Reducing pedestrian collisions in Melbourne’s Central Business District

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Abstract

Walking is an increasingly important travel mode, especially in highly urbanised areas. High levels of pedestrian activity occur in Melbourne’s Central Business District (CBD), and associated with this is a substantially high level of pedestrian trauma. Between 2000 and 2011, 451 pedestrian casualty collisions were recorded within the CBD, comprising 10 fatalities, 316 hospitalisations, 87 requiring medical treatment and 38 uninjured. For sustained population health, the environment and liveability of cities, it is desirable to promote walking, however, it is also essential that safe walking environments are provided. In order to apply ‘best-practice’ countermeasures within a Safe System framework, an understanding of collision types and contributing factors is required. An analysis of Victorian Police-reported casualty pedestrian casualty collisions in the CBD between 2000 and 2011 was undertaken to identify key factors in pedestrian collision involvement in the CBD area. The findings showed that almost half of crash-involved pedestrians were young adults, and half occurred at signalised intersections. Results also indicated differences in characteristics of collisions occurring at night and during business hours. During night hours, particularly on weekends, collisions were clustered around night clubs and bars and involved a higher proportion of young adult males crossing at intersections. In contrast, collisions occurring during business hours were evenly distributed throughout weekdays, across multiple locations on streets, more prevalent around public transport facilities and with less severe injury outcomes than those occurring during night hours. These findings have implications for the development of engineering and behavioural countermeasures in the built environment to target priority collision types including reducing vehicle travel speed, improvements to intersection design and operation, and measures to separate pedestrians from vehicles around drinking venues at night and around public transport facilities during the day.

Introduction

The vulnerability of pedestrians in traffic is well established. In a collision with a vehicle, pedestrians are always the weakest party and are at a greater risk of injury or death compared with most other road users. Currently, pedestrians contribute to approximately 12 percent of all road fatalities and serious injuries in Victoria.

Recently, concerns regarding the negative side effects of car usage have been raised in relation to the impact on climate change. Consequently, the benefits of alternative transport options such as walking and cycling have received wide recognition. In response, there has been a major push to promote safe walking and cycling in urban areas in order to meet important goals in urban traffic policy (i.e. accessibility for all, ‘walkability’, safety and a ‘good’ environment). Pedestrian safety concerns are, however, likely to grow if initiatives that promote walking and public transport use are successful in increasing the amount of walking without concurrent improvements in road safety initiatives.

One of the areas where there has been a significant push for increased walking is in highly urbanised areas, such as Central Business Districts (CBDs) in large cities, however, there is little consideration of the impact of the built environment on overall safety of vulnerable road users.

Crashes are complex in nature, often involving several contributing factors including behavioural elements such as distraction, poor road crossing skills, intoxication, etc., and environmental
elements such as land use, design and operation of the built environment, and high vehicle speeds. While it can be a difficult task to determine the major contributing factors, an understanding of the contributory factors to collision and injury risk is an important step in the development and implementation of appropriate strategies and countermeasures to ensure overall safety. This paper presents the findings of an analysis to identify key factors in pedestrian collisions in the Melbourne CBD area. The findings are discussed in terms of impact on approaches to managing pedestrian safety in the built environment and recommendations for innovative ways to take the next major step forward to eliminating serious pedestrian trauma.

Method

Victorian Police-reported mass crash data covering the period January 2000 to December 2011 were used in this analysis. Pedestrian collisions occurring within the CBD defined area were extracted from these data and selected crash variables were analysed to highlight the patterns associated with pedestrian serious casualties. The analyses were predominantly crash-based. The CBD area that was used for analysis consisted of the Melbourne city grid enclosed within Spring St, Flinders St, Spencer St and La Trobe St with a segment of Flemington Rd, north of the CBD included. Serious casualty pedestrians are defined as those pedestrians killed or taken to hospital as a result of involvement in a road crash. Variables identified for analysis included pedestrian characteristics (age, gender, BAC level, activity, etc.), injury severity, road geometry, DCA, time of day and day of week, speed zone, and traffic control type. Aggregate analyses comprised cross-tabulations of these descriptor variables and are presented in graphical format.

Results

Overall

Between 2000 and 2010 there was a total of 17,301 pedestrian collisions in Victoria, comprising, on average, 3.3 percent fatalities, 43.4 percent serious injuries and 53.3 percent other injuries (Figure 1). Further, while there has been an overall downward trend in the last few decades in pedestrian collisions, the reduction has not been significant over the last 10 years, and has remained relatively stable with an average of 52 deaths, up to 680 serious injuries and 840 other injuries each year.

