Accident Analysis and Prevention 122 (2019) 295–300

Contents lists available at ScienceDirect

Accident Analysis and Prevention

journal homepage: www.elsevier.com/locate/aap

Pedestrian injuries due to collisions with cyclists Melbourne, Australia

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ARTICLE INFO

Keywords:
Pedestrians
Cyclists
Road safety

ABSTRACT

Over the past decade in Melbourne the popularity of cycling has increased both as a mode of transport and a recreational activity, while at the same time walking has consistently been the most prevalent form of physical activity. Increasing levels of active transport use and physical activity are seen as important public health issues, particularly as the rate of urbanisation continues to grow throughout the world.

To date there has been limited research conducted in Australia looking at the prevalence of pedestrian injuries resulting from collisions with cyclists. However there is a potential for the issues surrounding pedestrian and cyclist conflict to increase, given the growing uptake of these modes of transport, the continued densification of the urban environment and the lack of cycling specific infrastructure in many Australian capital cities. This study investigated the prevalence of pedestrian injuries resulting from collisions with cyclists in Melbourne, Australia. The intention was to quantify the extent of these collisions and identify if the rate of collisions was increasing, which may highlight a growing road safety issue. Furthermore the study sought to identify any unique characteristic and injury outcomes associated with this collision type.

Aggregate analyses of two Victorian data sources were undertaken to enhance our understanding of pedestrian injuries resulting from collisions with cyclists, the Victorian Injury Surveillance Unit (VISU) and Victorian Police Report Crash Data (Crash Stats).

The analysis demonstrated that over the past ten years there does not appear to have been a substantial increase in the number of pedestrian injuries resulting from collisions with cyclists. Furthermore the prevalence of injuries was small, especially when compared to injuries sustained by pedestrians from collisions with motor vehicles. The findings highlight that efforts to increase active transport participation should be encouraged and there may be situations where is it suitable to increase interaction and sharing of space between pedestrians and cyclists.

1. Introduction

Over the past decade in Melbourne, Australia the popularity of cycling has increased both as a mode of transport and a recreational activity (Stevenson et al., 2015). Recent findings from the Australian National Cycling Participation survey estimate that 15.5% of Australian's ride a bicycle in a typical week. With the highest levels of participation amongst children (Australian Bicycle Council, 2017). At the same time walking has consistently been the most prevalent form of physical activity (VicHealth, 2016).

Increasing levels of active transport use and physical activity are seen as important public health issues (Stevenson et al., 2016). The benefits from increased participation in active transport are well documented and include a range of social, economic and environmental benefits (Garrard 2009a,b; Salmon et al. 2000). These benefits will become increasingly important, particularly as the rate of urbanisation continues to grow throughout the world (WHO, 2007).

Current estimates suggest that over 50% of the world's population now live within urban areas. Furthermore it is forecast that by 2030 this will increase to 60% of the world's population, which will further rise to 70% by 2050 (United Nations, 2016). These trends are reflected in Melbourne, where 4.5 million residents currently live in the metropolitan region and forecasts suggest that the population will grow to 7.5 million residents by 2051 (State Government of Victoria, 2014). While there are many benefits associated with increased urbanisation it is also resulting in cities that are becoming increasingly congested and constrained for space, particularly for additional and improved transportation infrastructure (Stevenson et al., 2016). These factors lead to difficulties accommodating vulnerable road users within the existing road network (Schramm and Rakotonirainy, 2009).

In line with Safe System principles, it is recognised that there are often competing priorities between transport modes and land use.

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https://doi.org/10.1016/j.aap.2018.10.018
Received 14 June 2018; Received in revised form 18 October 2018; Accepted 23 October 2018
Available online 03 November 2018
0001-4575/

Cyclists cannot always safely interact with motor vehicle traffic, particularly in high speed road environments, such as arterial roads (Stevenson et al., 2015). Likewise, pedestrians require a separated space from motor vehicle traffic, and there is a need to ensure that safe walking and cycling infrastructure are provided for vulnerable road users to facilitate modal shift (O'Hern and Oxley, 2015; Stevenson et al., 2016).

In environments where there is insufficient space for on-road cycling facilities, shared path facilities are often recommended (Grzebieta et al., 2011). While shared path facilities provide segregation between cyclists and motor vehicle traffic, they require pedestrians and cyclists to interact within the same space (Grzebieta et al., 2011). Shared path facilities have been shown to reduce the risk of cyclist injuries, however there is a concern that the burden of injury may be transferred from cyclists to pedestrians when these facilities are installed (Grzebieta et al., 2011). Similarly, evidence suggests that some adult cyclists, in Australia, choose to ride on footpaths, instead of riding on the road (Haworth and Schramm, 2011). Road rules regarding cycling on footpaths vary by state in Australia. However, in many jurisdictions this is against the law, where generally adult cyclists can only ride on the footpath if they are accompanying a child below the age of twelve (Haworth and Schramm, 2011) or they are transporting a child using a child bicycle seat or trailer (Oxley et al., 2016). Despite there being limited evidence of injury risk associated with riding on footpaths or shared path facilities (Haworth and Schramm, 2011), anecdotally there is a suggestion that providing shared path facilities increases risk for pedestrians, primarily due to the speed differential between cyclist and pedestrians, and there have been a small number of instances that have received media attention where cyclists have struck pedestrians while riding on footpaths.

