Evaluation of Australia's bicycle helmet laws

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Abstract

Australia's bicycle helmet laws were introduced in 1990-1992. Surveys and census information show the laws discouraged cycling, by more than 40% in some cases. Per million population, approximately two cyclist deaths occur annually compared to 2000 from cardiovascular disease. Dr Mayer Hillman from the UK's Policy Studies Institute calculated that life years gained by cycling outweighed life years lost in accidents by 20 times. The helmet laws have not delivered a net societal health benefit, with a calculated cost benefit ratio of 109 to 1 against. Comparing cyclists to pedestrians, pre-law (1986-89) cyclist deaths were 16.4% of pedestrians in number and in 2010-13 the figure was 22.7%. The ratio of serious injuries of cyclists compared to pedestrians increased from 1.49 in 1990 to 2.6 in 2008/09. This evaluation finds the helmet laws have failed in respect to the promotion of cycling, health, accident compensation, environmental issues and civil liberties. In addition, it has hindered the implementation of bike share schemes. There are serious concerns about the safety consequences of cycle helmets, with mixed evidence both for and against.

Background

In the early 1980s Australia had a road fatality rate of about 22 per 100,000 population and efforts to improve road safety were being made. By 1989 the rate was 16.5 per 100,000 population[1]. Schools were providing bike education courses to encourage safe riding behaviour[2]. Regular cyclists had an estimated fatality rate of 27 to 54 per billion kilometres[3] or about one per 180,000 population per annum. The risk level for cyclists varied with the road type. Major arterial roads in Melbourne were reported to be about nine times higher risk per kilometre of travel than minor roads. The accident rates in 1984-86 varied by age group with the ratios quoted: up to 11 years of age rated 1.0, the 12-17 age range rated 3.7 to 4.0 and for the 18 years and older 2.5 to 2.9[4]. In comparison to Great Britain, with a fatality rate of about 50 per billion kilometres in the late 1980s[5], the risk from cycling appeared to be similar. During the 1980s a focus on helmets developed, leading to recommendations for introducing a mandatory requirement[6].

In 1982 McDermott and Klug examined data for the period 1975 to 1980 and reported skull fractures for pedal cyclists exceeded those of motorcyclists in Victoria. However, fatalities were higher for motorcyclists/pillion passengers (497 cf 181)[7]. Per hour of travel, motorcyclists had about 16 times the fatality risk of cyclists[8]. Following the McDermott and Klug report, the Australian Medical Association (AMA) in 1983 adopted the policy of compulsory helmet wearing for pedal cyclists.

In 1983 a survey of attitudes revealed a strong negative reaction by older boys to bicycle helmets[9].

In 1985 a report from the Australian Capital Territory (ACT) detailed bicycle crashes[10]. Cyclist crashes resulting in hospital admission and involving a motor vehicle were age related: less than 11 years - 25% of crashes, 11-20 years - 52% of crashes, over 20 years - 23% of crashes. Three-quarters of all crashes involved a cyclist under the age of 19. For the under-16 age group, in 86% of cases they were judged to be responsible for traffic violations leading to an accident. Cyclists on average had shorter length of hospital stays compared to other road users.

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[1] Road Fatality Statistics Australia, 1992 FORS

[2] Safe roads for Children, Social Development Committee, Parliament of Victoria 1987.

[3] Mathieson JD, Gaps in current knowledge, Table 3, Bikesafe Conference, Newcastle, Australia, 1986.

[4] Drummond AE, Lee FM, The risk of bicycle accident involvement, Oct 1988 MUARC Appendix 6

[5] British Medical Association; Cycling towards Health and Safety, Oxford University Press,1992.

[6] Safe roads for Children, Social Development Committee, Parliament of Victoria 1987.

[7] McDermott FT, Klug GL Differences in head injuries of pedal cyclist and motorcyclist casualties in Victoria. The Medical Journal of Australia[1982, 2(1):30-32

[8] Clarke CF, The Case against bicycle helmets and legislation, VeloCity Munich, 2007. http://www.ta.org.br/site/Banco/7manuais/colin_clarke_cycle_helmet.pdf

[9] Wood T, Milne P, Head injuries to pedal cyclists and the promotion of helmet use in Victoria, Australia, Accid Anal & Prev Vol 20 No 3, p177-185, 1988

[10] Whately S, Bicycle Crashes in the Austrian Capital Territories, CR 35, FORS, 1985,p13 http://www.infrastructure.gov.au/roads/safety/publications/1985/pdf/Bic_Crash_1.pdf

Survey information from 1985/86,[11] for cyclists nine years or older, detailed that the group 9-16 years accounted for approximately 60% of all cycling travel in Australia.

Details for Queensland from the 85/86 survey reported cycling of 893,000 km per day (Brisbane 195,000km per day, rest of the state 699,000km per day). The average distance cycled per person for Queensland was about 40% higher than the national average. In 1985 about 75% of Queensland cyclist casualties were aged less than 20 years of age[12]. The accident rate for adults (20-70) averaged about eight per 100,000 people, whereas for the 5-19 age groups it was 72 per 100,000 people.

A 1986 report on child cyclist injuries from Redcliffe Hospital, Brisbane, detailed 93% of cases were not life threatening and from 18 admissions, they included nine with minor head injury for overnight observation[13]. In 1987 a report based on Brisbane hospitals detailed a majority of children aged five to seven years were in favour of wearing helmets, whereas older children were opposed[14]. Many children had helmets but did not wish to wear them. From 150 children admitted for head injuries, only two had worn helmets, 143 had a Glasgow coma score rating of nine or higher (mild to moderate head injuries) and all 143 made a good recovery. All admitted had skull x-rays and 18 had head computerised tomography (CT) scans.

A report from South Australia by Dorsch in 1987 claimed that helmets could save up to 90% of cyclists who had died of head injuries[15]. This report contributed to calls for helmet legislation. It was reported that Dr Dorsch, the report's principal author, told an Australian parliamentary committee that the conclusions of the study should be treated with care. She said: "That was a hypothetical procedure based largely on an adult group of cyclists"[16].

National fatality data[17] from 1988 reported the proportion of road accident deaths due to head injuries - see Table 1 for deaths and Table 2 for the coroner's assessment of final cause of death.

Totals	Cyclist - 86	Peds. - 541	MVO - 1910
0-12 yrs	84% (19)	96% (72)	87% (79)
13+	79% (67)	76% (469)	67% (1831)

Table 1

Totals	Cyclist - 40	Peds. - 233	MVO - 688
0-12 yrs	58% (11)	54% (39)	53% (42)
13+	43% (29)	41% (194)	35% (646)

Table 2

[11] Day–to-Day Travel in Australia, CR 69, INSTAT, FORS 1988.Table 4.1e http://www.infrastructure.gov.au/roads/safety/publications/1988/pdf/Aust_Trav.pdf accessed 11.1.2014

[12] Bicycle Safety in Queensland, p88, Bikesafe Conference, Newcastle, Australia, 1986

[13] Armson CJ, Pollard CW, Child cyclist injuries; a prospective study. Feb 3 Vol 144, Med.J.Aust. 1986.

[14] O'Rourke NA, Costello F, Yelland JDN, Stuart GG, Head injuries to children riding bicycles, Vol146 June15, Med J Aust. 1987

[15] Dorsch M M, 'Do bicycle safety helmets reduce severity of head injury in real crashes'. Accid. Anal. & Prev. Vol 19, pp183-190, 1987.

[16] 7 Reasons to Oppose a Child Helmet Law, http://www.cycle-helmets.com/ctc_child_cycling.pdf accessed 28.12.2014 LAW, 28.12.2014

[17] Attewell RG, Dowse MJ; Fatal crash types, Analysis of 1988 Fatality File, CR 105, FORS, Australia, March 1992.

Children in all groups had a higher proportion of deaths due to head injuries than adults. In 1993 more than 850 deaths in Australia were recorded as due to falls[18] (note: cyclists who fall are likely to be recorded in road accident statistics whereas pedestrians who fall would be unlikely to be included).

Transport Accident Commission (TAC) data from Victoria[19] for head injury claims by bicyclists involved in motor vehicle accidents detailed that most were aged less than 18 years of age in the period 1987-1989 - see Table 3 (added Melbourne cycling exposure 1987/88 data - refer Fig 9 Cameron 1992 and Fig 27, Finch 1993).

Age	Head	Concussion	Hd + Conc	Total claims	Percent Hd+Conc	Approximate exposure, billions of seconds per week
0-11	48	27	75	514	14.6	5-6
12-17	82	45	127	1162	10.9	9-11
18+	40	22	62	812	7.6	5-6
total	170	94	264	2488	10.6	20-24

Table 3 TAC head injury claimants 1987-89

From the 170 claims for head injury, approximately 28.2%, 48.2% and 23.5% came from the age groups 0-11, 12-17 and 18+ respectively. The head and concussion percentage rates for pedestrians were similar to cyclists by age group, 15.3%, 13.0%, 8.9% and overall 10.7%. Cyclist exposure information for Melbourne details the 5-18 age group having about three to four times that of adults in 1987/88.

Western Australia data for the years prior to legislation, 1986 to 1991, detailed approximately 75% of head/concussion and unspecified head injuries were to the under 18 year olds[20].

Data from the 1980s for Victoria was used to assess the rate of serious injury per 10 million km[21]. It varied by age group as shown in Table 4. The 'All' rate was 39 for males and 21 for females. On average, one injury equated to approximately 285,000 km cycled.

Age	9-10	11-13	14-17	18-29	30-60	60-64	65 +	All
Rate	107	45	32	16	22	12	110	35

Table 4 Approximate serious injury rate per 10 million km

From the published data, estimates of the injury rate for cyclists 9-16 years can be compared with 17+ age rates. Roughly, the 9-16 age group had a rate of 55 and the 17-64 age group a rate of 20 and for age 65+ a rate of 110 per 10 million km. Indications are that the 65+ group comprised about 1% of distance cycled, the 0-16 age group about 60%, and the 17- 64 age group about 39%.

Proportion of children's injuries

VISS data from Victoria[22] provided information on the distribution of injuries for children younger than 15 years of age, as shown in Figure 1.

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[18] Road deaths in Australia ABS
http://www.ausstats.abs.gov.au/ausstats/free.nsf/0/7C032330AC753A38CA257225000494E1/$File/33030_1993.pdf
accessed 21.11.2014

[19] Traffic Accident Commission data provided to C Clarke 1993

[20] Heathcote B, Bicycle helmet wearing in Western Australia, A 1993 Review, WA Police Depart. 1993 Appendix 10

[21] Victorian Bicycling Strategy; Vic Roads, Australia 1990.

[22] Victorian Injury Surveillance System, Hazard Vol 6, Dec 1990

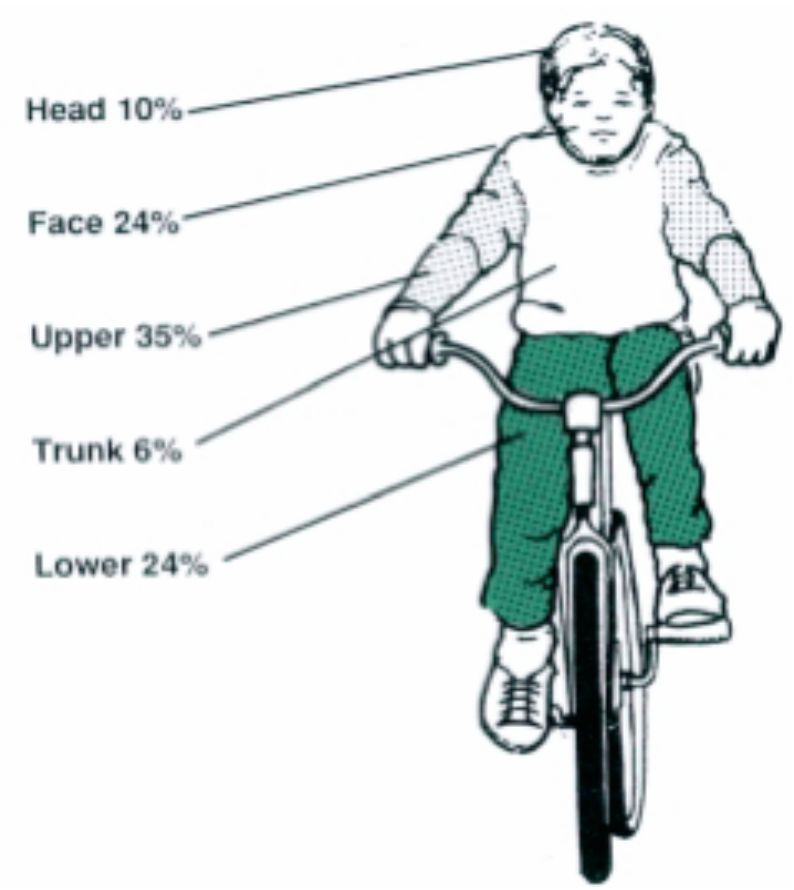

Figure 1 Percentage of injuries to child cyclists

Helmet wearing rates

Vic Roads had conducted annual surveys of the wearing rates from 1983 to 1990[23]. For primary schoolchildren the rate had increased in each year but for secondary it had reduced in the Melbourne area in 1988 and 1989. For adults the highest wearing rates reported were 46% for commuters in Melbourne and the lowest for recreational in country areas at 10%[24]. Other states seem to have lagged behind Victoria in the wearing rates[25].

Standards

The mandatory helmet standard is based on requirements specified and varied in the Regulations as published in AS/NZS 2063:2008-Bicycle helmets. In the late 1980s, investigations into helmet standards and designs were still being considered. Just before introducing legislation the standards changed to allow for soft shell outer covering. Brain injury is associated with linear and rotational acceleration and cycle helmets are only approved in tests for linear acceleration. Curnow discusses the issues involved in some detail[26]. In the 1990s, British Standards had no information on the effects of helmet weights on riding stability[27]. Helmets can weigh up to about 700 grams. Figure 2 shows x ray images.

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[23] Bicycle Helmet Usage Rates in Victoria 1983-1990 Vic Roads http://trid.trb.org/view.aspx?id=344514

[24] Victorian Bicycling Strategy; Vic Roads, Australia 1990.

[25] Walker M.B. Law compliance and helmet use among cyclists in New South Wales. April 1991 http://www.bicycleinfo.nsw.gov.au/downloads/cycle_research/law_compliance_and_helmet_use_amongst_cyclists_in_nsw_april1991.pdf

[26] Curnow WJ. Bicycle helmets; a scientific evaluation, Transportation Accident Analysis & Prevention, Nova Science Publishers, Chapter 6. 2008. http://www.cyclehelmets.org/papers/p787.pdf

[27] Letter to C Clarke, BSI Testing, 21 Nov 1994.

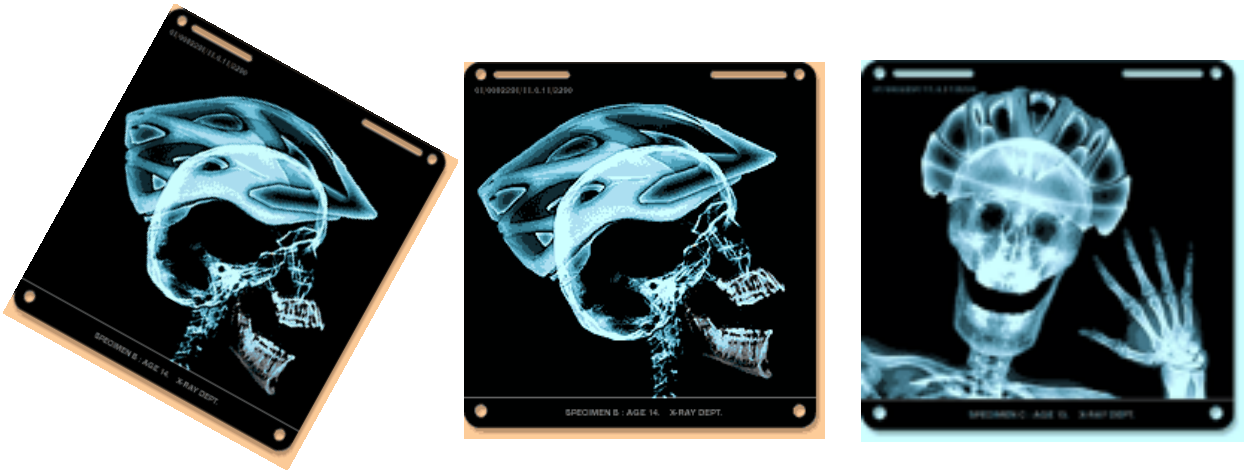

Figure 2

Legislation and enforcement

Legislation started in Victoria on 1 July 1990 and then followed in other states and territories - refer Table 5. Exemptions from the legal requirement are sometimes allowed on medical or religious grounds.

State	Introduced	Effective from	Fines imposed, limited data
Vic	1.7.1990		19,229 1st 12 month 20314 in 1997 15,950 in 1999 20,000 in 2003
NSW adults	1.1.1991	Initially low enforcement level	5853 in 1991 15,281 in 1992 14,072 in 1993
NSW children	1.7.1991		
QLD	1.7.1991	1.1.1993	22,654 in 1993 14,934 in 2000 Approx 7500 in 2010
SA	1.7.1991		
WA	1.1.1992	1.7.1992	
NT	1.1.1992		
ACT	1.7.1992		
Tas	1.1.1991		

Table 5 Legislation dates, enforcement and fines

Note: *http://www.cyclehelmets.org/ and http://www.cycle-helmets.com/ provide additional information. The Northern Territory removed the requirement for adults on cycle paths to wear helmets in 1994.*

Cycling activity assessment

Victoria

In 1990 bicycle helmet legislation in Victoria was associated with a drop of 36% in the numbers cycling in Melbourne[28] - see Figure 3. Post law in 1991, 10% extra wore helmets compared to 36% fewer people cycling. It is evident that it had discouraged cycling, which was in sharp contrast to seat belts which did not discourage driving.

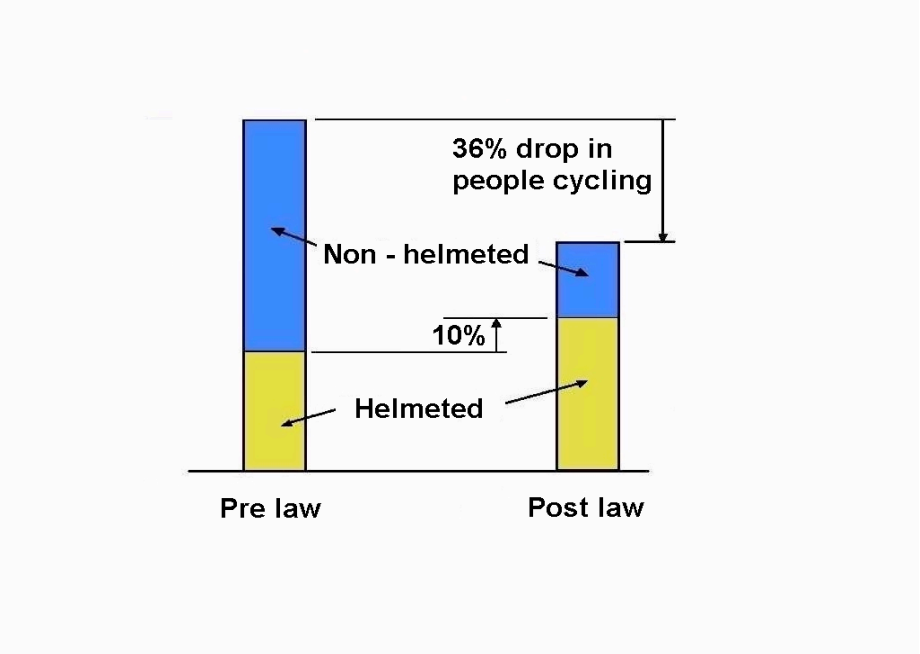

Figure 3 Changes pre to post law for Melbourne

***Note**: Figure 3 is based on data from Table 4, Robinson 1996[29] - 1110 fewer cyclists and 297 extra wearing helmets.*

A major criticism of the law in 1991 was that it had reduced cycling levels and one article, 'Riding numbers plummet'[30] reported that it seemed people who did not want to wear them had ceased cycling altogether - refer Appendix B.