![Figure 1. Number of pedestrian casualty collisions in Victoria, 2000-2010](attachment:image.png)

During this period, a total of 451 pedestrians were involved in a collision in the CBD, comprising 2.2 percent fatalities, 70 percent serious injuries, and 27.7 percent other injuries. In comparison with the rest of Victoria, a substantially higher proportion of pedestrian casualties occurring in the CBD resulted in a serious injury, compared with other severity levels.
Pedestrian characteristics

Table 1 shows the characteristics of pedestrians involved in pedestrian collisions by injury severity. First, the overall distribution of pedestrian casualty collisions was examined by age group and gender. There was a slightly higher proportion of males involved in pedestrian collisions compared with females (53.6% vs. 46.4%), and the majority of pedestrians were young adults, aged between 18 and 34 years of age. There was a significant association between age and gender, \( \chi^2(14) = 117.6, p<0.001 \). A higher proportion of those aged 18-35 years were male compared with females (53.6% vs 44.6%), while a higher proportion were females aged 17 years and under and 65-74 years, compared with males (10.3% vs 2.1%, and 5.9% vs 3.4%, respectively). Regarding pedestrian activities, almost all collisions occurred on the carriageway, with approximately three-quarters occurring while pedestrians were crossing a carriageway.

### Table 1. Characteristics of pedestrians involved in collisions

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Fatalities (n=10)</th>
<th>Serious Injuries (n=316)</th>
<th>Other Injuries (n=125)</th>
<th>Total (n=451)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;17 years</td>
<td>0</td>
<td>5.8</td>
<td>7.4</td>
<td>6.1</td>
</tr>
<tr>
<td>18-34 years</td>
<td>20.0</td>
<td>49.8</td>
<td>51.2</td>
<td>49.7</td>
</tr>
<tr>
<td>35-64 years</td>
<td>60.0</td>
<td>36.9</td>
<td>34.7</td>
<td>36.8</td>
</tr>
<tr>
<td>&gt;65 years</td>
<td>20.0</td>
<td>7.4</td>
<td>6.6</td>
<td>7.4</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>50.0</td>
<td>53.9</td>
<td>52.8</td>
<td>53.6</td>
</tr>
<tr>
<td>Female</td>
<td>50.0</td>
<td>46.1</td>
<td>46.4</td>
<td>46.4</td>
</tr>
<tr>
<td>Pedestrian movement:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crossing Carriageway</td>
<td>70.0</td>
<td>71.2</td>
<td>78.4</td>
<td>73.3</td>
</tr>
<tr>
<td>Working/lying/standing on carriageway</td>
<td>0</td>
<td>6.0</td>
<td>4.0</td>
<td>5.4</td>
</tr>
<tr>
<td>Walking on carriageway</td>
<td>10.0</td>
<td>7.3</td>
<td>4.0</td>
<td>6.5</td>
</tr>
<tr>
<td>Pushing/working on vehicle</td>
<td>0</td>
<td>0.6</td>
<td>0</td>
<td>0.4</td>
</tr>
<tr>
<td>Walking to/from or boarding tram/vehicle</td>
<td>10.0</td>
<td>6.3</td>
<td>8.8</td>
<td>7.2</td>
</tr>
<tr>
<td>Not on carriageway</td>
<td>10.0</td>
<td>5.1</td>
<td>3.2</td>
<td>4.7</td>
</tr>
<tr>
<td>Unknown</td>
<td>0</td>
<td>0</td>
<td>0.8</td>
<td>1.6</td>
</tr>
</tbody>
</table>

Blood alcohol content (BAC) was only known for seven cases, six of them were a fatal outcome and the majority of them recorded a zero BAC level.

Collision characteristics

The Definitions for Classification Accidents (DCA) chart was used to further examine the types of crashes in which pedestrians were involved (Figure 2). For all levels of collision severity, the most common crash type was a near-side collision, where the pedestrian emerged from the roadside and collided with a near-side approaching vehicle, accounting for 45.5 percent of all collisions. This was, by far the most common crash type for a fatal injury outcome (accounting for 60% of all fatal collisions). Far-side collisions, where the pedestrian was on the road and collided with a far-side approaching vehicle were also common, accounting for 22.3 percent of all collisions.
With regard to the day of week and time of day, collisions were evenly spread over all days of the week, with a slightly higher proportion occurring on Fridays (18.2%). With regard to time of day, overall, approximately one-third of collisions occurred at night, with 23 percent occurring between midnight and 6am, and 11 percent between 9pm and midnight. An additional 21 percent of collisions occurred in the afternoon between 3 and 6pm. As shown in Figure 3, there was an effect of age group on time of collision, $\chi^2(49) = 86.7, p<0.001$.

