series no. 67. Cat. no. INJCAT 143. Canberra: AIHW."
2. Australian Transport Safety Bureau (2006). Deaths of cyclists due to road crashes, Australian Government.
3. Bauman, A., C. Rissel, J. Garrard, I. Ker, R. Speidel and E. Fishman (2008). Cycling: Getting Australia Moving: Barriers, facilitators and interventions to get more Australians physically active through cycling. C. P. Fund. Melbourne.
4. Corben, B., D. B. Logan and J. Oxley (2008). Star rating school walking routes. Clayton, Monash University Accident Research Centre.
5. CROW (2007). Design manual for bicycle traffic. Ede, Centre for Research and Contract Standardisation in Civil and Traffic Engineering.
6. Garrard, J., S. Greaves and A. Ellison (2010). "Cycling injuries in Australia: Road safety's blind spot?" Journal of the Australasian College of Road Safety 21(3).
7. Haworth, N. (2012). The roles of subjective and objective risk in cycling safety. Cycling Safety Forum. Perth.
8. Johnson, M., J. Charlton, J. Oxley and S. Newstead (2010). "Naturalistic cycling study: identifying risk factors for on-road commuter cyclists." Annals Advanced Automotive Medicine 54: 275-283.
9. Johnson, M., D. Chong, J. Carroll, R. Katz, J. Oxley and J. Charlton (2014). Naturalistic cycling study: identifying crash risk factors for cyclists in the Australian Capital Territory. <http://www.roadsafetytrust.org.au/c/rtt>, NRMA-ACT Road Safety Trust.
10. Johnson, M., T. Gaudry and L. Bugeja (2014). a metre matters: using a public policy approach to create a safer cycling environment in Australia. International Cycling Safety Conference. Gothenberg, Sweden.

Toll

Safety is a core value at Toll. We believe everyone has the right to get home safely. As the largest mover of road freight in Australia we have a role to play in making our roads safer and in helping others understand the importance of safely sharing the road.

That's why working with the Amy Gillett Foundation, Australia's leading cycling safety group, is an important part of our ongoing efforts to prevent road incidents, protecting all road users and the communities they travel through. Together we can be safe.



11. Sikic, M., A. Mikocka-Walus, B. J. Gabbe, F. T. McDermott and P. A. Cameron (2009). "Bicycle injuries and mortality in Victoria, 2001-2006." *Medical Journal of Australia* 190: 353-356.
12. Tingvall, C. and N. Haworth (1999). *Vision Zero - An ethical approach to safety and mobility*. 6th ITE International Conference Road Safety and Traffic Enforcement: Beyond 2000. Melbourne.

Road Safety and cycling – a view from the handlebars

by John Armstrong¹ and Roger Bacon²

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Pedal Power ACT is a not-for-profit organisation founded in 1974 to act as a rallying point for people who ride bicycles in the Australian Capital Territory and Queanbeyan regions. It represents the interests of people who ride bicycles and who potentially would ride bicycles. It promotes the activity of cycling for transport, recreation and sport as well as the benefits of improved fitness and the positive contribution cycling makes to the community and a sustainable environment.

Road safety and cycling

How timely! The ACT government has just provided a response to a series of recommendations identified to address vulnerable road users – motorcyclists, cyclists and pedestrians - as a result of an inquiry to address the concerns in the ACT. This comes after similar inquiries in Queensland, NSW and Victoria.

The aim is to address the issues surrounding the vulnerability of those that choose to ride a bike on the road and identify the key platforms by which one would suggest the safety of all road users is improved.

Pedal Power ACT in its submission to the inquiry identified that there is no silver bullet – not one means (by itself) will be sufficient to see an increased level of safety for vulnerable road users. However there are some key platforms that address the safety of the cycling community on the road including;

- effective urban planning and road infrastructure
- the reduction in speed at conflict areas
- the increased use of cycling in itself leads to a reduction of incidence of injury
- education, training and increased awareness in the broader community
- policy development and legislative changes
- funding to implement the changes and the savings that such an investment makes.

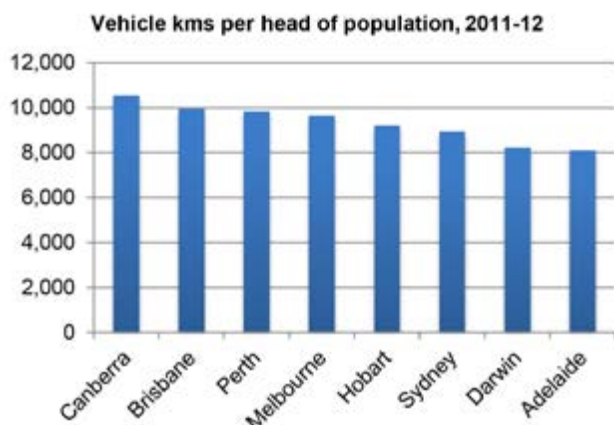
What is the case for increased safety measures?

This requires a review of the links between cycling infrastructure, cycling participation, injury rates and wider public health. Pedal Power ACT proposes that governments should invest in safe, convenient cycling infrastructure in order to encourage cycling by the large number of people (especially women and children) who would like to ride but currently don't because of the perceived risk. This in turn would reduce accident rates because of safer conditions and the 'safety in numbers' effect. The ultimate benefit would be a reduction in lifestyle illnesses, leading to major savings in public health budgets.

An unfit society

Canberra has the highest rate of car use of any city in Australia [7, 4].

ABS Census data show that for travel to work, four out of five Canberrans use cars — one of the highest rates in Australia and this has been unchanged for the last 30 years. Bus usage is declining, and is currently around 7%. Cycling and walking to work were 2.8% and 4.9% respectively at the 2011 Census. The ACT government realise this as well, noting in the ACT Budget Paper 2 in 2014 that "Our Healthy Weight Initiative goes hand in hand with additional walking and cycling infrastructure ..."



