An evaluation of intersection characteristics associated with crashes at intersections in Melbourne CBD

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ABSTRACT
The contribution of crashes occurring at intersections to road trauma is well documented. Developing ways of combating this problem is difficult, partly because there are so many types of intersections, each requiring specific treatments. The present study looked at one part of this problem by examining the rates of injury-causing crashes at different types of intersections in the Melbourne Central Business District. Police-reported crash data was used to analyse crash rates for the five-year period from 1999-2003. The Melbourne CBD is a well-defined area with a unique mix of road users that allows different factors that may increase the risk of having a crash at an intersection to be studied. These factors include the number of lanes of the intersecting roads, whether tram routes pass through the intersection, whether “hook” turns are required for right-hand turns and whether the intersection only allows right turns on green arrows. Crash rates are presented for different types of crashes. Intersection characteristics that increase crash-risk are presented along with possible countermeasures.

THE INTERSECTION PROBLEM
Crashes occurring at intersections are a major contributor to road trauma. Recent data from the Transport Accident Commission show that of the 343 people killed on Victorian roads in 2004, 14% died in intersection crashes. While 24% of those seriously injured in crashes were injured in intersection crashes (TAC, 2005a & 2005b). Furthermore the VicRoads’ Road Crash Information System showed that 23% of Victorian crashes that resulted in serious injuries occurred at intersections. While 26% of serious injury crashes in the Melbourne Statistical Division occurred at intersections (VicRoads, 2005b).

As intersections involve different types of road users moving in conflicting directions, traffic flow through intersections must be controlled using traffic signs, signalisation and turning lanes. Improving road safety at intersections must focus not only on changing potentially dangerous road user behaviour through education and deterrence, but continually looking for new countermeasures that can be incorporated into the design of intersections. However, safety is not the sole factor that determines the design of intersections. Other factors, such as the need for an acceptable level of mobility in urban areas, also play a role in intersection design. For example, the use of hook turns in the Melbourne CBD is designed primarily to prevent right-turning cars from blocking the progress of trams.

Crashes occurring at intersections represent a complex problem not only because of the wide variation in the types of intersections that feature in the road environment, but also because similar crashes occurring at the same intersection could have different or even multiple causes. For example a recent report by the Institute of Transportation Engineers (2003) reviewed potential countermeasures to prevent crashes caused by “red light runners”. It found that there were basically two different types of road users who caused crashes by running red lights: intentional and unintentional red light runners. The report found that using enforcement strategies effectively prevented crashes caused by intentional red-light runners. While crashes caused by unintentional red-light runners were most effectively prevented using engineering countermeasures such as improving the visibility and conspicuousness of

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the signal, providing the road user with more information about the signal or even eliminating the need for the driver to stop at the intersection by redesigning the geometry of the intersection.

Because intersections involve many different types of road users moving in conflicting directions, the list of different types of crashes that could occur at an intersection is extensive. It is therefore important to consider how the different types of countermeasures to prevent one type of crash will affect the likelihood of another type of crash occurring. It is the thesis of the present report that because intersections differ from each other in many ways, and because so many different types of crashes can occur at an intersection, approaching the intersection problem from a global perspective does not enable the best countermeasures for a particular intersection to be isolated. An alternative approach is to consider intersections with similar mixes of road users and traffic flows. The present paper studies intersection safety in the Melbourne Central Business District (CBD) as an example of an alternative method that focuses on a localised road environment to study intersection crashes.

WHY STUDY THE MELBOURNE CBD?

The present study examined the rates of injury-causing crashes at different types of intersections in the Melbourne Central Business District (CBD). This area was chosen as the study region for several reasons. Firstly, there is police-reported data available for crashes occurring in this region. Furthermore, the Melbourne CBD is a well-defined area with a unique mix of road users that allows different factors that may increase the risk of having a crash at an intersection to be studied.

