Submission to the Western Australian Parliamentary Inquiry on Personal Choice and Community Safety

Topic: mandatory bicycle helmet laws

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Abstract

This submission will address the terms of reference of the inquiry in regard to laws relating to bicycles, specifically the requirement by cyclists of all ages in all circumstances to wear a helmet. The terms of reference of this inquiry refer to cycling as a type of "outdoor recreation", however it is also a form of transport, and this submission seeks to question whether it is right to apply laws designed to legislate a sporting activity to a means of commuting to work, study, etc. Australia's all-ages mandatory bicycle helmet laws were the first in the world, and as such there was very little data available, pre-implementation, to assess their effectiveness at reducing rates of serious cycling injuries. Many of the claims made to support the laws since they were introduced are scientifically unsound for a number of reasons; the comparative safety data from before the laws were introduced are scare; changes in total injury numbers are often quoted, rather than rates of injury per journey or per hour; variations in cyclist numbers were poorly measured at the time the laws were introduced; changes in transport safety due to interventions like speed cameras and random breath testing are ignored; and little effort is made to distinguish between the risks involved in different forms of cycling (road racing, downhill mountain biking, transport cycling) and different cycling environments. Much of the debate about helmet laws focuses on the efficacy of helmets - however this ignores the matter of how common serious accidents are. Since a helmet is only useful once an

accident occurs, arguments about the efficacy of helmets are largely irrelevant to any discussion about whether cycling is an inherently safe or unsafe activity. In this submission I will argue that mandatory helmet laws should be significantly relaxed or repealed as they do not significantly benefit society, present several lines of evidence which indicate that helmet laws reduce cycling participation, show that the health benefits of cycling outweigh the risks in almost all circumstances (and hence that helmet laws actually do more harm than good for society, by discouraging cycling as an active transport choice), outline the flaws in common arguments in favour of helmet laws, and discuss the probability of serious injuries and why helmet use doesn't make the average cyclist substantially safer.

1 Personal background and involvement with cycling

I am a visiting research fellow and lecturer at the University of Adelaide. I hold a PhD in Theoretical Physics, and for the past few years have used my considerable training in mathematics and science to investigate the validity of arguments in favour of all-ages mandatory bicycle helmet laws.

I have regularly commuted to study and work by bicycle for the majority of the past thirty years, both in Australia and overseas. I am the national vice-president and South Australian coordinator for Freestyle Cyclists Inc. and have been involved with organising events such as helmet-optional protest rides.

I receive no funding or salary from any cycling or road safety organisations.

2 History of mandatory bicycle helmet laws in Australia

It is important at the outset to recognise that the term "cycling" covers a wide range of activities, which differ greatly in purpose and risk level. Broadly speaking cycling is a form of transport, performed at modest speeds, with very low levels of associated risk, but it can also be several different sporting activities (e.g. road racing, downhill mountain biking) which have a higher level of associated risk. Assessments of cycling injuries based on hospital admissions are inevitably biased towards the form of cycling in which most accidents occur - the high-risk sporting version of cycling. It is therefore not necessarily valid to draw conclusions about the risks of transport cycling based on hospital admissions, or to conclude that all

cyclists in all circumstances should be subject to the same legal requirements to use protective headgear.

A great deal of the controversy over mandatory helmet laws (MHLs) centres around not just the matter of personal choice, but the question of whether they discourage people from cycling (by creating inconvenience and the impression that cycling is a dangerous activity) and whether the safety benefits of mandatory helmet use are outweighed by the health benefits of cycling as a form of active transport. Australia was the first country in the world to introduce all-ages mandatory helmet laws for cyclists, beginning on the 1st of July 1990 in Victoria, and following in other states and territories over the next few years, with Western Australia implementing its law in 1992. Since that time very few other countries have adopted such laws, deeming them to discourage cycling as a transport choice - and hence detrimental to public health and efforts to reduce traffic congestion. Several jurisdictions that did implement MHLs subsequently repealed them or relaxed them to apply only to children (e.g. Israel, Mexico City, Bosnia-Herzegovina, Dallas and Austin in Texas).

In Australia mandatory bicycle helmet laws have gone largely unchallenged. In 1994 the Northern Territory amended its law to make helmet use voluntary for adults riding on off-road paths and footpaths. In November 2013 a Queensland inquiry into cycling issues by the Transport, Housing and Local Government Committee recommended that bicycle helmet laws should be relaxed in certain circumstances for a 24 month trial to assess the effect on cycling participation, health, and economic benefits. This recommendation was vetoed by the then state transport minister - an act which has impeded any fair assessment of the costs and benefits of repealing these laws. With the exception of these two instances, MHLs have been in place and largely unquestioned by governments across all Australian states and territories for almost thirty years. It is not unreasonable to review a law which was introduced without precedent, after several decades, to see whether it actually achieved what it was intended to. If it did not, it should be counted as a failure and modified or repealed.

It is worth noting that in 2012 Fremantle MP Adele Carles and Fremantle mayor Brad Pettitt called for a 24 month trial exemption to cycling helmet laws for adults on off-road paths. The Queensland inquiry mentioned above made a similar recommendation a year later, finding that

- There was not "sufficient evidence of the safety outcomes of compulsory helmet wearing to justify the mandating of helmet wearing for all cyclists of all ages regardless of the situational risk."

- "relaxing mandatory helmet laws in specific circumstances is likely to increase cycling participation rates with a range of associated health benefits and economic benefits."
- "there is sufficient evidence provided by the Northern Territory example that a relaxation of mandatory helmet laws in lower risk situations (such as cycling on footpaths and on dedicated cycle paths), does not inevitably reduce the safety of cycling."
- And recommended "a 24 month trial which exempts cyclists aged 16 years and over from the mandatory helmet road rule when riding in parks, on footpaths and shared/cycle paths and on roads with a speed limit of 60 km/hr or less".

Between 2016 and the present, ACT Road Safety Minister Shane Rattenbury has suggested that helmet laws might be relaxed in certain low-risk circumstances to encourage more people to cycle and improve the viability of bike share schemes. None of these calls for relaxation or repeal have been acted upon, although it is widely acknowledged that cycling provides substantial community benefits. Federal government statistics from 2013 show that each cycling trip to work and back saves the national economy $21 in reduced pollution, noise, congestion, infrastructure construction costs, and improvements in health.