To date there has been limited research conducted worldwide examining the prevalence of pedestrian injuries resulting from collisions with cyclists. However there is a potential for the issues surrounding pedestrian and cyclist conflict to increase, given the growing uptake of these modes of transport, the continued densification of the urban areas and the lack of cycling specific infrastructure in many urban environments internationally. This study, therefore, aims to quantify the prevalence of pedestrian injuries resulting from collisions with cyclists in Melbourne, Australia, identify any unique characteristic and injury outcomes associated with these collisions.

2. Method

Analyses of two Victorian data sources were undertaken to enhance our understanding of pedestrian injuries resulting from collisions with cyclists, the Victorian Injury Surveillance Unit (VISU) and Victorian Police Report Crash Data (Crash Stats).

The VISU holds hospital-treated injury data at two levels of severity: hospital admissions and Emergency Department (ED) presentations. De-identified unit record files are provided to VISU by the Department of Health. The VISU dataset includes both the Victorian Admitted Episodes Dataset (VAED) and the Victorian Emergency Minimum Dataset (VEMD). The VAED records all hospital admissions in public and private hospitals in the state of Victoria and the VEMD records all presentations to Victorian public hospitals with 24-h emergency departments (excluding patients who are subsequently admitted to hospital). VISU data was analysed for the most recent ten year period available, July 1st, 2006 to June 30th, 2016.

The VEMD is an ongoing surveillance dataset of injury presentations to 39 Victorian public hospital emergency departments. The VEMD data is collected in accordance with National Minimum Data Standards for injury surveillance. While data is not coded using the ICD-10-AM system, the code set in the VEMD is similar and comparable. Cases recorded in the VEMD were extracted if the injury cause code related to pedestrians and the cases were coded as non-intentional harm. The description of event text variable was manually checked to ensure cases were relevant, cases were limited to incidents, that is return visits and pre-arranged admissions were excluded.

For cases in the VAED, the International Statistical Classification of Diseases and Related Health Problems, Tenth Revision, Australian Modification external cause codes were used to extract data (ICD-10-AM) (ACCD, 2017). ICD-10-AM consists of a tabular list of diseases and accompanying index. Cases were extracted from the VAED that had an external cause code was a pedestrian injured in collision with cycle (V010, V011 or V019), where the principal diagnosis was a community injury (S00-T75 or T79) and the injury was the result of "Non-intentional harm". Admissions as a result of transfer from another hospital or due to a statistical separation from the same hospital have been excluded. All admitted cases identified using this method were examined for further injury details.

To complement the hospital data, pedestrian injuries due to collisions with cyclists were collected within the Victorian Police reported crash dataset. The dataset provides a means for identifying trends in crashes, however, it is important to note that the dataset only records Police reported injuries and that many minor injury collisions or events are not reported to Police or do not require Police attendance. The police reported dataset includes many variables related to the crash characteristics not included in hospital-treated injury data, as such it provides useful insight into the circumstances surrounding pedestrian collisions with cyclists. Analysis of the database was undertaken for the same time period of July 1st, 2006 to June 30th, 2016. It is noted that many of the police reported cases would also appear in the hospital dataset. However due to the de-identified nature of the hospital data, matching cases was considered beyond the scope of this investigation.

Aggregate analyses were undertaken, focusing on descriptive statistics (mean (M) and standard deviation (SD)) frequencies and cross-tabulations, and Pearson's chi-squared tests (χ^2) with post-hoc testing of standardised residuals utilised to identify associations between variables of interest, effect size was assessed using Cramer's V statistic (φ_c). Relative risk (RR) and confidence intervals (CI) were considered when comparing population adjusted incident rates with the population for each sub-group taken as the denominator. Population estimates were sourced from the Australian Bureau of Statistics regional population growth report (ABS, 2016). Trend data was analysed using log-linear regression models to assess estimated annual percentage change and confidence intervals. All analyses were undertaken at a level of significance (α) of 0.05. Statistical analysis was undertaken using STATA 13. Spatial analysis of crash locations was undertaken to identify collision clusters using ArcGIS 10.2.

3. Results

3.1. Crash rates and injury severity

Across the VISU data, there were at least 183 ED presentations and 273 admissions to hospital for pedestrian injuries as a result of being struck by a bicycle between July 1st, 2006 and June 30th, 2016 (Table 1). Comparatively over the same time period 4136 pedestrians presented to EDs as a result of a collision with a motor vehicle and there were 6699 pedestrian hospital admissions, highlighting that pedestrian collisions with cyclists are a relatively rare event compared to collisions with motor vehicles. Over the same study period 155 pedestrian collisions with cyclists were reported to police, representing just over one percent of the total 13,436 pedestrian collisions identified in the police crash dataset over the study period. It is noted that these collisions may correspond with those identified in the hospital datasets, however due to the aggregate analysis methods it was not possible to match cases.

