Pedestrian-Cyclist Collisions: Issues and Risk.

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Abstract

Governments, transport agencies and advocacy groups are promoting walking and cycling to encourage healthier lifestyles and provide for a more environmentally sustainable transport system. However, there are concerns over the relatively high number of pedestrian and cyclist deaths and serious injuries from collisions with motor vehicles. As a result shared cyclist-pedestrian pathways are being provided for to reduce conflicts with motor vehicles. This is resulting in considerable debate about the safety of pedestrians and bicyclist on such shared paths.

User advocacy groups rally for increased segregation of motor vehicles, cyclists and pedestrians and the restriction and regulation of shared path use. On the other hand, road authorities and councils support the use of shared paths since they are cost effective and provide a high benefit to the community. In addition, researchers often make contrasting conclusions about whether or not shared paths cause unacceptable conflict and injury risks. This paper presents an overview of the issues concerning shared cycling-pedestrian pathways and results of some studies quantifying the number of deaths that occur in Australia and injuries in NSW resulting from cyclist-pedestrian conflicts. The risk of these deaths and injuries using known available exposure data are contextualised in terms of other risk events. Some information regarding travel speeds of cyclists on footpaths are also provided.

Keywords

Cyclists, shared footpaths, pedestrian-cyclist impacts, pedestrians

Introduction

Governments, transport agencies and advocate groups continue to encourage walking and cycling. Successful education campaigns have made the community more aware of the health benefits and transport amenity associated with these modes. For example, Anderson et al found that bicycling to work decreased risk of mortality in approximately 40% compared to a sedentary control group [1]. Bicycle ownership is growing and cycling is quickly becoming more popular as indicated by cycling promotion groups [2,3]. In regards to walking Ogilvie et al assess the effects of interventions to promote walking and cite studies that promote the health benefits of walking [4]. As a result, there is growing pressure for infrastructure provision for both walking and cycling activities albeit any provision of facilities is required to be consistent with a Safe System approach to road safety where all road users interests must be considered [5].

Pedestrian fatalities have fallen whereas cyclist fatalities have remained fairly constant over the past decade [6,7]. With the increase in number of vehicles over the past five years by approximately 14.5% [8], there is concern by advocacy groups that road fatalities and injuries to vulnerable road users such as pedestrians and cyclists may increase if their rights and safety as road users are not properly considered. Thus, governments and road authorities have been challenged to provide infrastructure of adequate capacity for all users without impeding safety, amenity and enjoyment. Consequently, shared car-cycling, car-pedestrian and cycling-pedestrian roads and paths have become popular as a possible cost effective and space efficient means of addressing the issues of dangerous interactions between pedestrians, cyclists and motor vehicles. These facilities allow cyclists, pedestrians and motorised road users to travel freely on the same pathway. However, the integration of these different path/road users may lead to an increasing risk of conflict and collision where ultimately the pedestrian is the road user in the most vulnerable situation regardless of any sharing protocols.

For example, the speed and mass differential between a car and a cyclist appear to be substantially greater than that between a cyclist and a pedestrian. This is illusionary. The kinetic energy of, say, a 1500 kg family sedan car in a 50 km/hr zone compared to a 50^{th} percentile cyclist's kinetic energy of a riding at around 30 km/hr in the same direction is a ratio of around 44 to 1 in favour of the car. On the other hand, the kinetic energy ratio between the same cyclist still travelling at 30 km/hr and a 50^{th} percentile pedestrian walking at normal speed [9] of say 5 km/hr is around 48 to 1 in favour of the cyclist, i.e. the car-cyclist kinetic energy differential is similar to that of the cyclist-pedestrian ratio. However, councils and road authorities, in order to reduce cyclist fatalities and injuries, have moved the responsibility from the car driver over to the cyclists by moving the cyclist onto the pedestrian footpath. The belief is that cyclists are supposedly travelling at a slower speed on the shared footpath in contrast to a car travelling on a road. In other words, it is assumed cyclists are in a better position to avoid harmful impacts with pedestrians and any impact is of a lower severity.