In 2015-2016 the federal Senate conducted an inquiry into "personal choice and community impacts" which included bicycle helmet laws in its terms of reference, however this inquiry ceased to exist when the Senate and House of Representatives were dissolved for the 2016 election.

In 2017 the nation's largest cycling advocacy organisation, Bicycle Network, conducted a survey into MHLs which garnered around 20,000 submissions. Approximately 2/3 of these indicated support for some level of relaxation or repeal of bicycle helmet laws, and 30% said they would ride more often if helmet laws were relaxed.

3 Personal and community benefits of cycling

While this inquiry focuses on the situation in Western Australia, surprisingly little data was collected at the time these laws were introduced to compare before-and-after effects of helmet laws, so that a valid assessment of their effect as a public safety measure and any impact upon cycling participation rates is difficult

to assess. It will therefore be necessary to look at data from WA, the rest of Australia, and overseas to form a coherent picture.

At the time MHLs were introduced in Australia the health benefits of cycling were not so well understood as they are now. A recent study by researchers from the University of Glasgow ("Association between active commuting and incident cardiovascular disease, cancer, and mortality: prospective cohort study" Celis-Morales et al, BMJ 2017; 357) found that regular cycling, of the kind engaged in by people who use a bicycle as a means of transport to work, study, or to go shopping, is associated with a 52% reduction in risk of cardiovascular disease (CVD) and a 41% decrease in the risk of deaths from all causes. It should be emphasised that this study was conducted in the UK, where bicycle helmets are not mandatory, and that deaths due to cycling accidents are included in the "all causes" category, so a reduction in deaths from all causes indicates that even without MHLs the benefits of regular cycling outweigh the risks.

The question of whether bicycle helmets should be mandatory can be phrased in a different way; should cycling without a helmet be illegal? Activities are generally made illegal if they harm society as a whole, and/or if they harm the person undertaking them. If repealing or relaxing helmet laws encouraged people who are currently sedentary to be more active by cycling, would they benefit as individuals, and would society as a whole benefit, due to their increased levels of exercise?

According to data from the Heart Foundation, in Western Australia in 2013 there were 835 deaths due to CVD in persons under age 75. We will assume this figure is typical of the annual CVD fatality count in WA. According to the Road safety Commission "Preliminary summary of fatalities on Western Australian roads 2017" there were an average of 5.2 cyclist fatalities per year in WA between 2012 and 2017. According to the AustRoads Cycling participation surveys conducted between 2011 and 2017 around one in five Western Australians had ridden a bicycle on a weekly basis. This means $835 \div 5 = 167$ deaths due to CVD occur per year in a group of people (under age 75) equivalent in size to the Western Australian population of weekly cyclists. If regular cycling reduces the risk of CVD by 52%, this means 87 CVD deaths are prevented in a group of people of this size. In other words, the number of CVD deaths prevented outweighs the number of cycling fatalities by about 17-to-1. This is clearly a substantial benefit to each individual who takes up cycling as a transport choice rather than living a sedentary lifestyle, and to the community as a whole.

One might expect that this benefit would be reduced by a decrease in helmet usage. It is commonly claimed by proponents of MHLs that failing to wear helmet

makes one around 3.33 times more likely to sustain a serious head injury. However only 23% of serious cycling injuries are head injuries ("Serious injury due to land transport accidents, Australia 2008-09" AIHW: Henley G and Harrison JE 2012, Injury Research and Statistics Series no. 67, Table 4.3.12). Hence a total cessation of helmet wearing would only be expected to increase cycling injury and fatality rates by $3.33 \times 23\% = 77\%$, meaning that CVD deaths prevented would still outweigh cycling fatalities by about 10-to-1.

While helmets are designed to reduce the incidence of traumatic brain injury, it should be remembered that cardiovascular diseases include strokes, which can also cause traumatic brain injury, and so any increase in head injuries among cyclists must be offset against decreases in strokes. This assessment of the community benefits of cycling also neglects reductions in air pollution, reductions in damage to transport infrastructure, reductions in cases of type 2 diabetes, etc. and hence actually underestimates the community benefits of increased cycling. On this basis it seems clear that a repeal of helmet laws would benefit the community at large.

If an activity benefits the people who partake of it, and the community as a whole, surely that activity should be encouraged, rather than criminalised. Riding a bicycle, with or without a helmet, fits both these criteria.

Helmet laws also seem to have a negative economic outcome. The study "An economic evaluation of the mandatory bicycle helmet legislation in Western Australia" by Hendrie, Legge, Rosman and Kirov (1999), found that even under the most favourable assumptions, mandatory helmet use would have only saved the Western Australian economy $2 million per year (and may even have cost the state economy $10 million per year), and even then only if the healthcare costs associated with decreased cycling activity were ignored. In short, if the economic costs of sedentary lifestyles are taken into account MHLs cost the Western Australian economy several million dollars a year. Research from Macquarie University (De Jong, 2009) indicates that mandatory helmet laws cost Australia around half a billion dollars per year, due to reductions in cycling participation leading to reductions in the health and fitness of the average commuter. A number of other international studies have found that the social, economic and environmental benefits of cycling outweigh the costs of cycling injuries, with large benefit-to-cost ratios. These include Hillman (1992) with a benefit-cost ratio of 20:1, Rabl and de Nazelle (2011) with a ratio of 24:1, and de Hartog, Boogaard, Nijland and Hoek (2010) with a ratio of 35:1. Each of these studies indicates that even if injury rates increased due to helmet laws being repealed (and the experience of jurisdictions which have had MHLs and repealed them suggests they would not), the societal

benefit from cycling would be comfortably maintained, and that any reduction in cycling that arises as a result of MHLs induces a net cost to society.

4 Probability and the efficacy of helmets

The discussion about the safety effects of helmet use (and hence the merits, or otherwise) of mandatory helmet laws (MHLs) often focusses on head injury rates amongst cyclists admitted to hospital emergency departments. While this sounds sensible, it is in fact largely misleading, and to see why we must look closely at the concept of probability.

The probability of some event or outcome is just the number of times that outcome can be expected to happen, divided by the number of opportunities for it to happen. For instance, suppose you rolled a fair, six-sided die. The probability of getting any number is one chance in six (or 16.66%, or 0.1666), so if you rolled a die six hundred times you would expect to get approximately one hundred 1s, one hundred 2s, one hundred 3s, etc.