The Melbourne CBD is made up of a rectangular grid of streets approximately 1800m in length and 650m in width. Most streets intersect at right angles. The grid is made up of five evenly spaced main roads that run its length and another nine evenly-spaced main roads that run its width. The intersections of these main roads are signalised. The cross intersections formed by the main roads that run the width of the grid and some minor roads that run lengthwise are also signalised. The city is also made up of dozens of smaller streets and lanes, which form T-intersections with the main roads. These T-intersections are not usually signalised. Most of the main roads act as entry and exit routes for vehicles travelling into our out of the CBD. These roads will be referred to as *feeder* roads for the rest of the report. Some of the main roads form a T-intersection with a main road running perpendicular to it at the boundary of the CBD's grid. The CBD also has a tram network that runs the length of the grid on four of the main roads including both roads that run each outside length of the grid. Trams also run along five of the main roads that run the width of the grid (including the two boundary roads). There are seventeen intersections in the Melbourne CBD in which one has to make a 'hook turn' in order to turn right. Hook turn intersections require drivers to turn right from the far left lane. Drivers wishing to turn right enter the intersection when they have a green traffic light and wait in the far left lane until the traffic light for the street they wish to enter turns green. These sites all occur along a tram route and at the intersection of two main roads.

The CBD has changed somewhat in the last few years: some main roads that previously intersected the boundary of the grid with a T-intersection have recently been extended so that they now form a cross intersection at the boundary (these streets include Exhibition St and Collins St). There have also been some minor changes in the placement of traffic lights. All these changes were adjusted for when classifying crashes at affected intersections in different years.

METHOD

The VicRoads police-reported crash database provided information on crashes that occurred in Victoria for the five year period, 1999-2003 (VicRoads, 2005a). This database contains information on the location, crash circumstances, road users involved, vehicles involved and injury outcomes for police-reported crashes occurring in Victoria. Crashes occurring in the Melbourne CBD were isolated from other crashes using variables related the postcode of the crash location, as well as the name of the street that the crash occurred on, and the name of the nearest intersecting street. GIS data were also used to pin-point crash locations. Crashes occurring at the intersections on the boundary of the CBD were classified as crashes occurring in the CBD.

Results in this study are presented as aggregate numbers of crashes that resulted in serious injuries or fatalities occurring at particular types of intersections. Exposure measures, in terms of the number of cars entering intersections, could not be obtained. In their absence, the percentage of crashes that resulted in the death or serious injury of a road user is presented for a particular intersection or type of intersection. This measure gives an estimate of the secondary safety of (types of) intersections (i.e. it is a measure of the likelihood that when a crash occurs it will result in a serious injury or fatality).

Intersections in the Melbourne CBD were categorised with respect to eight characteristics. The characteristics studied include the geometry of the intersection, whether it is signalised, the presence of hook turns, proximity of tram routes, the number of lanes of intersecting roads, whether right turns are permitted without a green right arrow, whether intersecting roads have a median divider between opposing lanes and whether one of the intersecting roads is a feeder road.

The selection of which independent variables would be analysed for relatedness to the severity of the crash was determined by examining the VicRoads police-reported crash database to see what information about the crash environment was available for analysis. However, previous studies had shown that all eight factors could influence injury outcome in some types of crashes. For example, Abdel-Aty and Keller (2005) demonstrated that when one of the intersecting roads was a divided road, injury outcomes for crashes at signalised intersections were less severe. Some intersection characteristics that have proved important in other studies were not analysed in the present study because there was insufficient variance in the present sample of crashes. For example, the speed limit of the intersecting roads was not included as a factor as, throughout the study period, all roads in the CBD had either 50 or 60 km/h limits. Other potentially influential factors, such as the volume of traffic flow, sight distances at the intersection and the phasing of traffic lights are also likely to influence risk of serious crashes at such intersections. However such factors have been excluded from the present analysis because sufficient data detailing such features could not be acquired.

Statistically significant differences in the incidence of serious crashes at intersections were determined using Chi-Square Tests. As eight such tests were planned, the alpha value of 0.0064 was used to determine significance.

The present report also presents comparisons of severity outcomes for crashes occurring in the CBD and crashes occurring in other metropolitan regions as well as rural areas. Intersection crashes are also compared with non-intersection crashes in order to provide the reader with some background to the intersection problem. The report also lists the intersections in the Melbourne CBD that result in the greatest number of fatal or serious injury crashes.