A before-law survey in Melbourne showed that 272 out of 1293 teenagers (12-17yrs) wore helmets. In 1991 after the law was enforced, 302 wore helmets out of 670.

The law resulted in 30 more teenagers wearing helmets compared with 623 fewer cycling, a drop of 48%[31]

A major change occurred in teenage behaviour by stopping or reducing their cycling. Teenage bicycle use fell from a reported 13.1 billion seconds per week (3.64 million hours) in 1990 to 7.1 billion seconds per week in 1992, or a 46% decrease from pre law levels[32]. TAC data for Victoria reports 353 claims for the 12-17 age group in 1989, 303 in 1990, 200 in 1991, 198 in 1992, 188 in 1993 and 164 in 1994, so it appears that additional reductions for teenagers occurred in 1993 and 1994.

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[28] Finch C, Heiman L, Neiger D; Bicycle Use and Helmet Wearing Rates in Melbourne, 1987 to 1992: The Influence of the Helmet Wearing Law; Report 45. Melbourne (Vic): MUARC, 1993.

[29] Robinson DL; Head injuries and bicycle helmet laws; Accid Anal Prev, 28, 4: p 463-475, 1996 http://www.cycle-helmets.com/robinson-head-injuries.pdf

[30] Shepherd R, Helmet law discourages cycling, Australian Cyclist, Oct 1991

[31] Robinson DL; Head injuries and bicycle helmet laws; Accid Anal Prev, 28, 4: p 463-475, 1996 http://www.cycle-helmets.com/robinson-head-injuries.pdf

[32] Finch C, Heiman L, Neiger D; Bicycle Use and Helmet Wearing Rates in Melbourne, 1987 to 1992: The Influence of the Helmet Wearing Law; Report 45. Melbourne (Vic): MUARC, 1993.

For other parts of Victoria that generally had a higher proportion of cycling than in Melbourne and lower helmet wearing rates,[33] the reduction appeared to be similar or even higher judging by accident data for Melbourne compared with country locations[34,35]. Cameron et al 1992 and Carr et al 1995 provide related information. Cameron provided data to 1991 for head and other injuries. Carr detailed hospital admission head injury data for Victoria and Melbourne - Tables 6.4.1 and 6.4.2. The average reduction for 1991 and 1992 compared with 1988 and 1989 was 32% for Melbourne and 44.5% for country areas, suggesting more of a reduction in cycling levels for regional areas of Victoria.

VicRoads annual surveys

Morgan et al provided details of adult commuters counted in 1990 and 1991 - 5162 and 3226, a drop of 37%. They also detailed numbers counted at recreational sites - 2494 in 1990 and 1479 in 1991, a drop of 41%[36]. For Melbourne, cyclists aged 5-18 reportedly cycled 17.8 billion seconds per week pre law in 1990[37] and this dropped by 36% to 11.3 billion seconds by 1992. Estimating the population size for the 5-18 age group in 1990 to be about 600,000, this would equate to approximately 30,000 / 34,000 seconds per week for each person, or about eight hours per week on average. Garrard reported that Melbourne children aged 10-14 in the 1994-99 period averaged 26km per year[38] and this translated to about 400 seconds per week[39], or seven minutes. In Victoria, the number of children cycling to school halved between 1985 and 2001[40].

TAC accident data show a major reduction in claims by cyclists less than 18 years of age - see Table 6 and notes for details.

	1988	1990		1992	1994	1996	1998	2000	2004	2008	2012
		1-6	7-12								
0-17	560	272	145	271	259			66	36	36	19
18 +	294	161	102	231	284			146	179	248	339
Total	854	433	247	502	543			212	215	284	358
		680									

Table 6 TAC cyclist accepted claims by age group and year

Note: • *excludes fatality cases* • *TAC criteria assessment method changed in 2000 so that a direct comparison to data before may not be completely accurate* • *1988 -1994 claimant data[41], 2000-2012 data serious injuries[42]*

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[33] Victorian Bicycling Strategy; Vic Roads, Australia 1990.

[34] Cameron M, Heiman L, Nelger D; Evaluation of the Bicycle Helmet Wearing Law in Victoria During Its First 12 Months; Report No 32. Melbourne (Vic): MUARC 1992.

[35] Carr D, Dyte D, Cameron MH, 1995.
Evaluation of the bicycle helmet wearing law in Victoria during its first four years. MUARC Report 76

[36] Morgan M, Sullivan G, Nassau F, Rogerson P Peberdy P, Anderson A, Leicester P, Bicycle helmet usage rates in Victoria;1990 -1991, Vic Roads Report GR91-9

[37] Finch C, Heiman L, Neiger D; Bicycle Use and Helmet Wearing Rates in Melbourne, 1987 to 1992: The Influence of the Helmet Wearing Law; Report 45. Melbourne (Vic): Accident Research Centre, Monash University, 1993.

[38] Garrard J. Active transport: Children and young people, An overview of recent evidence, Dec 2009, Table 1
http://www.chpcp.org/resources/Active_transport_children_and_young_people_FINAL.pdf
accessed 5.8.2014

[39]Ironmonger, D.S and Norman, P (2007) "Travel Behaviour of Women, Men and Children: What Changes and What Stays the Same?"http://www.transport.vic.gov.au/__data/assets/pdf_file/0007/31210/Travel-behaviour-of-WomenMenChildren_IATUR-paper.pdf

[40] Hume C, What influences whether children walk or cycle to school?
http://www.deakin.edu.au/health/cpan/reports-downloads/02-book-reports/files/Influences%20to%20childrens%20travels%20to%20school.pdf accessed 30.9.2014

[41] TAC data provided to C Clarke 1995

[42] TAC, Claims involving hospitalisation
http://reporting.tacsafety.com.au/s/search.html?collection=tac-xml-meta

New South Wales

The 1985/86 year-round survey for Australia on day-to-day travel[43] revealed that 147,200 trips per day were made by bicycle in Sydney. On average, Sydney accounted for 35% of the total cycling trips in NSW. Between 1990 and 1993, four NSW reports provided details of helmet wearing and cyclists counted to monitor law compliance and helmet use. The first pre helmet law survey was conducted in the spring of 1990 (September)[44]. Later reports were conducted in the autumn of April 1991[45], 1992[46] and 1993[47]. In the 1991 report, Sydney had 73 survey sites and rural areas 49 sites.

Between 1991 and 1996, the NSW population increased from 5.899 million to 6.205 million and the inner suburbs of Sydney had high growth rates - see Table 7 giving a selection of data from 1991 to 2011[48].

Location	1991	1996	2001	2011
Homebush Bay - Silverwater	2057	2004	4607	11865
Waterloo - Beaconsfield	8796	9693	11117	22565
Sydney - Haymarket - The Rocks	3504	6467	14393	25021
Above combined areas population and increase from 1991	14357	18164	30117	59451
		26.5%	109.7%	414%

Table 7 Examples of inner Sydney suburbs population changes

Only NSW provided statewide surveys based on actual counts and for the 0-16 age group, cycling reduced by 44% in two years. Hume details: "Figures from New South Wales support the Victorian findings, with declines in walking to school ranging from 10% to 20% between 1985 and 2004. Declines in cycling were also seen during this period. For Year 8 boys, participation rates in regular cycling decreased from 7% in 1985, to only 0.3% in 2004. Declines were similar, if not greater among NSW girls'[49]. (note, 0.3/7.0 = 4.2%, reduction of 95.8%)".

In NSW, the largest recorded reduction in cycling was among secondary female students in Sydney[50]: 214 in 1991 down to 20 in 1993, a drop of 90.6%. A major reduction in cycling occurred for the 0-16 age group, with NSW surveys reporting 6072 in 1991 and 3414 in 1993, a drop of 44% - see Figure 4.

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[43] Day–to-Day Travel in Australia, CR 69, INSTAT, FORS 1988
http://www.infrastructure.gov.au/roads/safety/publications/1988/pdf/Aust_Trav.pdf

[44] Walker M.B. Law compliance and helmet use among cyclists in New South Wales, Dec 1990
http://www.bicycleinfo.nsw.gov.au/downloads/cycle_research/law_compliance_and_helmet_use_amongst_cyclists_in_nsw.pdf

[45] Walker M.B. Law compliance and helmet use among cyclists in New South Wales. April 1991
http://www.bicycleinfo.nsw.gov.au/downloads/cycle_research/law_compliance_and_helmet_use_amongst_cyclists_in_nsw_april1991.pdf

[46] Walker M.B. Law compliance among cyclists in New South Wales, April 1992
http://www.bicycleinfo.nsw.gov.au/downloads/cycle_research/walker_1992_law_compliance_among_cyclists.pdf

[47] Smith NC, Milnthorpe FW. An observational survey of law compliance and helmet wearing by bicyclists in NSW. Roads and Traffic Authority of NSW. 1993
http://www.bicycleinfo.nsw.gov.au/downloads/cycle_research/smith_milthorpe_1993_survey.pdf

[48] Population details http://www.citypopulation.de/php/australia-sydney.php?cid=125011473 accessed 6.10.2014

[49] Hume C, What influences whether children walk or cycle to school?
http://www.deakin.edu.au/health/cpan/reports-downloads/02-book-reports/files/Influences%20to%20childrens%20travels%20to%20school.pdf accessed 30.9.2014

[50] Smith NC, Milthorpe FW; An observational Survey of Law Compliance and Helmet wearing by Bicyclists in New South Wales – Road and Traffic Authority 1993, Table 3.3.

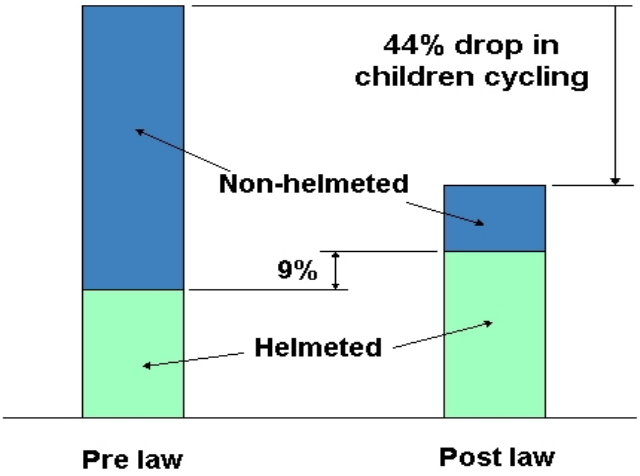

Figure 4 Changes pre to post law for children cycling in NSW

***Note**; Figure 4 is based on 1991 to 1993 data from Table 1, Robinson 1996[51] - from initial count of 6072, 2658 fewer child cyclists were counted and 569 extra were wearing helmets. The reductions by age groups 6-9yrs, 10-12yrs and 13-15yrs were 31%, 47% and 44% respectively - refer Table 3.2, Smith and Milthorpe 1993 report.*

The law resulted in 569 more children wearing helmets compared with 2658 fewer cycling

A selection of NSW cyclist road traffic accident data in Table 8 shows the proportional changes relating to the 0-16 age group from 1990 to 2011[52], down by 84% from 732 to 115. The accident and survey data both show the results from the reduction in cycling.

1990	**1991**	**1992**	**1993**	**1995**	**1997**	**1999**	**2001**	**2006**	**2010**	**2011**
732	503	454	393	391	401	340	268	225	132	115

Table 8 Road traffic accident data for cyclists 0-16 age range

NSW adults (16+ years)

The details of adult cyclists counted at road sites are shown in Table 9.

	1990	**1991**	**1992**	**1993**
Sydney	2730	3332	2796	2591
Rural	2650	2402	1933*	1660
Totals	5380	5734	4729	4251

Table 9 NSW adult cyclists counted at road sites

***Note:** The 1992 survey did not detail the adult count for Albury (1990 - 262, 1991 - 256, 1993 - 224)*
• See Table 12 1991 report, Table 9 1992 report, Table 3.1 1993 report.

[51] Robinson DL; Head injuries and bicycle helmet laws; Accid Anal Prev, 28, 4: p 463-475, 1996 http://www.cycle-helmets.com/robinson-head-injuries.pdf

[52] Road Traffic Accidents in NSW 1992 to 2011

The 1990 survey was conducted in spring, with poor Sydney weather conditions. Walker reported: "As it turns out, the first survey was conducted in overcast conditions in Sydney and, in some areas, was interrupted by rain whereas the second survey was conducted in sunny conditions". The first survey details that "Rain on successive weekends prevented completion of the Wollongong observations". Adult rural road cycling reduced by 37%, according to a simple estimate (1660/2650 = 0.63). From 1991 to 1993, a drop of 22% occurred in Sydney. In 1991, the helmet law already applied to adults but with a reportedly low level of enforcement. Details from adult recreational surveys were not compatible due to different instructions being given to observers in different years (see Note 1, Table 9 in 1991 report), with no information for 1990. In 1991, generally the 16-19 year olds were counted and over 20 year olds not. Recreational site selection was largely based on monitoring children's cycling activity. The 1993 report (page 26) advises against attaching too much significance to the much higher overall counts from recreational sites.

Queensland

Compared with NSW that provided four statewide surveys, Queensland provided limited survey information on the effects of the helmet law. Curnow quotes a reduction for schoolchildren cycling of 22% in the first year of the law[53] . Queensland accident data among the 0-16 age-group for 'hospital plus medical' shows a reduction of 34% by 1993, the first year of enforcement, compared with pre law 1990. Table 10 shows a selection of data[54].

1990	1991	1992	1993	1994	1995	1996	2001	2006	2011
419	344	348	275	270	305	313	214	159	99

Table 10 Road traffic accident data for cyclists 0-16 age range

For schoolchildren in south-east Queensland, the proportion cycling to school reduced from 10% in 1992 to 6% in 2004, and again reduced to 4% in 2007 before increasing to 5% in 2009[55]. The reduction in accidents from 419 in 1990 to 348 in 1992 indicates a possible reduction had already occurred by 1992.

South Australia

South Australia provided limited survey details relating to Adelaide, as reported by Marshall and White[56] and Harrison[57]. Cyclehelmets.org comments: "The report noted that Harrison's (1994) study of schoolchildren showed a 38 per cent decline in cycling from September 1988 to March 1994. This is likely to underestimate the decline due to the helmet law because cycling is more popular in March than September in southern Australia." Telephone survey data reported by Marshall and White only indicates marginal changes in cycling activity from 1990 to 1993. Census data from 1991 to 1996 for Adelaide show a reduction from 7186 to 4494, down by 37.5%. A selection of South Australia accident data[58] in Table 11 for the 5-15 age group shows a reduction of 46% from 1990 to 1993.

1988	1989	1990	1991	1992	1993	1994	1996	1998	2000	2004
231	228	223	149	141	121	133	108	101	81	64

Table 11 Road traffic accident data for cyclist's 5-15 age range

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[53] Curnow B, http://cyclehelmets.org/papers/p787.pdf, Table 1

[54] Data Analysis, Department for Transport and Main Roads, Queensland.

[55] School travel, State of Queensland (DoT and Main Roads) 2012, Travel in south-east Queensland. http://www.google.co.uk/url?sa=t&rct=j&q=&esrc=s&source=web&cd=3&cad=rja&ved=0CDcQFjAC&url=http%3A%2F%2Fwww.tmr.qld.gov.au%2F~%2Fmedia%2FProjects%2FQ%2Fqld%2520household%2520travel%2520survey%2Fseq%2520sections%2FSchooltravel.pdf&ei=xAEOU8TuBPOe7AbcmoDQBA&usg=AFQjCNHdSEsiU8sBnMicVQpx9dJDLW-xDg&sig2=y3q6Qext8pg6rcmHSZINJg accessed 26 Feb. 2014

[56] Marshall J, White M, 1994. Evaluation of the compulsory helmet wearing legislation for bicyclists in South Australia. South Australia Dept of Transport Report 8/94.

[57] Harrison R, 'Observational Study of Bicycle Helmet Wearing Amongst South Australian School Children' for the Office of Road safety, Department of Transport, South Australia, April 1994

[58] CASR Road Safety Research Report, Patterns of bicycle crashes in South Australia http://casr.adelaide.edu.au/publications/researchreports/CASR028.pdf accessed 12.9.2014

Western Australia

Western Australia survey data show recreational cycling reduced from pre law counts of 397 (220+177) to post law counts of 171 (79 + 92), in the period 1990 to 1993, a reduction of 57%[59]. Perth's population was increasing at about 2% per year[60], so the effective reduction may have been even higher. Prior to legislation as helmets were being promoted, cycling to school in WA also reduced[61]. Data from the Narrows and Causeway bridge crossings pre law to post law, 1991 to 1992, show a drop of 38.3%[62]. There was a 20% reduction in Perth, continuing to 30-40% below pre-law levels after three years[63]. Census data for Perth show a drop from 1991 to 1996, with counts of 6126 to 4690[64], down by 23%. Table 12 shows a selection of data for killed and seriously injured for the 0-16 age group.

1988	1991	1992	1993	1996	1999	2001	2005	2008	2012
66	69	50	41	63	27	26	32	24	14

Table 12 Road traffic accident data for cyclists 0-16 age range

Northern Territory

Curnow reports a decline of 45% in the first year for children and teenagers.[65]

Australian Capital Territory (ACT)

Curnow reports a 33% decline weekdays and 50% on weekends[66].

Tasmania

No Information.

Children 0-16 age group

Comparing the combined NSW and Queensland accident data for 1990 and 2011 indicates a major reduction in cycling for this age group - 1151 casualties in 1990 and 214 in 2011, a reduction of 81.4%, and this appears similar to the outcome in New Zealand[67,68]. Considering the data, it suggests that by 2001 cycling levels had approximately halved for the 0-16 age group.

Helmet laws reduced children's cycling by more than 50%

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[59] Heathcote, B., Bicyclist helmet wearing in Western Australia: a 1993 review, Traffic Board of Western Australia, Perth, 1993. Table 9

[60] State Planning Strategy Discussion Paper 1, Population http://www.planning.wa.gov.au/dop_pub_pdf/population.pdf

[61] Heathcote, B., Bicyclist helmet wearing in Western Australia: a 1993 review, Traffic Board of Western Australia, Perth, 1993.

[62] Heathcote 1993, Table 10

[63] Electronic count data from Main Roads Western Australia, reproduced at www.cycle-helmets.com/bicycle_numbers.html . See also www.cyclehelmets.org/1113.html .