There is a related, and very important concept called "conditional probability". This is the probability of an outcome, given an extra piece of information which tells you whether some relevant condition is (or is not) satisfied. For instance, the probability of a randomly selected person having a beard depends on several conditions, such as their gender and their age. If you had to guess whether someone you have never met before had a beard, knowing their gender would influence your guess.

In the case of cycling, being involved in a crash is a condition that affects the probability of sustaining an injury. When we examine cyclists admitted to hospital, this condition (having a crash or accident) has already been fulfilled - but in the case of the average cyclist starting out on a ride this condition has not been fulfilled, *and probably won't be, because accidents per journey are uncommon*. Therefore cyclists admitted to hospital are unrepresentative of the average cyclist.

It is an important point, and hence worth emphasising, that even if the conditional probability of being injured if an accident occurs is quite large, if the probability of an accident occurring in the first place is tiny then the probability of any injury occurring will be tiny as well. Likewise, a large change in the conditional probability of injury (as a result of wearing a helmet, for instance) may lead to only a small change in the probability of injury during any given cycling journey. In other words **the lower the chance of being involved in a crash is, the less safety benefit one gains from wearing a helmet**. This fact underscores

why it is more effective to focus on road safety measures that prevent accidents happening in the first place (such as reduced traffic speeds, and dedicated bicycle paths) rather than protective equipment like helmets, and why helmets need not be mandatory in low-risk circumstances such as off-road paths or slow transport cycling. Let us illustrate this with an example.

Suppose 100 cyclists in helmets and 100 cyclists without helmets go riding. Suppose 1 rider wearing a helmet, and 2 riders without helmets are seriously injured. At first glance, wearing a helmet seems to lead to a 50% reduction in injuries. This conclusion would be strictly correct, but it only tells us about the conditional probability of being injured if an accident occurs, and tells us nothing about how common accidents and injuries actually are. If we consider all 200 cyclists in our hypothetical example, we see that injuries are rare. Only 2% of the cyclists without helmets, and 1% of the cyclists with helmets were injured. So wearing a helmet reduces the chance of being injured by just $2\% - 1\% = 1\%$ (Figure 1).

When proponents of MHLs cite research based on patients admitted to hospital emergency departments they are focussing on the conditional probability of being injured if an accident occurs. This obscures the fact that helmet use has a tiny effect on the probability of being injured, per journey, even if it has a large effect on the conditional probability.

The terms odds ratio, the risk ratio, and risk difference are often used in medical assessments of the effectiveness of a medical or safety intervention. The odds ratio and risk ratio are good ways of assessing changes in conditional probability. However, they do not convey any useful information about how common the condition they depend on is in the first place. The risk difference provides a better measure of how many instances of the ailment under investigation are actually being prevented. In the example above, dividing the number of injured helmeted riders by the number of injured unhelmeted riders ($1 \div 2 = 0.5$ or 50%) was equivalent to calculating the risk ratio. Subtracting the percentage of injured helmeted riders from the percentage of injured unhelmeted riders ($2\% - 1\% = 1\%$) was equivalent to calculating the risk difference. Proponents of MHLs tend to quote calculations of odds ratios and risk ratios, even though these are not the most useful quantities for calculating the effect of helmet use on the safety of the average cyclist.

To assess overall cyclist safety, and how common accidents or serious injuries truly are we need to look at injury statistics as well as some measure of exposure to risk for all cyclists (e.g. hours cycled, total number of journeys, or distance cycled).

According to the Australian Cycling Participation Survey 2011 conducted by

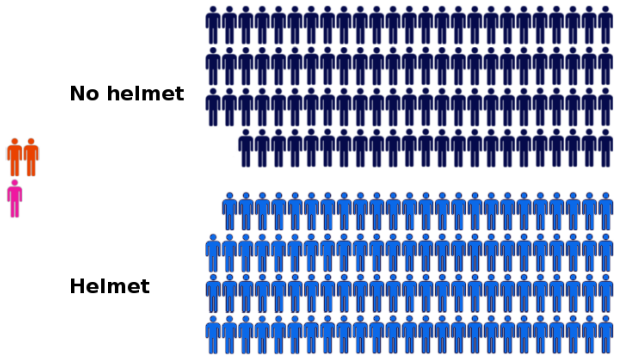

Figure 1: Helmet use makes very little difference to the number of safe cyclists (dark blue, light blue) when injuries (orange, pink) are rare.

AustRoads, in the week before the survey was conducted 22.1% of the Western Australian population rode a bicycle, with an average of 5.3 trips per week being undertaken. Given a state population of 2.24 million, and 52 weeks in a year, this equates to around 136 million cycling journeys per year. Reducing this number to account for seasonal variation in the number of cyclists between winter and summer still leaves around 110 million cycling journeys per year. As noted above, over the period 2012 - 2017 there have been an average of 5.3 cyclist fatalities per year in WA.

Recent serious injury figures are a little harder to find, as the WA Road Safety Commission seems to focus on fatality figures, however data from a RAC cycling safety forum indicates that between 2000 - 2009 there were 1022 cyclists seriously injured in WA, making an annual average of 102 serious injuries. Since only around 23% of serious cycling injuries are head injuries, as mentioned above, this leads us to conclude that there were on average only 23 serious head injuries per year.

Given a calculated total of 110 million cycling journeys per year, the odds of sustaining a serious injury (that might be prevented by helmet use) every time you get on a bicycle are a miniscule 0.00002% (or about one-in-five-million). The odds of a fatality every time you get on a bicycle in WA are about one-in-twenty-one-million).

For the sake of comparison, in South Australia (where good data on serious injury rates is available) the odds per journey of a serious head injury are about one-in-three-million.

A number of studies, including the widely-quoted CARRS-Q monograph by Haworth, Schramm, King and Steinhardt, and more recent work by Jake Olivier et al, suggest that helmet use reduces the conditional probability of cyclist head injury in the event of an accident by around 70%. In other words a complete cessation of helmet use would result in a 3.33-fold increase in head injury rates. Then the odds of sustaining a serious head injury every time you get on a bicycle would increase to 0.000067%. This is a tiny difference in injury rates, of only 0.000067% – 0.00002% = 0.000047%, or one half of one ten-thousandth of a percent per journey!