RESULTS

As there were few fatalities occurring in the CBD over the five-year study period, crashes in which at least one person died were grouped together with crashes in which at least one person was seriously injured. From this point forward these crashes will be referred to as *serious crashes*.

The VicRoads Police-Reported Crashes database shows that there were 236,023 road users involved in police-reported crashes from 1999-2003. Nearly half of these people were not injured, however there were 1,962 fatalities (0.8% of all the road users in the database), 32,753 (13.9%) serious injuries and 87,632 (37.1%) who were injured but not seriously. These 236,023 road users were involved in 87,586 separate crashes. Table 1 shows that of these 87,586 crashes, 1,435 occurred in the CBD. Only six (0.4%) of the 1,435 crashes were crashes in which a road user died. While 27.4% of crashes occurring in the CBD resulted in at least one serious injury. There was a significant relationship between crash severity and the location of the crash ($\chi^2(4) = 797.826$, p<.001). Crashes occurring in the CBD were 8.8 times less likely to be fatality crashes than crashes occurring in rural areas and 3.6 times less likely than a crash occurring in the non-CBD metropolitan region. While there were few fatalities in the CBD, there were 452 people seriously injured in the 5-year period. The CBD is a small area of high traffic volume and low speed, and yet there are still many crashes.

Table 1: Number of police-reported crashes by region (1999-2003).

Number of Crashes:	Region						Total*	
	CBD		Other Metro		Rural			
	N	%	N	%	N	%	N	%
- Fatality Crashes	6	0.4	943	1.5	829	3.6	1,778	2.0
- Serious Injury	393	27.4	18,050	28.7	8,163	35.1	26,609	30.4
- Other Injury	1,036	72.2	43,906	69.8	14,244	61.3	59,199	67.6
Total	1,435	100.0	62,899	100.0	23,236	100.0	87,586	100.0

* Counts in Total column do not match sum of other columns, as there were 16 cases in which the location could not be established (three serious injuries, 13 other injuries).

Of the six fatal crashes occurring in the CBD, five of them involved a car striking a pedestrian, while one involved two cars striking each other from adjacent directions. It can be seen from Table 2 shows that among crashes that resulted in a fatality or a serious injury, crashes involving a pedestrian were over-represented in the CBD when compared with distributions for other regions. Thirty-seven percent of serious crashes in the CBD were crashes in which a pedestrian was struck by a vehicle, compared with 15% of serious crashes in other metropolitan areas and 7% of such crashes occurring in rural areas. This suggests that the large volume of different types of road users that characterises the CBD has caused problems regarding pedestrian safety.

Table 2: Distribution of Fatal or Serious Injury crashes by DCA grouping and crash location (1999-2003).

DCA Grouping of Crash	Region						Total	
	CBD		Other Metro		Rural			
	N	%	N	%	N	%	N	%
Pedestrian	146	36.6	2,924	15.4	600	6.7	3,670	12.9
Adjacent	66	16.5	2,791	14.7	1,030	11.5	3,887	13.7
Opposing	57	14.3	3,100	16.3	936	10.4	4,093	14.4
Same Direction	47	11.8	2,850	15.0	612	6.8	3,509	12.4
Manoeuvring	33	8.3	1,220	6.4	339	3.8	1,592	5.6
Overtaking	1	0.3	234	1.2	171	1.9	406	1.4
On Path	11	2.8	894	4.7	440	4.9	1,346	4.7
Off Path - Straight	31	7.8	3,795	20.0	2,874	32.0	6,702	23.6
Off Path - Curve	1	0.3	995	5.2	1,850	20.6	2,846	10.0
Passenger/Miscellaneous	6	1.5	161	0.8	128	1.4	295	1.0
Other	Nil	Nil	14	0.1	11	0.1	25	0.1
Unknown	Nil	Nil	15	0.1	1	0.0	16	0.1
Total	399	100	18,993	100	8,992	100	28,387	100

Table 3 shows that there is a significant relationship ($\chi^2(2) = 857.5$, $p<.001$) between whether a crash occurs at an intersection and the severity of the crash in terms of the most severe injury outcome for a road user involved in the crash. The number of fatality crashes occurring at intersections is less than expected. In fact if a crash occurs at an intersection, it is 2.6 times less likely to result in a fatality than a crash that did not occur at an intersection. The fact that serious intersection crashes were under-represented may result from the fact that minor crashes at intersections may be more frequently reported to the police than minor crashes in other road environments. This is because intersection crashes are more likely to disrupt traffic flow.