[64] Mees P, Sorupia E, Stone J, Travel to work in Australian capital cities, 1976-2006, Dec 2007 http://www.abp.unimelb.edu.au/files/miabp/2GAMUT2007_DEC_02.pdf accessed 13.9.2014

[65] Curnow B, http://cyclehelmets.org/papers/p787.pdf, Table 1

[66] Curnow B, http://cyclehelmets.org/papers/p787.pdf, Table 1

[67] Clarke, CF, Evaluation of New Zealand's bicycle law, NZMJ 10 February 2012, Vol 125 No 1349 http://www.cycle-helmets.com/nz-clarke-2012.pdf accessed 11.1.2014

[68] Tin Tin S. Injuries to pedal cyclists on New Zealand roads, 1988-2007. BMC Public Health 2010;10:655. http://www.biomedcentral.com/1471-2458/10/655 accessed 10.2.2014

Census data on cycling to work

Prior to helmet legislation from 1986-1989, the proportion of people cycling in general was increasing by 10% -12% per year[69]. In Victoria and Western Australia it increased by 47%[70] and 33%[71] respectively over that period. In Sydney it increased 250% during the 1980s[72]. With Government support for cycling infrastructure and concerns about 'The Greenhouse Challenge', plus schools providing bike education and rising fuel costs, cycling should have increased substantially thereafter. Census data[73] below show the percentage cycling to work and an estimate for mid 1990 is provided in order to compare later data. A trend estimate is provided showing the levels that cycling may have reached or exceeded without helmet legislation. The results show the law failed to increase cycling and levels in 2001 to 2006 were less than half what could have been achieved - see Table 13. Sales of bicycles have increased substantially in Australia but their actual use has not kept pace with population growth. Census data from 1976 to 1986 for the capital cities show cycling increasing from 0.8% to 1.1%, a relative increase of 37%, For walking the reduction was from 5.6% to 3.9%, a relative reduction of 30%.

Year	Census % cycling to work	Percent 'Trend' if no helmet law	Percent drop from 1990 estimated value
1976	1.12		
1981	1.56		
1986	1.68		
1990* estimate	2.00		
1991	1.56	2.05-2.15	22
1996	1.24	2.35-2.50	38
2001	1.21	2.70-2.85	39
2006	1.24	3.05-3.20	38
2011	1.29	3.35-3.50	35

Table 13 Census data and estimates (see notes)

Note:
• No Census in 1990 - the 2.0% figure estimated is 19% higher than the 1986 value and only a guide value.
• Refer survey details at www.cyclehelmets.org, http://cyclehelmets.org/1241.html and www.cycle-helmet.com for more information.

Table 14 shows the percentage figures for cycling to work for Australia, the main capital cities and the 'Rest' - i.e. rural/country towns and cities. See notes Table 15.

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[69] Department of Transport and Communications. SPOKES, Information for cycle-conscious communities, Canberra, 1993.

[70] Lambert J. Number of cyclists, bicycle trips and bicyclist accident reports in Victoria, 1986-1989. Vic Roads internal report, May 1990.

[71] Newman P. Better cities for bicyclists. In: Shepherd R., Ed. Ausbike 92. Proceedings of a national bicycle conference, Melbourne, Australia, march 1992. Bicycle Federation of Australia; 1992.

[72] Cycling in Europe. Proceedings of a national bicycle conference, Melbourne, March 1992. Bicycle Federation of Australia, 1992

[73] Census data from Australian Bureau of Statistics

	Australia	% change from 1986	Capital cities	% change from 1986	Rest	% change from 1986
1976	1.12		0.84		1.94	
1981	1.56		1.11		2.87	
1986	1.68		1.14		3.18	
1991	1.56	-7.1	1.13	-1	2.76	-32
1996	1.24	-26	0.89	-22	2.07	-35
2001	1.21	-28	0.94	-18	1.80	-43
2006	1.24	-26	1.11	-23	1.52	-52
2011	1.29	-23	1.28	+12	1.31	-59

Table 14 Census data for Australia, Capital Cities and Rest

Data in Table 14 is illustrated in Figure 5.

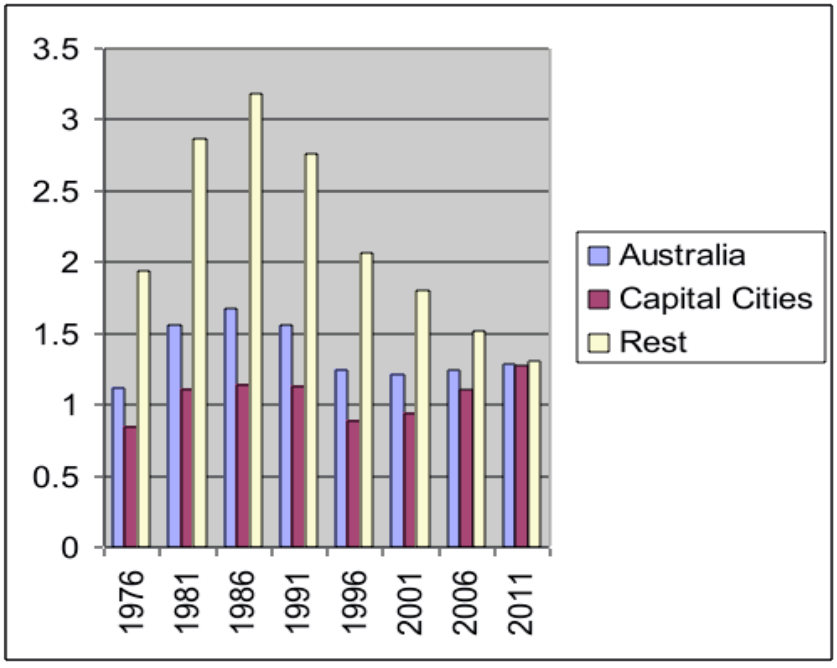

Figure 5 Bar chart of census data information

Cyclehelmets.org shows the Census data as in Fig 6, reflecting a drop following enforcement in most cases. The ACT, a relatively small area and generally subject to the coldest conditions, shows an increase and this could in part be connected to the change to August for the Census date. Cycling to work increased by 50% from 1976 to 1986, from 1.12% to 1.68%. In states that had enforcement by 1991, they had on average a reduction compared to 1986. States without enforcement had on average an increase. On average, an approximate 30% difference occurred which suggests a discouraging effect from the legislation by 1991.

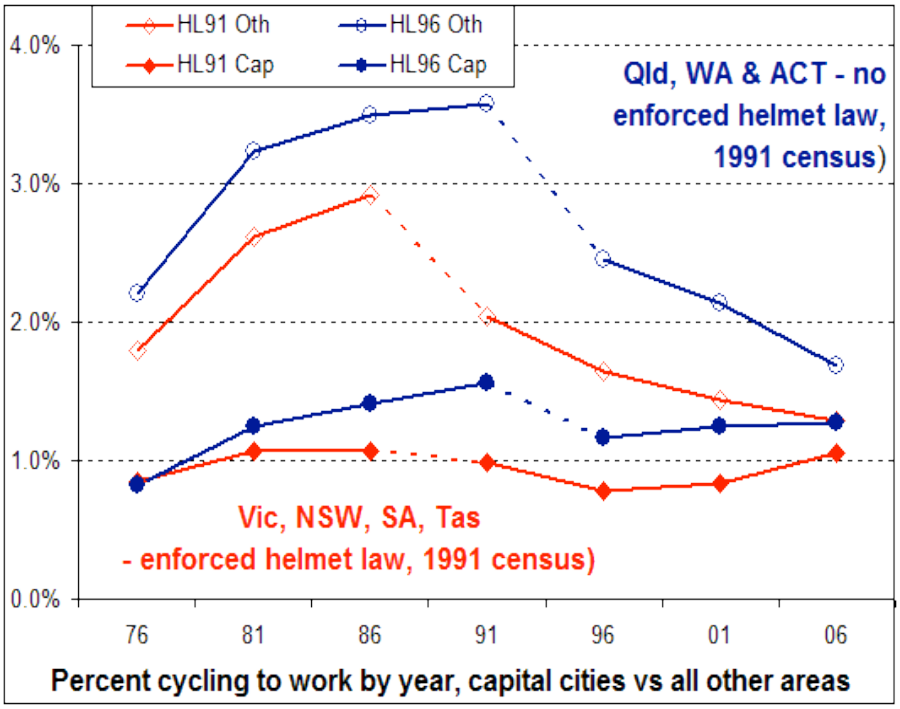

Figure 6 Percent cycling to work by year, capital cities vs all other areas

Table 15 provides data for individual states and territories.

State	1976	1981	1986	1991	1996	2001	2006	2011
Vic	1.35%	1.79%	1.75%	1.36%	1.15%	1.15%	1.40%	1.53%
NSW	0.56%	0.90%	1.09%	0.96%	0.87%	0.83%	0.84%	0.93%
Qld	1.55%	2.20%	2.40%	2.56%	1.84%	1.65%	1.41%	1.31%
S A	2.04%	2.45%	2.27%	1.95%	1.27%	1.17%	1.43%	1.25%
W A	0.98%	1.48%	1.72%	1.85%	1.20%	1.28%	1.25%	1.34%
ACT	0.90%	2.17%	2.05%	1.86%	2.27%	2.35%	2.56%	2.82%
NT	2.11%	3.81%	4.15%	5.55%	3.98%	3.95%	3.53%	3.24%
Tas	0.54%	0.75%	0.87%	0.76%	0.67%	0.80%	0.90%	0.78%

Table 15 Census data per state or territory

Notes:
1) Pre law Census, 1976-86, were conducted on 30 June while 1991 and later surveys were conducted in early August (slightly warmer conditions and approximately 42 minutes extra daylight).
2) Various websites[74,75] now promote cycling to work on Census day.
http://www.bicycles.net.au/forums/viewtopic.php?f=41&t=43219
3) Cycle infrastructure has been provided in a number of locations over the past 25 years.
4) Refer additional note 'Appendix - ABS census data on cycling to work' at http://www.cyclehelmets.org/1194.html

[74] Ride to work on census day Tue 9/8
http://www.bicycles.net.au/forums/viewtopic.php?f=41&t=43219 accessed 24.12.2012

[75] Census time: make your religion 'cycling'
http://www.adelaidecyclists.com/forum/topics/census-religion-cycling?commentId=3086792%3AComment%3A287578 accessed 24.12.2012

Between 2001 and 2011, Melbourne gained 636,300 new residents, followed by Sydney (477,600), Brisbane (408,900) and Perth (351,500). The Central Business Districts (CBDs) of all four cities had very rapid population growth due to redevelopment with high density housing.[76] Inner city population has increased substantially in four main cities and Census data 2006 to 2011 show increases in cycling to work for all four cities - 36%, 44%, 31% and 37% respectively[77]. The increase in cycling to work for capital cities from 0.94% in 2001 to 1.28% in 2011 (Table 14) appears connected to redevelopment of inner city areas.

Rates of cycling to work reduced by 28% to 39% (estimated value for 2001)

National travel surveys

In 1988, details were published on the year-round national travel surveys for 1985/86, based on mode of travel, number of trips, purpose of trip, distance, age groups, etc. The surveys were for travel by people aged nine and older. They reflected year-round travel patterns and for cycling reflected general-purpose cycling activity but not for younger children playing/cycling on bikes or riding in their gardens. Full-time students accounted for 62.6% of total time spent cycling[78]. Approximately 51% of cycling occurred in the capital cities and 49% in the 'rest' - other locations. Data from Victoria in 1984 detailed that among 5-9 year-olds, 12,000 children cycled to school from a total of 75100, or 16% cycling to school. The combined information from the 1985/86 survey and data on young children cycling indicates approximately 60% of cycling occurred from the 0-16 age group and 40% for 17 years and older in the mid 1980s.

Twenty one years after the first helmet law was introduced, Australia published a report titled 'Australian Cycling Participation 2011'[79] that conducted a telephone survey of cycling activity in the late summer/autumn period of March and April and included data on children cycling in their gardens. In 2013 another report was produced, again based primarily on cycling activity in the most popular months and for all ages, and reported a reduction from 2011. A detailed comparison of the data reports; 'Analysis of government data shows 16.6% more Australians cycling daily in 2013 than in 1985/86, despite population growth of 42.5%.'[80].

Assuming a sample of 1000 cycling in 1985/86 and with population growth of 42.5%, 1425 could be cycling in 2013 but 16.67% more are cycling than in 1985/86, meaning 1167. The level of cycling in 2013 is proportionately approximately 81.5% (1167/1432) with a reduction of 18.5%. This finding is based on the number of 'trips' and if a journey is broken by a stop, then it would be considered 2 trips, whereas in the 1985/86 survey it is not clear if this would apply.

Estimated approximate cycling reduction due to helmet legislation

Census data show cycling increasing prior to legislation and then reducing. Values for 1996 - 2006 averaged 1.23% and, compared to the 1986 value and estimate for mid 1990, indicates a reduction in cycling levels relative to population size of between 28% and 39% (Table 13 & 14). By 2011 the estimates are from 23% to 35% in reductions compared to population. For the 0-16 age group, by 2001 cycling levels seem to have halved and by 2011 were down even further, with an approximate 80% reduction.

Combining indications from Census data for adults and estimates for the 0-16 age group (with an assumed 40/60 split for adults vs the 0-16 age group in overall cycling activity in 1986 and adding estimates for 1990) provides an assessment of changes in cycling activity vs population from 1986 to 2011 - see Figure 7.

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[76] Bureau of Infrastructure, Transport and Regional Economics (BITRE), 2013, *Population growth, jobs growth and commuting flows—a comparison of Australia's four largest cities,* Report 142, Canberra ACT.

[77] Census 2011 Travel to work by bicycle only, Australia
http://bicyclecouncil.com.au/publication/australian-census-2011

[78] Day–to-Day Travel in Australia, CR 69, INSTAT, FORS 1988
http://www.infrastructure.gov.au/roads/safety/publications/1988/pdf/Aust_Trav.pdf

[79] Gillham C http://www.cycle-helmets.com/bike-hire-schemes.html

[80] Gillahm C http://www.cycle-helmets.com/cycling-1985-2013.html

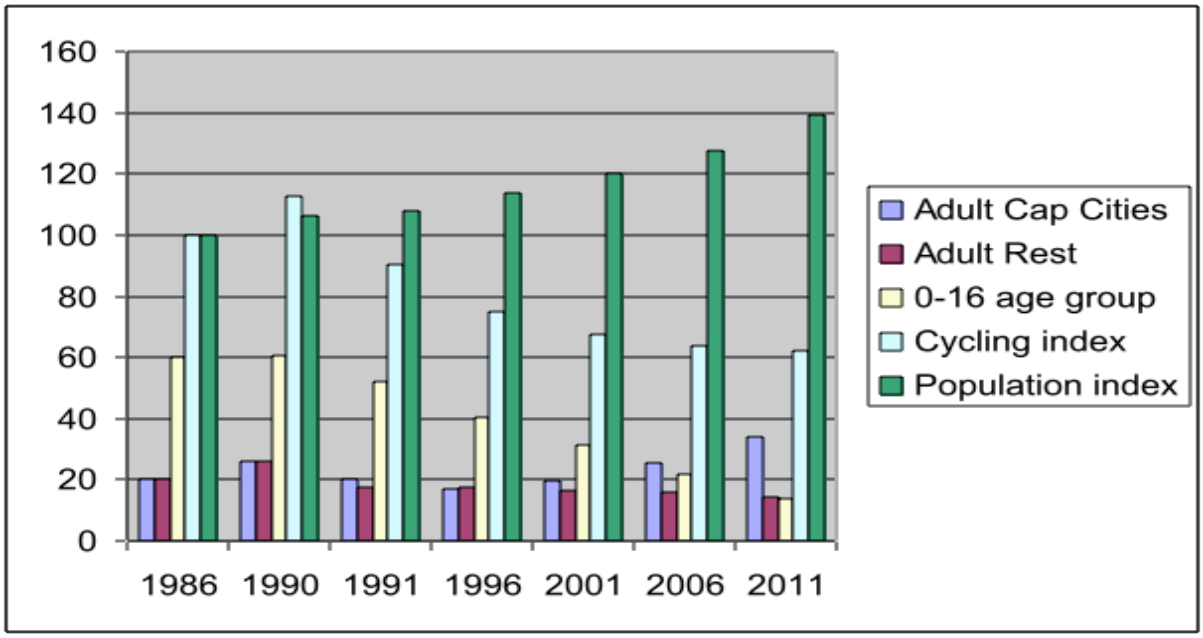

Figure 7 Indication of changes in cycling activity v population

Figure 7 indicates cycling reduced significantly for children from 1990 to 2011. The proportion of cycling to work journeys, 1.68% in 1986 v 1.29% in 2011, was down relatively by 23%. By 2011, cycling levels in proportion to population had reduced by approximately 57% compared with 1986 [(0.4 x 0.77) + (0.6 x 0.2) = 0.428] and from 2011 to 2013 additional reductions were reported [81]. It was reported that 'There appear to be many more bicycles sold in Australia than are used" [82] and Figure 7 indicates this is the case. Mountain biking activity is one area of cycling that has probably increased.

Fatality assessment

Road safety improvements (e.g. speed controls, anti drink drive and other measures) contributed to reductions in Australian road fatalities with a rate per 100,000 population reducing from about 18 in the mid 1980s to 5.16 by 2013 [83]. Table 16 shows a comparison of data and the relative change in deaths for cyclists compared to pedestrians with the C/P ratio increasing from 16.45% to 22.7%.

Years	86-89	90-93	94-97	98-01	02-05	06-09	10-13
Cyclists - C	342	224	216	161	144	139	155
Pedestrians - P	2079	1444	1444	1194	927	815	682
C/P%	16.45	15.51	14.96	13.48	15,53	17.05	22.7

Table 16 Cyclist vs pedestrian deaths 1986 to 2013

[81] Australian Cycling Participation 2013 https://www.onlinepublications.austroads.com.au/items/AP-C91-13 acessed 21.11.2014

[82] Bauman A, Merom D, Rissel C, Where have all the bicycles gone? Are bicycle sales in Australia translated into health-enhancing levels of bicycle usage? Prev Med 2012 Feb;54(2):145-7 http://www.sciencedirect.com/science/article/pii/S009174351100380X accessed 21.11.2014

[83] Australian Road Deaths Summary http://www.bitre.gov.au/publications/ongoing/files/RDA_Summary_2012_June.pdf accessed 14.9.2014

Figure 8 indicates the changes in fatalities.

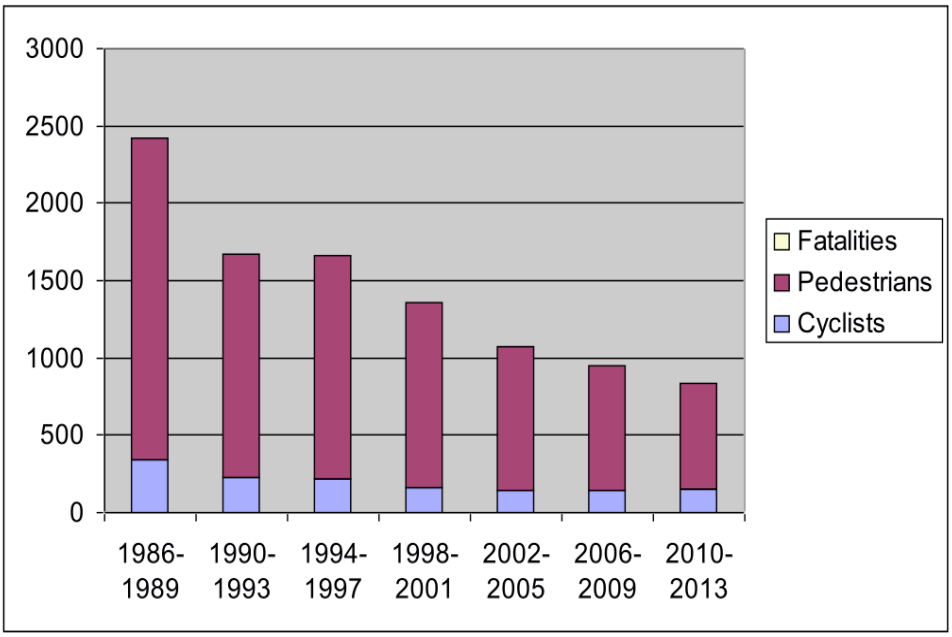

Figure 8 Pedestrian and cyclist fatality trend from 1986 to 2013

The C/P value for 2010-2013, 155/682 or 0.227, suggests that when related to the estimated 57% reduction in the proportion cycling for the period 2010-13 (assuming 2011 as a mid value), the 155 cyclist value would approximate to 360 if cycling had not been reduced, giving an equivalent C/P value of 52.7% (360/682). During the period the average distance walked per person may also have reduced. Walking to school reduced[84] but precise data for Australia is not available (New Zealand data reported 56 hours per year in 1989/90 to 50 hours in 2006/09[85]). Assuming reductions of 10% for walking and 57% for cycling levels, the equivalent C/P value would be 47.5% (360/758 approximately) by 2011, indicating a reduction in safety for cyclists compared to pedestrians.