Measuring the number of cycling journeys for this calculation is inexact, as the AustRoads survey is a phone survey which depends on people's recollection of their cycling activity, and extrapolation to a full year's cycling, but the rates of serious injury and fatalities calculated here are fairly consistent with the numbers calculated for bikeshare schemes in the USA, where exact numbers of journeys are counted ("Bikesharing and bicycle safety", Mineta Transportation Institute report 12-54, Martin, Cohen, Botha, and Shaheen, 2016).

Numerous studies have shown that countries with better infrastructure have fewer cycling accidents than countries with helmet laws and worse infrastructure. However it is always possible to claim that the differences in accident rates are due to cultural differences between countries. Studies which compare injured cyclists with helmets against those without helmets are not ideal because by design they are biased to consider only those cyclists who have been involved in accidents. Such accidents may be caused, for instance, by risk-taking behaviour on the part of the cyclists involved, and which is atypical of the majority of cyclists. Such studies also typically do not measure accident outcomes against the exposure to risk (i.e. how common are accidents, given the number of cycling journeys undertaken). These problems are addressed by a major Canadian study published recently in the British Medical Journal (Teschke, Koehoom, Shen, and Dennis, 2015). Canada has fairly uniform traffic laws and speed limits across the whole country, is quite culturally homogeneous, collects cycling participation data regularly and has a standardised national database of hospital admissions allowing cycling accident rates compared to risk exposure to be calculated. Canada consists of several provinces (the equivalent of states), some of which have all-ages mandatory helmet laws, and some of which do not. The study by Teschke et al was therefore able to compare hospitalisation rates between several jurisdictions, over a consistent time period. Importantly this was a study of the effects of helmet laws, not helmet use. The results of the study were summarised as follows (my parentheses, and my italics);

> "...only two characteristics explained this variability [in hospitalisation rates]. For all causes, sex was associated with hospitalisation rates; females had rates consistently lower than males. For traffic-related injury causes, higher cycling mode share was consistently associated with lower hospitalisation rates. *Helmet legislation was not associated with hospitalisation rates for brain, head, scalp, skull, face, or neck injuries*. "

The study by Teschke et al concluded that;

> "These results suggest that transportation and health policymakers who aim to reduce bicycling injury rates in the population should focus on factors related to increased cycling mode share and female cycling choices. Bicycling routes designed to be physically separated from traffic or along quiet streets fit both these criteria and are associated with lower relative risks of injury."

Cycling is an inherently safe activity, which sometimes takes place in dangerous environments. While helmet use can have a large effect on the conditional probability of being injured in a crash, reducing the probability of a crash occurring has a much more substantial effect on overall cyclist safety. Based upon accident data and cycling participation figures, it appears that helmet use has such as negligible effect on safety, per journey, that mandating helmet use for the average cyclist is unjustifiable. Surely any reasonable person would question whether a safety difference of less than one ten-thousandth of a percent per journey justifies a fine of, in some Australian states, several hundred dollars.

5 Do helmet laws affect cycling participation?

The discussion above is dependent on the idea that relaxing mandatory helmet laws will encourage more people to cycle. Is it reasonable to claim that helmet laws reduce cycling participation, and repealing them would increase cycling participation?

Unfortunately there are no long term national cycling surveys (like the National Cycling Participation Survey) spanning a period of several years before and after the introduction of MHLs. Cycling to work data from the national census suggests a large (20-30%) drop in cycling rates around the time MHLs were introduced. The journey to work numbers for cycling and walking in Victoria at this time can be found in Appendix A.

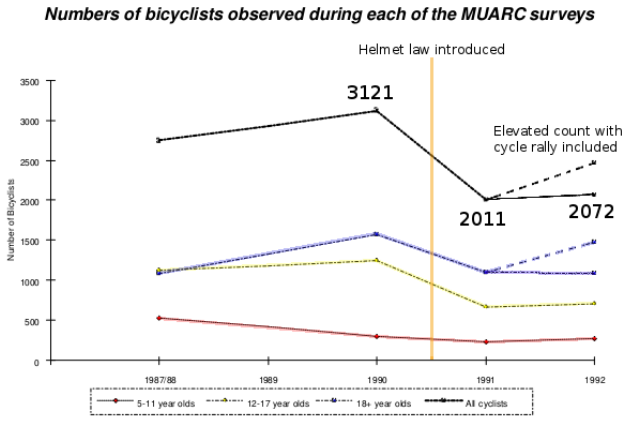

Figure 2: Cyclist counts in Melbourne 1987 to 1992, with an anomalously large count at one survey site due to cycling rally excluded (solid line) and included (dashed line). The red line is 5-11 year-olds, the yellow line is 12-17 year-olds, the blue line is adults, the black line is the total for all age categories.

The Monash University Accident Research Centre report no. 45 by Finch, Heiman, and Neiger from 1993 is often used to support the claim that cycling rates dipped temporarily after MHLs were introduced, but then recovered. In fact, this claim is extremely dubious. Cyclists were counted at 64 sites around Melbourne, with the counts being repeated in each of the three years 1990, 1991, and 1992, at the same time of year (data from 1987/88 was also included in the study, however this was collected at a different time of year, making a direct comparison more problematic). The total number of cyclists observed in each year, was 3121 (1990), 2011 (1991), and 2472 (1992). These figures are further broken down according to age range (5-11 year olds, 12-17 year olds, and adults), with the number of adult cyclists in 1992 only 5% below the level in 1990. The simple problem with claiming that this proves cycling quickly recovered to pre-MHL levels is that there are too few data points. It is not possible to determine if the count of cyclists in 1990 was typical of pre-MHL numbers, or unusually low or high. If cyclist numbers can rise from 1991 to 1992, they can fall again as well, and without more years worth of data it is utterly unjustified to claim that cycling levels remained high after 1992. Doing so would be like tossing a coin three times, to obtain the result heads-tails-heads, and then presuming that if the coin were flipped again, indefinitely, it would come up heads forever after, just because that was the most

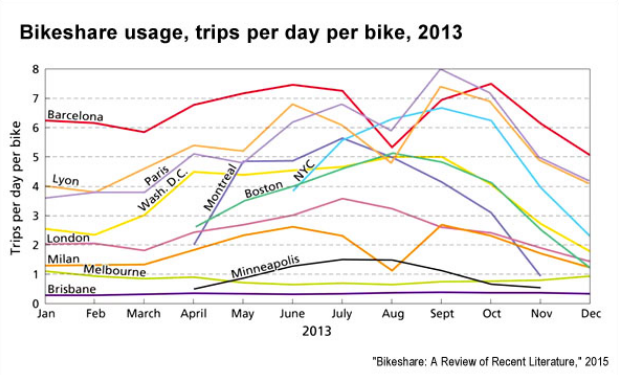

Figure 3: Comparison of bikeshare usage rates around the world.

recent result.