Table 3: Distribution of Crashes by Severity and whether the crash occurred at an intersection (Chi Square test).

Number of Crashes:	Road Geometry Group				Total
	Not at Intersection		At Intersection		
	Count	Expected	Count	Expected	Count
- Fatality Crashes	1,256	860.0	522	918.0	1,778
- Serious Injury	14,257	12,870.4	12,352	13,738.6	26,609
- Other Injury	26,851	28,633.6	32,348	30,565.4	59,199
Total	42,364	42,364	45,222	45,222	87,586

$\chi^2(2) = 857.5$, $p<.001$

Different types of crashes occur at intersections than on links between intersections. Table 4 shows that there is a significant relationship ($\chi^2(11) = 7{,}955.13$, $p<.001$) between the type of crash and whether it occurs at an intersection. It can be seen that there is a higher than expected number of intersection crashes that are classified as “Adjacent” or “Opposing” using the DCA codes. There is also a slightly higher than expected number of serious pedestrian crashes that occur at intersections. This shows that preventing serious crashes at intersections is a distinct problem in the road safety field that requires targeted solutions.

Table 4: Distribution of Serious Crashes by whether a crash occurred at an Intersection and DCA grouping (1999-2003)

DCA Grouping of Crash	Road Geometry Group				Total
	Not at Intersection		At Intersection		
	Count	Expected	Count	Expected	Count
Pedestrian	1,971	2,005.6	1,699	1,664.4	3,670
Adjacent	4	2,124.2	3,883	1,762.8	3,887
Opposing	1,576	2,236.8	2,517	1,856.2	4,093
Same	1,854	1,917.6	1,655	1,591.4	3,509
Manoeuvring	1,050	870.0	542	722.0	1,592
Overtaking	263	221.9	143	184.1	406
On Path	1,088	735.6	258	610.4	1,346
Off Path – Straight	4,933	3,662.5	1,769	3,039.5	6,702
Off Path – Curve	2,542	1,555.3	304	1,290.7	2,846
Passenger/Miscellaneous	205	161.2	90	133.8	295
Other	18	13.7	7	11.3	25
Unknown	9	8.7	7	7.3	16
Total	15,513	15,513	12,874	12,874	28,387

$\chi^2(11) = 7,955.13$, $p<.001$

There were 1,435 crashes in the Melbourne CBD during the period 1999-2003, 991 of which occurred at intersections. Of these 991 intersection crashes, 280 (28%) resulted in fatal or serious injuries. Table 5 shows the number and percent of crashes that occurred at intersections in Melbourne CBD from 1999 to 2003 that were serious. Only intersections with five or more crashes are listed. The table also provides the risk that a crash occurring at a particular intersection will be a serious crash and the risk that a road user involved in a crash at a particular intersection will be seriously injured or killed. Presenting risk of serious injury per crash and per road user is important because some intersections may be more at risk of multiple vehicle collisions than others.

It can be seen from Table 5 that 11% of road users involved in a crash at an intersection in the Melbourne CBD were seriously injured or killed. The intersection in with the most serious crashes was the intersection of William and Flinders Streets. From 1999-2003, 25 serious crashes occurred at this intersection. This intersection alone accounted for almost 9% of the serious injury crashes occurring at intersections in the CBD. It is possible that this intersection (and others with a high number of serious crashes) has a high incidence of serious crashes partly because there is likely to be a comparatively large number of vehicles passing through this intersection each day, when compared with other intersections in the CBD. The intersection of William and Flinders Streets acts as a “gateway” intersection for cars entering and leaving the south of the CBD via Queensbridge Road and William Street respectively. However, the comparatively large traffic flow through this intersection does not alone account for the high incidence of serious crashes at this intersection. Of the 59 police-reported crashes occurring at the intersection of William St and Flinders St form 1999-2003, 42% of these crashes resulted in a serious injury or death for at least one road user. For all intersections in the CBD, on average only 28% of crashes resulted in serious injury or death for a road user.