Comparing data for all road users near to the initial period of introducing and enforcing helmet legislation provides an alternative perspective. Allowing for the reduction in cycling of 30% (based on surveys, Census estimates and reductions for the 0-16 age group) would result in an estimated 239 deaths (0.7 x 342=239). The 209 actual deaths is 13% lower for cyclists and would give the smallest reduction of all road users - see Table 17.

	Peds	Mcyc	Cyclists	MVO	Total
1986-89	2079	1386	342 (0.7 x 342=239)	7519	11348
1993-96	1447	790	209	5415	78348
% reduction	30.4%	43.0%	38.9% (13% adjusted)	28.0%	30.7%

Table 17 Road deaths, 1986/89 vs 1993/96
Ped - pedestrians, Mcyc - motorcyclists, MVO - motor vehicle occupants

[84] Hume C, What influences whether children walk or cycle to school? http://www.deakin.edu.au/research/src/cpan/documents/book-7.pdf accessed 30.9.2014

[85] Clarke, CF, Evaluation of New Zealand's bicycle law, NZMJ 10 February 2012, Vol 125 No 1349 http://www.cycle-helmets.com/nz-clarke-2012.pdf

Some reports detail if cyclists were wearing helmets. The Australian Transport Safety Bureau (ATSB) examined data from 1996 to 2000[86]. Information was available on 222 who died, 187 male and 35 female. Of 55 male cyclists in the 10-19 age group, 27 were not helmeted. For the period 2001-04, of known cases 62% were helmeted (30 cases). From 2008 to 2012 about 75% of known cases were helmeted[87]. Survey data showed lower wearing rates for teenagers compared to other age groups.

For NSW in the period 1992-2011 there were 231 cyclist deaths, 154 helmeted, 66 not wearing and 11 unknowns. Of known cases, 70% were helmeted. The 1993 Smith survey reported wearing rates of 68% for children under 16 at road sites (56% for Sydney) and 83% for adults (77% for Sydney). The wearing rate for cyclists varied and the lowest use appears to be associated with nighttime cyclists and teenagers[88].

The use of hi-vis vests is typically associated with adult cyclists and they reportedly result in a lower accident rate[89]. Some non-wearers may typically be at higher risk due to other factors[90]. Between 1996 and 2011, of known cases who had been drinking alcohol, 10 were helmeted and 12 were without helmet[91]. Nine of the 12 non-helmeted cyclists had a Blood Alcohol Content (BAC) of 0.150 or above and only one of the 10 helmeted had this level. Six of the 10 helmeted had low levels of between 0.001-0.019. Of known cases, 10% of helmeted and 29% of non-helmeted had been drinking. For pedestrians, around 30% of fatalities involve a pedestrian with a blood alcohol concentration of 0.05 or more[92].

For Queensland in the period 1993-2008 there were 146 cyclist deaths, 82 helmeted, 44 not wearing and 20 unknowns[93]. Of known cases, 65% were wearing helmets. In critical accidents helmets can dislodge and on inspection it may not be known if the rider was wearing or carrying a helmet. Of the 44 not wearing, 13 (29.5%) had been drinking alcohol and from the 82 helmeted, five (6.1%) had been drinking.

In comparison, for pedestrians about 25% had been drinking alcohol. Queensland data (1999 to 2004)[94] shows 51 deaths in the six years, 35 wearing, 10 not wearing and 6 unknown. Of known cases, 77.7% were wearing helmets which was similar to the reported wearing rate of 77%[95]. From the 10 not wearing, three had been drinking alcohol and none of the 35 wearing helmets. Refer to page 31 for "Queensland proposed law reform" information.

Four tragic cases of young children being hanged by their helmet straps have been reported, two in Victoria, one in South Australia and one in Tasmania[96]. Suitable warnings about the danger of strangulation are not provided by states detailing the requirement to wear helmets[97].

Injury assessment

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[86] Consumer Product Safety Standard for Bicycle helmets ACCC 2009

[87] Data from Australian Bureau of Infrastructure, Transport and Regional Economics.

[88] Walker M.B. Law compliance among cyclists in New South Wales, April 1992
http://www.bicycleinfo.nsw.gov.au/downloads/cycle_research/walker_1992_law_compliance_among_cyclists.pdf

[89] Conspicuity and bicycle crashes: preliminary findings of the Taupo Bicycle Study, Inj Prev 2008.

[90] Invine A, Row BH, Sahia V, Bicycle helmet-wearing variation and associated factors in Ontario teenagers and adults. Can J Public Health. 2002 Sep-Oct;93(5):368-73
http://www.ncbi.nlm.nih.gov/pubmed/12353460 accessed 7.12.12

[91] Road Safety Statistics, Bureau of Infrastructure, Transport and Regional Economics, Department of Infrastructure and Transport, NSW.

[92] Alcohol affected pedestrians
NSW Centre for Road Safety http://www.rta.nsw.gov.au/roadsafety/pedestrians/vulnerablepedestrians/index.html

[93] Bicycle Helmet Research, CARRS-Q Monograph Series - Monograph 5, Queensland, 2010 (non-peer reviewed), Table 13.

[94] QLD Road Traffic Crashes in Queensland 1999-2004
http://www.tmr.qld.gov.au/Safety/Transport-and-road-statistics/Road-safety-statistics.aspx

[95] Bicycle Helmet Wearing Survey Traffic and Safety Department, RACQ, 3.8 Enforcement, Table 4

[96] Bicycle helmet - Accidental hanging by helmet straps
http://en.wikipedia.org/wiki/Bicycle_helmet#Accidental_hanging_by_helmet_straps accessed 14.9.2014

[97] WA http://www.transport.wa.gov.au/mediaFiles/active-transport/AT_CYC_P_cycling_and_the_law.pd

In 2003-04 there were approximately 6.8 million hospital admissions in total for Australia, with about 50,000 (0.7%) due to land transport injury. There were 7929 hospitalisations for cyclists compared to 3716 for pedestrians[98], a ratio of 2.13 to 1. In 1990 there were 7520 hospitalised cyclists compared to 5048 pedestrians[99], a ratio of 1.49 to 1. The ratio change from 1.49 to 2.13 suggests cyclists are more at risk - see Table 18.

	Ped (P)	Mcyc	Cyclist (C)	MVO	Total	C/P
1990	5048	6460	7520	20435	39816	1.49
2003/04	3716	10612	7929	24605	46862	2.13
2005/06	3779	12455	8814	20009	45057	2.33
2008/9	3686	14493	9577	19666	47422	2.60
20010/11	4124	12933	9001	18265	50775	2.18

Table 18 Serious injury data (see notes)

Notes:
1) Australian Bureau of Statistics (ABS) data on motorcycle registrations indicate the number of motorcyclists almost doubled from 1999 to 2008[100].
2) Cyclist data for 1990 reported 6412 hospitalised and was further adjusted in the report for 'Unknowns' where the mode of transport was not known to make 7520.
3) Victoria introduced the helmet law mid 1990 and the 1990 'Cyclist' number of 7520 may have been higher without the law.
4) The proportion of injuries due to mountain biking may have increased.

Taking account of the proportional change in cycling levels and injury data (see Figure 7 and Table 18), they can be used to estimate changes in safety. For 2008/09, Figure 7 suggests an approximate reduction in cycling of 43% compared with 1990. In 1990, admissions were 7520 and by 2008/09 admissions were 9577, with a cycling activity level of approximately 57%. The 57% cycling level should equate to approximately 4286 admissions based on the 1990 data (0.57 x 7520=4286) but was 123% higher at 9577. The C/P values indicate a reduction in safety for cyclists compared to pedestrians and the admissions data compared with estimated cycling levels also strongly suggest a reduction in safety.

Cyclists who have falls that result in injury would likely be recorded as road accident cases whereas pedestrians having falls are generally not considered road accidents. In 2010/2011 there were more than 46,000 falls recorded for pedestrians[101].

Cyclist hospitalisations in 1990 were 1.49 higher than pedestrians and by 2003/04, they were 2.13 higher

Specific evidence of an associated risk from helmet use from four states

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[98] Serious injury due to land transport accidents, Australia, 2003-04, AIHW, October 2007.

[99] Road crashes resulting in hospitalisation, Australia 1990, FORS, October 1993

[100] Grzebieta R, Inquiry into Vulnerable Road Users – NSW Parliament, Submission No 54 to Staysafe Committee on Research Relating to Vulnerable Road Users. 2010.

[101] AIHW: Pointer S 2013. Trends in hospitalised injury, Australia, 1999–00 to 2010–11. Injury research and statistics series no. 86. Cat. no. INJCAT 162. Canberra: AIHW.
http://www.aihw.gov.au/WorkArea/DownloadAsset.aspx?id=60129544396

1) Cameron et al 1994[102] provided details of TAC data (from motor vehicle/cyclist accidents) with the percentage reduction in severe bicyclist casualties relative to the 1989/90 financial year. For Melbourne, (Table 4, in report, copied below) bicyclists without head injuries fell by 4% and 12% for the years 1990/91 and 1991/92.

TABLE 4
PERCENTAGE REDUCTIONS IN SEVERE BICYCLIST CASUALTIES
RELATIVE TO 1989/90 FINANCIAL YEAR
MELBOURNE : TAC CLAIMS

Financial Year	Bicyclists with head injuries	Bicyclists without head injuries
1990/91	36%	4%
1991/92	64%	12%
1992/93	40%	35%

Cycling was generally reduced by 36% compared to the reported 4% and 12% reductions. The highest risk group for TAC cyclist claims were aged 12-17 years and their cycling levels reduced in Melbourne by approximately 45% - 48%. The data indicate there was an increase in risk of serious injury for Melbourne cyclists, relative to cycling levels. See note below.

Note:

Care is required in considering the claim of a 64% reduction. In 2013 Vic Roads reported "Two years after the legislation was introduced, there was a 16% reduction in head injuries in metropolitan Melbourne and a 23% reduction in head injuries throughout Victoria. There was also an immediate reduction in bike riders, however, by 1992 the numbers of bike riders had approached pre-legislation levels".[103] The claim "however by 1992 the numbers of bike riders had approached pre-legislation levels" is misleading - see Tables 6 and 15 for indications of cycling levels.

2) Western Australian hospital data shows approximately 178 cyclist arm fractures in 1991 and approximately 210 in 1996[104], up by 18%. Census data show reduced cycling from 1.85% to 1.20% for the same years, down by 35% (see Table 15 above). Allowing for population growth and Census data, approximately 120-125 arm fractures could have been expected in 1996 but in fact 210 were recorded, about 68% higher.

3) Queensland data published in Monograph 5 Table 9 details 826 police recorded accidents in 1993 and 977 in 1996, up by 18%. The initial four year period of enforcement from 1993 to 1996 shows an increase in the number of accidents. Census data indicate a reduction in cycling levels from 2.56% in 1991 to 1.84% in 1996, proportionally down by 28%.

4) Robinson's 1996 report[105] provided injury data for children. In Victoria, the equivalent number of injuries for pre law levels of number of cyclists increased by 15% from 1990 to 1992. Robinson provides data in Table 2 for children in NSW. The equivalent number of injuries increased from 1310 (384 head + 926 other injuries) pre law in 1991 to 2083 (488 head + 1595 other injuries) in 1993. The relative injury rate increased by 59% from 1310 to 2083. The relative increase in 'other' injuries of 72% and 27% for 'head' raises serious concerns. The proportion of head injuries decreased from 29.3% to 23.4% and would give the impression of a benefit if viewed in isolation.

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[102] Newstead S, Cameron M, Gantzer S, Finch C, 1994, 'Bicycle head injuries in Victoria, Three years after the introduction of mandatory use' report no 75 MUARC, 1994.

[103] Vicroads,Wearing a bicycle helmet, http://www.vicroads.vic.gov.au/Home/SafetyAndRules/SaferRiders/BikeRiders/WearingABicycleHelmet.htm accessed 6.8.2014

[104] Meuleners LB, Gavin AL, Cercarelli LR, Hendrie D, Bicycle Crashes and Injuries in Western Australia, 1987 – 2000, Report RR131, 2003 Fig 5.10

[105] Robinson DL; Head injuries and bicycle helmet laws; Accid Anal Prev, 28, 4: p 463-475, 1996 http://www.cycle-helmets.com/robinson-head-injuries.pdf

5) Erke and Elvik 2007[106] examined research from Australia and New Zealand and stated: "There is evidence of increased accident risk per cycling-km for cyclists wearing a helmet. In Australia and New Zealand, the increase is estimated to be around 14 per cent." The findings were based on six reports, four from when legislation was in place.

Injury rate

Victorian Injury Surveillance Unit (VISU) data published in 2010 for Melbourne detailed a cycle injury rate of 315.3 per 100 million km for hospital admissions. Similarly a rate for Sydney of approximately 500 per 100 million km was reported[107]. Per billion km these equate to 3153 and 5000 or 31.5 and 50 per 10 million km. Assuming a head injury rate of 27.4%[108], there would be approximately 864 to 1370 admissions per billion km for Melbourne and Sydney. Data from the Netherlands on head injuries (where most cyclists do not wear helmets) detail the risk of head injury admissions per billion km (54 for motor vehicle involvement and 157 without motor vehicles involvement[109]) assuming a mid value of 105 per billion km. Data from Melbourne and Sydney with high helmet usage is indicating about 1000 admissions per billion km. Australian data from the 1980s indicated a serious injury rate of 35 per 10 million km - see Table 4. The rates for Melbourne and Sydney indicate a similar rate to that from the 1980s.

The risk of head injury varies due to several factors. A 2010 report mentions "A cyclist travelling at 30kph or over prior to the crash was estimated to have nearly 5 times the odds of sustaining a head injury in the crash compared to a cyclist travelling below 20kph. This was statistically significant. Even cyclists travelling at 20-29kmh before the crash were estimated to have 2.7 times the risk of a head injury compared to those travelling below 20kph".[110]. Research from the USA[111] reported that "Alcohol use showed a strong correlation with head injury (odds ratio, 3.23; 95% confidence interval, 1.57-6.63; P = .001). As reported from NSW, "Non-helmeted cyclists were almost three times as likely to have disobeyed traffic controls as helmeted riders, and more than four times as likely to have been above the blood alcohol limit"[112].

Comparing helmeted to non-helmeted cyclists

Some reports have mentioned differences that tend to occur between helmet wearers and non-wearers[113]. Bambach et al[114] provided details of differences between helmet wearers and non-wearers for cycle accidents with motor vehicles involved, as shown in Table 19. e.g. 55% of those not wearing a helmet were in the age 0-19 yrs.

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[106] Erke A, Elvik R, Making Vision Zero real: Preventing Pedestrian Accidents And Making Them Less Severe, Oslo June 2007. page 28
https://www.toi.no/getfile.php/Publikasjoner/T%C3%98I%20rapporter/2007/889-2007/889-2007-nett.pdf

[107] Garrard J, Greaves S, Ellison A, Cycling injuries in Australia: Road safety's blind spot?, Journal of the Australasian College of Road Safety – August 2010 http://www.cycle-helmets.com/cycling-blind-spot.pdf accessed 27.12.2014

[108] Serious injury due to land transport accidents, Australia, 2003-04, AIHW, October 2007.

[109]SWOV Fact sheet http://www.swov.nl/rapport/factsheets/uk/fs_bicycle_helmets.pdf

[110] Biegler P, Newstead S, Johnson M, Taylor J, Mitra B, Bullen S, Monash Alfred Cyclist Crash Study (MACCS), MUARC Report 311, 2012

[111] Crocker, P., O. Zad, T. Milling, et al., Alcohol, bicycling, and head and brain injury: a study of impaired cyclists' riding patterns R1. The American Journal of Emergency Medicine, 2010. 28(1): p. 68-72.

[112] Crash data shows cyclists with no helmets more likely to ride drunk, http://theconversation.com/crash-data-shows-cyclists-with-no-helmets-more-likely-to-ride-drunk-11944 accessed 28.12.2014

[113] Rethinking bicycle helmets as a preventive tool: a 4-year review of bicycle injuries B. Joseph, V. Pandit, B. Zangbar, M. Amman, M. Khalil, T. O'Keeffe, T. Orouji, A. Asif, A. Katta, D. Judkins, R. S. Friese, P. Rhee October 2014 http://link.springer.com/article/10.1007%2Fs00068-014-0453-0#

[114] Bambach, M; Mitchell RJ, Grzebieta RH, Olivier J (April 2013).
"The effectiveness of helmets in bicycle collisions with motor vehicles: A case-control study.". Accid Anas and Prev.

53: 78–88. doi:10.1016/j.aap.2013.01.005. PMID 23377086.

	No helmet	Helmet
Age 0-19	55%	18.5%
Disobeying traffic control	9.4%	3.3%
BAC over 0.5	7.2%	1.7%
Riding on footpath	34.4%	12.9%
Serious injury other than head	9.5%	7.3%
Not in daytime	27.9%	23.3%

Table 19

Fatality data from NSW and Queensland show non-wearers have higher proportions of BAC than wearers but lower or similar to pedestrians.

Bambach et al reports that for 'No helmet', 34.4% were riding on a footpath compared to 12.9% for helmeted. The sort of impact that results from cyclists riding from the footpath into the road or intersection and being hit side-on by a motor vehicle could incur high impact loads to the head[115]. A driver may have less warning and time to slow down. In 16% of cyclist fatalities during the period 1996-2000, the cyclist was riding from the footway or verge onto the road and was hit by a motor vehicle travelling along the road[116]. The age grouping also suggests non-wearers may have higher rates of head injury due to their younger age range (see TAC data Table 3), the head injury rate of 12% for the 0-17 age group vs 7.6% for 18+ years of age. Fatality data indicate a high level of disobeying traffic controls for cyclists can occur. "More than two-thirds of the deaths of cyclists aged 5-17 years were the result of the cyclist failing to give way to oncoming traffic and about half of these cases occurred at intersections. A typical behaviour for the younger (pre teenage) cyclists was to enter the intersection from a footway without dismounting and without looking". Bambach et al detail non-wearers to be almost three times higher, 9.4% vs 3.3%, in "Disobeying traffic control". It appears the higher head injury rate for non-wearers can in several ways be attributed to age and behaviour in addition to not wearing a helmet.

Queensland data Monograph 5 Table 14 show helmet wearers to have a 'Shoulder/Upper limb' rate of 28.3% and non-wearers a rate of 18.4%. Bicycle alone accidents result in a higher proportion of arm fractures than bicycle/motor vehicle accidents[117], so it appears that helmet wearers may have had a larger proportion of injuries due to bicycle alone type accidents or falls. See Appendix A for more details.