The more subtle problem with claiming this study proves cyclist numbers recovered is a result of the way data was pooled together from each of the 64 survey sites. Rather than presenting trends at the 64 survey sites independently, and conducting a standard statistical test (called a "paired t-test") to determine if cyclist numbers at each of the sites seemed to have changed or stayed the same from year to year, the results from each site were simply lumped together. In fact the authors of the study note that a cycle rally passed through one of the survey sites in 1992, increasing the total count of bicycles by approximately 400 in that year. If this unusual event is excluded (so that we are in effect looking at the other 63 survey sites), a very different picture emerges, of a sustained drop in cyclist numbers following the introduction of MHLs (Figure 2).

It should also be noted that this survey indicated a sustained drop in the number of cyclists between the ages of 5 years and 17 years old. Any claim that MHLs had no long-term effect on cycling participation, based on adult cyclist numbers alone amounts to "cherry picking" the data that favours a particular result. It seems reasonable to suspect that those 5 - 17 year olds who gave up cycling when MHLs were introduced, and who are now adults with children of their own, have not resumed cycling or encouraged their children to cycle, leading to a long-term reduction in cycling participation.

It is well known that bikeshare schemes in cities with MHLs under-perform compared to other cities. Melbourne, Brisbane, and Seattle bikeshare schemes typically record 0.3 - 0.8 trips per bike per day. Dozens of other cities around

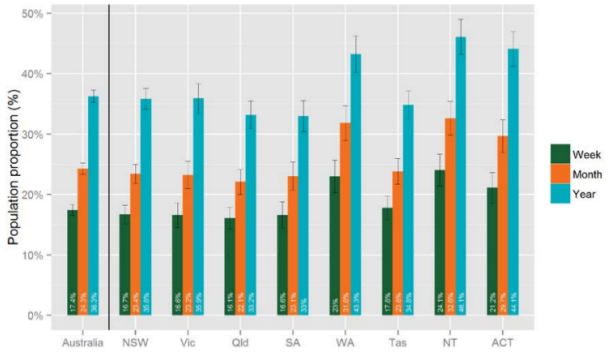

Figure 4: National cycling participation in 2015 by week, month, and year, for all states and territories.

the world typically record figures of 3 - 6 trips per bike per day (Figure 3). This is especially noteworthy given the favourable weather of cities like Brisbane and Melbourne compared to cities like Montreal or London.

A survey of Brisbane's CityCycle members in 2011 found that one in three would not be renewing their subscription to the service. When asked their reasons for not renewing their subscription 11% cited mandatory helmet laws as the main reason, and a further 9% called for removal of the law ("Bike Share - Options for Adelaide" (2016), Report from the Institute for Sensible Transport). The requirement to wear a helmet has also been found to be a significant barrier to use of Melbourne's bike share scheme, with around 25% of respondents saying they don't want to wear a helmet.

Cycling participation in Australia is highest in the Northern Territory, the only place in Australia where helmet use is optional (for adults on off-road paths and footpaths). Female cycling participation is also highest in the NT, with around half of all cyclist being women. The next-highest cycling participation rates occur in the ACT, and in Western Australia (Figure 4), where MHL enforcement seems to have decreased recently, with only 529 infringement notices given in 2015, and 750 in 2016 for failure to wear a helmet. By comparison, there were over 2300 fines for failure to wear a helmet given out in South Australia in the 2015-2016 financial year. This is especially noteworthy given that South Australia has a smaller population than Western Australia.

The comparison between Western Australia, the ACT, the NT, and the other states is even more illustrative if we look at Figure 5, which compares the cost

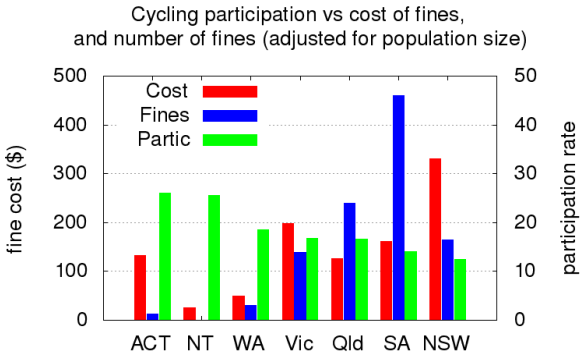

Figure 5: National cycling participation in 2017 by week, for all states and territories, compared against the per-capita number of helmet fines, and cost of helmet fines.

of MHL fines (which vary from state to state) against the per-capita number of fines given out by police, and the weekly cycling participation rate. It is apparent that as the number and cost of fines goes up, participation goes down. This hints strongly that enforcement of MHLs discourages cycling, and illustrates that by having modest fines and a low level of enforcement, Western Australia is already prioritizing cycling participation over the enforcement of helmet laws.

A survey conducted in Sydney (Rissel & Wen, Health Promotion Journal of Australia 2011; 22: p178-183) found that about one in five respondents (22.6%) said they would cycle more if they did not have to wear a helmet, particularly occasional cyclists. Consistent with this figure, a member survey conducted by the RAA in South Australia in 2014 found that 20% of respondents said they would cycle more if they were not required to wear a helmet. Furthermore the study by Clarke (New Zealand Medical Journal, Vol 125 No 1349 , 2012) found that mandatory helmet laws in New Zealand reduced the average hours cycled per person by 51%. The comparison of cycling participation in Australia between 1985/86 and 2011, by Gilham and Rissell (World Transport Policy and Practice Volume 18.3, May 2012) found that growth in cycling participation after the introduction of mandatory helmet legislation was only around one-third of the rate of population growth, indicating a significant decrease in the popularity of cycling.

Taken together, several independent lines of evidence indicate that MHLs suppress cycling participation. It is often claimed that safety concerns are the biggest

deterrent to people taking up cycling, however this doesn't mean that helmet laws are not also a significant factor. It is also possible (and worthy of further investigation) that MHLs create a false impression that cycling is dangerous, thereby contributing indirectly to the deterrent effect of safety concerns. Reductions in cycling participation when MHLs were introduced, increased participation where MHLs are not strongly enforced (e.g. the Northern Territory and Western Australia), and the results of multiple surveys suggest that repealing MHLs could lead to a 20% to 30% increase in cycling participation, and hence a significant net community benefit.