Over the study period the number of ED presentations remained relatively constant with an average of 18 presentations per annum (SD = 5.3) (Table 2), representing a non-statistically significant estimated annual change of −0.9% (−5.8% to 4.2%). Similarly the number of police reported pedestrian collisions per annum remained

Table 1
Injuries by dataset (July 1st, 2006 to June 30th, 2016).

Demographics		Hospital reported pedestrian injuries		Police reported	
		Emergency department (n = 183)	Hospital admissions (n = 273)	Pedestrian injuries (n = 155)	Collision partner (cyclists) (n = 155)
Gender	Male	78	136	53	101
	Female	105	137	102	15
	Unknown	–	–	–	39
Age Group	0–14yrs	25	56	18	8
	15–34yrs	40	39	37	64
	35–64yrs	81	95	68	39
	65 + yrs	37	83	32	–
	Unknown	–	–	–	39

Table 2
Pedestrian injuries per year (July 1st, 2006 to June 30th, 2016).

Year	Hospital data		Police reported (n = 155)
	Emergency department (n = 183)	Hospital admissions (n = 273)	
2006/07	16	21	15
2007/08	23	19	26
2008/09	16	14	8
2009/10	15	28	16
2010/11	22	24	12
2011/12	13	25	19
2012/13	29	30	16
2013/14	21	44	17
2014/15	16	30	14
2015/16	12	38	12

constant over the study period, with a non-statistically significant estimated annual change of −2.3% (−7.5% to 3.2%). In contrast, hospital admissions increased from 21 to 38 per annum (M = 27, SD = 8.9), representing an annual change of 9.1% (4.6% to 13.8%). When adjusting for population growth over the study period the rate of ED presentations fell an estimated 2.7% per annum (−6.3% to 1.1%), while there was a 6.9% (3.6% to 10.4%) annual increase in hospital admissions.

When considering demographic characteristics of the injured pedestrians, older adults, aged 65 or older, were over-represented in each of the datasets when considering injury incident rates per 100,000 population for each subgroup, with a relative risk (RR) between 1.6 and 4.0 times higher than pedestrians in the 15–34 year age group. Children also experienced higher rates of hospital admissions compared to adult pedestrians (RR = 2.4, $p < 0.01$, CI [1.5, 3.8]) (Table 3). Comparison by gender revealed that female pedestrians were over-represented in ED and police reported cases, however the difference was only significant for the police reported dataset (RR = 1.8, $p < 0.01$, CI [1.3, 2.6]). Hospital admissions were evenly distributed by gender.

Table 3
Pedestrian injuries per 100,000 population by dataset (July 1st, 2006 to June 30th, 2016).

Demographics		Hospital data		Police reported (n = 156)
		Emergency Department (n = 183)	Hospital Admissions (n = 273)	
Gender	Male	2.6	4.4	1.7
	Female	3.4	4.4	3.2
Age Group	0-14yrs	2.2	4.9	1.6
	15-34yrs	2.2	2.2	2.1
	35-64yrs	3.5	4.1	2.9
	65 + yrs	4.0	8.9	3.5

When considering the cyclists involved in the collisions the vast majority were male (65.1%) or their gender was unknown (25.1%). The majority of cyclists were adults (63.2%), or the information on their age was not recorded in the police dataset (28.3%) (Table 1). Of the 8.3% of collisions involving child cyclists, the majority occurred in outer metropolitan or regional areas. Conversely, the majority of collisions involving adult cyclists occurred in the central Melbourne or inner metropolitan areas. Interestingly the cyclists involved in the collisions typically sustained lower severity injures compared to the pedestrians ($\chi^2{}_{(1)} = 35.2$, $p < 0.01$, $\varphi c = 0.34$), with only 7.7% of cyclists sustaining an injury that required treatment at a hospital compared to 35.4% of pedestrians who sustained serious or fatal injuries.

3.2. Collision characteristics

Police crash data were examined to gain an understanding of collision characteristics. The variables selected for analysis included: speed zone, road geometry and time of day. Additionally spatial analysis of crash locations was undertaken to identify any clustering of pedestrian cyclist collisions.

Analysis of speed zone data illustrated that pedestrian and cyclist collisions typically occurred in low speed environments of 60 km/h or less, representing almost three-quarters (74.8%) of collisions. It is noted that speed zone may not be relevant for all cases, particularly if the collision occurred on a footpath adjacent to the roadway. The temporal distribution highlighted collisions occurring at three distinct times; in the morning, around noon and in the afternoon. This differs from typical crash distributions that tend to cluster in the morning and afternoon peak periods, which correlates with peak vehicle movements. Analysis of datasets identified seasonal trends with the highest proportion of admissions and ED presentations occurring in warmer months of the year, which are typically associated with higher volumes of cyclist and pedestrian movements (Pucher et al., 2011).