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[115] Janssen EG, Wisemans JSHM; Experimental and mathematical simulation of pedestrian –vehicle and cyclist-vehicle accidents; Proceedings of the 10th International Technical Conference on Experimental Safety Vehicles, Oxford July 1985.

[116] Deaths of cyclists due to road crashes, ATSB Road Safety Report July 2006

[117] Whately S, Bicycle Crashes in the Austrian Capital Territories, CR 35, FORS, 1985, Table 25 http://www.infrastructure.gov.au/roads/safety/publications/1985/pdf/Bic_Crash_1.pdf accessed 11.1.2014

Helmet risk and personal perceptions of safety

A Melbourne report detailed that 45% of participants who were wearing helmets sustained helmet damage as a result of their crash[118] and VISS data from 1989 detailed that children incur 10% of injuries to that part typically covered by a helmet - see Figures 1 and 2. Helmet wearers report hitting their helmets, giving the impression that the helmet may have provided a benefit. Robinson 1996 detailed the incidence of hitting their head/helmet in a cycling accident was "significantly higher for helmet wearers (8/30vs 13/476, i.e. 20% vs 2.7%, p 0.00001)". A bare head width of approximately 150mm may avoid contact compared to a helmeted head at approximately 200mm width. The combination of extra accidents, extra impacts and helmets easily breaking can probably add to the impression of a benefit from helmet use. In some situations a benefit may be provided and in other situations a disadvantage may have occurred. Experience from American football where helmet impacts are frequent has shown that players can develop brain damage with repeated impacts[119]. Experience from boxing has shown that once boxers have concussions they are at higher risk from suffering concussions[120]. Helmets seem to provide more protection from skull fractures than from intracranial injuries[121]. Apart from the extra risk of accident and the risk of extra impacts, there is a longer term risk associated with low level impacts that is not possible to precisely calculate.

Clarke 2007 detailed a number of reasons why the accident rate increases with helmets use, listing potentially 13 disadvantages and two advantages[122]. Robinson detailed hospital admission for serious head injury as 2.2 per million hours cycled, or approximately one per 454,000 hours cycled, meaning the average person would not be likely to experience a serious head injury in a lifetime of cycling - e.g. a person cycling two hours per week for 50 years would cycle for 5200 hours, roughly a 1% risk on average of hospital admission for serious head injury - see Table 20.

	Cyclists	Peds	MVO	M/Cyc
Fatality risk per million hours	0.41	0.80	0.46	7.66
Hospital admission serious head injury rate per million hours	2.2	2.0	1.6	18.0
Hospital admission for serious HI per life (5200 hrs activity)	1.1%	1.0%	0.8%	9.4%

Table 20 Estimate of average risk level of serious head injury

The actual risk of serious head injury when cycling is low and the risk of accident increases with helmet use. Also, the risk of impact to the helmet compared with a non-helmeted head increases. The personal perception of improved safety is likely to increase with more accidents and impacts but in most cases, actual safety is decreasing with more accidents and impacts.

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[118] Biegler, P., Newstead, S., Johnson, M., Taylor, J., Mitra, B. & Bullen, S. MACCS Monash Alfred cyclist crash study, Report 311, 2012

[119] American football the next tobacco? Examining the connection between football and brain damage http://www.irishexaminer.com/viewpoints/analysis/is-american-football-the-next-tobacco-examining-the-connection-between-football-and-brain-damage-297915.html accessed 21.11.2014

[120] Committee on Sports-Related Concussions in Youth; Board on Children, Youth, and Families; Institute of Medicine; National Research Council; Graham R, Rivara FP, Ford MA, et al., editors. Sports-Related Concussions in Youth: Improving the Science, Changing the Culture. Washington (DC): National Academies Press (US); 2014 Feb 4. 5, Consequences of Repetitive Head Impacts and Multiple Concussions.
Available from: http://www.ncbi.nlm.nih.gov/books/NBK185336/

[121] Rethinking bicycle helmets as a preventive tool: a 4-year review of bicycle injuries B. Joseph, V. Pandit, B. Zangbar, M. Amman, M. Khalil, T. O'Keeffe, T. Orouji, A. Asif, A. Katta, D. Judkins, R. S. Friese, P. Rhee October 2014 http://link.springer.com/article/10.1007%2Fs00068-014-0453-0#

[122] Clarke CF, The Case against bicycle helmets and legislation, VeloCity Munich, 2007. http://www.ta.org.br/site/Banco/7manuais/colin_clarke_cycle_helmet.pdf

Hospital treatments occur once in 526 hours for football, once in 769 hours for squash, once in 909 hours for basketball, once in 1667 hours for soccer, and only once in 20,000 hours for cycling[123]. For Australia 2003/04, serious injuries with a high threat to life were 655 for cyclists vs 960 for pedestrians[124]. Mountain bike racing had a rate of hospital treatment of approximately one per 2000 hours[125].

A helmet petition to the Victorian Parliament expressed concerns that helmet wearing would increase the accident rate[126]. The petition mentions accidents increased by 117% for cyclists aged 17 - 50 years as helmet use was increasing in Victoria from 1984 to 1989. Parliament failed to discuss the petition. Monash University provided several reports detailing aspects of the helmet law for Victoria but had limited exposure data so did not include any calculation on risk per km or per hour cycled.

Hospital length of stay

For 2003-04, road vehicle traffic data for head injury show the mean 'length of stay' (total patient days) in hospital were:

Cyclists … 3.0 days ... (2597)
Pedestrians … 8.8 days ... (6791)
Motorcyclists ... 5.4 days ... (3264)
Car passengers ... 5.2 days ... (6982)
Car drivers ... 4.9 days ... (10350)

The ratio of total patient days for car occupants to cyclists is about 6.7 to 1. By comparison, Australians spend about 24 million days in hospital each year[127]. Cycling accounts for one in approximately 90,000 of hospital patient days (24,000,000/2597 = 92,414).

Main reports providing injury data

A range of reports is mentioned in Appendix A to provide extra information, mainly relating to individual Australian states.

Estimates from helmet effects and mandatory effects

Most reports evaluating helmets have compared the results from injuries to wearers compared to non-wearers that also tend to involve comparing cyclists who behave in different ways. Estimates from helmet effects listed below are based on 17 reports that involved nearly all voluntary use. Estimates from mandatory effects are based on five reports, three from Victoria[128].

Estimates from helmet effects

-41% to -64% on head injuries
-34% to +14% on facial injuries
+36% on neck injuries
+5% on other injuries

Estimates from mandatory effects

-25% for head injuries
+14% for extra accidents per km cycled
-29% for less cycling
Net effect -22% for all injuries

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[123] Roberts I, Owen H, Lumb P, MacDougall C. Pedalling Health - health benefits of a modal transport shift: http://safety.fhwa.dot.gov/ped_bike/docs/cyhealth.pdf http://sciweb.science.adelaide.edu.au/sundries/ph.nsf; 1996

[124] Serious injury due to land transport accidents, Australia, 2003-04, AIHW, October 2007.

[125] Taylor, N. B., & Ranse, J. (2013). Epidemiology of injuries at the Australian 24 hour mountain bike championships. Australasian Journal of Paramedicine, 10(1).Retrieved from http://ro.ecu.edu.au/jephc/vol10/iss1/4 accessed 19.12.2014

[126] VICHANSARD, Cycle helmet petition, 28 May 1991

[127] Media release, 'Australians spent 24.3 million days in hospital last year' 31 May 2007, AIHW.

[128] The Handbook of Road Safety Measures http://www.cycle-helmets.com/elvik-helmets-handbook.pdf

Many reports from Australia provide details of changes in head injury and other injuries but without good exposure data. Fatality data provide details of the number of deaths to wearers vs non-wearers, generally about 70% of known cases wearing helmets. Indications from reports suggest some protection from skull fractures could be expected. McDermott 1982 detailed 73 skull fractures for Victoria in the period 1977 to 1979 - i.e. 24 per year from a population base of approximately 3.8 million people, or one per 158,000 people per annum. The main safety outcomes from helmet effects and their mandatory requirement seem to be discouragement of cycling, a lower proportion of head injuries that are relatively infrequent per lifetime of cycling, possible higher accident rates and a higher impact rate for helmeted compared with no helmet. In comparison to pedestrians, the fatality and injury ratios have indicated a decrease in safety. The safety evidence for wearing helmets and helmet legislation is far from sound. The European Cycling Federation[129] stated that "… the evidence from Australia and New Zealand suggests that the wearing of helmets might even make cycling more dangerous".

Bike share scheme issues

A number of Australian states have tried to implement bike share schemes but in each case the helmet requirement acts as a deterrent to some potential users[130]. A recent analysis of the barriers to bike share program usage in Melbourne and Brisbane included information on helmets[131].

Fremantle City Council proposed that cyclists over 18 years of age have the option of riding without a helmet within the municipality for a trial period of between two and five years [132]. More detailed information is available from cycle-helmets.com[133]. Promoting cycling in all its forms is easier without helmet requirements. For example, bicycle hire in Paris has been a massive success without having to provide helmets[134]. In many of the smaller towns and cities across Australia, cycling into town may only take a few minutes and a helmet requirement adds inconvenience to cycling and can detract from enjoyment.

Health assessment

The principal threats to children and adult's lives are obesity, heart disease and other illnesses resulting in large part from inactivity[135,136]. Changes from 1989 to 2007 show the scale of the problem.

- 1989-90 - 36% of Australians aged 15 years and over were overweight or obese.
- 1990-92 - helmet laws introduced.
- 1989-95 - approximately 8%-10% more Australians became overweight - see Fig 9.
- 2001 - 8% increase to 44% or approximately 1,680,000 extra people were overweight or obese.
- 2000-01 - cardiovascular disease cost the Australian health system $5.4 billion[137].
- 2004 – 47,637 people died from cardiovascular disease and in 2004/05 approximately 3.5 million Australians reported having a cardiovascular condition.
- 2006-07 - the direct cost of physical inactivity was $1.49 billion for Australia[138].

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[129] European Cycling Federation; Improving bicycle safety without making helmet use compulsory; Brussels, Belgium. 1998. http://www.fiab-onlus.it/andare/helm_gb.doc

[130] Fishman, E., S. Washington, and N. Haworth, *Barriers and facilitators to public bicycle scheme use: A qualitative approach.* Transportation research part F: traffic psychology and behaviour, 2012. 15(6): p. 686-698.

[131] http://www.theage.com.au/victoria/spoke-too-soon-melbourne-bike-share-to-drag-chain-another-year-20140904-10c7hc.html accessed 14.9.2014

[132] Should Freo go helmet-free
http://blogs.crikey.com.au/theurbanist/2012/05/16/should-freo-go-helmet-free/ accessed 6.9.2014

[133] Australian bike hire schemes fail because of helmet laws
http://www.cycle-helmets.com/bike-hire-schemes.html accessed 13 Oct 2014

[134] City Bikes and helmets, Bicycle Helmet Research Foundation
http://www.cyclehelmets.org/1192.html , accessed 22.10.2008.

[135] Stewart S, Tikellis G, Carrington C, Walker K, O'Dea K. *Australia's future 'Fat Bomb':*
A report on the long-term consequences of Australia's expanding waistline on cardiovascular disease. April 2008, BHRI, Melbourne, Australia http://www.cycle-helmets.com/fatbomb.pdf accessed 14.9.2014

[136] Difficulties in provision of bariatric surgical services to the morbidly obese , Aust Med J. April 2005
http://www.mja.com.au/public/issues/182_07_040405/tal10771_fm.html accessed 14.9.2014

[137] Cardiovascular Disease in Australia: A snapshot, 2004-05, Australian Bureau of Statistics.

[138] Econtech, 2007 Economic modeling of the net costs associated with non-participation in sport and physical activity, Prepared by Econtech for Medibank Private.

- One study details that the total direct cost for overweight and obesity in 2005 was $21 billion[139]. The same study estimated indirect costs of $35.6 billion per year, resulting in an overall total annual cost of $56.6 billion (Colagiuri et al. 2010).
- 2013 - the rising number of overweight Australians costs $120 billion a year[140] (approximately $5200 per Australian per year).

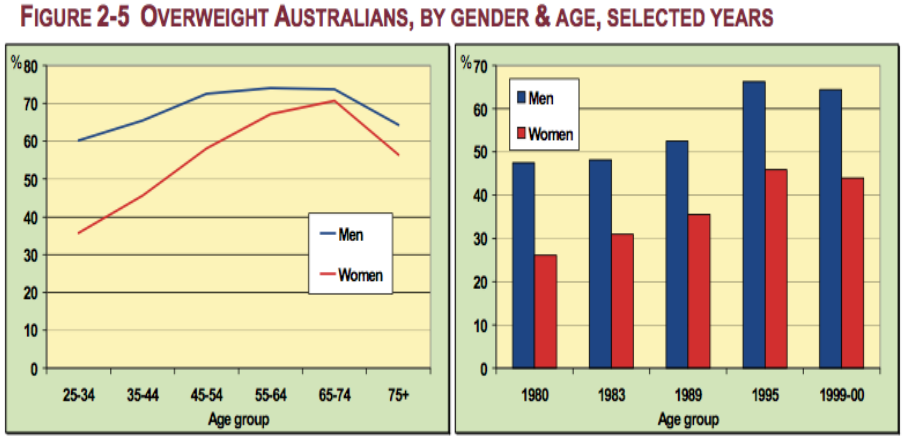

Fig 9

One study reported if current upward trends in overweight/obesity continue, there will be approximately 1.75 million deaths at ages 20+ years and 10.3 million PYLL (deaths and premature years of lost life) at ages 20-74 years caused by overweight/obesity in Australia in 2011 to 2050. Each Australian aged 20-74 years who dies from overweight/obesity in 2011 to 2050 will lose, on average, 12 years of life before age 75 years. This equates to more than 40000 lives per year[141].

In 1997, Dr Kennedy performed medical examinations on regular cyclists and non-cyclists who had died[142]. He reported that cyclists had a reduced risk of developing heart disease, providing convincing evidence of the benefits of cycling. Cycling helps to provide protection against;[143, 144] :

• coronary heart disease
• stroke (brain damage)
• non-insulin dependent diabetes
• falls, fractures and injuries (through improved strength and coordination)
• colon cancer
• overweight and obesity

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[139] Obesity and Overweight https://www.nhmrc.gov.au/your-health/obesity-and-overweight accessed 27.112014

[140] http://www.smh.com.au/national/health/obesity-costs-drag-down-national-good-20130308-2fr0b.html#ixzz3KCimRFEL accessed 21.11.2014

[141] Gray V, Holman JCD, Deaths and premature loss of life caused by overweight and obesity in Australia in 2011-2050: Benefits from different intervention scenarios. School of Population Health The University of Western Australia

[142] Kennedy A, Exercise and heart disease: cardiac findings in fatal cycle accidents, B J of Sport Medicine, Vol31, No4, p328- 331, Dec 1997.

[143] The Health Benefits of Cycling, Bicycle Helmet Research Foundation http://www.cyclehelmets.org/1015.html accessed 22.10.2008.

[144] Benefits of exercise http://www.nhs.uk/Livewell/fitness/Pages/Whybeactive.aspx accessed 2.10.2014

Cycling plays a key role in preventing these illnesses. Less cycling due to helmet laws has aggravated the situation. Deaths due to obesity and cardiovascular disease compared to cycling are about 80,000 vs 50 per year. Cycling gives a level of fitness equivalent to being 10 years younger and a life expectancy two years above the average[145].

Recently the CTC (UK national cycling charity) stated[146]: "However, CTC is not only concerned about the harmful effects of mandatory helmet use. By creating exaggerated perceptions of the risks of cycling, even voluntary helmet promotion campaigns have been found to deter some people from cycling. Given that the health benefits of cycling outweigh the risks by around 20:1 (one recent study put it at 77:1), it can be shown that only a very small reduction in cycle use is needed for helmet promotion (let alone helmet laws) to shorten more lives than helmets themselves could possibly save, regardless of how effective helmets might be."

People who cycle regularly live longer than non-cyclists, with a 29% lower mortality rate and better health throughout their lives. Indeed, cycling regularly to work (and, by extension, to school) has been shown to be the most effective thing an individual can do to improve health and increase longevity[147].

In Australia, physical inactivity contributes to the risk of 6400 deaths per annum. In 2004/05, 70% of Australians aged 15 years and over were classified as sedentary or having low exercise levels[148]. Curnow in 2008[149] concluded that "Compulsion to wear a bicycle helmet is detrimental to public health". Regular utility cycling where people cycle to schools, shops and work helps to provide a major health benefit[150].

In the mid 1980s, deaths to cyclists numbered about 85[151] (in comparison about 500+ for pedestrians) and distance cycled was approximately 4.0-4.5 million km per day (age 9+ comprised about four million km per day)[152]. An estimated figure of approximately 21 million km cycled per death occurred. If a person cycled on average 1km per day for 50 years, this would total 18,250km and on average they would be killed once in 1150 lifetimes. Relatively, cycling posed a low risk of being killed. The WHO has developed an assessment method for adults in the 20-64 age range "quantifying the positive health effects of cycling and walking" and this allows the positive benefits of cycling to be evaluated[153]. An approximate estimate for adults is that the equivalent of about 160 lives per year were saved by the health benefits of cycling. In comparison, for cyclists aged 20-64, about 20 lives were lost due to accidents[154]. With the helmet law discouraging cycling by about 30% to 35%, this equates to a net loss of about 46 lives per year for the 20 to 60 age group ((0.325 x 160 =52) – (20 x 0.325=6) = 46). In 2014 with improved road safety, the 20 lives lost in the mid 1980s could today be expected to have reduced.

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[145] Health, Fitness, Physical Activity and Morbidity of Middle Aged Male Factory Workers, Tuxworth et al. Br J Indus Med 1986;43:p733.

[146] http://www.ctc.org.uk/campaign/cycle-helmets-evidence accessed 21/.9.2014

[147] All-Cause Mortality Associated with Physical Activity During Leisure Time, Work, Sports and Cycling to Work, Andersen LB et al. Arch Intern Med 2000 Jun 12;160(11):1621-8
http://www.eltis.org/sites/eltis/files/case-studies/documents/anderson_et_al_2008_all-cause_morality_5.pdf accessed 8.12.2014

[148] Physical Activity in Australia: A Snapshot, 2004-05, Australian Bureau of Statistics Issue 21.12/2008

[149] Curnow WJ. Bicycle helmets and public health in Australia. Health Promotion Journal of Australia, 2008 Apr;19(1): 10-15.

[150] Geffen R, Health benefits of utility cycling: evidence overlooked
http://www.bmj.com/rapid-response/2011/10/31/health-benefits-utility-cycling-evidence-overlooked accessed 20.12.2014

[151] Victorian Bicycling Strategy; Vic Roads, Australia 1991.

[152] Day–to-Day Travel in Australia, CR 69, INSTAT, FORS 1988.Table 4.1e
http://www.infrastructure.gov.au/roads/safety/publications/1988/pdf/Aust_Trav.pdf accessed 11.1.2014

[153] Quantifying the positive health effects of cycling and walking
http://www.euro.who.int/transport/policy/20070503_1

[154] Australia Road Traffic Accident data, Victorian Bicycling Strategy; Vic Roads 1991

The health loss for other age groups has also to be considered. For children and adolescents (5-17 years) it is recommended they do 60 minutes (one hour) or more of physical activity each day[155]. In comparison, adults about two hours and 30 minutes (150 minutes) of moderate-intensive activity every week, which is 20-25 minutes per day on average. It is important to note that children and adolescents need more than adults. Pre law data for Melbourne indicated that children did about eight hours cycling per week, possibly meeting all of their exercise needs. Overweight and obesity in children is a major health concern. Studies have shown that once children become obese they are more likely to stay obese into adulthood and have an increased risk of developing both short and long-term health conditions such as type 2 diabetes and cardiovascular disease. A recent report identifies a range of cancers associated with being overweight[156].