6 Cycling safety and the introduction of helmet laws

One of the earliest arguments for the success of mandatory helmet laws (MHLs) was a reduction in cyclist injury counts at the time the laws were introduced. Supporters of MHLs claim that following the introduction of helmet laws in Victoria the number of cyclist injuries fell immediately by 20% to 30%. Figure 6 shows fatality data for cyclists, motorists, motorcyclists and pedestrians in Victoria by year, created from data obtained from the Traffic Accident Commission website. There is a clear reduction around 1990, when MHLs were introduced, for motorists (both drivers and passengers), pedestrians, and cyclists, with a more gradual downward trend for motorcyclists. The most likely explanation is the introduction and increased enforcement of random breath testing, anti drink-driving campaigns, reduced speed limits, etc. It does not make sense to claim that any reduction in cyclist casualties is exclusively the result of helmet laws. Furthermore the number of cyclist fatalities seems to rise from 1988 to 1989 before dropping again, which may indicate that the apparently large reduction in cyclist casualties at the time MHLs were introduced is illusory, arising from a statistical fluctuation - an anomalously high casualty count in 1989.

This reduction in cyclist injuries - at the same time as other transport injuries were falling, was also observed in other states. Figure 7 shows serious injury numbers (those injuries requiring hospitalisation for 24 hours or more) for motorists, motorcyclists, pedestrians, and cyclists, obtained from publications of the Department of Planning Transport and Infrastructure in South Australia. Once again we observe that all forms of transport became safer at the same time (MHLs were introduced in SA in 1991). In Figure 8 these data are rescaled so that they all have the same value in 1989, making the similarity in downward trends across transport modes even more apparent. Figure 9 shows the trend in head injuries in

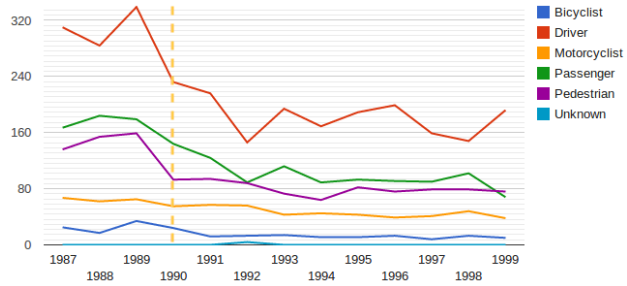

Figure 6: At the time helmet laws were introduced in Victoria all forms of transport were becoming safer, and so improvements to cycling safety cannot simply be ascribed to helmet laws.

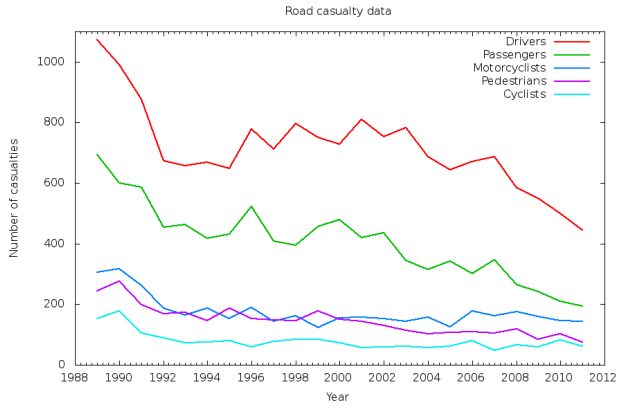

Figure 7: Transport casualty trends in South Australia, by year.

Western Australia over the period when MHLs were introduced. Once again the cycling injury data and the data for other forms of transport track each other extremely closely. This trend is repeated on a state-by-state basis and at the national level. Reductions in cycling casualties were part of this trend and hence cannot be attributed to helmet laws.

We also need to assess whether this reduction in cyclist fatalities was due to a reduction in the number of people cycling. If a reduction in cyclist casualties corresponds with a reduction in the number of cycling trips undertaken, it weakens the case that any reduction in casualties was due to helmet use. Note that this is not dependent on the reason the number of cycling journeys fluctuates. There is

a long-running debate in Australia about whether MHLs discourage people from cycling, which has been discussed above. But for the purposes of the current argument, this is irrelevant. The number of people cycling may vary from year to year because of increased car ownership, economic factors (e.g. the price of petrol), population growth, demographic shifts that make commuting to and from work by bicycle more or less practical, etc. The reasons cycling participation fluctuates from year to year are not important. All that matters is that, all other things being equal, fewer cyclists means fewer cycling casualties.

To assess any effect on casualty rates from the introduction of mandatory helmet laws alone, we need to compare the number of cycling casualties (taking into account the number of cycling trips undertaken) against the number of casualties for other modes of transport. Pedestrians are the natural choice for such a comparison, since fluctuations in the number of people travelling by bicycle and by walking are likely to be similarly influenced by bad weather, and motor vehicles may become safer as time goes by due to improvements in brake technology, airbags, crumple zones, etc. making cycling look more dangerous in later years, compared to driving. Therefore for each year with available data we should calculate the ratio

$$W = \frac{\text{(number of bicycle fatalities per bicycle journey)}}{\text{(number of pedestrian fatalities per pedestrian journey)}} \tag{1}$$

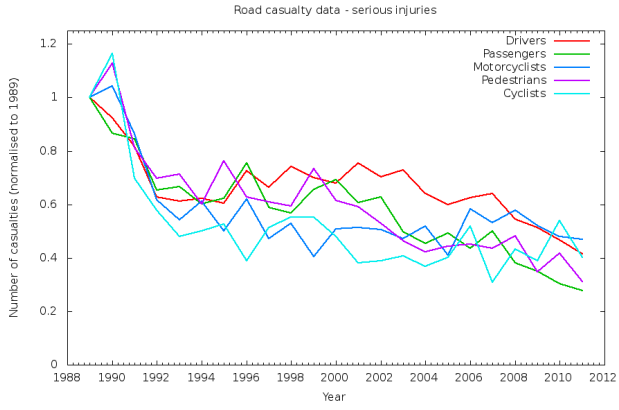

Figure 8: Transport casualty trends in South Australia, by year, rescaled to make the similarities between transport modes clearer.