When considering crash types each pedestrian crash was classified according to VicRoads' codes for classifying accidents (DCA codes). Near-side (30.3%) and far-side (15.5%) collisions were prevalent amongst the police reported dataset, these collisions are associated with pedestrians crossing the road either from the left or right side of the cyclist. A further 6.4% of pedestrians were struck while boarding or alighting a vehicle. Notably, 15.5% of pedestrian injuries occurred while on a footpath, median or traffic island, locations where adult cyclists typically should not be riding a bicycle. Analysis of crash location further revealed that the majority of collisions occurred at midblock locations (53.5%) compared to 45.8% at intersections.

Spatial analysis of the crash locations focused on cluster analysis, using a kernel density estimation process to calculate injury densities (injuries/km^2). The analysis identified that pedestrian collisions with cyclists tended to occur in inner Melbourne (47.1%). With the only significant clustering of collisions identified towards the very centre of the city (20 injuries/km^2) (Fig. 1).

3.3. Injury patterns and outcomes

A summary of the main body region injured for ED and hospital admitted pedestrians is shown in Table 4. The majority of collisions resulted in pedestrians sustaining head injuries. The next most prevalent injury type for ED patients were injuries to the knee and lower leg (15.4%), or the elbow and forearm (10.3%). In contrast, the most commonly injured body regions for hospital admitted pedestrians included injuries to multiple body regions (15.8%) or to the wrist and hands (9.3%). When considering ICD Injury severity scores for hospital admitted patients, 20.1% of cases were deemed serious injuries, with the remaining 79.9% classified as other injuries. Illustrating that generally pedestrians do not suffer major trauma in collisions with cyclists.

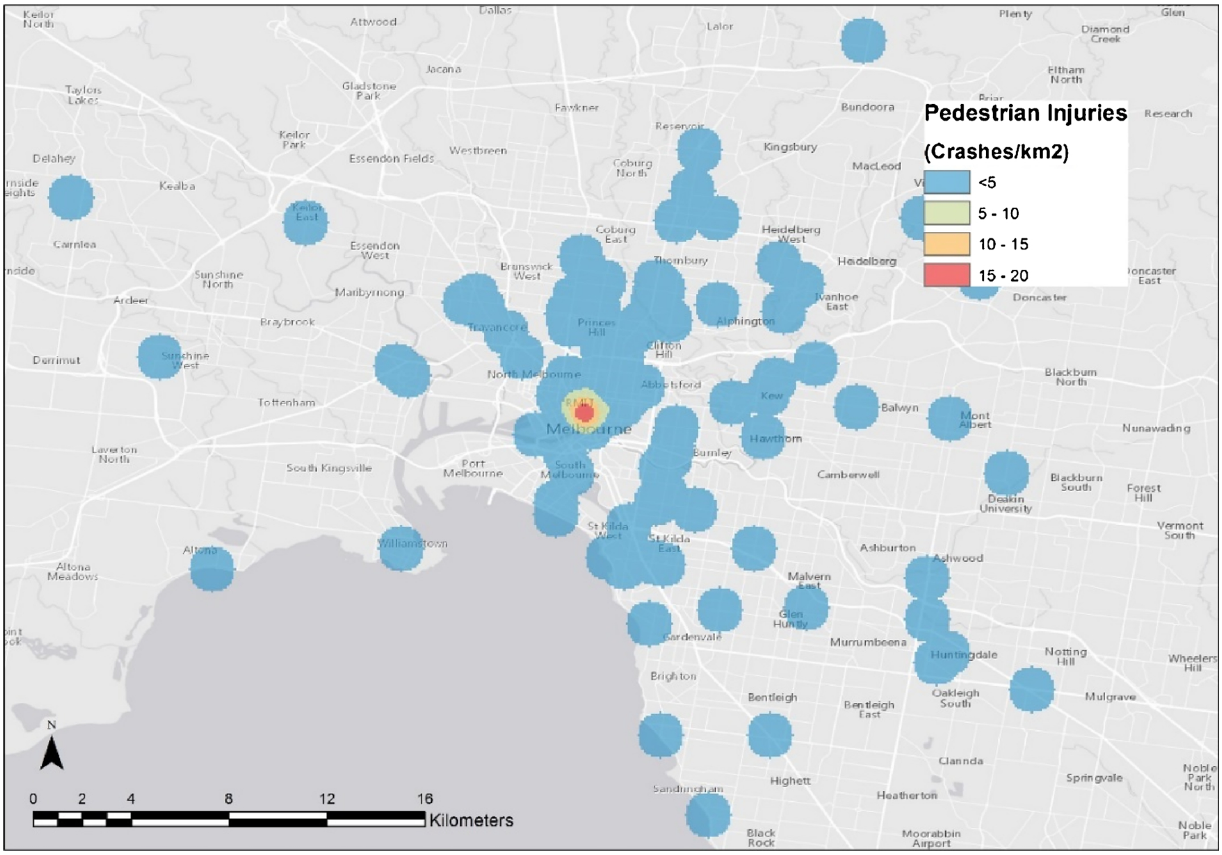

Fig. 1. Pedestrian and cyclist collision density (July 1st, 2006 to June 30th, 2016).