Of Australian commuters who travel between 5 and 10 kilometres, 2.3% cycle and 0.1% walk[157]. Cycling such distances is more practical and can save time and expense in addition to delivering perhaps 30 minutes per day in exercise and saving on other forms of transport pollution. Often no other form of transport delivers the same individual and social benefits as cycling.

Cost effectiveness

Piet de Jong in 2012 provided a way to evaluate the question whether mandatory bicycle helmet laws deliver a net societal health benefit[158]. He reported that "in jurisdictions where cycling is relatively unsafe, helmets will do little to make it safer and a helmet law, under relatively extreme assumptions, may make a small positive contribution to net societal health." From the information available, an estimate can be made for Australia.

The formula for the cost benefit ratio is (mu x beta)/(e x q), where:

mu = odds of cycling is not maintained
beta = health benefit of cycling
e = proportional reduction in head injuries
q = proportion of accidents involving the head

The Handbook of Road Safety Measures[159] detailed its findings on 'Effects on injuries of mandatory wearing of bicycle helmets' with:

- Increased use of helmets, Head injuries -25 (-30; -19)
- Increased risk per km cycled, All injuries +14 (+10; +17)
- Less cycling, All injuries -29 (-30; -28)
- Net effect, All injuries -22 (-23; -21)

Assuming values of 29% discouraged as reported, assuming 20 to 1 for health factor, e = - 0.25 as reported and q =0.3 matching general data (Whately 1985).

mu value is 0.408, using 0.29/1-0.29 = 0.29/0.71= 0.408
beta = 20
e = 0.25
q = 0.3
Cost benefit ratio is (0.408 x 20)/(0.25 x 0.3) = 8.16/0.075 =109

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[155] How much physical activity do adults need?
http://www.cdc.gov/physicalactivity/everyone/guidelines/adults.html access 14.9.2014

[156] Campbell T, Obesity: a certain and avoidable cause of cancer
http://www.thelancet.com/journals/lancet/article/PIIS0140-6736(14)61172-7/fulltext accessed 30.9.214

[157] Cycling Infrastructure for Australian Cities March 2009 http://www.infrastructureaustralia.gov.au/publications/files/Cycling_Infrastructure_Background_Paper_16Mar09_WEB.pdf Accessed 26.12.2014

[158] De Jong, P. (2012), The Health Impact of Mandatory Bicycle Helmet Laws. Risk Analysis, 32: 782–790. doi: 10.1111/j.1539-6924.2011.01785.x

[159] The Handbook of Road Safety Measures
http://www.cycle-helmets.com/elvik-helmets-handbook.pdf

The cost factor against helmet laws is then more than 100 to 1. Put simply, helmet laws are not worthwhile because the health loss is far greater than the possible gains. This does not include the extra accident risk or the social aspects of fines, environmental harm, safety in numbers, bike share issues, etc. The serious injury data from Table 18 show that helmets may not even provide a safety benefit.

Law enforcement assessment

More than 200,000 fines have been issued in Victoria alone for not wearing helmets. The courts rapidly became overloaded with the prosecution of those who had not paid their fines. The Victorian Children's Court pleaded to the police to reduce the number of helmet fines being issued[160]. It was reported in 1997 that a boy faced detention for non-payment of fines[161]. Also reported was a 15 year old Aboriginal girl who had been detained and "Jailed for not putting on a bike helmet" - see Appendix C.

Concerns have been expressed by Amnesty International about human rights provided in Australia[162], stating:

"Statistics continue to demonstrate the disproportionate, increasing contact between indigenous people and the criminal justice system in Australia. Indigenous people represent 2% of Australia's population but indigenous prisoners represent 27% of Australia's total prison population."

"The Western Australian government has been criticised for its policy requiring people to serve prison time for unpaid fines, with reports suggesting that one in seven admissions to Western Australian prisons are people who are paying off fines."

The first helmet law in Victoria was introduced with a $15 fine if for not wearing one. In 2010 it was reported that "The fine for not wearing a helmet has jumped to $146 - which is likely to bring in at least $1 million in revenue for the state government this financial year" [163]. In 2014 the fine was $176[164]. In support of the helmet law and excessive fines, Vic Roads list 11 research reports in support of helmets or legislation and make questionable claims,[165] see Appendix D.

A NSW judge, after hearing evidence about cyclist Sue Abbott, agreed that the helmet law was unnecessary,[166] stating; "I frankly don't think there is anything advantageous and there may well be a disadvantage in situations to have a helmet - and it seems to me that it's one of those areas where it ought to be a matter of choice." An issue arose concerning costs that resulted in goods being confiscated from Mrs Abbott's home[167].

Avoiding unnecessary legal requirements and conflict situations where young adults may be cycling without a helmet could help in legal, social and health aspects. Using excessive fines as a means to persuade or coerce people to wear helmets, discouraging them from cycling, is not socially beneficial.

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[160] Focus on Petty Sins Defeats Court's Purpose. The Age, 2nd Sept 1993.

[161] Boy Faces Detention for Unpaid Bike Fines. Sydney Morning Herald, 12th Dec 1997.

[162] Document - Australia: Submission to the United Nations Committee Against Torture: 53rd Session (3 – 28 November 2014)
http://amnesty.org/en/library/asset/ASA12/004/2014/en/9b81f8cd-aa6d-4943-92d0-58522f6dc3df/asa120042014en.html accessed 21.11.2014

[163] Riders left reeling by bike fine increase
http://www.theage.com.au/victoria/riders-left-reeling-by-bike-fine-increase-20100526-we7e.html accessed 21.11.2014

[164] Fighting a helmet fine in the Victorian courts
http://crag.asn.au/2837 accessed 21.11.2014

[165] Wearing a bicycle helmet
https://www.vicroads.vic.gov.au/safety-and-road-rules/cyclist-safety/wearing-a-bicycle-helmet accessed 21.11.2014

[166] Heady freedom as judge agrees helmet laws are unnecessary
http://www.smh.com.au/nsw/heady-freedom-as-judge-agrees-helmet-laws-are-unnecessary-20100827-13vz2.html accessed 25.9.2014

[167] The only proven thing helmets protect us from are fines
http://www.theguardian.com/environment/bike-blog/2012/nov/13/helmets-australia accessed 21.11.2014

Environmental assessment

Bicycles use the least energy (kilojoules per person per kilometre) for general transport and have average values[168].

Cyclist ... 150
Pedestrian ... 230
Tram ... 2000
Motorcyclist ... 2100
Bus ... 2500
Car (driver only) ... 5000

Australia's per capita contribution to climate change is one of the highest in the world. Transport emissions rose 30% between 1990 and 2005 and this is expected to soar 67% above 1990 levels by 2020[169]. From the 1980s, oil shortages for Australia were foreseen and by 2015 it has been predicted that the trade deficit for petroleum products will be $25 billion[170]. In addition to discouraging cycling and causing environmental harm, helmets use petroleum products in their manufacture - contributing to environmental damage.

Safety in numbers

When more people cycle and motorists expect to encounter cyclists, the risk of injury per cyclist reduces. If cycling doubles it falls by 35% to 40%[171]. An international comparison shows that in those countries where cycle use is high, cycling is much safer yet very few people wear helmets. Moreover, the countries with highest cycle use (and low helmet wearing) also have the lowest levels of childhood obesity. Refer www.cyclehelmets.org for more details in regards to Australia[172].

Accident compensation assessment

Approximately six times more pedestrians and 20 times more motor vehicle occupants suffer lethal head injuries than cyclists[173]. Discrimination can occur in accident compensation cases where a cyclist was not wearing a helmet, compared to pedestrians or indeed motor vehicle occupants who sustained head injuries. The helmet laws result in unfair compensation and a biased legal process.

Civil liberties

Where there is a high risk and strong need to insist that people wear added protection, a case for overriding individual choice may be justified. With cycling the risk level is generally quite low[174] and the health benefits quite high. Individuals know their cycling situation and can use a helmet if they wish.

Most cities around the world have higher wearing rates in response to the perceived dangers. Individuals can make a personal choice on the issue without too much difficulty and without a Big Brother approach insisting on what is best for them. The case for helmets is not conclusive because numerous reports raise serious doubts whether helmet wearing improves safety overall. The evidence for helmets is mixed so individuals should be allowed choice.

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[168] Victorian Bicycling Strategy; Vic Roads, Australia 1991.

[169] Economic Benefits of Cycling for Australia, Cycling Promotional Fund 2008

[170] Curnow WJ. Bicycle helmets and public health in Australia.
Health Promotion Journal of Australia, 2008 Apr;19(1):10-15.

[171] Safety in Numbers: More Walkers and Bicyclists, Safer Walking and Bicycling, Jacobsen PL. Injury Prevention, 2003;9:205-209

[172] http://www.cycle-helmets.com/safety_in_numbers2.pdf

[173] Fatal crash types, Analysis of 1988 fatality File, CR 105, FORS 1992

[174] Mindell JS, Leslie D, Wardlaw M (2012) Exposure-Based, 'Like-for-Like' Assessment of Road Safety by Travel Mode Using Routine Health Data. PLoS ONE 7(12): e50606. doi:10.1371/journal.pone.0050606
http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0050606

The UK's National Children's Bureau (NCB) provided a detailed review in 2005[175] stating "the case for helmets is far from sound", "the benefits of helmets need further investigation before even a policy supporting promotion can be unequivocally supported" and "the case has not yet been convincingly made for compulsory use or promotion of cycle helmets".

On average, a person cycling would not be admitted to hospital for head injury in their lifetime, and if a helmet requirement deters them from cycling it will most likely have a negative health impact. To insist by legislation that they must wear a helmet shows a lack of regard for the individual human right to engage in cycling that suits their needs for health and wellbeing.

The Cyclist Touring Club (CTC UK national cycling charity) states that "Individuals should be free to make their own decisions about whether or not to wear helmets, with parents making these decisions in the case of younger children. Their decisions should be informed by clear information about the uncertainties over the benefits or otherwise of helmets.[176]' and "it is therefore entirely possible that helmet wearing might have a net disbenefit even in safety terms (a point also suggested by some of the empirical evidence), not to mention the health and other disbenefits identified above".

It is unreasonable to prosecute children or their parents for cycling without a helmet. Cycling is beneficial to health while helmet law discouragement of the recreational pastime causes sedentary lifestyles which lead to worse health and greater costs for society.

Queensland proposed law reform

A Queensland Parliamentary Committee recommended changes to the helmet law[177]. In 2013, the Queensland Transport, Housing and Local Government Committee suggested changes should be tried to the helmet requirements for cyclists aged 16 years and over[178].

The recommendation allowed for choice when riding in parks, on footpaths and shared/cycle paths, on roads with a speed limit of 60 km/hr or less, and for bicycle hire. Cycle hire schemes that require helmets appear to have weak demand compared with schemes that do not require helmets[179]. Brisbane City Council suggested trialling helmet-free zones in an effort to increase cycle use[180]. Census data for Queensland show a reduction in cycling to work from 2.56% in 1991 to 1.31% in 2011 - see Table 15.

The government response did not support the recommendations and referred to details of cyclist deaths, the 2010 Monograph 5 report, injury risk estimates and data from the Netherlands[181]. Out of 48 cyclist deaths in Queensland between 2005 and 2011 where helmet use was known, 14 were not wearing. This included six who had been drinking alcohol (43%) and out of 34 wearing, two had been drinking alcohol (6%).

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[175] Gill T, Cycling and Children and Young People – A review, National Children's Bureau, 2005. http://www.cycle-helmets.com/cyclingreport_timgill.pdf accessed 25.9.2014

[176] Cycle helmets: An overview of the evidence http://www.ctc.org.uk/sites/default/files/file_public/cycle-helmets-evidencebrf.pdf accessed 27.11.2014

[177]Queensland ponders relaxing cycle helmet laws http://www.theaustralian.com.au/news/nation/queensland-ponders-relaxing-cycle-helmet-laws/story-e6frg6nf-1226771527022?nk=758135f89965eeb38984774467f209cd

[178] Report No. 39 – Inquiry into Cycling Issues, Transport, Housing and Local Government Committee, 2013 http://www.parliament.qld.gov.au/documents/committees/THLGC/2013/INQ-CYC/rp-39-29Nov13.pdf accessed 11.1.2014

[179] Australian bike hire schemes fail because of helmet laws http://www.cycle-helmets.com/bike-hire-schemes.html accessed 11.1.2014

[180] Trial helmet-free cycling zones, says Brisbane City Council. Katherine Feeney. Brisbane Times August 10, 2013. http://www.brisbanetimes.com.au/queensland/trial-helmetfree-cycling-zones-says-brisbane-city-council-20130809-2rmrq.html accessed 11.1.2014

[181] Response 15, http://www.parliament.qld.gov.au/documents/committees/THLGC/2014/INQ-CYC/gr-28May2014.pdf accessed 12.12.2014

The government's response referred to data from the Netherlands where helmet use is low and cycling levels high. Their head injury rate is detailed for accidents involving motor vehicles and collisions not involving motor vehicle. Both sets of data show that the over 70 age group has higher rates. The number of cyclists with head/brain injury per billion kilometres cycled involving motor vehicles was 54 and 157 without motor vehicle involvement - one hospital admission per 18.5 million km and one per 6.4 million km cycled respectively. In both cases the data proves that riding without helmets can have a low risk[182].

The government's response stated that "according to the most recent estimate, the risk of sustaining head injury is 1.72 times higher for cyclists who do not wear a bicycle helmet than for the cyclists who do". This calculation was generated from studies that compared results for helmet wearers vs non-wearers in the proportion of injuries, not in risk per km cycled. More recent data show that the two groups can have significant differences so that the 1.72 factor would likely also include important differences due to behaviour - refer Table 19. Appendix A part 4 provides details on the Monograph 5 report and shows that its conclusions may not be as strong as they first appear.

Data from New Zealand where travel surveys are widely available show the risk of collisions not involving motor vehicles after helmet laws were introduced increased. It is reported that "cycling injuries not involving motor vehicles increased dramatically, quadrupling in 15-19 year olds (from 11.6 to 45.9 injuries per million hours) and more than doubling for children (from 39.5 to 85.4 per million hours) and adults (from 15.9 to 32.3 per million hours)"[183].

Summary of assessments

With helmet laws removing the civil liberty of personal choice and helmet promotion as an option to increase helmet use, a positive outcome was required in all assessments to justify the principle of helmet laws. The outcomes were:

Cycling activity assessment - negative result, relative to population size reductions of 40% by 2001 and 57% by 2011. Children's cycling activity was high prior to legislation and has been discouraged by approximately 80%.

Fatality assessment - not a strong outcome when taking account of known differences of wearers to non-wearers in terms of age, drinking issues and other factors. Comparing cyclists to pedestrians, pre-law (1986-89) cyclist deaths were 16.4% of pedestrians in number, but by 2010-13 the equivalent figure was about 47% when adjusted for the estimated changes in cycling/walking levels and population.

Injury assessment - with the ratio for serious injury of cyclist to pedestrian increasing appreciably, 1.49 in 1990 to 2.6 in 2008/09, it suggests a negative outcome. Accident data suggest helmet wearers have a lower proportion of head injuries and an increased risk of accident involvement from helmet use. Children's injury rate relative to cycling levels increased by up to 59%.

Environmental assessment - negative result with increased transport emissions due to reduced cycling levels.

Health assessment - negative result, with an estimated equivalent loss of 46 lives per year for the 20-60 age group and a negative health effect on other ages. From 1989 to 1995 there was a notable increase in overweight people at a time of cycling being reduced.

Bike share scheme issues - negative result by a helmet requirements adding to inconvenience and detracting from the appeal of using hire bikes.

Safety in numbers - negative result in reducing the proportion of people cycling and the expectation of motorists encountering cyclists.

Accident compensation assessment - negative result with discrimination against cyclists not wearing helmets compared to pedestrians or motor vehicle occupants who may suffer similar head injuries.

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[182] SWOV Fact sheet http://www.swov.nl/rapport/factsheets/uk/fs_bicycle_helmets.pdf

[183] http://cycle-helmets.com/new-zealand-road-users.html

Law enforcement assessment - reasonable enforcement levels but perverse outcome with excessive fines and taking up valuable police and court time.

Civil liberties - negative result in reducing personal choice by imposing a Big Brother approach and not allowing individuals to follow their own beliefs, convictions or choice based on convenience, health, safety, enjoyment and their personal circumstances.

Cost effectiveness - the cost benefit ratio is calculated at 109, proving that the Australian helmet laws do not deliver a net societal health benefit.

Conclusions

This evaluation of the Australian cycle helmet laws finds they have seriously failed in many ways. 'Australia's helmet law disaster'[184] sums up the outcome. The safety aspects of cycle helmets were overestimated and the negative health consequences of introducing legislation and discouraging cycling were not properly assessed. The actual risk of serious head injury when cycling is low. The societal health cost factor against the laws is calculated at 109, indicating they cause considerable harm. The ratio for serious injury for cyclists compared to pedestrians has increased from 1990 to 2008/09. The loss of civil liberty in having a personal choice for the individual is important. Fines for not wearing them and police involvement adds to social and legal problems.

Children's health, safety and wellbeing are also negatively affected by the laws, with more discouragement than among adults. Children require more exercise than adults so the laws, which were primarily aimed at child protection when first suggested, most likely result in harming them more than adults. Using alternative approaches to improve safety is the better route, as recommended by the European Cycling Federation in 1998. Based on available evidence, helmet laws should be repealed because several reports raise serious doubts whether helmet wearing improves safety overall and the resulting harm to health, environment and social consequences are considerable.

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[184] Turner L, Australia's helmet law disaster, http://ipa.org.au/publications/2019/australia%27s-helmet-law-disaster access 14.9.2014

Appendix A

Additional injury data

1) Cameron et al 1992[185] reported on the first 12 months of the law in Victoria, stating that "In the year following the introduction of a law requiring all cyclists to wear helmets (1990), reductions ranging from 37% to 51% were recorded in the number of cyclists killed or admitted with head injuries to hospitals in Victoria. There were also substantial reductions (21% to 24%) in the number of severely injured cyclists who did not have head injuries".

Victoria implemented stricter drink drive and speed enforcement measures, resulting in the road fatality rate per 100,000 population reducing from 17.9 in 1989 to 8.9 in 1992. Transport Accident Commission (TAC) Victoria data show for pedestrians from 1989 to 1992, head/concussion injury claims reduced by 33% and for other injuries by 12%[186]. Cycling levels reduced by 36% in Melbourne and indications from accident data suggest a higher reduction in the rest of the state.

In 2013, Vic Roads[187] reported on head injuries to cyclists, stating: "Two years after the legislation was introduced, there was a 16% reduction in head injuries in metropolitan Melbourne and 23% reduction in head injuries throughout Victoria". Vic Roads now refers to a smaller reductions in head injuries than were reported in 1992, a 16%-23% reductions compared with the claims of 37%-51% in 1992.

