Roadside Environment Safety: a statistical analysis of collisions with fixed roadside objects in Victoria

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Abstract
This study aims to investigate the nature and extent of the problem of collisions with fixed roadside objects in Victoria using VicRoads data on casualty crashes from 1996 to 2000. The analysis is conducted in two parts, separating metropolitan Melbourne and regional Victoria.

The severity of collisions with fixed roadside objects is examined and compared with the severity of non-fixed-object collisions using a chi-squared test. The results show that the proportion of collisions resulting in fatal and serious injuries is greater for fixed-object than non-fixed-object collisions. A number of other crash characteristics are also examined including the types of objects hit, the speed zone of the crash and the types of vehicles involved in these collisions. The results from the analysis of speed indicate that the likelihood of a fatality is greater for collisions occurring at higher speeds in both metropolitan Melbourne and regional Victoria.

Driver characteristics such as age, licence type and BAC are examined as well as environmental characteristics including the road conditions at the time of the crash and the light and atmospheric conditions. The results of the analysis show that a number of driver characteristics and environmental factors are over-represented in collisions with fixed roadside objects including younger drivers, poor weather and road surface conditions, and night-time collisions.

This study updates previous research in this area using the most recent data available for Victoria. However, the results are limited by the length of the data set used and relate to collisions with fixed roadside objects in Victoria only.

Acknowledgements
The authors of this report would like to sincerely thank and acknowledge the valuable contribution of the RACV in the completion and funding of this project.

1. Introduction

Crashes involving vehicles leaving the roadway are a large and severe contributor to road trauma in Australia and, indeed, Victoria. This problem is also a source of major concern internationally. In order to appropriately address the problem of collisions with fixed roadside objects, an understanding of the particular characteristics of these crash types is required. This study evaluates the nature and extent of fixed-object collisions in metropolitan Melbourne and regional areas of Victoria using casualty crash data from January 1996 to December 2000. Further to the analysis an examination of the results as they relate to the development of road safety countermeasures is conducted.

Collisions with fixed roadside objects have been identified in the Victoria Police reported crash data supplied by VicRoads using the variable 'definition for classifying accidents' and the descriptions of the object impacted in the first and second events for each crash. The analysis conducted uses both vehicle and crash-based data to ensure that all vehicles involved in collisions with fixed roadside objects were included in the analysis where appropriate, but not double-counted when crash-based statistics were required.

The remainder of this paper is structured as follows. Section two examines the trends in collisions with fixed roadside objects over time and considers the frequency and severity of crashes over the five-year period under examination. Section three examines collisions with fixed roadside objects in metropolitan areas of Melbourne and section four provides similar analysis for regional areas of Victoria. A discussion of the results and the application of them to the development of road safety countermeasures is presented in section five, and section six concludes.

2. Crash Analysis

For each year from 1996 to 2000, collisions with fixed roadside objects represented between 16 and 19% of all casualty crashes recorded in Victoria. Over this five-year period a total of 15,556 casualty crashes involving collisions with fixed roadside objects were recorded. Of these, approximately 60% occurred in metropolitan Melbourne and 40% in regional Victoria (Figure 1).

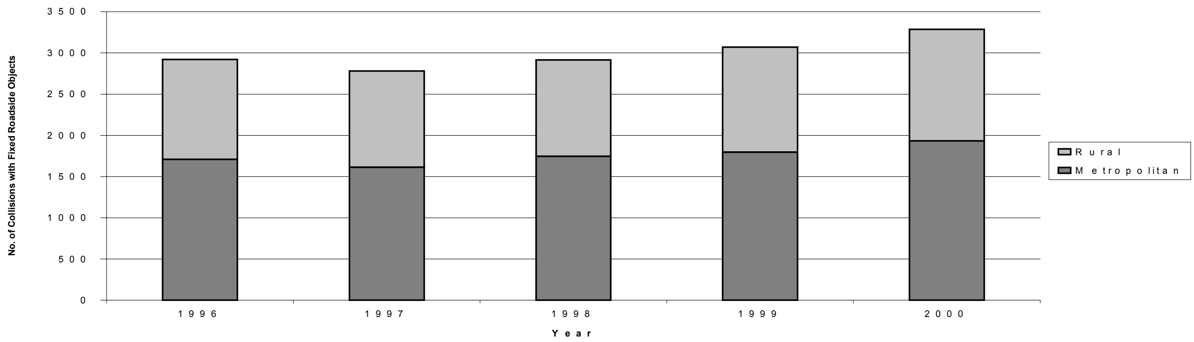

Figure 1. Number of casualty crashes involving collisions with fixed roadside objects from 1996 to 2000 in metropolitan and regional areas of Victoria.