Table 4
Pedestrian injured body region (July 1st, 2006 to June 30th, 2016).

Injury location	Emergency department (n = 183)	Hospital admissions (n = 273)
Head	42.5%	31.7%
Wrist & hand	5.5%	9.3%
Knee & lower leg	15.4%	7.7%
Shoulder & upper arm	7.3%	7.1%
Elbow & forearm	10.3%	7.1%
Abdomen, lower back, lumbar spine & pelvis	5.9%	6.0%
Thorax	3.3%	5.5%
Ankle & foot	1.8%	5.5%
Hip & thigh	5.9%	2.2%
Neck	2.2%	1.1%
Multiple body regions	*	15.8%
Unspecified body region	*	1.1%

*Suppressed due to small cell sizes.

Table 5
Pedestrian injury types (July 1st, 2006 to June 30th, 2016).

Injury type	Emergency department (n = 183)	Hospital admissions (n = 273)
Superficial injury	24.0%	7.0%
Fracture	24.0%	52.4%
Dislocation, sprain & strain	13.7%	3.3%
Open wound	12.0%	13.6%
Other & unspecified injury	9.3%	5.9%
Intracranial injury	8.2%	16.1%
Injury to muscle & tendon	5.5%	*
Injury to nerves & spinal cord/Blood vessels/crushing injury/injury to internal organs	3.3%	*

*Suppressed due to small cell sizes.

The nature of injury differed significantly between those admitted to hospital and pedestrians who presented to EDs ($\chi^2_{(9)} = 65.1$, $p < 0.01$, $\varphi c = 0.38$) (Table 5). Most notably hospital admitted patients were more likely to suffer from fractures (52.4% vs 24.0%) and intracranial injuries (16.1% vs 8.2%) compared to ED patients. While ED patients were more likely to sustain dislocations, sprains, strains (13.7% vs 3.3%) and superficial injuries (24.0% vs 7.0%).

When considering the average length of hospital stay, the majority of pedestrians involved in collisions with cyclists were admitted for fewer than two days (53.1%), while only 7.7% required a hospital stay greater than 7 days. Compared to pedestrian collisions with motor vehicles, the duration of hospital stays were significantly shorter ($\chi^2_{(1)} = 27.5$, $p < 0.01$, $\varphi c = 0.06$), furthermore the severity of collisions were also significantly lower compared to collisions involving motor vehicles ($\chi^2_{(1)} = 9.85$, $p < 0.01$, $\varphi c = 0.04$).

4. Discussion

This study investigated the prevalence of pedestrian injuries resulting from collisions with cyclists in Melbourne, Australia. The intention was to quantify the extent of these collisions and identify if the rate of collisions was increasing, which may highlight a growing road safety issue. Furthermore the study sought to identify any unique characteristic and injury outcomes associated with this collision type. The impetus for this study stemmed from anecdotal suggestions that cyclists were involved in increasing number of collisions resulting in pedestrian injuries, particularly when riding illegally on footpaths and also when riding on shared paths or in mixed use zones, where pedestrians and cyclists must interact within the same space.

It is important to note that the research presented in this paper focuses on the prevalence of injury and that causality has not been assigned for any of the collisions. Due to the nature of the minimum hospital datasets it is not possible to identify causality. Furthermore, an in-depth analysis of individual police reports was not undertaken during this study, however, further comprehensive analyses are warranted, particularly to gather more information on the specific locations and infrastructure associated with pedestrian injuries due to collisions with cyclists. A further noted limitation with this research is the use of population to measure prevalence and it is noted that this may not accurately reflect an appropriate exposure measure for pedestrians and cyclists and an increase in population does not necessarily correlate with an increase active transport use. Notwithstanding, the current analysis demonstrated that over the past ten years there does not appear to have been a substantial increase in the number of pedestrian injuries resulting from collisions with cyclists. With, no significant change identified with the rate of ED and police reported cases. While, the rate of hospitalisations was found to increase over the study period, the prevalence of injuries was small, especially when compared to injuries sustained by pedestrians from collisions with motor vehicles.