The health benefits are being recognised across the world with the UK recognising an increased focus on the health benefits of cycling citing that *“The NHS could save more than £1 billion (A\$1.75b) a year if the Government matched Dutch levels of spending on cycle provision, health experts have claimed...”* with health experts telling the Get Britain Cycling parliamentary inquiry this year that *“... the NHS spent about £5 billion (A\$8.75b) a year on obesity-related conditions, adding that health services could make £4 of savings for every £1 invested in cycling.”* It was interesting to note that Reindert Augustijn, a Dutch transport director, said to the same inquiry *“In the Netherlands, we used to invest in cycling to reduce the number of accidents, but now we do it for economic and health reasons”*.

In the ACT Chief Health Officer’s Report 2014 (a biennial Report that covers the period July 2010 to June 2012) lifestyle factors (including physical activity) are implicated as major preventable causes of chronic disease. A third of all men, almost half of all women and three-quarters of all children were insufficiently active. Almost two-thirds of all adults and a quarter of all children were overweight. *“Urgent, sustained, inter-sectoral action is required to address this problem at the societal level”*.

The proportion of ACT people with heart, stroke and vascular disease is the highest in Australia, and 27% higher than the national average. A total of 15.5% of the ACT population had mental and behavioural problems; the highest proportion of all states and territories (Australia: 13.4%) and an increase from previous years. People reporting mental health problems were more likely to be current smokers and to be undertaking inadequate physical activity. The report indicates that car use and inactivity are making us increasingly sick.

Cycling is one of the best medicines for physical and mental health. Other cities are recognising the benefits. For instance, San Francisco has embarked on a program to reduce car use to half of all trips, by increasing public transport usage and active travel (cycling and walking).

Cycling injuries

According to the ACT Chief Health Officer’s report, the ACT had the highest rate of high threat to life injury among pedal cyclists of all the jurisdictions (8 per 100,000 as against the Australian average of 4.2).

“ACT Government Territory and Municipal Services data show that in 2012 there were 110 casualties from pedal cycle accidents, including one fatality, 26 hospital admissions and 83 people receiving medical treatment. Pedal cyclists accounted for 12.3% of all on-road casualties in 2012. Most of the reported injury from crashes involving cyclists and vehicles occurred in the city and inner suburbs. In 2012, 15% of these crashes occurred in the CBD, 12% in Turner and 10% in Braddon.

The June 2014 report of the inquiry into vulnerable road users for the ACT Legislative Assembly found that between 2007 and 2012, cycling casualties admitted to hospital remained constant at 12 per year. Those receiving other medical treatment increased from 40 to 83 per year, with the largest increases in 2010-12.

The inquiry recommended action to:

- improve road rules, road user behaviour and driver licensing
- mandate minimum separation between bicycles and motor vehicles
- improve data on accidents
- reduce speed limits
- increase legal protections.

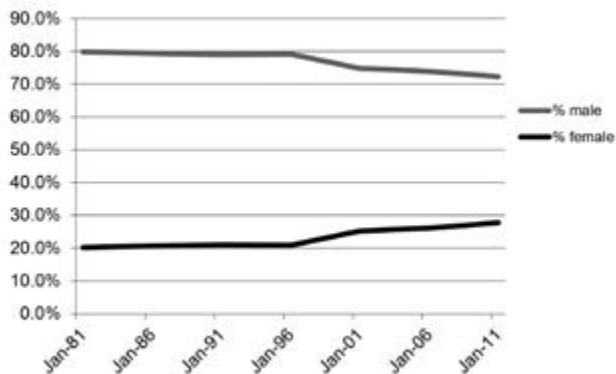
Pedal Power ACT has urged the ACT Government, in its response to the inquiry report, to pay more attention to funding quality cycling infrastructure, especially segregation of cycle lanes in areas of heavy traffic. At present, many people are deterred from cycling by the perceived danger of motor traffic.

Pedal Power ACT considers that cycling injury rates are also influenced by:

- the narrowness and poor condition of many shared paths and on-road lanes;
- poor quality intersection design;
- the number of ‘missing links’ in the cycle network, leading to rapidly changing riding conditions; and
- the primary focus of the ACT transport system on private motor vehicles.

The perception of safety – why women don't ride

Historically, men have outnumbered women three to one in the ACT cycle commuting statistics from the five-yearly Census. Men appear more willing to accept the risk of riding in adverse road conditions suitable only for the 'enthused and confident' or the 'strong and fearless' categories.



The Heart Foundation and Cycling Promotion Fund *Women and cycling survey 2013* found that:

- The overwhelming majority of respondents agreed that riding a bike is a good way to get fit and that it is important for children to learn how to ride. Similarly, the majority of respondents also agreed that road traffic makes people afraid to ride.
- Three in five respondents reported they would like to cycle more than they currently do, with 78% of respondents who reported cycling in the past six months indicating they would like to cycle more. Furthermore, more than 50% of respondents who hadn't cycled in the past six months would like to do so.
- Whilst traffic speeds was a prominent factor that prevents women from cycling and was also a safety concern, very few women felt reducing the traffic speeds would entice women to cycle. The overwhelming majority of women agree that government should improve cycling facilities by providing more bike paths and/or lanes. This is consistent with having more bike lanes and off-road cycling paths that would entice more women to ride.
- When asked to nominate all reasons that prevent women from cycling, traffic and aggression from other road users featured prominently. The main safety concerns amongst women associated with cycling (aside from personal safety) involved traffic and cars, with speed and volume of cars/trucks, and distracted drivers being the major safety concerns.

The lack of safe, convenient infrastructure is clearly holding back large numbers of people in the '8 to 80' age cohort, especially women, who would otherwise like to be able to cycle as part of their daily activities.

The perception of safety – why children don't ride

The Heart Foundation and Cycling Promotion *Active travel to school 2012* survey found that:

- Close to 60% of parents surveyed drive their children to school.
- Whilst seven in ten parents surveyed think it is important for children to be able to independently ride a bike, close to half do not believe that it is safe for children to ride a bike to school.
- There are some clear barriers to children riding a bike to school. Eight in ten parents surveyed agreed that there is too much traffic on the roads and there are not enough bike paths for children to cycle safely to school.
- The reasons parents do not allow their children to ride a bike to school are centred around safety and the dangers posed by traffic and other road users.
- Parents surveyed indicated that they would be more likely to let their children ride a bike to school if safety, and the dangers posed by traffic and other road users was changed or improved.