It is evident that since 1997 the number of collisions with fixed roadside objects occurring on Victorian roads has increased slightly in both metropolitan and regional areas. Further, between 1996 and 2000, the fatalities resulting from collisions with fixed roadside objects represented an average of 32% of all road fatalities. Therefore, although fixed-object collisions represent between 16 and 19% of all casualty crashes they contribute more to road fatalities than this result suggests. Given the high frequency and severity of collisions with fixed roadside objects it is important to examine the particular characteristics of these crash types. The analysis that follows examines the attributes of collisions with roadside objects separately for metropolitan Melbourne and regional areas of Victoria.

3. Metropolitan Melbourne

Collisions with fixed roadside objects occurring in metropolitan Melbourne were defined as those occurring in metropolitan VicRoads regions.

The severity profile of crashes involving collisions with fixed roadside objects has remained fairly constant from 1996 to 2000. During this period between 3 and 4% of reported collisions with fixed roadside objects resulted in a fatality and 36 to 39% resulted in serious injury. To determine whether serious and fatal crashes are over-represented in collisions with fixed roadside objects, the distribution of crash severity for these collisions was compared with the distribution of crash severity for non-fixed object crashes using a chi-squared test. (Non-fixed-object crashes are defined as all crash types where a fixed object is not struck and includes off-carriageway crashes). The results indicate with 95% confidence that the two distributions are statistically different. In particular, the proportion of fatal and serious crashes was greater for fixed-object crashes than for non-fixed-object crashes. This confirms the earlier observation that collisions with fixed roadside objects contributed more to the total number of fatal and serious crashes than would be expected based on the frequency of these crashes alone. Probable explanations for the severity of collisions with fixed roadside objects relate to the incompatibility between the types of objects struck, the crashworthiness of vehicles colliding with the objects and the speed at which the objects are struck. These characteristics are explored below.

An analysis of the types of objects struck in collisions with fixed roadside objects revealed that roadside trees and poles were the objects most commonly struck, followed by walls or fences and embankments (Figure 2).

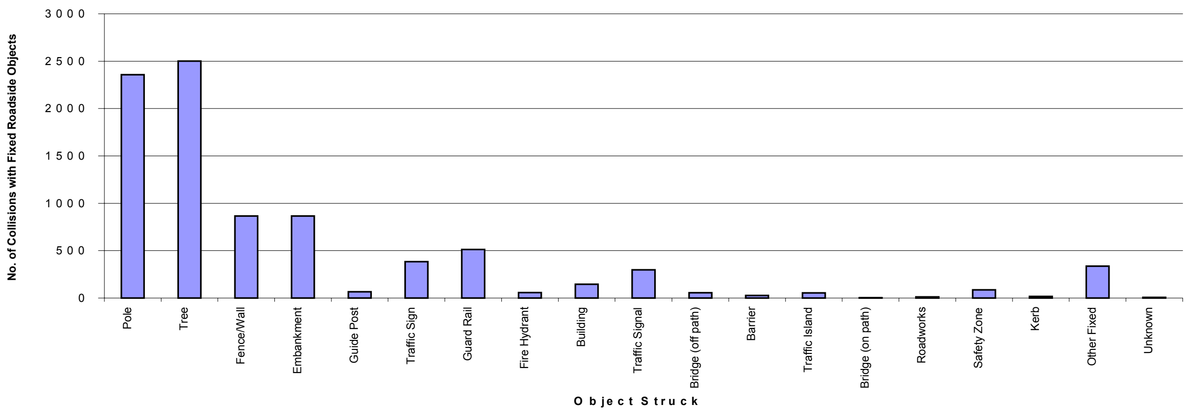

Figure 2. Objects hit in collisions with fixed roadside objects from 1996 to 2000 in metropolitan Melbourne.

Given that collisions with poles and trees were the most frequent types of collisions with fixed roadside objects the severity of injuries resulting from these types of crashes is relevant. The analysis showed that in 4.1% of cases collisions with roadside trees resulted in a fatality and in 3.3% of cases collisions with roadside poles resulted in a fatality. This is in comparison to collisions with other roadside objects that resulted in a fatality in only 2.3% of cases. These results suggest that collisions with roadside poles and trees are more frequent and more harmful than collisions with other fixed roadside objects.