Despite the paucity of research addressing collisions between pedestrians and cyclists, the current findings confirm earlier research. A report for the European Commission (SafetyNet, 2009) noted that, while severe injuries to pedestrians in collisions with cyclists were infrequent, collisions between these groups often occur at facilities designed for pedestrians and cyclists such as crossing locations, cycle tracks and cycle lanes. In addition, there are reports that, in the UK, the number of pedestrians killed or seriously injured as a result of a collision with a cyclist are on the rise, with close to 2500 recorded collisions that resulted in a pedestrian casualty between 2011 and 2016 (albeit contributing to a small proportion of overall pedestrian injuries (UK Department for Transport, 2018). Research conducted in other states of Australia have also shown that pedestrian trauma due to collisions with cyclists is relatively rare. For example in Queensland, Rees (2011) identified an average of 4.7 injury collisions per year between cyclists and pedestrians on footpaths and bikeways. Similarly previous research conducted in Victoria identified only 2.1% of pedestrian injuries occurred as a result of a collision with a cyclists (Cassell et al., 2010), while Grzebieta et al. (2011) reported a somewhat higher rate of 7.6% in New South Wales.

The findings also confirm previous research showing that older pedestrians are disproportionally represented in collisions with cyclists (Boufous et al., 2010). With Australia experiencing an ageing population due to sustained lower fertility rates and increases in life expectancy and older pedestrians are over-represented in road trauma statistics (O'Hern and Oxley, 2015). Similarly, in this study, older pedestrians were found to be over-represented in collisions with cyclists, highlighting the increased fragility of older adults. It is important that any changes to the road environment that encourage increased pedestrian and cyclist interaction consider the vulnerability and functional ability of all road users to ensure that the burden of injury is not disproportionally held by vulnerable sub-groups within the population.

Unsurprisingly, comparison of pedestrian injuries sustained from collisions with bicycles compared to motor vehicle collisions resulted in significantly lower levels of injury severity and were also associated with shorter hospital stay durations when considering patients who were admitted to a hospital due to their injuries. This highlights the reduced average severity of pedestrian and bicycle collisions, notwithstanding there is still the potential for significant injuries.

It is noted that an issue with vulnerable road user injuries in police reported datasets, and to a lesser extent hospital datasets, is the issue of underreporting. This has previously been noted by various researchers including Sikic et al. (2009); Garrard (2009b); Boufous et al. (2013) and Oxley et al. (2017). For example in their analysis of police reported and hospital based cyclist crashes, Boufous et al. (2013) identified that single-vehicle bicycle crashes represented only 5.2% cases in police reported datasets, compared to 55% in hospital data. It is for this reason that it is important to consider hospital recorded injuries, particularly when considering vulnerable road users and collision types that may not be reported to police, as has been done in this research. Even still there are limitations with hospital datasets, particularly when considering minor injuries that may not have been treated in a hospital setting. Furthermore, due to the de-identified and aggregate nature of the data available for this research there are limitations with the analysis techniques that can be used to interrogate the data. Both Police and Hospital datasets are also subject to issues of data quality and completeness and these issues are likely to have affected this study, and these limitations should be taken into account when interpreting the findings, as it is likely that the frequencies and rates reported in this manuscript underestimate the true nature of these injuries.

Despite the various limitation of the chosen datasets, it appears that the prevalence of pedestrian injury due to collisions with cyclists is relatively low, which is not altogether unexpected considering the relatively low levels of cyclist mode share in Victoria (Australian Bicycle Council, 2017), with estimates from the 2016 census that only 1.2% of Victorians cycle to work (ABS, 2016; Australian Bicycle Council, 2017). That being said, Australia, like much of the developing world is experiencing unprecedented urbanisation, resulting in increased population densities in metropolitan areas (Stevenson et al., 2016). Concurrently there are attempts at various levels of government and non-government organisations to encourage increased participation in active and sustainable modes of transport, both due to the health benefits offered by these modes and their ability to reduce traffic congestion and improve the quality of life in cities (Lusk et al., 2011; Handy et al., 2014) particularly when active modes of transport are utilised in place of private vehicles.

These emerging trends of increasing urbanisation and an uptake in active transport modes could see the issue of pedestrian injuries due to collisions with cyclists increase into the future. The findings of this research indicate that inner Melbourne, which currently has both high pedestrian movements (Garrard, 2009a; O'Hern and Oxley, 2015), relatively high cyclist mode share, compared to the rest of the city, and has high land use densities (Pucher et al., 2011), had the highest concentration of pedestrian injuries as illustrated through the cluster analysis. These findings are likely to be replicated in other Australian and Internationally cities with similar urban densities and growing cycling mode shares. In these areas there is a need for coordinated urban and transportation planning where appropriate facilities are provided for each mode of transport. In many European countries with high cycling mode share, dedicated cycling facilities such as cycle tracks or bicycle lanes are provided to separate cyclists from pedestrian and motor vehicle traffic. These dedicated facilities should be considered in locations with high volumes of pedestrian and cyclist interaction, particularly in locations where cyclists travel at higher speeds.