Youth and young adults aged under 34 years were more likely to be involved in a collision during night-time hours compared with older adults, particularly between midnight and 3am. A high
The proportion of collisions involving young people aged 17 years and under also occurred during the late afternoon. In contrast, older adults were more likely to be involved in a collision in the morning between 9 am and noon. Time of collision was also statistically associated with hit and run, with hit and run collision most likely to occur during night hours, between midnight and 3am (17%) and 3am-6am (35%), $\chi^2_{(14)}=26.9, \ p<0.01$. There were no significant associations between time of collision and other variables such as injury severity, gender, DCA.

The location of collisions was also examined and the findings showed that almost half of collisions occurred at cross intersections (48.8%), and a further 12 percent at T-intersections. The remainder (39.4%) of collisions occurred at mid-block locations.

In addition, speed zone was examined. The vast majority of collisions occurred in 60 km/h and 50 km/h speed zones (31.9% and 62.7%, respectively). This was not a surprising finding, given that most streets in the CBD area were zoned at 50 or 60 km/h during the period of interest.

Further examination of the spatial pattern of collisions revealed some clustering of collisions (Figures 4 and 5). These analyses showed that, during night hours, and particularly on weekends, collisions were clustered around night clubs and bars and involved a higher proportion of young adult males crossing at intersections. In contrast, collisions occurring during business hours were evenly distributed throughout weekdays, across multiple locations on streets, more prevalent around public transport facilities and with less severe injury outcomes than those occurring during night hours.

![Figure 4. Spatial mapping of pedestrian collisions in Victoria (map view)](image-url)
Last, examination of vehicle type was undertaken. Not surprisingly, the majority (63.6%) of vehicles involved in pedestrian collisions were private passenger vehicles (cars, wagons, utilities, and panel vans), with a further 4% involving a truck. Public transport vehicles also contributed to a substantial proportion of collisions (tram: 9.1%; bus: 3.5%).

Discussion

This study identified some key factors associated with pedestrian collisions within the Melbourne CBD area, focusing on collision characteristics and spatial patterns of collisions. It highlighted the disproportionate burden of pedestrian injury within the Melbourne CBD area. Overall, the findings showed that the contribution of collisions within the CBD area to pedestrian trauma in Victoria is substantial, despite the relatively small land area. Further, the analyses revealed that a comparatively high proportion of collisions within the CBD area resulted in a serious injury outcome. The majority of collisions involved younger adults and most involved collisions with passenger cars while on the carriageway on near-side lanes and at intersections.

While it was not surprising that all collisions occurred in speed zones of 50 and 60 km/h, the finding that speed zoning is set at 50km/h or 60 km/h within an area of such high pedestrian activity is or some concern and may have contributed to the relatively high proportion of serious injury outcomes. There is overwhelming evidence that speed has a great impact on pedestrian safety. The risk of injury or death for pedestrians can occur at relatively slow impact speeds, and severity of injuries arising from a collision increases exponentially with vehicle speed – to a power of four for fatalities, three for serious injuries and two for casualties. At vehicle impact speeds of under 30 km/h the probability of pedestrian death is approximately 5 to 10 percent. However, the probability of death at impact speeds greater than 40 km/h increases rapidly with almost certain death at impact speeds over 55-60 km/h (Ashton & Mackay, 1979; Anderson, McLean, Farmer, Lee & Brooks, 1997; Davis, 2001). More recently, Ballesteros et al. (2004) showed that pedestrian mortality and injury severity increased with vehicle speed. Pedestrians hit in speed limit areas of 25 mph or under died 24 percent of the time, whereas, those hit in areas of 40 mph or greater died 39 percent of the time. Likewise, Stone and Broughton (2003) showed that, while three-quarters of fatal and reported serious cycle crashes occurred on 30 mph (50 km/h) roads, the fatality rate rose markedly with increases in speed limit. The fatality rate on 30 mph roads was 3.0 and this rose to 13.0 on 50 mph roads and further to 19.6 on 70 mph roads.
Moderation of vehicle speeds, especially to speeds not exceeding 30 or 40 km/h, is essential to reduce pedestrian trauma. This can be achieved through adoption of low urban speed limits (maximum 50 km/h) with lower speeds (30-40 km/h) in areas of high pedestrian activity, residential and shopping areas and in school zones, and should be considered for roads within the CBD area. Additional measures could also be considered to increase speed limit compliance and adoption of appropriate travel speeds and include out-of-vehicle Intelligent Transport System (ITS) applications (e.g., dynamic messaging in the form of active speed warning signs and variable message signs) and introduction of traffic calming measures (e.g., pavement narrowing, refuge islands, alterations to the road surface, speed humps, roundabouts and gateway treatments). In ‘best-practice’ designs, these physical modifications to the roadway are part of an overall design concept to enhance the ‘walkability’ of urban environments, providing a safe and comfortable place to walk, giving vulnerable road users greater priority and discouraging high traffic volumes and high speed through-traffic (Leslie, Coffee, Frank, et al., 2007; Sallis, Frank, Selens, et al., 2004).