The analysis also demonstrates that fixed roadside objects were most frequently hit by cars (75%) followed by station wagons (9%) and motor cycles (6%). In 86% of cases, collisions with fixed roadside objects were the result of crashes involving one vehicle only and 12% of crashes involved two vehicles. Collisions with fixed roadside objects were very rarely the result of crashes involving more than two vehicles.

In relation to the speed zone in which the collision occurred, over half of the collisions recorded occurred on roads with speed limits of 60 km/h (56%). This is not unexpected given the exposure of drivers to these roads in metropolitan Melbourne. There were also 1,600 collisions with fixed roadside objects on roads with speed limits of 100 km/h and 1,243 and 937 collisions on roads with speed limits of 80 and 70 km/h respectively. Therefore, it can be concluded that the problem of collisions with fixed roadside objects is not restricted to one road type only. Rather, these collisions affect road users travelling on both high and lower speed roads (Figure 3).

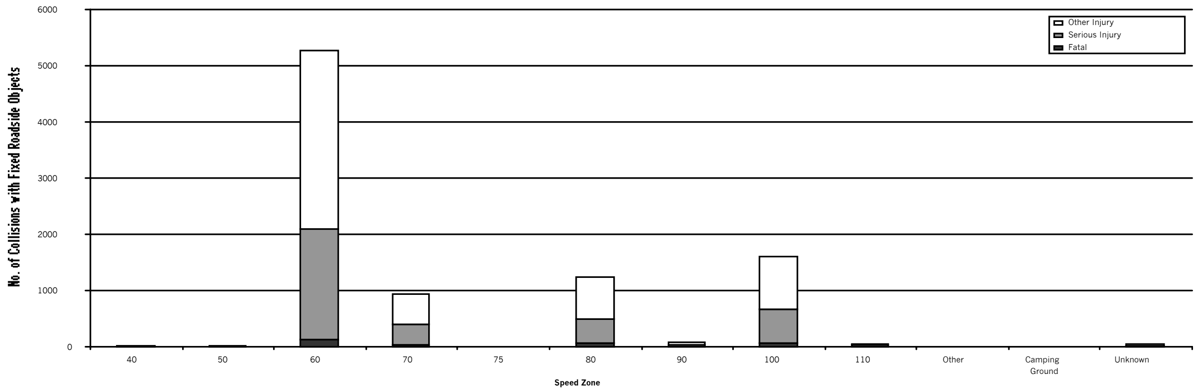

Figure 3. The number of collisions with fixed roadside objects in metropolitan Melbourne by speed zone and crash severity from 1996 to 2000.

The severity of crashes occurring in each speed zone is also relevant. The proportion of fatal collisions with fixed roadside objects within each speed zone increased as the speed zone of the crash increased. Of the crashes occurring in 60 km/h speed zones, 2.3 percent resulted in a fatality. In contrast, in 100 km/h speed zones, 4.1 percent of all fixed-object crashes were fatal.

3.1. Driver Characteristics

The characteristics of individual drivers involved in collisions with fixed roadside objects are also of interest. It was determined that 25% of drivers involved in collisions with fixed roadside objects from 1996 to 2000 in metropolitan Melbourne were aged between 18 and 21 years and a further 25% were aged between 26 and 35 years (Figure 4). The relationship between these proportions and exposure has not been investigated. However, the results are likely to be influenced by the relative exposure of drivers in each of these age groups.

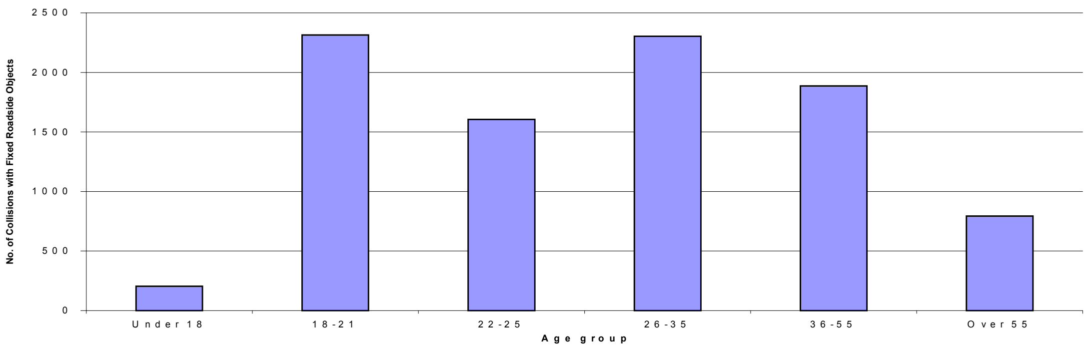

Figure 4. The number of collisions with fixed roadside objects in metropolitan Melbourne from 1996 to 2000 by age group.