Outside of the inner Melbourne region, pedestrian injuries due to collisions with cyclists were relatively rare events and the spatial dispersion did not identify any significant spatial clustering. Again these areas are characterised as having very low cycling mode share and also typically have less cycling infrastructure (Pucher et al., 2011). As such, to increase cycling mode share it may be appropriate to allow certain sub-groups of cyclists to utilise footpaths. It has previously been identified that one of the key barriers to cycling participation is the fear of cycling on-road and providing options for more cyclists to use footpaths may encourage increased participation (Garrard et al., 2010). Currently in Victoria cyclists up to the age of twelve are allowed to ride on footpaths. Adults can only legally ride on the footpath if they are accompanying a child under twelve (Haworth and Schramm, 2011). Analysis of the cyclist involved in police report collisions identified that 8.4% of pedestrian collisions involved a child cyclist, representing thirteen collisions over the ten year study period. Given this low rate of collision, it may be appropriate to extend the age range of child cyclists who are allowed to ride on footpaths. This could not only improve the number of children engaging in active transportation, which offers a range of benefits, but may help to establish sustainable transport behaviours that are carried into adulthood (Yang et al., 2014; Oxley et al., 2016).

The construction of a larger network of shared path facilities may also be another viable option to improve the pedestrian and cyclists infrastructure networks. Shared paths are fairly common throughout Australia and provide an off-road facility which is accessible by pedestrians and cyclists. They are typically cheaper to construct compared to separated pedestrian and cyclist facilities and are warranted in locations where there is demand for both pedestrians and cyclists (Langdon, 2014). However the width of the path is a particular concern with these facilities, particularly from the perspective of pedestrians (Garrard, 2013) and the facilities should only be implemented in locations were the is sufficient width for cyclists and pedestrians to safely interact.

Apart from infrastructure solutions education and training programs can be implemented or existing programs enhanced to improve pedestrian and cyclist interaction. Some key messages may include encouraging cyclists to use warning devices to alert pedestrians as they approach, cycling at appropriate speeds in shared environments and exhibiting predictable behaviours when using shared facilities. It is also possible that the issue of pedestrian and cyclist distraction are contributing factors for some collisions, particularly when engaged in text-messaging, listening to portable music devices, talking on phones and engaging with various technologies while walking and cycling (Hatfield and Murphy, 2007; Schwebel et al., 2012).The nature of this research did not allow for distraction to be identified. Notwithstanding, there is some recent research suggesting that distracted pedestrians are more likely to take greater risks when engaging with the road environment (Schwebel et al., 2012). Studies have found that distracted pedestrians take longer to cross intersections, watch the road less when searching for acceptable gaps in traffic and will accept shorter gaps in traffic when crossing (Schwebel et al., 2012). Research has also shown that distracted pedestrians show a reduction in cautionary behaviours when crossing the road such as looking both ways before they cross and watching for traffic while crossing (Bungum et al., 2005; Stavrinos et al., 2011; Schwebel et al., 2012). Complex cognitive tasks, such as text messaging have also been shown to pose a greater risk to pedestrian than talking on the phone or listening to music (Stavrinos et al., 2011). With further research needed to understand the influence of technology and distraction on these collision types, particularly in off-road and shared space environments.

In summary, the research has illustrated that pedestrian injuries due to cyclist collisions in Melbourne are a relatively rare event and confirms findings conducted in other jurisdictions in Australia. Furthermore these collisions typically result in lower severity injuries, compared to collisions involving motor vehicles. Efforts to increase active transport participation should be encouraged and there may be situations where it is suitable to encourage increased interaction and sharing of space between pedestrians and cyclists. Of course further understanding of these interactions are required beyond retrospective analysis of police and hospital datasets to consider additional factors such as under-reporting of collisions, near misses and safety concerns of various sub-groups of the population.

References

Abs, 2016. 2016 Census of Population and Housing. Australian Bureau of Statistics, Canberra, Australia.

Accd, 2017. The International Statistical Classification of Diseases and Related Health Problems, Tenth Revision, Australian Modification (icd-10-am/achi/acs) (tenth Ed.). Australian Consortium for Classification Development, Darlinghurst, NSW.

Australian Bicycle Council, 2017. National Cycling Participation Survey 2017.

Boufous, S., De Rome, L., Senserrick, T., Ivers, R.Q., 2013. Single- Versus Multi-vehicle Bicycle Road Crashes in Victoria, Australia. Injury Prevention.Single- Versus Multi-vehicle Bicycle Road Crashes in Victoria, Australia. Injury Prevention.

Boufous, S., Senserrick, T., De Rome, L., Ivers, R., Stevenson, M., Hinchcliff, R., Memon, M., 2010. Factors in Pedestrian Casualty Crashes in Victoria: a Report to Vicroads.

Bungum, T.J., Day, C., Henry, L.J., 2005. The association of distraction and caution displayed by pedestrians at a lighted crosswalk. J. Community Health 30 (4), 269–279.

Cassell, E., Clapperton, A., Alavi, H., Jones, S., 2010. Traffic-related Pedestrian Injury in Victoria (1): Hospital-treated Injury.

Garrard, 2009a. Active transport: Adults - an overview of recent evidence. VicHealth, Melbourne.

Garrard, J., 2009b. Active Transport: Children and Young People: an Overview of Recent Evidence.