The potential for conflict on shared paths is exacerbated by the differences in type, abilities and movements of users. Shared use pathways are frequented by pedestrians, cyclists, joggers, in-line skaters, skate-boarders, dogs, babies in prams, riders of powered recreational devices and many others. Particularly vulnerable users are identified as disabled (including visual, hearing and cognitively impaired persons), elderly and children [10]. Users have differing degrees of ability and experience, health and fitness, reaction and perception time, age and purpose. Their reasons for path usage include recreation, social, sporting and commuting. Generally, walkers will travel for recreation purposes at significantly less speed than commuter cyclists who can travel at over 50km/hr down hills [11]. Users mingle readily at low speeds but where higher density flows are experienced, the risk of collisions rises [12]. In addition, pedestrians are often distracted especially by conversation, their surroundings or music listening devices [11]. Consequently, users' capacity to manoeuvre, avoid incidents and anticipate the movements of others differs greatly and the risk of conflict and injury is real.

There is substantial debate about the safety and benefits of pedestrian bicycle shared paths [13]. User advocate groups rally for increased segregation of motor vehicles, cyclists and pedestrians and the restriction and regulation of shared path use. Road

authorities and governments support the use of shared paths since they are cost effective and provide a high benefit to the community. In addition, researchers often make contrasting conclusions about whether or not shared paths cause unacceptable conflict and injury risks.

A recent study by the NSW Roads and Traffic Authority with Taverner Research [14], where a total of 672 observation hours at 10 shared path locations in Sydney, Newcastle and Wollongong were carried out observing 51,031 pedestrians and 12,319 bicyclists, concluded that the perception of danger is much greater than the actual risks of bicyclists and pedestrians on shared paths. They observed only five near miss incidents and no actual contact between bicyclists and pedestrians.

Drummond [15] concluded in his report that the problem of casualties due to collisions between cyclists and pedestrians on footpaths was of very small proportions such that it need not be considered in the formulation of policy. Moreover, a report on Pedestrian and Cyclists Safety from the Legislative Assembly of Queensland (1993) concluded that collisions with motor vehicles caused the vast majority of cyclist deaths and injuries [16].

Trevelyan and Morgan [12] found pedestrians were more likely to be injured in bicycle-pedestrian collisions with the severity depending upon age. They added that the integration of cyclists and pedestrians on shared user paths would largely protect cyclists from vehicle impact injuries without unreasonably enhancing the risk to pedestrians. They proposed that there were no major reasons to justify the exclusion of cyclist from pedestrian areas. It was found that pedestrians do not alter their behaviour in the presence of cyclists but cyclists do adjust appropriately to pedestrian density. The report concluded that collisions between cyclists and pedestrians seldom occur and that a great variety of regulatory and design measures could be taken to ensure the safe and efficient integration of cyclists and pedestrians.

The OECD review paper *Safety of Vulnerable Users* [10], concluded that conflicts were generated mainly by narrow footpaths, narrow cycle-tracks, relatively high speeds of cyclists, poor visibility, or considerable age difference between cyclists and pedestrians. Nevertheless, it stated that few conflicts were dangerous but the danger increased when several of the factors mentioned were combined.

Lyhne [17], Director of Policy and Strategy of the Office of Road Safety in WA, found that "*this is an area in which there is very little research and next to no statistics, so we relied heavily on anecdotal information and the community telling is what the issues were.*" However, she reported that one cyclist had been killed on a shared path in WA in 1997 and a number of injuries were reported. Lyhne suggested that this was likely an underestimation of the injuries sustained on shared paths.

Franklin [18] reported from Milton Keynes in the UK that more cycle deaths and injuries occurred on the shared "Redway" paths than on roads. In addition, pedestrians, dogs and poor path design were found to be a major cause of collisions.

Despite this, cycling and walking is increasing in urban towns and cities. A paper entitled *Research, Development, and Implementation of Pedestrian Safety Facilities in the United Kingdom* by Davies [19] raises concerns about the safety of shared

pathways in particular where footways have been converted into shared facilities. It provides research which suggests that clear linear separation or grade separated paths between walking and cycling tracks would reduce the conflict and make the paths safer for vulnerable users such as the visually impaired. More recently, German research indicated that although fatal collisions were rare, cyclists were more likely to cause collisions but pedestrians usually suffered more severe injuries [20]. They found young mountain bike riders were often at fault and the victims were often frail elderly people.