The finding that a high proportion of collisions occurred at intersections, including cross and T-intersections suggests that intersection design and operation in the CBD may not be optimal for pedestrians, despite being important places for pedestrians to cross streets. Unfortunately, intersections are often the most challenging and dangerous places to do so. Traffic at intersections may cross a pedestrian’s path from multiple directions, for example drivers turning right into a cross street, drivers turning left into a cross street, and drivers exiting a cross street or turning right on red. The design of an intersection affects how fast this traffic moves, how effectively drivers yield to pedestrians, and how effectively pedestrians can avoid those drivers who do not. It was difficult to determine from these data what specific design features and road user movements may have contributed to collisions, and therefore warrants further investigation. Nonetheless, the literature highlights many factors that influence pedestrian safety and ‘walkability’ at intersections. Previous literature generally suggests that good intersections are those that are designed to promote pedestrian safety and comfort and:

- encourage people to walk by creating a safe and inviting pedestrian realm;
- provide adequate sight distance for both pedestrians and drivers;
- minimise pedestrian crossing distance, time and exposure to potential conflicts;
- maximise pedestrian visibility while providing design treatments that slow vehicles;
- slow traffic to allow drivers more reaction time and decrease severity when collisions do occur; and
- appropriately reflect the street and transportation context.

Some specific features of pedestrian-friendly intersection design and operations have been identified (European Transport Safety Committee, 1999) and include:

- Visible crosswalks: Well-marked, visible crossings can enhance drivers’ awareness that they are approaching a location where they may encounter crossing pedestrians. In some cases, raised or coloured crossings may be appropriate.
- Parking restrictions: Restricting parking adjacent to corners makes pedestrians and vehicles approaching intersections more visible to one another.
- Crossing aids: Accessible pedestrian facilities such as kerb ramps and accessible pedestrian signals should be provided, as well as signal phasing that allows enough time to cross safely.
- Kerb features: Kerb radii for turning vehicles should be minimised to shorten crossing distances, increase pedestrian visibility, and slow turning traffic. The installation of kerb extensions should be considered in areas with high pedestrian volumes to reduce crossing times, increase pedestrian visibility, and slow turning traffic.
• Median refuges: Where medians are present or space otherwise exists, median refuges should be provided up to the crosswalk to provide a space for crossing pedestrians who may not be able to cross the entire roadway before the end of the walk phase.

• Street lighting: Intersections should be well lit at night to improve visibility for all users. Sufficient lighting to illuminate crossing pedestrians should be provided.

The findings also showed that a substantial proportion of collisions, particularly day-time collisions occurred around public transport facilities. Every public transport user is also a pedestrian and the creation of a better quality environment for public transport users should be seen as a necessary adjunct to improving the public transport service (Public Transport Users Association [PTUA], 2011). By necessity, a bus or tram passenger will have to cross the street to board the vehicle at each end of their journey, therefore the potential for unsafe pedestrian conditions is apparent. Transit can improve pedestrian safety by making sure its bus and tram stop network is safe and by working with cities to ensure that public transit stops provide safe pedestrian access. The evidence suggests that the most successful transit systems have safe and convenient pedestrian access and provide comfortable waiting areas, all of which encourage greater transit use (Nabors, Schneider, Leven, Lieberman & Mitchell, 2008).

Public transport stops can be improved by selecting appropriate and safe locations. The site of a stop should be selected considering a number of factors including i) adequate sight lines between approaching vehicles and passenger waiting and loading areas, ii) positioning in locations that serve the highest number of pedestrians, minimise walking distance and reduce the number of roadway crossings for pedestrians, iii) located with good proximity to destinations in the surrounding area.