Clearly there is a common theme holding back Australia's and Canberra's cycling participation rate: cycling in and around traffic is seen as inherently unsafe. The logical consequence is that to reap the community benefits of mass cycling, governments will have to invest in quality cycling infrastructure which is protected from vehicle traffic.

The 'safety in numbers' effect

The theory has gained currency in recent years that (paradoxically) the more people cycle, the lower the injury rate. This is because other road users are more used to seeing and coping with bicycles, and adapt their behaviour accordingly.

"A motorist is less likely to collide with a person walking and bicycling if more people walk or bicycle. Policies that increase the numbers of people walking and bicycling appear to be an effective route to improving the safety of people walking and bicycling." PL Jacobsen, [12]. Such policies also help overcome the 'them and us' stereotyping that can characterise mutual perceptions between people in cars and people on bikes.

Garry Brennan of Bicycle Network (Victoria), quoted in Matt de Neef, [9] identified that

“The reason that [some motorists] do show aggression on the road towards cyclists is because they think we’re a different species. They’ve framed us as an edge group so we’re not worthy of respect. We need more women, more school kids, more elderly people — we need a full cross-section of society on our streets riding bikes, not just super-fit roadies or super-brave commuters.

That’s what’s going to deliver us the huge benefits in safety because bike riding will be normalised; it will be socially acceptable, social empathy will be driving a much greater understanding and respect for people on bikes and that will be a net gain for everybody.”

Cycling in the ACT is on a very good platform to increase its cycling numbers even more. The Australian Bureau of Statistics survey [5] estimated that 44,200 Canberrans cycled for recreation at some point in 2011-12. The 2011 Census found that 4,671 Canberrans cycled to work on census day. The latest cycling participation survey by the Australian Bicycle Council [3] confirms that ACT has the highest cycling rate - just under 40% higher on average.

‘Build it and they will come’

The evidence from around the world shows that better cycling infrastructure leads to greater cycling participation, and in turn leads to fewer cycling injuries and better public health outcomes. Greater participation creates a feedback loop leading to even better infrastructure, greater community acceptance of active travel, and greater community benefits. The initial investment requires political leadership, but is essential to trigger the process.

Pucher and Buehler [13] argue the key reason cycling is so successful in many Dutch, Danish, and German cities relative to other places (not just Australia) is due to:

- extensive systems of separate cycling facilities;
- intersection modifications and priority traffic signals;
- traffic calming;
- bike parking;
- coordination with public transport;
- traffic education and training; and
- sympathetic traffic laws.

They also point to the positive way cycling is promoted.

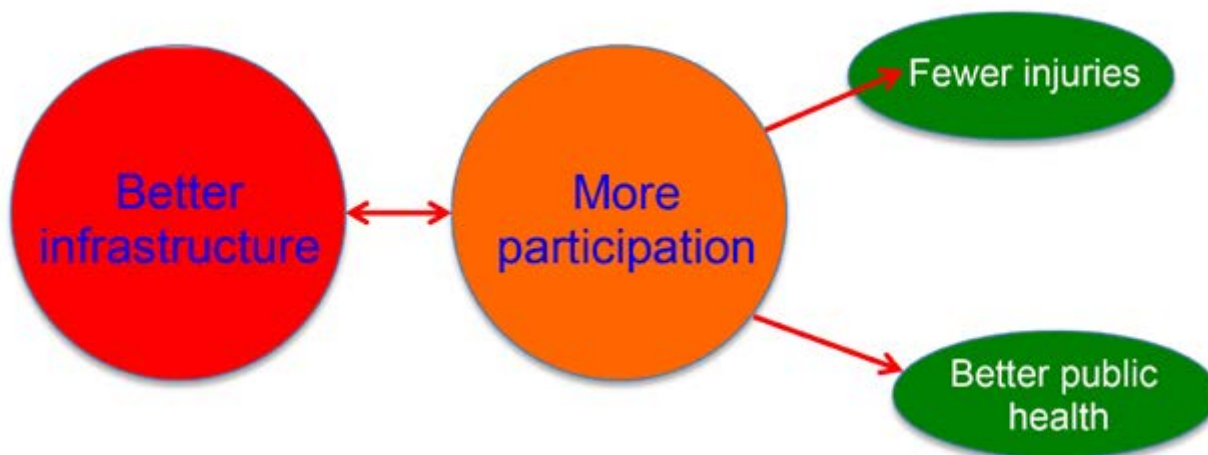
Community acceptance

Greater cycling participation by a wide cross-section of the community, together with a broad framework of government policies supporting active travel, will help create a cultural climate in which cycling is not just tolerated but is enthusiastically adopted as a normal means of daily transport.

Road user attitudes

‘Sharing the road’ has become a mantra of traffic authorities around the world. It is recognised that this will involve attitudinal changes especially on the part of motor vehicle drivers, who occupy the highest position in the road ‘pecking order’. There has been a focus on the need for improved driver education, particularly in the initial licensing phase.

The need for changed attitudes is evident with the trend to introduction of ‘shared space’ in inner urban areas, where most markings and signs are removed and all road users have to negotiate a safe passage with everyone else. Some drivers feel threatened by this phenomenon, and not just because of the loss of parking spaces.



As a community, with the rise of active travel we will need to progress beyond ‘defensive’ road use to ‘supportive’ road use. For some years, ‘defensive’ driving has been portrayed as the safe approach characterised by:

- being able to stop within the distance you can see to be clear;
- being alert and anticipating risk;
- covering the brake on approach to hazards; and
- assuming that other road users will do the wrong thing, and preparing to deal with it.

Bicycle riders habitually practice defensive road use as their main form of protection in traffic. As a community, we need to build on this approach and move beyond it to ‘supportive’ road use, characterised by:

- extending and acknowledging courtesy;
- being aware of other road users’ situation and needs;
- letting others merge ahead; and
- anticipating difficulties for other users and helping them out.

Where to from here?