Inappropriate user behaviour [13] has been cited as a major cause of conflict between cyclists and pedestrians. Sometimes the feelings of conflict are one-way – pedestrians are frightened when a cyclist passes silently and closely but the cyclist may not share this concern. For example, Figure 1 shows a shared path that has inadequate capacity and width for a cyclist to pass when two pedestrians walk alongside each other. Paths that were designed for low usage and, after subsequently becoming more popular, require upgrading which may not occur or is delayed because of lack of resources. Hence, types and volumes of users may not have been adequately predicted by designers and safety issues arise. Path design is especially critical on high volume and higher speed paths. It has been noted that although path guidelines exist [21], these guidelines were not always being used [17, 22].

Figure 1: Shared pedestrian cycling pathway on Lane Cove Bridge Sydney. Width of shared space is inadequate for cyclists to pass safely.

Injuries can be serious where cyclists strike pedestrians at higher speeds. This is particularly so where elderly pedestrians are involved [23]. However, in general researchers agree that conflicts were usually infrequent despite there being no absolute consensus on the issue. Some researchers argue that conflicts are not dangerous while other researchers have indicated that the conflict is real and has caused deaths and serious injuries. Nevertheless, the significance of the risk of injury to users continues to be debated.

There were three objectives pursued in this study. They were to quantify:

1. The number of fatalities resulting from bicycle-pedestrian impacts in Australia;
2. The number of injuries in NSW;
3. The risk of the fatalities and injuries, and then contextualise this risk by comparing it to other risk events, e.g. lightening strike, plane crash etc.

By quantifying these values and risks, designers and policy makers can make informed decisions regarding shared bicycle-pedestrian pathways and better rationalise any decisions to the various advocacy groups.

Methods

Two studies looking at pedestrian cyclist impacts were carried out. The first study determined the number of fatalities resulting from a cyclist impacting a pedestrian for the whole of Australia. The second study assessed the number of injuries to pedestrians in NSW. The risk of a fatality and an injury in NSW were also assessed and compared to other risk events. A preliminary analysis of bicycle speeds using Global Position System (GPS) data from cyclists was also carried out to determine average speeds of cyclists on different cycling infrastructure.

Ethics approval to access and use the National Coroners Information System (NCIS), was sought and obtained from the University of New South Wales Human Research Ethics Committees (HREC) and further approval was then obtained from the Departments of Justice in Victoria and Western Australia. Ethics approval to explore hospitalised injuries using the NSW public and private hospital separations for NSW residents came under a general ethics approval that the Injury Risk Management Research Centre (IRMRC), obtained from the UNSW HREC and from NSW Department of Health. The IRMRC was the organisation where this research was carried out prior to the formation of TARS.

The NCIS was searched between the years 2001 and 2006 for all fatalities on footpaths and roadways that involved a collision between a bicyclist and a pedestrian.

In regards to injuries resulting from a cyclist-pedestrian collision and single pedestrian or bicycle injuries with no partner vehicle involved, only NSW data could be obtained. Hospitalisations data were obtained from NSW Health Inpatient Statistics Collection (ISC) using the Health Outcomes Indicators Statistical Toolbox (HOIST) of the NSW Department of Health for the five-year financial calendar period commencing 1st July 2000 through to the 30th June 2005 (5 year period: 2000/2001 to 2004/2005). The results of this investigation were published in Chong et al [16].

All NSW public and private hospital separations were collected and analysed for pedestrians injured resulting from pedal cycle into pedestrian collisions. The severity of each injury was measured using the ICD-10-AM diagnosis based Injury Severity Score (ICISS). ICISS is an estimate of a patient's probability of survival, which is computed from each individual's injury diagnosis code. ICISS scores range from 0 (death) to 1 (complete recovery). Patients with an ICISS score less than or equal to

0.941 were defined as being seriously injured, i.e. had a probability of death (at admission) of at least 5.9% [24].