Public transport stops can also be improved by providing effective ‘safety zones’ and safe conditions for pedestrians travelling to and from transit stops. Adequate footpaths, pathways and roadway crossings in the areas around access points such as benches, shelters, and lighting at stops and stations are also important. Recently, in the Melbourne CBD, the tram Superstop has been implemented to provide more conspicuous and safer access to trams. In contrast to the general safety zones, the Superstops provide larger, sheltered and raised access. While these are more convenient and comfortable for passengers, they restrict access to trams by providing only entrances at each end, leading to pedestrian congestion at peak times (PTUA, 2011). The PTUA add that, in the absence of safety zones, Superstops or kerb access stops, traffic must stop to allow the movement of people on and off trams. While much more convenient for the public transport user as pedestrian, this arrangement has its own perils. With the onus on the motorist to avoid passing a stationary tram, negligence on his or her part poses the single greatest danger to users of public transport, and better enforcement and education of motorists of these laws is vital. A partial solution to this is the ‘easy access’ stop. This has no barrier between the kerb and the tram, but the road pavement rises like a tabletop speed hump, giving a strong visual and physical signal to drivers that they must give way to passengers. These stops help minimise the danger posed by relying on cars giving way to tram passengers. Further, the PTUA suggests that, where possible, streets with trams should be more fully “pedestrianised”, as with the Bourke Street Mall and Swanston Street, to create a safe and pleasant environment for pedestrians, public transport users and other vulnerable road users.

Last, an important finding of this study was the relatively high proportion of night-time collisions in the CBD area, as well as the distinct characteristics of night-time collisions compared with day-time collisions. Collisions at night involved younger males and collisions at intersections, a substantial proportion of which were hit and run, and the presence of bars and night clubs was associated with risk of night-time collisions.

The finding that night-time pedestrian collisions were clustered around drinking establishments was not surprising, and is consistent with previous research suggesting that the presence of these
establishments is a strong predictor of alcohol-related pedestrian trauma (Corben & Diamantopoulou, 1996; Schuurman, Cinnamon, Crooks & Hameed, 2009; LaScala, Gerber & Gruenwald, 2000). While it was not possible to gauge whether alcohol was a definitive contributing factor for these collisions, as BAC levels were rarely reported for pedestrians, the somewhat concentrated distribution of pedestrian casualties around drinking establishments suggests some association, and may perhaps involve alcohol-affected drivers as well as pedestrians. Intoxicated pedestrians have been recognised as a high-risk pedestrian group and there have been many initiatives suggested to reduce these crashes including educational and behavioural measures such as ‘Responsible Serving of Alcohol’ and safe drinking guidelines and enforcement measures and have had varying success (e. g., Stockwell, 2001). Other engineering-based countermeasures were identified by Corben, Diamantopoulou and Mainka (1996) and include:

- Reduced pedestrian exposure to high crash risk by i) introducing traffic management measures to promote safer walking routes, ii) reducing excessive roadway widths, and iii) encouraging greater use of crossing facilities by improving level of service to pedestrians, erecting fences/barriers to direct pedestrians to cross-walks, automatically introducing pedestrian phases on every cycle;
- Simplifying the crossing task by i) providing highly responsive pedestrian-operated signals, ii) providing medians or refuges, iii) providing well-maintained lane line markings to strengthen driver lane discipline, iv) improving the likelihood of safe driver responses at/near intersections by displaying red to all vehicle directions when there is zero traffic demand (the ‘dwell-on-red’ initiative);
- Improve driver responses to high crash risk by i) providing above-standard street lighting and skid resistant pavement surfaces; and ii) avoiding the need for vehicles to merge; installing symbolic pedestrian warning signs.

Conclusions

This preliminary study has highlighted the city centre of Melbourne, a highly urbanised and congested area for all modes of transport, as a hazardous environment for pedestrians. The findings confirm that the build environment, including land use and road infrastructure, pedestrian infrastructure and streetscape, has a strong influence on pedestrian safety. Educational, awareness, enforcement and behaviour change programs are vital to the success of improving pedestrian safe mobility, particularly to increase the adoption of safe walking practices. While education, training, publicity and promotion programs are valuable tools, these strategies often require a long period of time until the benefits can be realised. Engineering countermeasures that can modify the physical environment of the transport system can provide quick and effective mobility and safety benefits.

Designing pedestrian-friendly roadways has the potential to significantly reduce pedestrian injury and measures that can potentially address the pedestrian safety issues in city areas include:

- Improved land use and spatial design and planning of the pedestrian environment to enhance the ‘walkability’ of the city centre;
- Enhancements to intersection design and operation;
- Improved pedestrian access to and from public transport vehicles;
- Measures to improve pedestrian facilities around entertainment areas at night;
- Measures to moderate vehicle speed including reduced speed limits and traffic calming measures. constructing traffic calming to protect pedestrians;
- Improved educational and enforcement initiatives.

References