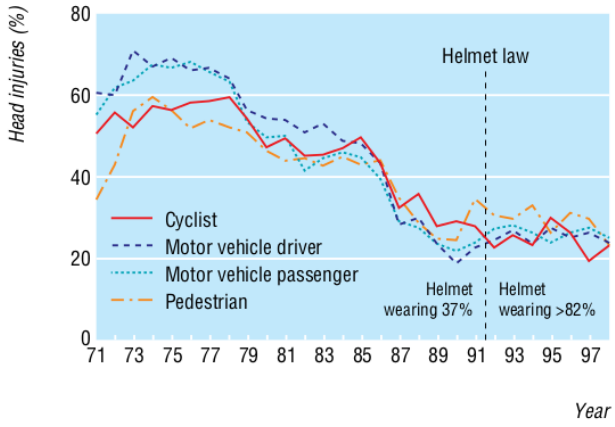

Figure 9: Head injury figures for different transport modes in Western Australia, by year.

This ratio can be thought of as the odds of a cycling fatality relative to a walking fatality. If W remains roughly constant before and after the introduction of mandatory helmet laws, it indicates that any changes in cycling safety correlated with an equivalent change in the safety of walking, and therefore is probably not a result of mandatory helmet legislation. In the absence of a large-scale survey of cycling and walking participation from this time, we will use census data on methods of travel to work. Details of the data and calculations used for such a comparison are given in Appendix A. The results are as follows;

Year	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
W value	1.06	0.73	0.82	1.76	0.70	0.81	1.08	0.58	0.74	0.72

It is easy to see that there is barely any difference between pre-law (1987-1989) and post-law (1991 onwards) values, suggesting that pedestrians and cyclists experienced roughly equal changes in the odds of being killed in a traffic accident. In fact, the average value of W for the three years pre-law is almost exactly the same as the average W value for the three years immediately post-law (1991-1993). This strongly suggests that any reduction in cyclist fatalities in Victoria after 1990 was due more to general road safety measures such as random breath testing, speed cameras, and the like, and not to mandatory helmet laws. The value

of W is at its highest in 1990, the year MHLs were introduced. Examining the raw casualty data (in Appendix A) indicates that this was due to an anomalously low number of pedestrian casualties that year. The fact that W is less than 1 in most years indicates that cycling fatalities are rarer (per journey) than pedestrian fatalities. Discussion in chapter 2 of the AustRoads publication AP-R155 "Pedestrian and Cyclist Safety - Recent Developments" (2000) supports this.

7 Dubious claims about single vehicle crashes, and off-road crashes

As mentioned above, the Northern Territory allows helmet-optional cycling on off-road areas and footpaths. Proponents of mandatory helmet laws sometimes argue against adopting such location-based exemptions throughout the rest of Australia by claiming that cycling in off-road areas is comparably dangerous to cycling on roads. To back up this claim, they often state that a large percentage (typically around 40%) of cyclist crashes are single-vehicle crashes. However it should be clear, given a moment's thought, that this is an invalid line of argument which confuses two separate issues. Single-vehicle crashes can occur on roads as well as on off-road paths, and hence single-vehicle cyclist crashes are not synonymous with off-road cycling. Furthermore this line of argument lumps all off-road cycling together, so that high-risk off-road activities (such as downhill mountain biking) and low-risk off-road activities (such as slow cycling on a shared use path) are classified as the same type of activity - when clearly they are not!

An evaluation of the comparative safety of different cycling environments can be found in the Monash Alfred Cyclist Crash Study (MACCS) conducted by P. Biegler, S. Newstead, M. Johnson, J. Taylor, B. Mitra, and S. Bullen, for the Monash University Accident Research Centre, published in July 2012, which assessed the characteristics of cyclists admitted to the Alfred and Sandringham hospitals in Melbourne. Significantly, helmet use (or non-use) was not found to be a significant predictor of head injuries in the MACCS study. Rather the only significant predictor of head injuries was found to be cyclist speed at the time of the crash;

> " 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 20-29kph before the crash were

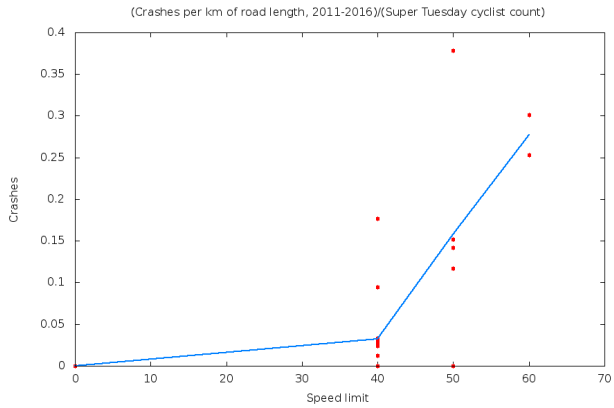

Figure 10: Cyclist crashes (2011-2016) per kilometer per cyclist count (Super Tuesday 2016) in the City of Unley, in 60 kph, 50 kph, 40 kph, and shared use off-road path (represented by 0 kph) speed limit areas. Red dots correspond to individual roads, the blue line denotes average crash counts in each speed limit zone.

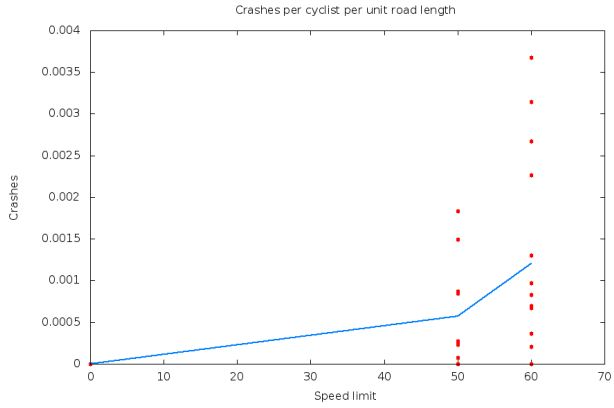

Figure 11: Cyclist crashes (2011-2016) per kilometer per cyclist count (Super Tuesday 2016) in the Adelaide City Council area, in 60 kph areas, 50 kph areas, and off-road shared use paths (represented by 0 kph speed limit). Red dots correspond to individual roads, the blue line denotes average crash counts in each speed limit zone.

estimated to have 2.7 times the risk of a head injury compared to those travelling below 20kph."