Table 5: Frequency of serious crashes at each intersection in the Melbourne CBD, 1999-2003.

Name of intersection	Number of Crashes	% of Intersection Crashes	Risk of Serious Injury	
			Per Crash	Per Road User
William St & Flinders St	25	8.9	0.42	0.16
Latrobe St & Elizabeth St	10	3.6	0.42	0.20
Swanston St & Flinders St	8	2.9	0.29	0.13
Queen St & Little Collins St	8	2.9	0.44	0.12
Spencer St & Flinders St	7	2.5	0.25	0.09
William St & Lonsdale St	7	2.5	0.33	0.16
William St & Bourke St	6	2.1	0.32	0.12
Latrobe St & King St	6	2.1	0.46	0.20
Spencer St & Latrobe St	6	2.1	0.40	0.10
Elizabeth St & Collins St	6	2.1	0.25	0.10
King St & Bourke St	6	2.1	0.35	0.11
Lonsdale St & Elizabeth St	6	2.1	0.33	0.12
Russell St & Collins St	6	2.1	0.38	0.22
Spring St & Collins St	5	1.8	0.36	0.16
King St & Flinders La	5	1.8	0.36	0.15
Queen St & Bourke St	5	1.8	0.50	0.23
Spring St & Lonsdale St	5	1.8	0.25	0.07
Market St & Flinders St	5	1.8	0.42	0.14
Russell St & Flinders La	5	1.8	0.26	0.08
Flinders St & Exhibition St	5	1.8	0.16	0.06
Total	280	100.0	0.28	0.11

The intersection at which the second most number of serious crashes occurred was at Latrobe St and Elizabeth St. Ten serious crashes occurred at this intersection from 1999 to 2003. However, serious crashes occurring at this intersection accounted for 42% of police-reported crashes at the intersection. This suggests that crashes occur at this intersection less often than at William and Flinders Streets, but when they do occur, they are just as likely to be serious.

It is also interesting to note from Table 5 that the intersection of Queen St and Little Collins St was ranked equal third in terms of the intersections where the most serious injury crashes occurred. This is the only intersection in the ten highest-ranking intersections in which a one-way street intersects with a two way street. There were eight serious injury crashes occurring at the intersection of Queen St and Little Collins St from 1999-2003, which was the same number of crashes occurring at the intersection of Swanston St and Flinders St. The latter intersection is unique as it is adjacent to a limited access traffic zone (Swanston St). Forty-two percent of crashes occurring at the intersection of Queen St and Little Collins St resulted in serious injury or death to one or more road users, compared with only 29% of crashes occurring at the intersection of Swanston St and Flinders St.

While most of the streets listed Table 5 are signalised four-leg cross intersections, they differ in terms of other features, such as the presence of tram routes running through the intersections, the presence of hook turns, wide median or parking bays in the middle of one or more of the intersecting streets, etc. This brings us to the question that this paper attempts to answer: what physical features of an intersection make it dangerous?

Chi-Square analyses were used to study how various intersection characteristics affect the severity of a crash were it to occur. The first characteristic to be studied was whether the crash occurred at a signalised intersection or not. There were only 71 crashes occurring at non-signalised intersections in the CBD and 24% of them were serious. While 29% of the 917 crashes occurring at signalised intersections were serious. There were also two crashes (one serious) occurring at an intersection that only had pedestrian lights. The difference in the distributions of serious and non-serious crashes for signalised and non-signalised intersections was not significant ($\chi^2(2) = 0.696$, p=.404). Most of the cross intersections in the Melbourne CBD are signalised intersections. There was also no significant relationship between crash severity and the geometry of the intersection (Fisher's Exact Test=2.712, p=.434). Twenty-nine percent of crashes at a cross intersections were serious crashes, compared with 22% of crashes at T-intersections; 29% or crashes at Y-intersections and 21% of crashes at multi-leg intersections.