Strategically, Pedal Power ACT is advocating for:

- top-level political leadership and recommitment to cycling as a mainstream daily transport mode
- a ‘cycling champion’ to drive change
- integrated and efficient governance for active transport
- consideration of cycling mandated in the early stages of all urban planning for city and town centre plans, and for greenfield and redevelopment projects
- a much more substantial commitment to funding as part of the budget process
- building the numbers of the ‘8-80’ group (especially women and children) riding as part of their daily routine
- priority to infrastructure that will make a big difference to participation rates
- recognition of the positive benefit-cost returns on cycling infrastructure and
- action to achieve mode share targets and prevent Canberra falling behind other cities.

Pedal Power ACT see huge potential for savings in the ACT health budget from active travel reform. Our analysis of long-term Census data on travel to work indicates that:

- car mode share has averaged 82% over the last 30 years
- the number of car journeys to work has increased by 89%
- the non-car mode share (bus, walking and cycling) has averaged 15%
- the active travel mode share (cycling and walking) has averaged 6.6%
- women’s active travel mode share has averaged only 2.3%

Other cities worldwide are implementing ambitious active travel plans. Copenhagen is aiming at a 50% mode share for cycling alone. San Francisco is working to reduce the car mode share to 50% by 2018.

If more people cycle and walk to work in Alaska (8.9%) than in Canberra [15], it highlights the need for significant effort and infrastructure funding to reap the benefits of active travel for the ACT community.

The recently proposed ACT government changes look to the diversity of solutions to enhance the safety of the cycling community in the ACT and it is only through a determined and sustained approach in each and all of these areas that Pedal Power ACT believes we will see significant improvement in numbers and safety for those that choose to ride their bikes.

References

1. ACT Health: Australian Capital Territory Chief Health Officer’s Report 2014, ACT Government, Canberra, ACT, 2014.
2. ACT Legislative Assembly - Standing Committee on Planning, Environment and Territory and Municipal Services, Inquiry into vulnerable road users, June 2014.
3. Australian Bicycle Council, National cycling participation survey, December 2013.
4. Australian Bureau of Statistics, Census of population and housing, 1981-2011.
5. Australian Bureau of Statistics, Participation in sport and physical recreation, Australia, 2011-12, December 2012.
6. Australian Transport Safety Bureau, ATSB road safety report: Deaths of cyclists due to road crashes, July 2006.
7. Bureau of Infrastructure, Transport and Regional Economics, Australian infrastructure statistics yearbook 2013
8. Centre for Accident Research & Road Safety – Queensland, Fact sheet – Bicycle safety: state of the road, updated May 2011.

9. De Neef, Matt: 'Safety in numbers': reducing the risks for cyclists, 12 June 2014 at <http://cyclingtips.com.au/2014/06/safety-in-numbers-reducing-the-risks-for-cyclists/>
10. Heart Foundation and Cycling Promotion Fund, Active travel to school survey 2012.
11. Heart Foundation and Cycling Promotion Fund, Women and cycling survey 2013.
12. Jacobsen, Peter Lyndon, Safety in numbers: more walkers and bicyclists, safer walking and bicycling, *Inj Prev* 2003;9:205-209 doi:10.1136/ip.9.3.205.
13. Pucher, John & Buehler, Ralph: City cycling, MIT Press, October 2012.
14. Burgess, Kaya, Going Dutch on cycling 'could cut £1.6bn a year from health budget', London, The Times, 13 June 2013.
15. United States Alliance for Biking and Walking Bicycling and walking in the United States - 2014 benchmarking report, The Alliance in conjunction with the Centers for Disease Control and Prevention, 2014. <http://www.bikewalkalliance.org/resources/benchmarking>

Cycling on rural roads

by Dick van den Dool and Justin Murphy

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Setting the scene

Providing bicycle facilities on rural roads is challenging due to the high vehicle speeds (generally with speed limits of 70km/h or above) and often physical constraints of the road reserve. International guidelines and practice in 'cycling' countries such as the Netherlands and the UK provide cyclists with paths separated from high speed traffic. A summary of international practice is provided in Table 1.

In Australia and New Zealand guidelines and practices for higher speed roads vary between jurisdictions. However, the majority of jurisdictions are providing more off-road paths along urban motorways and generally sealed shoulders along high speed rural roads. The NSW Bicycle Guidelines are focused primarily on providing guidance for the design of cycling facilities in urban environments.

High speed roads present an increased safety risk to all road users including cyclists. There are inherent risks where cyclists and high speed vehicles share road space, primarily due to:

- the high differential in operating speeds between cyclists and vehicles
- increase in crash severity
- often large amount of heavy vehicle traffic.

Providing off-road paths as an alternative to on-road facilities on higher speed rural roads as is done in the Netherlands and the UK is often not feasible in Australia and New Zealand due to the high financial cost, long distances of facilities required and land ownership issues.

As cycling is a legitimate transport mode and cyclists are legally permitted to use roads, there is a need to improve facilities and conditions for cyclists riding on-road in higher speed rural roads environments. Techniques for improving space and conditions for cyclists on high speed rural roads can be infrastructure related as well as non-infrastructure related and can include:

- **Providing an alternative route** – such as using a lower speed route

Table 1. International practice in providing for cyclists on high speed roads

Country	Practice	Reference
UK	Where the 85 th percentile speed is greater than 40 mph (64.4 km/h), segregated bicycle facilities (tracks/paths) should generally be provided. For high speed roads with low traffic volumes (less than 3,000 vehicles per day/less than 300 vehicles in the typical AM peak hour), on-road bicycle lanes may also be considered.	TfL (2005)
Germany and Denmark	Provision of fully integrated off-road paths and bicycle lanes along roads and at intersections in cities and surrounding areas.	Pucher and Buehler (2008)
The Netherlands	Cyclists should always be separated from high speed traffic by providing a separate path or alternative (cycling) route. Consideration should also be given to lowering traffic speeds.	CROW (2007)
New Zealand	On urban roads with a speed limit of 80 km/h or more, cycle paths should be provided. Where speed limits are 70 km/h, sealed shoulders may be acceptable where there are fewer than 2,000 vehicles per day.	LTSA (2004)

- **Reducing the speed limit**
- **Technology** – such as providing bicycle activated signs to alert drivers to the presence of cyclists
- **Using non-infrastructure solutions** – such as education (advertising campaigns), enforcement (policing) and encouragement programs (behaviour change).