The MACCS study also found that;

" The odds of the crash involving a travel speed above 20kph were over 80% lower for off-road crashes compared to those on-road."

Taken together these results suggest that cycling on off-road paths is around five times less likely to result in a crash at high speed (compared to cycling on-road), and any crashes that do occur are around five times less likely to result in a head injury. indicating that riding off-road (i.e. most probably at less than 20km/h) could lead to a twenty-five-fold reduction in the odds of sustaining a head injury in a crash. The most optimistic estimates from helmet law supporters claim only a three-fold to five-fold reduction in head injuries due to mandatory helmet laws.

Further insight into the comparative safety of various cycling environments can be found by looking at cyclist crashes on streets with various speed limits. Using crash data from the South Australian government collected over 2011 - 2016, and cyclist counts from Super Tuesday I have calculated the number of crashes per kilometer per cyclist for streets in the Adelaide City Council and City of Unley council areas. These results are plotted in Figures 10 and 11 (note that since the crashes are counted over a five year period, while the number of cyclists was only counted on a single day, the "crashes per cyclist" numbers calculated are much larger than they should be if the two time periods over which the data were collected were the same). In these figures each red dot corresponds to a single street, categorised by speed limit (with speed limit zero being off-road shared-use paths). The blue lines correspond to average crash counts. Clearly there is a lot of variation between streets, but the rate of crashes per cyclist drops by around 50% in going from 60kph zones to 50kph zones, and by around 80%-90% going from 60kph to 40kph zones.

8 Discussion

We have seen that mandatory helmet laws are not an effective way of reducing the risks associated with cycling. Reducing the likelihood of crashing has a much bigger effect upon safety than helmet use. Policy makers should focus on providing safer transport environments through infrastructure and reducing vehicle speed

limits, instead of enforcing mandatory helmet laws. By discouraging some people from cycling, mandatory helmet laws may be counterproductive, in that they reduce the safety in numbers effect, which (unlike helmet laws) has been shown to be correlated with increased cycling safety, and reduce the positive health benefits of cycling upon cardiovascular disease rates, leading to a net negative health outcome for society. If cycling in safe environments (such as off-road paths), the risk of accidents is significantly reduced and the net health benefits for society as a whole are even easier to achieve, strengthening the case for at least a Northern Territory style relaxation of MHLs in certain circumstances, if not all.

I hope that the Western Australian government will recognise that support of mandatory helmet laws sends an unfortunate and innacurate message to the community, that cycling is a dangerous activity which needs to be regulated. Support for MHLs is therefore incompatible with the promotion of cycling. The truth is that cycling is a healthy, safe activity which needs to be encouraged. Helmets are a cyclist's last line of defence against injury, yet for 27 years Australia has treated them as the first (and in many cases, only) line of defence. This approach has proven to be a failure, both in terms of risk reduction and the promotion of active transport, and it's time to recognise this simple fact. Mandatory bicycle helmet laws are an imposition on individual freedom, which do not provide a compensatory societal benefit, and it is well past time that these laws were scrapped. Western Australia has a chance to lead the country on this matter.

Appendix A: Comparison of cyclist and pedestrian casualties in Victoria, pre- and post-MHL

The most consistent source of information about transport for the relevant time period is provided by ABS census data. Unfortunately this is only available every five years (with 1986, 1991, 1996, 2001, 2006, and 2011 being the years most closely overlapping with the range of TAC fatality data, and of these only 1986 falls before the introduction of MHLs). Travel to work is not a perfect measure of the total amount of cycling undertaken, but the data is collected in a fairly consistent manner between years. By comparing the ratios of fatalities per journey to work for different modes of transport, we automatically cancel out any effects due to population growth and changes in employment levels. We will only consider fatalities occurring in the 16 - 60 age group, to try to eliminate any confounding influences from people who were not travelling to work because they were too young to be employed, or were retired.

The following table lists the number of trips to work by bicycle and walking, for four consecutive census years

Year	1986	1991	1996	2001
Walking	79,580	74,133	63,668	64,732
Bicycle	24,022	18,334	17,190	18,910

The number of walking and cycling trips drops to a minimum in 1996 before making a slight resurgence (possibly due to an increase in the population of Victoria, counteracting a downward trend in participation rates). To extrapolate the number of people walking and cycling to the years between censuses, these data points were used to fit a polynomial of the form

$$y = Ax^3 + Bx^2 + Cx + D$$

Where y is the number of trips, and x is (year - 1986), so that for 1986 data, $x = 0$, for 1991 data $x = 5$, etc. For walking and cycling data, values of the parameters A, B, C and D were found that matched the value of y to the census figures. For walking, this yielded the polynomial

$$y = 22.06266x^3 - 431.3x^2 + 515.533x + 79580$$

For cycling, the corresponding polynomial was

$$y = -2.24x^3 + 124.48x^2 - 1704x + 24022$$

By choosing values of x = 1, 2, 3, etc. these polynomials were used to approximate the number of walking and cycling trips to work in the years between census years. For instance, when $x = 1$ we obtain approximations of the number of walking and cycling trips in 1987, the first year for which TAC fatality data is available. The resulting number of walking and cycling trips to work in each year were

Year	'87	'88	'89	'90	'91	'92	'93	'94	'95	'96
Walking	79686	79062	77841	76153	74133	71911	69623	67397	65368	63668
Bicycle	22330	21094	19970	19054	18334	17795	17425	17210	17136	17190

Although we could include data for later years, the three years before the introduction of MHLs and the six years after should be sufficient to spot any change in casualty rates.

The number of fatalities per year from the TAC database is

Year	'87	'88	'89	'90	'91	'92	'93	'94	'95	'96	'97	'98	'99	'00	'01
Walking	54	62	76	34	46	40	26	27	41	36	41	43	32	27	42
Bicycle	16	12	16	15	8	8	7	4	8	7	4	7	8	9	5

We now wish to find the ratio of cyclist fatalities per journey to pedestrian fatalities per journey for each year. For instance, for the year 1987 we calculate

$$W = \frac{(16 \div 22330)}{(54 \div 79686)} = \frac{0.00071650}{0.00067766} = 1.057$$

or approximately 1.06. A similar calculation for the remaining years from 1988 to 1996 yields the table of results

Year	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
W value	1.06	0.73	0.82	1.76	0.70	0.81	1.08	0.58	0.74	0.72