Garrard, J., 2013. Senior Victorians and Walking: Obstacles and Opportunities. Victoria walks, Victoria.

Garrard, J., Greaves, S., Ellison, A., 2010. Cycling injuries in Australia: Road safety's blind spot? J. Australas. Coll. Road Saf. 21 (3), 37.

Grzebieta, R., Mcintosh, A., Chong, S., 2011. 2011. Pedestrian-cyclist collisions: issues and risk. Proceedings of the Australasian College of Road Safety Conference–Safe System: Making It Happen.

Handy, S., Van Wee, B., Kroesen, M., 2014. Promoting cycling for transport: research needs and challenges. Transp. Rev. 34 (1), 4–24.

Hatfield, J., Murphy, S., 2007. The effects of mobile phone use on pedestrian crossing behaviour at signalised and unsignalised intersections. Accid. Anal. Prev. 39 (1), 197–205.

Haworth, N.L., Schramm, A.J., 2011. Adults Cycling on the Footpath: What Do the Data Show?.

Langdon, M., 2014. Speed Management on Shared Paths. Queensland Department of Transport and Main Roads.

Lusk, A.C., Furth, P.G., Morency, P., Miranda-Moreno, L.F., Willett, W.C., Dennerlein, J.T., 2011. Risk of injury for bicycling on cycle tracks versus in the street. Inj. Prev. 17 (2), 131–135.

O'Hern, S., Oxley, J., 2015. Understanding travel patterns to support safe active transport for older adults. J. Transp. Health 2 (1), 79–85.

Oxley, J., O'Hern, S., Raftery, S., Woolley, J., 2016. How safe are children when transported by bicycle? Traffic Inj. Prev. 17 (sup1), 163–167.

Oxley, J., O'Hern, S., Burtt, D., Rossiter, B., 2017. Falling while walking: a hidden contributor to pedestrian injury. Accid. Anal. Prev.

Pucher, J., Garrard, J., Greaves, S., 2011. Cycling down under: a comparative analysis of bicycling trends and policies in Sydney and Melbourne. J. Transp. Geogr. 19 (2), 332–345.

Rees, 2011. Speed Limit Setting on Shared Paths. Griffith University.

Safetynet, E., 2009. Pedestrians & cyclists. EC, Brussels.

Salmon, P., Williamson, A., Lenné, M., Mitsopoulos-Rubens, E., Rudin-Brown, C.M., 2010. Systems-based accident analysis in the led outdoor activity domain: application and evaluation of a risk management framework. Ergonomics 53 (8), 927–939.

Schramm, A.J., Rakotonirainy, A., 2009. The effect of road lane width on cyclist safety in urban areas. Proceedings of the Proceedings of the 2009 Australasian Road Safety Research, Policing and Education Conference: Smarter, Safer Directions.

Schwebel, D.C., Stavrinos, D., Byington, K.W., Davis, T., O'neal, E.E., De Jong, D., 2012. Distraction and pedestrian safety: how talking on the phone, texting, and listening to music impact crossing the street. Accid. Anal. Prev. 45 (0), 266–271.

Sikic, M., Mikocka-Walus, A.A., Gabbe, B.J., Mcdermott, F.T., Cameron, P.A., 2009. Bicycling injuries and mortality in Victoria, 2001-2006. Med. J. Aust. 190 (7), 353–356.

State Government of Victoria, 2014. Plan Melbourne. State Government of Victoria, Melbourne.

Stavrinos, D., Byington, K.W., Schwebel, D.C., 2011. Distracted walking: cell phones increase injury risk for college pedestrians. J. Safety Res. 42 (2), 101–107.

Stevenson, M., Johnson, M., Oxley, J., Meuleners, L., Gabbe, B., Rose, G., 2015. Safer cycling in the urban road environment: study approach and protocols guiding an Australian study. Inj. Prev. 21 (1), e3.

Stevenson, M., Thompson, J., De Sá, T.H., Ewing, R., Mohan, D., Mcclure, R., Roberts, I., Tiwari, G., Giles-Corti, B., Sun, X., 2016. Land use, transport, and population health: estimating the health benefits of compact cities. Lancet 388 (10062), 2925–2935.

UK Department for Transport, 2018. Cycling and Walking Investment Strategy: Proposals for New Cycling Offences. UK Department for Transport London.

United Nations, 2016. D.O.E.A.S.A., Population division. The World's Cities in 2016 – Data Booklet.

Vichealth, 2016. Vichealth Indicators Survey 2015: Selected Findings. Victorian Health Promotion Foundation, Melbourne.

Who, 2007. Global Age-friendly Cities: a Guide World Health Organization.

Yang, X., Telama, R., Hirvensalo, M., Tammelin, T., Viikari, J.S.A., Raitakari, O.T., 2014. Active commuting from youth to adulthood and as a predictor of physical activity in early midlife: the young finns study. Prev. Med. 59 (Supplement C), 5–11.