On-road treatments for cyclists on higher speed rural roads include:

- **Exclusive bicycle lanes** – these should be a minimum of 2 metres wide
- **Sealed road shoulders (Figure 1)** – similar to bicycle lanes, sealed shoulders should be a minimum of 2 metres wide with additional width provided where there is a large number of heavy vehicles.



Figure 1. Typical motorway sealed shoulder treatment

On-road bicycle facilities

Road shoulders

Road shoulders are provided to carry out two key functions; traffic and structural. Structurally road shoulders provide lateral support to the road pavement. In terms of traffic, road shoulders serve several key functions by providing:

- operating space for cyclists outside of the vehicle travel lanes
- a refuge for stopped vehicles on a firm surface, a safe distance from the adjacent traffic lanes
- an initial recovery area for an errant vehicle
- clearance to lateral obstructions.

The minimum sealed width requirements for road shoulders are outlined in Austroads guidelines. The width requirements vary depending on the intended function and road type as summarised in Table 2 and Table 3 respectively.

Table 2. Minimum sealed shoulder widths by function

Function of shoulder	Minimum sealed width (m)
Lateral support of pavement	0.5
Control of moisture or on outside of curves	1.0
Initial recovery area	0.5
Discretionary stopping	
Cars	2.5
Trucks	3.0
Bicycle demand	2.0/3.0

As shown in Table 3, for single carriageway, rural roads, the Austroads guidelines recommend a minimum sealed shoulder between of 0 and 1.5 metres, increasing with traffic volumes.

As shown in Table 3, these guidelines recommend a minimum sealed shoulder width of 2.0 – 3.0 metres, depending on bicycle demand. It is also noted that a shoulder width of 2.5 metres is needed for a passenger vehicle to stop clear of the traffic lanes.

Where sealed road shoulders are of sufficient width to permit cycling (i.e. wider than 2.0 metres), signage and PS-2 bicycle logos can be used to designate the shoulder's shared use for motor traffic and cycling, and to increase driver awareness. An example of such a treatment is shown in Figure 1.

While for the purposes of cycling it is desirable to seal road shoulders where a width of 2.0 metres can be achieved, such treatments have high financial cost as all road shoulders need to be constructed to cater for heavy vehicle usage.

Edge lines

Where sealed road shoulders are provided edge lines are used at the edge of the traffic lane to distinguish the traffic lane from the shoulder. These markings reduce the likelihood of moving traffic travelling in the road shoulder. The requirements for providing edge lines are contained in the relevant Australian Standard and vary depending on the road type as summarised in Table 4.

Advisory bicycle lanes

Advisory bicycle lanes (also known as suggestion lanes) are semi-formal facilities which indicate an area of the carriageway that is intended for use by cyclists and is

Table 3. Minimum sealed shoulder widths by road type

Road type	Minimum sealed shoulder width
Urban freeway	Between 2.0 and 3.0 m (3.0 m allows enough room for a truck to pull off clear of the traffic lane) 3.0 m adjacent to a safety barrier or on a freeway with 3 or more lanes
Rural road - single carriageway	Between 0 and 1.5 m, increasing with increasing traffic volumes
Rural road - divided carriageway	1.5 m where design AADT < 20,000, or 2.5 m if it is beside safety barriers and on the high side of superelevation 3.0 m where design AADT > 20,000, or 3.0 m if it is beside safety barriers and on the high side of superelevation
General	A minimum of 0.5 m where AADT < 1,000 Consideration should be given to sealing the full width of the shoulder under certain conditions (see p. 38 of Austroads AGRD03 2009a for a more extensive list) A minimum of 2.0 to 3.0 m to cater for bicycles

Table 4. Requirements for marking edge lines on rural roads

Road type	Divided?	Further description	Requirements regarding edge lines
Rural	No	Sealed pavements less than 5.5m wide	Edge lines shall not be used
		Sealed pavements between 5.5m and 6.8m wide	Edge lines are generally not used unless the conditions are poor (e.g. poor alignment, frequent fog, etc). Edge lines shall not be used unless: a dividing line is also marked and the lane widths within the edge lines are at least 3.0m or if there is a high proportion of heavy vehicle traffic, 3.2m There are some exceptions, for example at localised pavement narrowing.
		Sealed pavements 6.8m wide or greater	Edge lines are normally required
	Yes	Including rural expressways	Edge lines shall be marked

delineated from the adjacent traffic lane by a ‘broken’ longitudinal line with gaps. Motorists are advised, but not required to keep out of advisory cycle lanes, unlike formal bicycle lanes. Contrasting coloured pavement is often used on bicycle advisory lanes to improve delineation. Parking is not permitted in advisory cycle lanes.

Advisory cycle lanes are used where there is insufficient road width to provide formal bicycle lanes (which are delineated from the adjacent traffic lane by a continuous line with no gaps.) On roads with advisory cycle lanes, no centre line is provided, resulting in vehicles generally travelling in the centre of the carriageway. When vehicles from opposing directions pass one another, they can enter the bicycle lane where it is safe to do so. As such advisory cycle lanes are shared by cyclists with vehicles.

Advisory cycle lanes also give the perception that the carriageway is narrower than it is which in turn functions as a method of traffic calming by reducing vehicle speeds.

Advisory cycle lanes are used widely on urban and rural roads in the US and Europe, and in particular in the UK, Netherlands, Denmark and the Republic of Ireland. The Netherlands mainly utilise shared bicycle lanes on narrow urban and rural collector roads with low to moderate traffic to allow roads to remain two-way and still provide bicycles

with a safe lane of travel. An example layout of advisory cycle lanes contained in guidelines from Europe is shown in Figure 2.