The injury-related hospital separations were identified using the following criteria:

- the hospitalisation was for a patient who was a resident of NSW;
- a principal diagnosis was in the ICD-10-AM range S00-T98 ;
- an ICD-10 external cause code was assigned as a pedestrian injured in collision with pedal cycle (V01), a cyclist injured in collision with pedestrian/animal (V10) or a cyclist injured in collision with motor vehicle (V12–V14, V19.0–V19.2, V19.4–V19.6).

Hospitalisations relating transfers or statistical discharges were excluded to minimise multiple counts which may occur when a person has more than one episode of care for a given injury.

To determine the risk of a fatality or an injury occurring multiple exposures were used due to lack of accurate exposure data, with the idea that if rates are found to be low for every alternative exposure then there is reasonable evidence that such collisions are low risk.

To contrast the risk of a bicyclist pedestrian fatal collision occurring with other pedestrian related fatalities that occur, the number of pedestrian fatalities where no other vehicle is involved and the pedestrian stumbles, falls, jumps or is pushed, was also investigated in NCIS for the years 2001 and 2006.

To further compare the risk of a bicyclist-pedestrian impact to other low risk events in Sydney Central Business District (CBD), the following NSW statistics were obtained from the NSW Government website 'Cycling in Sydney' for the year 2005 [25]:

- Sydney's resident population in 2006 was at around 4.1 million people [26];
- a total of 1.48 million bicycles were owned by Sydney's residents in 2005;
- the proportion of households with a bicycle is 45%;
- 1% of Sydney's residents cycle each day;
- bicycles account for 0.71% of all trips by Sydney residents on weekdays and 1.1% on weekends;
- 1.04% of trips to work are by bicycle [27].

Using this information the risk per number of trips and risk per number of person years was calculated.

Results

Fatalities

Whilst there are a large number of traffic related cycling deaths and pedestrian deaths (numbering in the many hundreds over the five year period), only four fatalities were identified in NCIS that have resulted specifically from a cyclist – pedestrian collision for the period 2001 to 2006. In all four fatalities the pedestrian died as a result of the

impact. No cyclist fatality has been recorded resulting from a cyclist crashing into a pedestrian. However, when a pedestrian is killed in such an event it is usually elevated in the media profile. Such was the case in the death of a 77 year old male when he was struck down in Victoria by a bicycle rider in 2006. The rider was competing in the "Hell Ride" bicycle race along Beach Road, Mentone, when he collided with the pedestrian.

Of the four bicyclist-pedestrian collision related fatalities found in NCIS, two were aged above 70 years and two were in their thirties. Two were female and two were male. One occurred in NSW, one in Tasmania, one in Victoria and one in Queensland. Three of the cases directly related to a bicyclist not being capable of stopping in time and striking the pedestrian down. In one of the cases the pedestrian crossed and intersection against a "don't walk" red light and walked into the path of the cyclist, who was proceeding on a green light. In the fourth case, the impact was perpetrated for criminal gain, i.e. the pedestrian was struck down and then robbed.

In regards to pedestrians where no other vehicle was involved, for the years 2001 to 2006, a total of 57 fatalities were identified. The state by state numbers are as follows: NSW=23, WA=8, Victoria=19, SA=3, ACT=1, TAS=3. The mean age was around 64 with the median being 68 and ranged from 26 to 92 years old. Fourteen fatalities were alcohol related (9 in NSW, 3 in Victoria, 1 in the ACT and 1 in Tasmania). This identifies that the risk of being struck by a cyclist and killed as opposed to simply walking along a footpath or roadway, stumbling/tripping and falling albeit whether intoxicated or not, is more than an order of magnitude higher than the risk of being struck by a cyclist.

In regards to risk per number of trips, based on the statistics provided in the previous section, each day around 41,000 people are bicycling in Sydney although there could be multiple trips per person. If we have had only one fatality in NSW over a five year period being in Sydney's CBD, this means that the risk of a pedestrian being struck by a cyclist is of the order 1 in every 75 million trips, i.e. an extremely rare event. This figure doesn't include trips made outside Sydney, hence NSW rates based on 75 million trips in 5 years is an upper limit and is likely to be lower than this in reality.