There was also no relationship between the severity of the crash and whether it occurred at an intersection requiring a hook turn ($\chi^2(2) = 0.104$, p=.944). Thirty-one percent of crashes that occurred at intersections in which hook turns were required on both intersecting roads were serious, compared with 29% of those occurring at intersections that required hook turns on only one of the intersecting roads and 29% of those occurring on signalised cross intersections in which hook turns were not required.

Even though there was no significant relationship between the hook turn characteristic and whether the crash was serious, it is interesting to note that there was a significant relationship ($\chi^2(8) = 52.344$, p<.001) between the types of serious crashes occurring at intersections and whether the intersection required right turning cars to complete a hook turn. Table 6 shows that 30% of serious crashes at signalised cross intersections that did not require a hook turn were crashes in which two vehicles travelling from adjacent directions collided, compared to 13% of serious injury crashes in which a hook turn was required. Furthermore, 23% of serious crashes at non-hook turn signalised cross intersections occurred when two vehicles travelling in opposing directions collided, compared with 15% in which one of the intersecting roads required hook turns and 4% for intersections in which a hook turn was required on both intersecting roads.

While some types of crashes may be less likely at hook turn intersections, 52% of serious crashes at an intersection in which a hook turn must be performed to turn right on both intersecting roads were crashes in which the two colliding vehicles were travelling in the same direction. Only 15% of serious crashes at intersections in which a hook turn is required for only one of the intersecting roads were crashes in which the colliding vehicles were travelling in the same direction. Only 5% of serious crashes at signalised cross intersections not requiring hook turns involved two vehicles travelling in the same direction colliding. Therefore, serious injury crashes caused by vehicles moving in adjacent or opposing directions are less likely at intersections requiring a hook turn, but hook turn intersections pose greater risk of serious crashes occurring because of collisions between vehicles travelling in the same direction.

Table 6: Distribution of the types of serious crashes that occur at signalised cross intersections by whether the intersection involves a hook turn to turn right onto one or both intersecting roads

DCA grouping of Crash	Hook Turn intersection?						Total	
	No		In 1 direction		In 2 directions			
	N	%	N	%	N	%	N	%
Pedestrian	49	28.7	19	40.4	5	21.7	73	30.3
Adjacent	52	30.4	6	12.8	3	13.0	61	25.3
Opposing Direction	39	22.8	7	14.9	1	4.3	47	19.5
Same Direction	9	5.3	7	14.9	12	52.2	28	11.6
All Other	22	12.9	8	17.0	2	8.7	32	13.3
Total	171	100	47	100	23	100	241	100

$\chi^2(8) = 52.344$, p<.001

Comparing the percentage of crashes at intersections with a tram route passing through them with other intersections without tram routes revealed that there was no significant relationship between whether the crash involved a serious injury or fatality and whether a tram route passed through the intersection (χ^2 (2)=0.784, p=.676). Twenty-six percent of crashes at intersections with tram routes along both intersecting streets were serious crashes, compared with 29% of crashes at intersections in which a tram route only passed along one of the intersecting streets and 29% of those at intersections with no tram route passing through them.

Another characteristic of the design of intersections that may influence the severity of impacts at intersections is whether the intersection provides clear sight lines for vehicles about to enter the intersection (see Antonucci, Hardy, Slack, Pfefer & Neuman, 2004). If drivers of vehicles that are approaching an intersection are not able to see if other vehicles that are travelling in conflicting directions will be entering the intersection, the time they have to take avoidance action or take action that will limit the severity of the impact will be minimal. In the Melbourne CBD, some of the major roads have parking bays in the middle of the road right up to a couple metres before the intersection begins. If vehicles are parked in these areas, the visibility for a driver whose vehicle is approaching the intersection is likely to be reduced, especially for detecting whether vehicles travelling from the right (perpendicular to their own vehicle's direction) are entering the intersection. There was a non-significant trend (χ^2 (1)=3.43, p=.064) for crashes occurring at intersections where one or more of the intersecting streets had median parking to within a couple of metres of the intersection to be more likely to be serious crashes than crashes occurring at intersections without median parking. Thirty-one percent of crashes occurring at intersections in which at least one of the intersecting streets had median parking were serious, compared with 25% of those in which none of the intersecting streets had median parking. Table 7 also shows a trend that if a serious crash did occur at an intersection with median parking, whether one of the intersecting roads has median parking was related to the type of crash (χ^2 (4)=12.12, p=.016). Twenty-nine percent of serious crashes at intersections where one of the intersecting roads had median parking involved a collision between two vehicles travelling in adjacent directions, compared with 15% of serious crashes at intersections of roads without median parking.