2) Marshall and White provided an evaluation of the helmet law for South Australia in 1994[188]. They reported that the results were not conclusive about the effects of the law on the number of cyclists. They considered that the substantial reduction in hospital admissions immediately after the legislation was introduced suggested that it was likely an immediate reduction in exposure occurred. They mention changes in hospital admissions policy for concussion injury and reported that bicycle helmets can be linked to a 12.1% decrease in hospital admissions for potentially preventable injuries by comparing the year before legislation data to the year after. The claim made, for a two year period before to two year after comparison, was of a 24.7% reduction in hospital admissions for potentially preventable injuries. They assumed non preventable injuries to be a suitable substitute for exposure. The first estimate was based on a 26.6% reduction in exposure and the second on a 9.4% reduction in exposure. They refer to the Harrison 1994 study[189] that reported a reduction of 38% in children cycling to school between 1988 and 1994. Census data 1991 to 1996 for Adelaide showed a reduction from 7186 to 4494, down in number by 37.5%. It appears the 9.4% reduction figure may not be reliable when considering school and Census data. Official accident statistics show a drop in cyclist injuries from 545 in 1990 to 320 in 1992, down by 41%. In 1993 it was reported that head injuries in South Australia were a diminishing problem for all road users[190].

3) Meuleners et al[191] reported findings from Western Australia: "the number of cyclists involved in bicycle crashes in the police data decreased from 1987 to 2000, while the hospital data shows a significant increase in the number of hospitalised cyclists." They reported that "The majority of cyclists (57%) spent only one day in hospital, while 33% spent between two and seven days in hospital. The length of hospital stay has decreased over the period".

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[185] Evaluation of the Bicycle Helmet Wearing Law in Victoria During its First 12 Months: *M Cameron et al, Monash University Accident Research Centre,* Report 32, 1992

[186] TAC data provided to C Clarke 1995

[187] Vicroads,Wearing a bicycle helmet, http://www.vicroads.vic.gov.au/Home/SafetyAndRules/SaferRiders/BikeRiders/WearingABicycleHelmet.htm accessed 6.8.2014

[188] Marshall J, White M, 1994. Evaluation of the compulsory helmet wearing legislation for bicyclists in South Australia. South Australia Dept of Transport Report 8/94.

[189] Harrison, R., Observational Study of Bicycle Helmet Wearing Amongst South Australian Schoolchildren, for the Office of Road Safety, Department of Transport, South Australia, April 1994.

[190] North B, et al, Head injuries from road accidents – a diminishing problem (letters), Med J Aust.Vol 158, March 15, 1993.

[191] Meuleners LB, Gavin AL, Cercarelli LR, Hendrie D, Bicycle Crashes and Injuries in Western Australia, 1987 – 2000 http://www.cycle-helmets.com/RR131.pdf

4) From Queensland 2010, Monograph 5 provides a range of information. Tables 29 and 30[192] detail information on head injuries from 1993 to 2008, all post law data. From the 16 years of data, the average number of head injuries per year was 74. The average population size was roughly 3,750,000 and on average one head injury equates to approximately 50,000 people, a rate of two per 100,000.

Monograph 5 Table 13 details that of known accident cases, 2037 (17.1%) were non-wearers compared with 9854 (82.9%) wearers. Tables 17 to 21 provide data by age group, in total 1184 head injury cases. Table 14 details the proportion of head injuries at 7.4% wearers v 17.0% non-wearers v 5.3% for 'unknowns' (where they are not sure if a helmet was worn or not). The 'unknowns' had the lowest proportion of hospital admissions and lowest rate of head injuries.

Monograph 5 Table 13 shows the proportion hospitalised at 39.7% for non-wearers v 31.5% for wearers v 19.7% for 'unknowns'. Helmet law enforcement reportedly started in 1993 and Figure 3 shows a marked increase in accidents from 1993 to 1997 while Census data from 1991 to 1996 shows a reduction in cycling levels, 2.56% to 1.84% - a relative reduction of 28%. Monograph 5 Table 9 details 826 cases in 1993 and 977 by 1996, up by 18%. The initial four year period of enforcement, 1993 to 1996, shows an increase in the number of accidents with Census data indicating a fall in cycling levels.

Data from Monograph 5 may help explain why more arm injuries occur. Table 21 below shows the proportions for head and shoulder/upper limb:

	Head	**Shoulder/ upper limb**	**Total**
0 - 17	559 (34%)	1083 (66%)	1642
18+	625 (20.5%)	2424 (79.5%)	3049

Table 21 Head, shoulder/upper limb vs age group

The data suggests that if fewer children cycle and more adults, then head injuries decrease in overall proportion. Table 22 below shows additional information from Monograph 5.

Monograph 5 Table 14 shows helmet wearers to have a 'Shoulder/Upper limb' rate of 28.3% and non-wearers a rate of 18.4%. Bicycle alone accidents result in a higher proportion of arm fractures than bicycle/motor vehicle accidents[193], so it appears helmet wearers may have had a larger proportion of injuries due to bicycle alone type accidents or falls.

	Shoulder/upper limb	**Lower limb**	**Ratio: Shoulder-upper limb to lower limb**
Not worn	375	603	0.621
Helmeted	2793	2884	0.968

Table 22 Shoulder/upper limb to lower limb vs helmet use

The data in Table 22 suggests a change in the risk of arm injury may occur with helmet use by increasing upper limb injuries.

Monograph 5 refers to data collected over a 16 year period and the higher rates of non-wearing coinciding with earlier years of lower levels of road safety. The helmet law was introduced in 1991 but details for 1991 and 1992 were not included in the report. Accident data show a drop of about 19% from 1992 to 1993 and indicate a reduction in cycling levels at the time of enforcement. Care is required in considering data on head injury in that the admissions criteria for Traumatic Brain Injury (TBI) can change due to several factors[194].

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[192] Bicycle Helmet Research, CARRS-Q Monograph Series - Monograph 5, Centre for Accident Research & Road Safety Queensland, 2010 (non-peer reviewed), Tables 29/30

[193] Whately S, Bicycle Crashes in the Austrian Capital Territories, CR 35, FORS, 1985, Table 25 http://www.infrastructure.gov.au/roads/safety/publications/1985/pdf/Bic_Crash_1.pdf accessed 11.1.2014

[194]McNaughton H[1], Wadsworth K. Assessing the accuracy of hospital admission and discharge diagnosis of traumatic brain injury in a New Zealand hospital. http://www.ncbi.nlm.nih.gov/pubmed/10917079 accessed

Queensland - comparing hospitalised pedestrians and cyclists in Table 23

Year	90	91	92	93	94	95	96	97	98	99	00	01
Cycle	305	272	291	221	227	210	259	253	240	241	277	276
Peds	444	377	433	388	418	445	411	373	393	385	426	424
C/P %	69%	72%	67%	57%	54%	47%	63%	68%	61%	63%	65%	65%

Year	02	03	04	05	06	07	08	09	10	11	12
Cycle	292	242	307	312	260	280	320	354	344	281	341
Peds	418	424	405	429	385	431	426	424	419	414	374
C/P %	70%	57%	76%	73%	67%	65%	75%	83%	82%	68%	91%

Table 23 Cyclist vs pedestrian injury data from 1990 to 2012[195]

Two years following enforcement in 1995, data show the lowest cyclist and highest pedestrian figures. Therefore some transfer may have occurred from cycling to walking. Monograph 5 details the increasing proportion of hospitalisation for cyclists in Figures 9-11 from 1993 to 2008. There seems little if any improvement for cyclists compared with pedestrians considering the reductions in proportion cycling to work was down by 49% (Census data above, Table 15 - 2.56% in 1991 to 1.31% in 2011).

The Queensland fatality data mentioned above - "Of the 44 not wearing, 13 (29.5%) had been drinking alcohol and from the 82 helmeted, five (6.1%) had been drinking" - could reflect a difference in behaviour for adults in wearers v non-wearers. Research from the USA reported[196] that "Alcohol use showed a strong correlation with head injury (odds ratio, 3.23; 95% confidence interval, 1.57-6.63; P = .001). In Queensland some of the differences in the head injury rate as well as fatality rates for wearers and non-wearers could be due to alcohol use. Data for NSW reported 7.2% of non-wearers had a BAC over 0.5 compared with 1.7% for wearers[197].

5) Curnow 2008 explains the history to the understanding of head injuries and the need to consider rotational accelerations in comparison to linear accelerations, and how the standards were developed. Details of deaths due to head injury for cyclists v pedestrians v all road users are provided for 1988 and 1994, showing a 30% reduction in the proportion for cyclists v a 38% reduction for pedestrians. Serious casualty data is provided for 1989 to 1993, showing reductions from 3965 to 3014 for pedestrians and from 1658 to 1247 for cyclists - 24% v 25%. Curnow comments that "No benefit from compulsory wearing of helmets is evident: rather, it would appear that the risk to cyclists increased"[198].

6) Olivier et al 2012[199] reported on changes in NSW from 1991 to 2010, together with changes to head and arm rates per 100,000 population. From 1991 to 2006 their data suggest an increase in the combined rates from about 21 to 38 hospitalisations from head and arm, up 83%. In contrast, the reported accident statistics in Table 13 show a drop from 1478 in 1991 to 1186 in 2006, down 20%. The population of NSW in 1991 was about 5.9 million and 6.8 million in 2006. The rates of hospitalisation for head and arm per reported road accident changed from 21/1478 (1.4%) to 38/1186 (3.2%). The report failed to relate to Census data showing the change in numbers cycling to work - 18,851 in 1986, 16,970 in 1991 and 19,274 in 2006 - or to regional cycling levels or to the change in level of children's cycling. It did relate to the Sydney CBD cycling count but failed to provide the population changes for inner suburbs of Sydney - see Table 7 for a selection of data from 1991 to 2011.

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[195] Data Analysis, Department for Transport and Main Roads, Queensland

[196] Crocker, P., O. Zad, T. Milling, et al., Alcohol, bicycling, and head and brain injury: a study of impaired cyclists' riding patterns R1. The American Journal of Emergency Medicine, 2010. 28(1): p. 68-72.

[197] Bambach, M; Mitchell RJ, Grzebieta RH, Olivier J (April 2013). "The effectiveness of helmets in bicycle collisions with motor vehicles: A case-control study.". Accid Anas and Prev. **53**: 78–88. doi:10.1016/j.aap.2013.01.005. PMID 23377086.

[198] Curnow B, p166, http://cyclehelmets.org/papers/p787.pdf

[199] Olivier, J., et al., Long term bicycle related head injury trends for New South Wales, Australia following mandatory helmet legislation. Accid. Anal. Prev. (2012), http://dx.doi.org/10.1016/j.aap.2012.09.003

One main point from the Olivier et al report is that arm injuries increased more than head injuries, suggesting a potential benefit from helmet use. Reportedly, "Blunt trauma may result in bone fractures in the adult population, while the cartilaginous nature of children's bones tends to prevent them from fracturing"[200]. A partial explanation to account for more arm injuries with relatively fewer head injury could be connected with fewer children cycling - see details Tables 8.

A selection of NSW road traffic cyclist accident data in Table 24 show the proportional changes relating to age (ignoring unknowns) from 1990 to 2011[201].

	0-16	17 and above	Total
1990	732	1148	1880
1991	503	975	1478
1992	454	852	1306
1993	496	955	1451
1996	522	837	1359
1999	340	836	1176
2001	268	887	1155
2006	225	961	1186
2010	132	956	1088
2011	115	890	1005

Table 24

The major change occurred with the large reduction in injuries for the 0-16 age group, suggesting the reduction in cycling continued for this age group.

7) Bambach et al 2013[202] provided NSW details relating from 2001 to 2009 by comparing head and other injuries from accidents involving motor vehicles for wearers (5087) and non-wearers (1658). From the 106 cyclist deaths recorded in the accident statistics between 2001 and 2009, Bambach et al refer to 42 deaths and had injury information on 18 cases only. A noticeable feature in the details was for the ages - 55% of non-wearers were in the 0-19 age group compared with 18.5% for wearers. Overall, the data showed that wearers had a lower proportion of head injuries and on average were about 33 years old while non-wearers about 22 years old. They claim that helmets reduce the risk of head injury by up to 74%. TAC data from Victoria Table 1 show that younger cyclists tend to have a higher head injury rate when involved in motor vehicle accidents. Bambach et al detail about half of cyclists less than 19 years old were wearing helmets. Considering data in Table 3, their findings may indicate less of a benefit than they first appear. Table 19 provides details from the Bambach et al report of differences between wearers and non-wearers. Note 34.4% of non-wearers riding on footpath vs 12.0% for wearers. The sort of impact that results from cyclists riding from the footpath into the road and being hit side-on by a motor vehicle could incur higher impact loads to the head. A driver may have less warning and time to slow, consequently resulting in more severe injuries. A combination of factors would contribute to non-wearers having a higher head injury rate, apart from helmet use.

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[200] How are children different
http://www.rch.org.au/paed_trauma/manual/11_How_are_children_different/ accessed 29.9.2014

[201] Road Traffic Accidents in NSW 1992 to 2011

[202] Bambach, M; Mitchell RJ, Grzebieta RH, Olivier J (April 2013)
"The effectiveness of helmets in bicycle collisions with motor vehicles: A case-control study.". Accid Anas and Prev. 53: 78–88. doi:10.1016/j.aap.2013.01.005. PMID 23377086.

Appendix B

Helmet law discourages cycling

Riding numbers plummet

by RON SHEPHERD

WHY rake over the coals of the helmet debate? Most of us have moved on to more important bicycle issues — getting space on main roads, and promoting cycling as part of Australia's better cities of the future.

However two recent reports — one from New South Wales, the other from Victoria — provide data on the effect of the compulsory helmet law. It's too soon yet to draw definitive conclusions and more surveys still need to be done but so far it seems most cyclists in both states are wearing helmets. But many people who don't want to wear them have ceased cycling altogether. From the safety expert's point of view this is good because there are fewer cyclists who could be injured.

For those of us who want to promote cycling as a convenient, enjoyable, environmentally-responsible way to travel, it's a disaster.

The NSW report (1) was prepared by University of Sydney psychologist Michael Walker for the Roads and Traffic Authority. This study found that by April this year 80% of Sydney cyclists were wearing helmets (although in the 16-20 age group the rate had risen to only 46%). The report also claims there are 22% more adult cyclists in Sydney since the compulsory helmet law. On closer reading this claim is suspect because the "before" survey was done in a wet September and the "after" survey in a sunny March. The surveys must continue until at least March 1992 before any clear pattern emerges.

The Victorian report (2), still in draft form, comes from the Accident Research Centre at Monash University. It tells us the proportion of Victorian cyclists wearing helmets has also shot up to around 80% overall. The other major finding of the report is more contentious. Between June 1990 — just before helmets became compulsory — and December 1990 the number of cyclists admitted to public hospitals with head injuries decreased by 56%. But wait on! Over the same period the number of cyclists admitted with all other injuries decreased by 47%, almost the same as the decrease in head injuries.

A likely interpretation of these figures is that much less cycling is being done in Victoria since the helmet law was introduced. The Accident Research Centre has done surveys showing substantial and significant reduction in the number of people cycling, but has not yet (as at September) published its findings.

Nevertheless, the downward trend in bicycle usage is consistent with numerous anecdotal reports Bicycle Victoria has received of people giving up cycling because of the helmet law. Many older people who have cycled all their lives without head injury are either furious or devastated by the compulsory helmet requirement.

Teenagers are another group which resents the helmet requirement. The NSW report found helmet-wearing was lowest in the 13—15 age group. In Melbourne secondary school teachers have stories of students throwing their helmets down in disgust (perhaps in imitation of the Tour de France riders?). In response to a telephone survey by Bicycle Victoria, some secondary school principals reported a reduction in the number of students riding bicycles to school. Others said there had been little change in the number of students cycling to school, but admitted that few wore helmets.

The main effect of the compulsory helmet law seems to have been a reduction in cycling. Indeed, as the NSW report points out, if people who were not wearing helmets stopped riding their bikes, then the percentage of cyclists wearing helmets will have gone up impressively!

With hindsight it seems cyclists have been the victims not so much of injury on the road but of selective attention by overzealous regulators. No one disputes that helmets work. But why aren't motorists required to wear them? Far more people die of head injury in cars than on bikes. Again, why don't footballers, skiers, skateboarders and horseriders have to wear helmets? Their activities are more dangerous for their heads than cycling is. Looking at an area other than road safety, more people suffer and die from sexually-transmitted diseases than from falling off bikes. We are exhorted to wear protective devices if we participate in promiscuous sex, but there are no police in our bedrooms to check that we do.

In many aspects of our lives we want to make responsible decisions about our individual safety rather than hand that responsibility over to the police. Let's look at the statistics:

Each year some 400 Melbourne cyclists end up in hospital with head injuries. Horrifying. But there are over a million cyclists in Melbourne. An individual's chances of head injury from bicycle riding are one million divided by 400. That equals once in 2500 years!

On average you'd have to have been wearing your helmet since the year 509 BC for it to protect you. So for the individual cyclist it's highly unlikely a helmet will ever be any protection. In fact it's an encumbrance, a damn nuisance. At the same time our society as a whole benefits from all cyclists wearing helmets. This is an irreconcilable conflict, and in this instance society has won over individual responsibility and decision-making.

What can we learn from this? It is easy to speculate that Volvo-ensconced motorists regard bicycles as anomalies on the roads. They resent us because they are worried they may hit us, they think we might delay them for a few seconds, or perhaps that we don't pay directly to ride our bicycles. So they impose some obligation on us to 'be safe'.

Travel is not just a matter of safety. It is a trade-off between convenience, safety, cost, health, and the environment. Overall, we think that bicycles score very well and should be selectively promoted and provided for. Although promoting bicycle helmets is commendable, the enforcement of a helmet law has been a disincentive to bicycle riding.

We need to change government emphasis from cycling as a safety problem to cycling as part of the solution to traffic congestion and alienation in Australian cities. Our overuse of cars is a victory of individual convenience over societal needs for clean air, a quiet environment, and conservation of our historic buildings, parks and bushland. How can we persuade motorists to be as socially responsible as they require cyclists to be?

(1) M.B.Walker (1991), *Law compliance and helmet use among cyclists in New South Wales*, April 1991, Consultant Report CR 1/91, Road Safety Bureau, Roads and Traffic Authority, Rosebery, NSW.

(2) A.P.Vulcan, M.H.Cameron and W.L.Watson (1991), *Mandatory bicycle helmet use: experience in Victoria, Australia (draft)*, Accident Research Centre, Monash University, Clayton, Victoria.

Appendix C

Jailed for not putting on a bike helmet

AUSTRALIA

Aboriginal and children's rights groups are campaigning against sentencing laws that have led to youngsters being jailed after being fined for minor offences.

The groups want the laws, imposed by the Northern Territory and Western Australian governments, repealed, especially as those most likely to be imprisoned are young Aborigines.

This is despite recommendations last year by a Royal Commission that imprisonment should be a last resort — and not for children.

In the Northern Territory last year, a 15-year-old Aboriginal girl was strip-searched and spent a night in a detention centre for not paying a fine. Her crime was not wearing a bicycle helmet.

In another case a 12-year-old boy, faces three months in the Darwin detention centre for failing to pay $2,000 (£444) in fines — also for not wearing a bicycle helmet. Ricky was originally given a $25 (£10) on-the-spot fine by police which he threw away. The fines increased over three months until a warrant was issued for his arrest. His grandmother said she could not afford to pay the fines. "I feel everything is wrong with the system," she said.

In Western Australia, a "three convictions and you're in" law has led to teenagers being sent to jail but a federal parliamentary committee believes this could be in breach of the UN Convention on the Rights of the Child.

Geoff Maslen

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Appendix D - VicRoads misleads the public

In 1991 Victorian Transport Minster Peter Spyker stated:

"Bicycling has an important role in transport and is to be encouraged as the most energy efficient travel mode. Bicycles produce minimal effects on the environment and cycling has positive effects on personal health and it is a popular recreational activity." [203]

Bicycle helmet legislation requires consideration of all of these issues in addition to safety. VicRoads provides information about bicycle helmets and legislation at https://www.vicroads.vic.gov.au/safety-and-road-rules/cyclist-safety/wearing-a-bicycle-helmet.