Alternatively, the risk in fatalities per million person years can also be calculated and compared to the values provided by Higson [28]. We know that there was an average of approximately 4 million people years lived in Sydney each year over the five year period. This equates to a total of 20 million person years with 1 fatality occurring during that time, i.e. 0.05 fatalities per million person years.

This comparison indicates that the risk of a pedestrian being struck down by a bicyclist and killed is currently less than the risk of being struck by lightning (0.1 chances of fatality per million person years), 23 times less likely than tripping on a footpath or roadway (1.15 chances of fatality per million person years), 200 times less likely being involved in an airline crash (10 chances of fatality per million person years), and 700 times less likely than being struck and killed by a motor vehicle (35 chances of fatality per million person years).

Injuries

For the 5 year period 2000/01-2004/05 there were 163 pedestrian hospital admissions (84 males and 79 females) resulting from pedal cycle collisions, accounting for 7.6% of all pedestrian injuries [29]. The age-adjusted rate is about 0.5 per 100,000 population [16]. Fig. 2 and Table 1 show the type and distribution of the injuries. The majority of the injuries appear to be to the head and superficial injury of the lower leg.

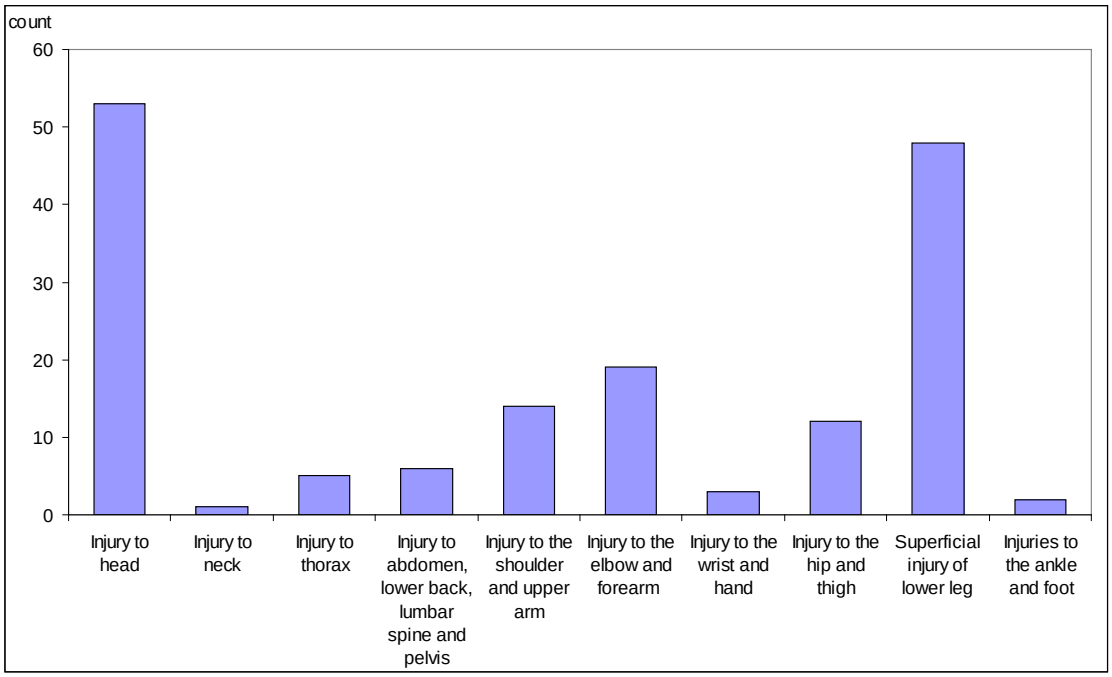

Figure 2: Distribution of non-serious and serious injuries to 163 pedestrians struck by a cyclist over a 5 year period (2000/2001 to 2004/2005 in NSW), see Table 1.