Table 7: Distribution of the types of serious crashes that occur at intersections by whether at least one of the intersecting roads has median parking

DCA grouping of Crash	Median Parking on intersecting road?				Total	
	No		Yes			
	N	%	N	%	N	%
Pedestrian	43	38.7	48	28.4	91	32.5
Adjacent	17	15.3	49	29.0	66	23.6
Opposing Direction	18	16.2	36	21.3	54	19.3
Same Direction	18	16.2	14	8.3	32	11.4
All Other	15	13.5	22	13.0	37	13.2
Total	111	100	169	100	280	100

χ^2 (4)=12.12, p=.016

During 1999-2003 there were only thirty police reported crashes in the Melbourne CBD that occurred at the intersection of two minor roads. More than 60% of intersection crashes occurred at the intersection two “feeder” roads. There was no significant relationship between whether the crash occurred at the intersection of two feeder roads, a feeder road and a minor road or two minor roads. Twenty-eight percent of crashes that occurred at the intersection of two feeder roads were serious crashes, compared with 29% of crashes occurring at the intersection of a feeder road and a minor road and 20% of crashes occurring at the intersection of two minor roads.

DISCUSSION

With the data that was available at MUARC from the police-reported crash database, it was not possible to determine which signalised intersections permitted right hand turns without a green arrow. However we understand this is available on request, but not in time for this analysis. Therefore, no examination of the secondary safety of intersections that allowed right hand turns without a green arrow could be made. Similarly, it was not possible to determine the number of lanes of each intersecting road at each intersection. However, results for the relationship between the secondary safety of an intersection and the number of lanes of the intersecting roads are probably similar to the results for the analysis of whether serious crashes are more likely at the intersection of feeder roads with other roads. However, the fact that these analyses could not be attempted is a limitation of the present study.

This study also highlighted the fact that it is important that real-world crash databases can be easily merged with data sources that describe the road environment in detail. For example, being able to merge police-reported crash records with detailed data concerning the type of traffic control would enable analysis of whether signalised intersections allowing only controlled right turns reduces the risk of serious crashes as opposed to intersections in which right turns can be made without a green arrow.

Another limitation is that traffic flow data was not obtained for signalised intersections in the CBD. While the traffic volume through an intersection is likely to affect the incidence of crashes of all severities, it may also affect the secondary safety of an intersection. Increases in traffic volume may place greater cognitive demands on the driver and thus gives them less opportunity to recognise a hazardous situation and take appropriate action to minimise the severity of an imminent crash. Obtaining traffic volume data would enable rates of serious crashes to be calculated per vehicle entering the intersection. This would also enable more complex multivariate analyses (such as Poisson Regression) to be undertaken to determine which intersection characteristics are significant risk factors for a crash resulting in serious injury or death.

The fact that such adjustments were not made may explain why the six intersection characteristics studied in this report were not shown to be significantly related to crash severity. However the report did present some other interesting results. Firstly it was shown that whether the intersection required drivers turning right to complete a hook turn had a significant effect on the distribution of types of serious crashes occurring at the intersection. Serious crashes resulting from impacts involving cars travelling from adjacent directions were less likely at hook turn intersections than intersections not requiring hook turns. While serious crashes resulting from impacts between vehicles travelling in the same direction were more likely at intersections involving hook turns. Countermeasures that could prevent the latter type of crash include promoting greater public awareness of how to turn right at a hook turn intersection and adjusting the phasing of traffic signals so that there is a greater length of time for drivers to safely complete a hook turn.