There is little formal guidance on the use of advisory cycle lanes in Australian and NZ jurisdictions. In NSW, bicycle shoulder lanes would be the most similar facility with the shared use status being indicated by bicycle logos (PS-2) and solid edgelines rather than unbroken lines. Examples of advisory cycle lanes from Europe are shown in Figure 3 and Figure 4.

In many respects vehicle movements on roads with advisory cycle lanes are similar to historical rural road environments whereby a 3.7 metre wide sealed road width was provided and drivers would use unsealed shoulders to pass oncoming traffic.

On many roads in rural areas of Australia and NZ, traffic volumes do not exceed 150 vehicles per day (Average Annual Daily Traffic, AADT). In such environments, current Australian guidance permits the use of single lane carriageways with a minimum width of 3.7 metres. A carriageway width of less than 3.7 metres can result in excessive shoulder wear. A carriageway width greater than 4.5 metres but less than 6.0 metres may lead to two vehicles attempting to pass while remaining on the seal, potentially

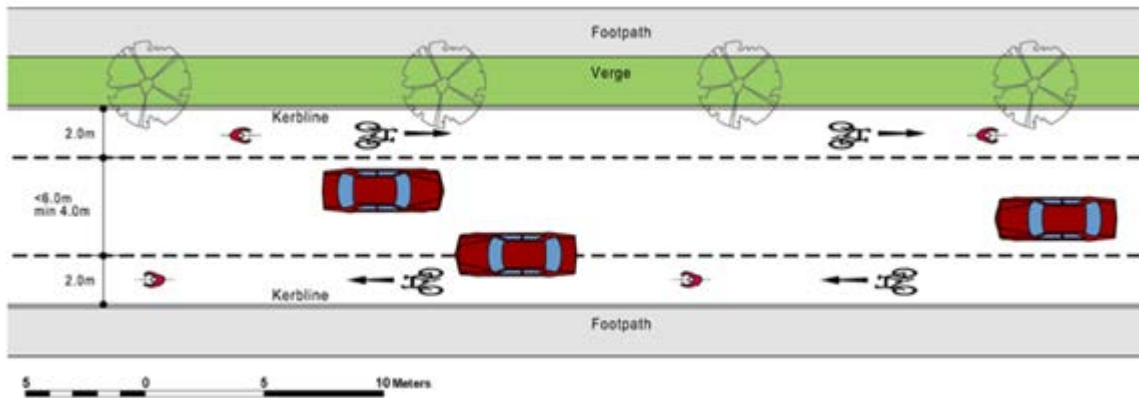


Figure 2. Advisory cycle lanes



Figure 3. Advisory cycle lanes



Figure 4. Advisory cycle lanes

resulting in head-on accidents. The width requirements for single carriageway rural roads are contained in Austroads guidelines and are summarised in Table 5.

Conformity with Australian Road Rules

A review of current Australian Road Rules indicates there are no road rules that would prevent the implementation of advisory cycle lanes. The following road rules are of particular importance with respect to advisory cycle lanes:

- **150 Driving on or across a continuous white edge line**

(1A) A driver may drive on or over a continuous white edge line on a road if the driver is:

(e) avoiding an obstruction.

- **129 Keeping to the far left side of a road**

(1) A driver on a road (except a multi-lane road) must drive as near as practicable to the far left side of the road.

This rule does not apply to the rider of a motor bike. In this rule – road does not include a road-related area.

Note: Road related area includes the shoulder of a road.

Schedule 4 of the NSW Road Rules provides the following definition of an obstruction:

“obstruction includes a traffic hazard, but does not include a vehicle only because the vehicle is stopped in traffic or is travelling more slowly than other vehicles.”

In recently developing a Council Bike Plan, consultation with a State Road Authority was undertaken in relation to the legality of advisory cycle lanes. A preliminary assessment indicates that advisory cycle lanes are permissible.

Minimum passing laws

A recent Queensland parliamentary inquiry investigated ways to improve the interaction between cyclists and

Table 5. Single carriageway rural road widths (metres)

Element	Design AADT				
	1 – 150	150 – 500	500 – 1,000	1,000 – 3,000	> 3,000
Traffic lanes ⁽¹⁾	3.7 (1 x 3.7)	6.2 (2 x 3.1)	6.2 – 7.0 (2 x 3.1/3.5)	7.0 (2 x 3.5)	7.0 (2 x 3.5)
Total shoulder	2.5	1.5	1.5	2.0	2.5
Minimum shoulder seal ^{(2),(3),(4),(5),(6)}	0	0.5	0.5	1.0	1.5
Total carriageway	8.7	9.2	9.2 – 10.0	11.0	12.0

1. Traffic lane widths include centre-lines but are exclusive of edge-lines.
2. Where significant numbers of cyclists use the roadway, consideration should be given to fully sealing the shoulders. Suggest use of a maximum size 10mm seal within a 20 km radius of towns.
3. Wider shoulder seals may be appropriate depending on requirements for maintenance costs, soil and climatic conditions or to accommodate the tracked width requirements for Large Combination Vehicles.
4. Short lengths of wider shoulder seal or lay-bys to be provided at suitable locations to provide for discretionary stops.
5. Full width shoulder seals may be appropriate adjacent to safety barriers and on the high side of superelevation.
6. A minimum 7.0 m seal should be provided on designated heavy vehicle routes (or where the AADT contains more than 15% heavy vehicles).

other road users. The report made 68 recommendations to improve interactions between motorists and cyclists, and also the safety of cyclists on the road.

Following the inquiry, new legislation was introduced in Queensland related to the minimum passing distance for cyclists riding on-road. In 2014, new legislation came into force where, by law, motorists must stay wider of a cyclist riding on-road by giving:

- a minimum of 1.0 metre when passing cyclists in a speed zone of 60km/h or less; and
- 1.5 metres where the speed limit is over 60km/h.

Under the law motorists can cross centre lines (including double unbroken centre lines), straddle lane-lines and drive on painted islands to pass cyclists, provided the driver has a clear view of any approaching traffic and it is safe to do so. Motorists who break the rule will receive three demerit points and a fine of \$330. A maximum fine of \$4,400 can apply if the matter goes to court. The law applies to all vehicles on the road including motorcycles, heavy vehicles and public transport vehicles.