1
It states as fact:

"Two years after the legislation was introduced, there was a 16% reduction in head injuries in metropolitan Melbourne and a 23% reduction in head injuries throughout Victoria. There was also an immediate reduction in bike riders, however by 1992 the numbers of bike riders had approached pre-legislation levels."

The claim that "*There was also an immediate reduction in bike riders, however by 1992 the numbers of bike riders had approached pre-legislation levels.*" is misleading and not a fact. VicRoads refers to both Melbourne and Victoria in its claims. Survey information for Melbourne is detailed in a 1996 report [204] by Robinson, Table 4, with an extra 878 wearing helmets compared with 643 fewer cycling. For children to 17 years of age, 560 fewer were counted compared with 195 extra wearing helmets. The reduction in cyclists counted in Melbourne was from 3,121 in 1990 to 2,478 in 1992, down by 20.6%. Details provided in 2006 explain that the 1992 survey count was inflated by a cycle rally passing through one site and excluding this site reveals a 27% reduction from 1990 to 1992[205]. In comparison, VicRoads reported a 16% reduction in head injuries for Melbourne cyclists, less of a reduction than in the cycling level for Melbourne. It may have been a misguided opinion that "by 1992 the numbers of bike riders had approached pre-legislation levels" but it is certainly not a fact. Table 5 in the 1996 article reports *"Equivalent no. of injuries for pre law cycle use"* and for children the rate increased relative to cycle use levels. The equivalent number for "all injuries" rose from 806 to 944. This represented a reduction in safety. See http://www.cycle-helmets.com/robinson-head-injuries.pdf

Census data for Victoria [206] is shown in Table 1. The data clearly show that cycling levels had not approached pre-legislation levels in the proportion of people cycling to work until 2011 when it was still 13% below the 1986 level. From 1986 to 1989, VicRoads reported cycling had increased in Victoria by 47%[207] so that by June 1990 (pre-law) cycling to work levels may have been 2.57% (1.75 x1.47 = 2.57). The percentage cycling to work in 2011 may be approximately 40% below the estimated 1990 value and 13% below the 1986 value.

Erke and Elvik 2007 [208] examined research from Australia and New Zealand and stated:

"*There is evidence of increased accident risk per cycling-km for cyclists wearing a helmet. In Australia and New Zealand, the increase is estimated to be around 14 per cent."*

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[203] Victorian Bicycling Strategy; Vic Roads, Australia 1991

[204] Robinson DL; Head injuries and bicycle helmet laws; Accid Anal Prev, 28, 4: p 463-475, 1996 http://www.cycle-helmets.com/robinson-head-injuries.pdf

[205] Robinson DL, Do enforced bicycle helmet laws improve public health? BMJ 2006 http://www.cycle-helmets.com/robinson-bmj.pdf

[206] Changes in cycle use in Australia http://www.cyclehelmets.org/1194.html

[207] Victorian Bicycling Strategy; Vic Roads, Australia 1990

[208] Erke A, Elvik R, Making Vision Zero real: Preventing Pedestrian Accidents And Making Them Less Severe, Oslo June 2007. page 28 https://www.toi.no/getfile.php/Publikasjoner/T%C3%98I%20rapporter/2007/889-2007/889-2007-nett.pdf

The findings were based on five reports, four since legislation was in place. Few studies have data on the relative accident rate compared with cycling levels, so the above reports by Robinson and Erke and Elvik are important indications of overall safety. Clarke 2012 also reported an increased accident rate compared to cycling activity level for New Zealand [209].

2
VicRoads links to https://www.vicroads.vic.gov.au/safety-and-road-rules/road-safety-education/helmet-tips-for-parents-and-carers

2a
VicRoads details "**Helmet tips for parents and carers**". It states:

"*Research shows that wearing a bicycle helmet reduces the risk of head injury by 60 to 90 per cent.*"

VicRoads reported a change in the proportion wearing helmets from 31% to 75% (Melbourne survey data) and a 16% reduction in head injuries, along with survey data showing a 20.6% reduction in cycling, so the reduction in head injuries appears to be similar to the reduced cycling - 16% v 20.6%. The "60 to 90 per cent" may be supported by some research findings but actual data and research from Victoria does not support such a bold claim. Cyclehelmets.org reports:

"US federal agencies The National Highway Traffic Safety Administration (NHTSA) and the Centers for Disease Control (CDC) have decided that they can no longer justify citing the claim that bicycle helmets reduce the risk of head injury by 85%[210]." VicRoads continues with excessive claims.

3
VicRoads refers to "**Research about bicycle helmets**". It states:

"The rule is based on strong research evidence and has been adopted by all jurisdictions in Australia."

The word "adopted", tending to imply choosing to take up or follow (an idea, method, or course of action). Curnow explains: *"The Prime Minister of Australia announced on 5 December 1989 an invitation to the states and self-governing territories to legislate for compulsory wearing of bicycle helmets, among a range of other measures. As an inducement, he offered additional funds for roads".*

The rule was adopted with the incentive of receiving extra funding and not necessarily due to strong research. Refer page 158 of "Australian Legislation" [211].

Research from Canada published in the British Medical Journal (BMJ) in 2013 concluded that making helmets compulsory in certain provinces has had minimal impact on reducing the rate of admissions to hospital for cycling-related head injuries. Injury rates, the authors say, were already going down in the provinces that introduced compulsion [212].

A study in 2014 reported:

"Bicycle helmets may have a protective effect against external head injury but its protective role for intra-cranial hemorrhage is questionable. Further studies assessing the protective role of helmets for intra-cranial hemorrhage are warranted[213].

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[209] Clarke, CF, Evaluation of New Zealand's bicycle law, NZMJ 10 February 2012, Vol 125 No 1349 http://www.cycle-helmets.com/nz-clarke-2012.pdf accessed 11.1.2014

[210] http://www.cyclehelmets.org/1207.html?NKey=103 accessed 22.2.2015

[211] Curnow WJ. Bicycle helmets; a scientific evaluation, Transportation Accident Analysis & Prevention, Nova Science Publishers, Chapter 6. 2008. http://www.cyclehelmets.org/papers/p787.pdf

[212] Cycle helmets: An overview of the evidence http://www.ctc.org.uk/sites/default/files/file_public/cycle-helmets-evidencebrf.pdf accessed 15.2.2015

[213] B. Joseph, V. Pandit, B. Zangbar, M. Amman, M. Khalil, T. O'Keeffe, T. Orouji, A. Asif, A. Katta, D. Judkins, R. S. Friese, P. Rhee Rethinking bicycle helmets as a preventive tool: a 4-year review of bicycle injuries, October 2014 http://link.springer.com/article/10.1007%2Fs00068-014-0453-0#

4
Vic Roads refers to:

"A 2013 study investigated the factors, including helmet use, that contribute to head linear and angular acceleration in bicycle crash simulation tests. It was found that helmet use was the most significant factor in reducing the magnitude of head and brain injury. The study reinforces the benefits of wearing a bicycle helmet in a crash. It also demonstrated that helmets do not increase angular head acceleration, as some researchers have claimed. (Andrew S. McIntosh , Adrian Lai & Edgar Schilter (2013): Bicycle Helmets: Head Impact Dynamics in Helmeted and Unhelmeted Oblique Impact Tests, Traffic Injury Prevention, 14:5, 501-508) (External link)

The 2013 McIntosh et al study tested helmets for impact acceleration levels, lateral and rotational, for helmeted v non-helmeted and reported that both indicated a benefit from wearing helmets. However, it failed to account for various additional factors. Robinson 1996 reported:

"*Assuming the observed helmet wearing was typical of the cyclists' regular habits, head injury rates in helmeted and non helmeted cyclists (7/476 vs 0/49) were therefore not significantly different ($p < 0.55$), but the incidence of hitting their heads in a cycling accident was most significantly higher for helmet wearers (8/40 vs 13/476 i.e. 20% vs 2.7%; $p < 0.00001$)."*

McIntosh et al failed to take account that helmet wearers had been reported at a have a higher rate of impact than non-wearers. Also, they failed to take full account of the difference in duration of impact for rotational accelerations. The Wayne State Tolerance Curve for head injury indicates higher accelerations can be tolerated for shorter durations[214]. The duration of impact for non-helmeted was approximately 3 ms and 8ms for helmeted. The product of rotational acceleration and duration are important elements of evaluating head injury[215].

McIntosh et al results indicate a rotational product of approximately 8 krads/s² for 8 ms for helmeted (Fig 3), (64 krad/s²-ms) vs for non-helmeted (Fig 4),13 krad/s² for 3 ms (39 krad/s²-ms). In effect, their results show that helmeted may be more at risk from rotational acceleration by the extended time involved. Consequently their conclusions may not be reliable. The research also fails to take account of a major report by St Clair and Chinn [1] who conducted tests showing that helmeted can experience rotational acceleration levels up to 20 krad/s² by impacting a central vent position. McIntosh et al failed to test for central vent impacts.

5
VicRoads refers to:

"A 2013 study on the effectiveness of helmets in collisions between bike riders and motor vehicles in New South Wales between 2001 and 2009 found that helmet wearing significantly reduced the risk of moderate, serious and severe head injury by up to 74%. Helmets were found to be particularly effective in reducing the risk of more severe head injuries. The study also found that non-helmeted bike riders were more likely to engage in risky cycling behaviour, such as:

- *disobeying traffic controls (9.4% compared with 3.3%)*
- *cycling with a Blood Alcohol Concentration greater than 0.05 (7.2% compared with 1.7%)*

The study also found high rates of helmet non-use amongst children and adolescents. The research is the first of its kind in that it specifically analysed data relating to bike rider collisions with motor vehicles and the injury outcomes. (Bambach, M. R., Mitchell, R. J., Grzebieta, R. H., Olivier, J. The effectiveness of helmets in bicycle collisions with motor vehicles: A case-control study. Accident Analysis and Prevention, Issue 53, 2013)."

Page 37 above provide information about the 2013 NSW report. Page 3 Table 3 relates head injury rate to age grouping, showing younger cyclists have a higher proportion of head injury. Pages 18, 21 and 22 above provide additional information for NSW.

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[214] Dokko Y, et al, Validation of the Human Head Model Against Pedestrian Accidents and its Tentative Application to eh Examination of the Existing Tolerance Curve http://www-nrd.nhtsa.dot.gov/pdf/esv/esv18/CD/proceed/00230.pdf

[215] King et al, Is Head Injury Caused by Linear or Angular Acceleration? http://www.smf.org/docs/articles/hic/King_IRCOBI_2003.pdf

The Bambach et al 2013 study made its assessment by comparing differences in injury rates, had no information on risk per km cycled and did not contain information for accidents not involving motor vehicles that account for approximately 50% of cycle accidents. Clearly the two groups, helmeted vs non-helmeted, had major differences. See Table 19 on page 22 for factors that could affect the head injury rate. The report only provides an indication of a benefit in lowering the proportion of head injuries, not strong evidence of a net safety benefit.

The report claimed:

"The research is the first of its kind in that it specifically analysed data relating to bike rider collisions with motor vehicles and the injury outcomes."

In 1985, Whately [216] provided separate injury data for cyclists involved in motor vehicle accidents and also data for non-motor vehicle accidents, so the claim appears unreliable.

6
VicRoads refers to:

"*A 2010 study commissioned by the Queensland Department of Transport and Main Roads found the following: A review of the most scientifically rigorous research concluded that bicycle helmets that meet national standards protect against head, brain, and facial injuries. Helmet wearing was associated with a 69% reduction in the likelihood of head or brain injury and a 74% reduction in the likelihood of severe brain injury. The benefit was the same whether a motor vehicle was involved in the crash or not. Helmet wearing reduced the likelihood of injury to the upper and mid-face by 65%. (Haworth N, Schramm A, King M, Steinhardt D. (2010) Bicycle Helmet Research, CARRS-Q) [PDF 6.1 MB] (External link)*

Pages 17, 34 and 35 provide related information.

Table 22 on page 35 shows that, using the Queensland data, it would appear that helmet use changes the proportion of shoulder/upper arm to lower limb injuries. It shows that comparing the proportion of injuries can lead to unreliable conclusions. The Queensland report selected data from 1993 and this could have masked a reduction in cycling activity. See Table 10 on page 10.

7
VicRoads refers to a list of six additional reports in support for helmet use and legislation. Considering each report listed:

7a
Attewell R, Glase K, McFadden M. (2000) Bicycle helmets and injury prevention: A formal review (CR 195) Australian Transport Safety Bureau [PDF 118 Kb] (External link) (PDF).

The Bicycle helmet research Foundation (BHRF) provides commentary on this paper [217]:

"In general, the reanalysis of Attewell, Glase and McFadden, 2001 shows a modest benefit from bicycle helmets. However, based on the more recent papers only, the benefit vanishes entirely. Taking all the papers together, the best estimate is for helmets to reduce injury to the head, face or neck by 15%.

Conclusion
This is a powerful paper that discredits some of the most widely cited pro-helmet research by applying rigorous tests for bias and conflict of interest. It also notes that more recent research does not show any clear benefit from helmet use and that the failure of post-law research to find the predicted benefits from helmet use may be explained by behaviour patterns that could be an artefact of promoting and mandating helmet use."

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[216] Whately S, Bicycle Crashes in the Austrian Capital Territories, CR 35, FORS, 1985,p13 http://www.infrastructure.gov.au/roads/safety/publications/1985/pdf/Bic_Crash_1.pdf

[217] BHRF http://www.cyclehelmets.org/1251 .html accessed 24.2.2015

The Attewell 2001 study compared injuries for helmeted vs non-helmeted and in some cases had relatively low wearing rates - e.g. 11% of cyclists were wearing in the Maimaris report. As shown from the Bambach et al 2013 study, major differences can occur in behaviour for helmeted vs non-helmeted and with some of the behaviour of non-wearers this is likely to result in more accidents and in some cases more severe impacts. The strongest results for head injury protection from the Attewell study came from early reports of Wasserman 1988, Wasserman 1990 and Spaite 1991. The helmet wearing rates (37%, 57% and 41%) appear to be much higher than the normal community wearing rate at the time, probably around 5% to 15%. This suggests that wearers may have had more falls resulting in lower severity injury levels. Spaite mentions that helmet users without head injuries were also less severely injured than non-users without head injuries (4% vs 32%).

7b
Hynd D, Cuerden R, Reid S, Adams S. The potential for cycle helmets to prevent injury: A review of the evidence – Transport Research Laboratory (TRL) report for the Department for Transport, UK, 2009 (External link).

The BHRF provides commentary on this paper [218]:

"Conclusions
The study report includes a lot of useful analysis and data but several factors about the brief, methodology and the summary of results suggest a predisposition to results showing helmets to be beneficial. In that context, it is a significant outcome that no reliable evidence was found that helmet wearing has reduced risks to cyclists in the real world. It is also an important outcome that the published evidence commonly used to justify helmet wearing was shown to be unreliable."

7c
Macpherson A, Spinks A. Bicycle helmet legislation for the uptake of helmet use and prevention of head injuries. Cochrane Database of Systematic Reviews 2008, Issue 3. Art. No.: CD005401. DOI: 10.1002/14651858.CD005401.pub3 [PDF 226 Kb] (External link) (PDF)

The BHRF provides commentary on this paper[219]:

"None of the studies included in the Cochrane review measured pre- and post-legislation cycling participating rates, ***making it impossible for the authors to draw any conclusions about the laws' effect on either cycling or injuries***

Ethics
This review raises questions with regard to ethical and moral issues. The principal author is a known campaigner for cycle helmet laws and clearly not neutral in her enthusiasm for them. She is the author of other papers on helmet laws that have been criticised for not presenting a balanced view of the evidence. In this review, although its limitations are acknowledged, the overall presentation is not a good reflection of the null outcome of the review but, arguably, an attempt to present as positive an ***outcome (in favour of helmet laws) as possible despite the evidence."***

7d
Olivier J, Walter SR, Grzebieta R. Long term bicycle related head injury trends for New South Wales, Australia following mandatory helmet legislation. Accident Analysis and Prevention, in press 2012. (External link)

Details from pages 36/37 show the report raises doubts about helmets improving safety, stating:

"The rates of hospitalisation for head and arm per reported road accident changed from 21/1478 (1.4%) to 38/1186 (3.2%). The report failed to relate to Census data showing the change in numbers cycling to work - 18,851 in 1986, 16,970 in 1991 and 19,274 in 2006 - or to regional cycling levels or to the change in level of children's cycling."

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[218] BHRF http://www.cyclehelmets.org/1230.html accessed 24.2.2015

[219] BHRF http://www.cyclehelmets.org/1181.html accessed 24.2.2015

7e

SWOV (Institute for Road Safety Research, The Netherlands) Fact sheet: Bicycle Helmets, 2012. [PDF 85 Kb] (External link) (PDF)

The report assumes that the Elvik 2011 report provides reliable findings. It was a reanalysis of the meta-analysis of Attewell et al. (2001) and included new studies. Helmet use rates in the Netherlands are generally low and their fatality and injury rates per billion km for cyclists are some of the lowest in the world[220]. The Elvik study may have overestimated the value of helmets in not relating to the information in 7a above.

Cyclehelmets.org provides commentary on the Elvik 2011 paper[221]

7f

Thompson DC, Rivara F, Thompson R. Helmets for preventing head and facial injuries in cyclists. Cochrane Database of Systematic Reviews 1999, Issue 4. Art. No.: CD001855. DOI: 10.1002/14651858.CD001855 [PDF 364 Kb] (External link) (PDF)

The BHRF provides commentary on this paper [222]:

"*For bicycle helmets, the main questions are likely to be, are they effective (and cost effective), and should we recommend or mandate that cyclists wear them? In this case, the act of recommending or mandating that helmets be worn may change the circumstances, eg by making cyclists feel safer and take more risks. The act of recommending or mandating helmets may also discourage people from cycling. These factors cannot be considered in isolation from the effect of helmets. They are part of the package that comes with mandating or recommending helmets."*

In short, Thompson et al review cannot be recommended as a valid interpretation of the existing published information on helmets.

Conclusion

None of the above reports quoted by VicRoads dispute the 14% figure reported by Erke and Elvik 2007[223] for helmet use increasing the accident rate per km cycled. VicRoads misleads the public by selecting evidence to support the existing legislation without giving a balanced appraisal of the evidence. VicRoads makes excessive claims given the evidence from the state's own accident data. VicRoads quotes NSW research and fails to disclose the increase in accident risk for children reported by Robinson 1996 - Table 2 Equivalent number of injuries for pre law numbers of cyclists[224]. "Facts" claimed by VicRoads are not supported by the evidence.

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[220] http://www.swov.nl/rapport/Factsheets/UK/FS_Cyclists.pdf accessed 24.2.2015

[221] http://www.cyclehelmets.org/1251.html accessed 24.2.2015

[222]BHRF http://www.cyclehelmets.org/1243.html accessed 24.2.2015

[223] Erke A, Elvik R, Making Vision Zero real: Preventing Pedestrian Accidents And Making Them Less Severe, Oslo June 2007. page 28 https://www.toi.no/getfile.php/Publikasjoner/T%C3%98I%20rapporter/2007/889-2007/889-2007-nett.pdf

[224] Robinson DL; Head injuries and bicycle helmet laws; Accid Anal Prev, 28, 4: p 463-475, 1996 http://www.cycle-helmets.com/robinson-head-injuries.pdf