Similarly, it was shown that at intersections in which drivers' sight lines could be obscured by median parking strips on one of the intersecting roads, there was a trend for serious crashes to be more likely to result form vehicles travelling from adjacent directions colliding with each other than for intersections without median parking areas. This problem could be alleviated by removing median parking zones that are in close proximity to the edge of the intersection.

Another interesting result to arise from the study was that 37% of serious crashes in the Melbourne CBD were crashes involving pedestrians, compared with only 15% of serious crashes in other metropolitan areas and 7% of serious crashes in rural areas. This discrepancy requires detailed separate examination. However, Table 8 shows the intersections in the Melbourne CBD in which two or more serious pedestrian crashes have occurred from 1999-2003. It can be seen that six serious pedestrian crashes occurred at the intersection of Swanston St and Flinders St and in 38% of crashes involving a pedestrian at this intersection someone was either seriously injured or killed. For all intersections in the Melbourne CBD, 32% of crashes involving a pedestrian resulted in a serious injury or a fatality to a road user. There were four serious pedestrian crashes at the intersection of Queen St and Bourke St as well as the intersection of Spring St and Collins St. Sixty-seven percent of police-reported pedestrian crashes at the intersection of Spring St and Collins St resulted in a serious injury or the death of a road user, compared with 57% of crashes as the intersection of Queen St and Bourke St.

Eighty-three percent of serious pedestrian crashes at intersections occurred while the pedestrian was walking across the carriageway. While 9% occurred while the pedestrian was walking to or from a tram. Only 10% of serious pedestrian crashes at intersections occurred at intersections without traffic lights. In order to confidently determine risk factors for serious pedestrian crashes, it is necessary to know the movements of the striking vehicle prior to the impact. The current form of the DCA codes does not allow coding whether the vehicle was turning left or right or whether it was travelling straight when it hit the pedestrian. Knowing such information would facilitate the identification of potentially dangerous intersection designs. For example, in the case of a signalised intersection which allowed for right had turns without a green right arrow, if there were a high proportion of pedestrian impacts involving right turning vehicles, an effective countermeasure might be to introduced controlled right turns.

Table 8: Frequency of serious pedestrian crashes at each intersection in the Melbourne CBD. 1999-2003 (table only shows intersections with 2 or more pedestrian crashes)

Name of intersection	Number of Crashes	% of Intersection Crashes	Risk of Serious Injury	
			Per Crash	Per Road User
Swanston St & Flinders St	6	6.6	0.38	0.17
Lonsdale St & Elizabeth St	5	5.5	0.42	0.16
Queen St & Bourke St	4	4.4	0.57	0.27
Spring St & Collins St	4	4.4	0.67	0.31
Russell St & Bourke St	3	3.3	0.27	0.13
Spencer St & Flinders St	3	3.3	0.33	0.13
Flinders St & Elizabeth St	3	3.3	0.25	0.11
King St & Bourke St	3	3.3	0.60	0.27
Russell St & Lonsdale St	3	3.3	0.43	0.17
Swanston St & Collins St	2	2.2	0.33	0.13
Lonsdale St & Exhibition St	2	2.2	0.29	0.12
Swanston St & Little Collins St	2	2.2	0.67	0.29
Spring St & Bourke St	2	2.2	0.67	0.25
William St & Collins St	2	2.2	0.33	0.17
Russell St & Flinders St	2	2.2	0.40	0.20
Elizabeth St & Collins St	2	2.2	0.13	0.06
Russell St & Collins St	2	2.2	0.33	0.15
Latrobe St & King St	2	2.2	1.00	0.50
Flinders La & Exhibition St	2	2.2	1.00	0.50
William St & Bourke St	2	2.2	0.29	0.13
Swanston St & Latrobe St	2	2.2	0.22	0.09
Spencer St & Collins St	2	2.2	0.40	0.14
Total	91	100.0	0.32	0.14

To conclude, this report has shown a method of analysing intersection safety in a localised area, in this case the Melbourne CBD. This method enabled characteristics of the road environment particular to the local area to play a prominent role in the analysis. This will allow countermeasures tailored to the area's intersections to be identified. The report also identified ways in which this method could be improved by relating traffic flow and infrastructure data with crash data.

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