These new road rules will initially be trialled over two years. This law is the first of its kind in Australia and will road-test the impact the rules have on saving lives.

Many cyclist fatalities on the road are caused by cyclists being hit from behind by vehicles travelling in the same direction. Introducing a minimum distance for passing cyclists is intended to reduce confusion about how much space is safe when passing a cyclist and to raise awareness of the vulnerability of cyclists on the road.

Increasing driver awareness

Increasing driver awareness of the presence of cyclists is important for improving the safety of on-road cyclists. There are currently few bicycle warning signs or share the road signs in many rural road locations across Australia and NZ. This factor, coupled with the lack of dedicated on-road bicycle infrastructure results in a road environment whereby many motorists are not anticipating encountering cyclists, let alone groups of training cyclists which can be found in many locations.

Static signage

Providing bicycle warning signage on key on-road routes and in particular those popular with bunch riders/ training cyclists will increase driver awareness of the presence of cyclists. Such signage also assists to legitimise cyclists riding on-road. Bicycle facility warning and guidance signage used in NSW are shown in Figure 5.

Of the warning signs shown in Figure 5, the bicycle warning sign (W6-7) and the share the road sign (W6-214) are the appropriate signs for use on the roads outside the shire's main centres. Such signs are used extensively across Australia.

Electronic bicycle activated warning signs

Electronic bicycle activated warning signs have recently been installed at several locations in Australia and New Zealand to increase driver awareness of the presence of cyclists. The sign illuminates the LED warning sign once activated by a cyclist, generally using induction loops under the carriageway.



Figure 5. Warning and guidance signage for bicycle facilities (source: NSW Bicycle Guidelines)

Such signs have been used at physically constrained locations such as on bridges, where bicycle lanes are present on approach but due to the limited road width it is not possible to provide formal bicycle lanes across the bridge. Examples of electronic bicycle activated warning signs in Australia are shown in Figure 6 and Figure 7, with an example from New Zealand shown in Figure 8.

These signs can feature solar power; bicycle induction loops located under the carriageway which detect bicycle movements, activating the sign; and a push button for manual call-up.

There is significant opportunity for the implementation of such signs on roads which connect the towns and villages of the shire. Solar powered versions offer a cost-effective solution where cabling to supply mains power is unnecessary.

Bicycle awareness zone pavement symbols

Bicycle awareness zones are treatments used to highlight the presence of cyclists at locations where cyclists transition from road shoulders to the vehicle travel lane. Such treatments generally use line marking and signage to highlight the presence of cyclists at specific locations and are used in both urban and rural road environments.



Figure 6. Bicycle activated warning sign

There is a real opportunity to implement bicycle awareness zone treatments at locations where road shoulders terminate, such as at bridges, culverts and adjacent to safety barriers. At these squeeze point locations, there is generally not a viable alternative route and cyclists are forced to merge into the vehicle travel lane. Bicycle awareness zones are used specifically to increase driver awareness of the transition of cyclists from the road shoulder to the vehicle travel lane.



Figure 7. Bicycle activated warning sign push button



Figure 8. Bicycle activated warning sign (source: Opus International Consultants Ltd)

Sharrow road markings

Previously used in the US, sharrow road markings have been used in several jurisdictions in Australia to raise awareness of cyclists on the road where the road narrows and cyclists must ride in traffic lanes. Sharrows are used in similar scenarios to bicycle awareness zones.

An example sharrow road marking treatment on approach to a single lane roundabout in Australia is shown in Figure 9.

A study commissioned by a State road authority indicates that use of sharrows at other locations has improved safety and comfort of cyclists and enabled cyclists to ‘claim the lane’. This allows cyclists to comfortably ride in the middle of the lane which removes cyclists from the ‘door-opening’ zone adjacent to parked cars.

While Figure 9 shows the application of sharrows in an urban environment, there is opportunity to utilise sharrow road markings in rural roads. Sharrows could be used where sealed road shoulders terminate such as at bridges, culverts and guard rails to highlight locations where cyclists are merging to travel in the vehicle lane.



Figure 9. Sharrow road markings

International guidance and research

The majority of research related to the planning, design and implementation of advisory cycle lanes in rural road environments originates from Europe. The below section summarises key international guidance on the use of, and effects of the implementation of, advisory cycle lanes on rural roads.

United Kingdom

The primary guidance document for bicycle facilities design in the UK provides the following guidance on the use of advisory cycle lanes:

- used to signify that vehicles other than cyclists should not enter the lane unless it is safe to do so
- not recommended where they are likely to be blocked by parked vehicles
- are useful treatments across intersections to help raise driver awareness of the likely presence of cyclists.

Table 6 summarises the guidance for advisory cycle lanes based on half-carriageway width. It is important to note that cycling is not permitted on motorways in the UK.

The Republic of Ireland

Irish national cycling guidelines on the use of advisory cycle lanes in the Republic of Ireland include:

- advisory cycle lanes are to be a minimum of 2.0 metres wide
- the adjacent carriageway is to be a minimum of 4.0 metres wide and less than 6.0 metres wide where traffic flow is two-way
- road centrelines shall not be provided
- the maximum speed limit shall be 50 km/h or less

Table 6. Options for advisory cycle lanes on two-way roads based on half-carriageway width

	Half-road width (m)	Minimum cycle lane width (m)	General traffic lane width (m)	Notes	Drawing number
No parking/loading	3.5–4.4	1.5	2.0–2.9	2-way motor vehicle flows<5000vpd 30mph max speed limit	CCE/B6
	3.5–4.0	1.5	2.0–2.5	2-way motor vehicle flows<5000vpd 30mph max speed limit with central refuge/islands Diag 1010 marking	CCE/B7
	≥4.0	1.5	≥2.5	alongside refuge/islands	CCE/B7
	4.5–5.0	1.5–2.0	≥3.0	All cases (mandatory lanes preferred)	-
With parking/ loading bay 1.8m wide	5.3–6.3	1.5–2.0	2.0–2.5	2-way motor vehicle flows<5000vpd 30mph max speed limit Coloured surface lane only with no road markings – minimum width of 1.5m	CCE/B9
	≥6.3	1.5 plus 0.5m gap to parking bay	≥2.5	2-way motor vehicle flows<10000vpd 30mph max speed limit	CCE/B9

Notes:

1. Lane widths are measured from kerb face to centreline of markings
2. Cycle lanes on roads with 40mph or higher speed limit should preferably be wider than 1.5m

- they are most effective where there is no demand for kerbside parking
- coloured surfacing is only required at conflict points or where an area may be confused with on-street parking
- only to be used in exceptional circumstances where formal bicycle lanes are inappropriate.