Principal diagnosis	Count	%
Injury to head	53	32.5%
Injury to neck	1	0.6%
Injury to thorax	5	3.1%
Injury to abdomen, lower back, lumbar spine and pelvis	6	3.7%
Injury to the shoulder and upper arm	14	8.6%
Injury to the elbow and forearm	19	11.7%
Injury to the wrist and hand	3	1.8%
Injury to the hip and thigh	12	7.4%
Superficial injury of lower leg	48	29.4%
Injuries to the ankle and foot	2	1.2%
Total	163	100.0%

Table 1: Distribution of non-serious and serious injuries to 163 pedestrians struck by a cyclist over a 5 year period (2000/2001 to 2004/2005 in NSW).

Using the exposure data set out for the fatalities, this is 163 injuries per 75 million trips, or approximately 1 injury in every 460,000 trips.[1] In person years, this represents 8.2 pedestrians injured per million person years. This appears to be an event which is

[1] Exposure data is based on cycling trips made by Sydney residents whereas hospitalisation admission data is for the whole of NSW. Hence the risk per trip is being over estimated but it is not clear by how much. Nevertheless this provides a measure of risk against which to compare to other events and maximum risk estimate. Exposure data for rural areas is not available.

around 8 times greater than tripping on a footpath and killing yourself as a result and just slightly less riskier than being killed in an airline crash event. In other words, it is still a very low risk event.

Speeds

To assess what speeds cyclists were found to travel at on different types of infrastructure in the Sydney region a number of volunteer cyclists were fitted with GPS and recorded. Preliminary data of minimum, maximum and average cyclist speeds in km/h were measured over 200 m long sections within a travel segment of the same type and average grade. Speeds range from a minimum of 16 km/h to a maximum of 55 km/h. It was found that speeds of 30 km/h were regularly and readily achievable. Mean average section speeds for different infrastructure were for: Footpath - 21 km/h; Bicycle lane - 23 km/h; Cycleway in a Park - 19 km/h; Roads 50 to 70 km/h - 26 km/h; roads less than or equal to 50 km/h - 21 km/h. What is disturbing is that a maximum speed of 50 km/h was recorded for a footpath. While this speed is consistent with the Austroads guidelines for cyclists on a segregated cycleway, it is entirely inappropriate for a footpath [11].

Further details regarding the speed study will be published elsewhere by one of the authors.

Discussion and Conclusions

The risk of a fatality resulting to a pedestrian from a cyclist pedestrian collision is presently a very rare event for the whole of Australia. None have been recorded for a cyclist. It should be further noted that addressing the issue of collision severity would not have assisted in the case where the pedestrian was struck down in order to rob them of their money.

With respect to hospitalisation injuries, there appear to be on average around 33 people admitted to hospital every year in NSW. The number of hospitalisation injuries Australia wide is most likely well in excess of 100 people per annum. However the injuries vary from non-serious to serious injuries. It should also be noted that only hospitalised injuries have been analysed, and that data for treatment received in an emergency department (not requiring hospitalisation) or at a general practice have not been included. Although emergency department and general practice visits were not included, admitted cases represent a certain level of severity and hence would be expected to capture the majority of the burden/cost of such injuries. Even so, the numbers given may underestimate actual injuries sustained, i.e. the number of injuries could be under-reported and thus injuries could well be higher. Nevertheless the risk of a pedestrian being injured as a result of an impact with a cyclist is a low risk event and of the order equivalent to being killed in an airline crash.

It is important to recognise the severity of such collisions, and address issues to mitigate potential conflicts particularly with elderly citizens [23,20]. For example, Short et al recommend a speed of 10 km/h for shared footpaths based on computer simulations. The current Austroads guides recommend a maximum speed of 15 km/h for shared pedestrian-bicycle pathways.

Thus the costs of any initiative introduced needs to account for the very low risk of the collision event occurring, and weighed against the substantial health benefit gains resulting from increased bicycling activity. Nevertheless, this may well change with the ageing population, increased sales of bicycles, and demand by local government for shared pedestrian-cyclist footpaths in an attempt to increase physical activity. For example, 138 cyclists died in the Netherlands compared to Australia's 28 cyclists. The Netherlands is often cited as the model country for cycling infrastructure and safety. Introducing more cycling may well assist in health benefit gains but it must be weighed against the risk of being killed or injured as a result of increasing exposure.

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