The Netherlands

The comprehensive guide for the planning and design of bicycle facilities in the Netherlands outlines that advisory cycle lanes are an appropriate treatment where:

- the speed limit is 60 km/h or less
- the road has less than 3,000 vehicles per day and less than 300 vehicles per hour
- edge lines should be marked along the edge of the sealed road pavement no more than 0.3 metres from the road edge.

It is noted that the Dutch guidance related to maximum vehicle volumes for roads where advisory cycle lanes are appropriate is 3,000 vehicles per day. This volume is higher than that provided in Austroads for single carriageway roads (Table 5) of 150 vehicles per day where no sealed shoulder is provided.

The research from the Netherlands noted that the crux of advisory cycle lanes was the method of how to mix bicycles

and vehicles in a safe manner which directly related to three key parameters:

- vehicle speed
- vehicle volumes
- physical size differential (i.e. difference in size between cyclists and heavy vehicles).

Reducing the speed of the motorised traffic should not be done radically. The low profile speed humps used in locations in The Netherlands (Figure 10) on roads with a speed limit of 60 km/h can be negotiated comfortably by vehicles travelling at or below the speed limit. These speed humps are typical in height (100mm above the pavement) but the ramps extend up to 5.0 metres in length. Such low profile speed humps with extended ramp lengths enable good rideability for cyclists.

Reducing vehicular traffic volumes is difficult and often requires considerable effort to persuade drivers to choose alternate routes. When the volumes are too high, it is necessary to consider cycle paths with a physical segregation from motorised traffic. Sometimes there is a need to consider both speed and volume reductions.

No formal evaluation was carried out, but private communications with the project manager are summarised in Table 7.

Table 7. Advisory rural cycle lanes - before and after traffic patterns

Parameter	Before	After
Example 1		
Traffic Calming and Cycling	-	Stage 1) 60km/h speed humps Stage 2) two-way shared path, separated from the road
Traffic Volume	2,500 vehicles per day	2,500 vehicles per day
Bicycle Volumes	not provided, mainly recreational/	weekend cyclists
Speed Limit	80 km/h	60 km/h
Speed Travelled	100 km/h	65 – 70 km/h
Example 2		
Traffic Calming and Cycling	-	60km/h speed humps spaced at 300-500m), red bicycle (suggestion) lanes, single car lane for two way traffic
Traffic Volume	3,000 vehicles per day	3,000 vehicles per day
Bicycle Volumes	150 cyclists per day (commuters)	150 cyclists per day (commuters)
Speed Limit	80 km/h	60 km/h
Speed Travelled	80 – 100 km/h	65 – 70 km/h

**Figure 10. A 60km/h speed hump**

Sweden

The Swedish conducted trials of advisory bicycle lanes on two rural roads, including before and after traffic surveys and user interviews. Similar to Australia and NZ, advisory lanes in Sweden are classified as road shoulders (i.e. “vägren”), the key parameters of which include:

- Pavement width – 6 metres
- Bicycle lane width - 1.25 metres
- Vehicle travel lane width (two-way) - 3.5 metres
- Speed limit – 70 km/h
- Vehicle volumes – 1,500 vehicles per day.

The travel lane is designed to carry traffic in both directions, i.e. one lane for two way traffic, with vehicles using both shoulders to pass. This is akin to historical rural road environments with very low volumes, where the main carriageway is sealed and the shoulders are gravel. Two sites were investigated, with the results of the formal before and after evaluation summarised in Table 8.

Conclusion

High speed rural roads present an increased safety risk to all road users including cyclists. In many rural road environments in Australia and New Zealand there is little provision for cyclists. Where road shoulders are available, they provide operating space for cyclists outside of the vehicle travel lanes, however on many two-lane, two-way rural roads, there are no road shoulders.

Providing off-road paths as an alternative to on-road facilities on higher speed rural roads is often not feasible in Australia and New Zealand due to the high financial cost, long distances of facilities required and land ownership issues. Advisory cycle lanes are an internationally established, relatively low-cost treatment for cyclists on rural roads, where there is insufficient width for dedicated bicycle lanes. Such facilities also have the potential to reduce vehicle speeds, thereby increasing safety for all road users.

It is hoped that Australia and New Zealand may be able to trial advisory cycle lanes in the future.

Table 8. Advisory rural cycle lanes - before and after traffic patterns in Sweden

Parameter	Before	After
Example 1		
Traffic Calming and Cycling	-	bicycle suggestion lanes (road shoulders)
Traffic Volume	864	848
Bicycle Volumes	56	56
Speed Limit	70 km/h	
Speed Travelled – 85th%ile		
- cars	80.0 km/h	80.0 km/h
- trucks	73.2 km/h	71.1 km/h
Lateral Clearance		
- car to bike	-	-
- bike to berm	-	-
Crashes	5 (5 years to 2010)	4 (22 months to August 2013)
Example 2		
Traffic Calming and Cycling	-	bicycle suggestion lanes (road shoulders)
Traffic Volume	1,745 vehicles per 16 hours	1,426 vehicles per 16 hours
Bicycle Volumes	49 bicycles per 16 hours	56 vehicles per 16 hours
Speed Limit	70 km/h	70 km/h
Speed Travelled – 85th%ile		
- cars	75.5 km/h	75.0 km/h
- trucks	70.7 km/h	62.8 km/h
Lateral Clearance		
- car to bike	2.3 metres	2.9 metres
- bike to berm	0.45 metres	0.86 metres
Crashes	4 (5 years to 2010)	0 (22 months to August 2013)

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