Drivers involved in these crash types most frequently held a standard licence (61%) with a probationary licence being the second most frequently held licence type (24%). The blood alcohol concentration (BAC) of drivers involved in collisions was frequently unknown (68%) but, in 13% of cases the BAC recorded was below the legal limit of 0.05. Approximately 3% of collisions with roadside objects involved drivers with a BAC of more than 0.2.

Formal testing of the relative prevalence of drivers with the above characteristics in collisions with fixed roadside objects was also conducted. In relation to age, it was found that drivers aged under 25 years were over-represented in collisions with fixed roadside objects in comparison to non-fixed-object crashes. This is supported by a comparison of the distributions by licence type. Drivers who held a learner or probationary licence (with or without conditions) were found to be over-represented in collisions with fixed roadside objects, as were unlicensed drivers. That is, the proportion of drivers aged under 25 years and the proportion of drivers who were yet to obtain a standard licence was greater for fixed-object collisions than for non-fixed-object collisions. It is therefore concluded that the risks posed by roadside objects are of particular concern for younger drivers.

The results relating to the BAC of drivers involved in collisions with fixed roadside objects demonstrate that drivers with zero or unknown BACs were under-represented in collisions with fixed roadside objects. That is, drivers involved in collisions with fixed roadside objects were more likely to have a recorded BAC than drivers involved in other types of collisions and the proportion of drivers who recorded a zero BAC was less for fixed-object collisions than for non-fixed-object collisions. It is possible that the higher proportion of recorded BACs is a result of the higher severity of fixed-object collisions in comparison to non-fixed-object crashes. In high severity crashes, BAC recordings are perhaps more likely to be taken than in less severe crashes. It is noted that those drivers who recorded positive BACs were all over-represented in collisions with fixed roadside objects in comparison to non-fixed-object crashes.

3.2. Environmental Conditions
Environmental conditions at the time of a crash are thought to play a role in many types of collisions. In terms of collisions with fixed roadside objects from 1996 to 2000, approximately 69% of collisions occurred when the road surface conditions were dry and 30% of collisions occurred when the road was wet. Further, 77% of collisions occurred when atmospheric conditions were clear and 20% of collisions occurred while it was raining. It was also found that approximately 33% of crashes occurred when it was dark but street lights were on. A further 49% of crashes occurred during the day. These results are not unexpected and may reflect the weather and light conditions in metropolitan Melbourne that result in greater exposure to driving in these conditions.

Formal testing of the distribution of crashes occurring in these condition found with 95% confidence that the proportion of collisions occurring in poor weather conditions was greater for collision with a fixed roadside object than non-fixed-object collisions.[1] In addition, the proportion of crashes occurring when it was dark was greater for collisions with fixed roadside objects than non-fixed-object collisions.

4. Regional Victoria
Collisions with fixed roadside objects occurring in regional Victoria were defined as those occurring outside metropolitan VicRoads regions. It is noted that these regions include major population centres.

The severity profile of collisions with fixed roadside objects in regional Victoria is slightly different to that of the metropolitan areas. From 1996 to 2000 between 4 and 5% of collisions with fixed roadside objects resulted in a fatality. The proportion of collisions that resulted in serious injuries increased from 32% in 1997 to 43% in 2000. This corresponded to a decrease in the proportion of collisions resulting in other injuries. However, as for metropolitan Melbourne, the results of the chi-squared test of the distribution of crash severity demonstrate with 95% confidence that both fatal and serious crashes were over-represented in collisions with fixed roadside objects. That is, in comparison to non-fixed-object collisions, collisions with fixed roadside objects were more likely to result in fatal and serious injuries. The characteristics of the crashes that may lead to this increased risk of fatal and serious injury are expected to be similar to those for metropolitan Melbourne although some differences have been identified.

The first of the key differences between the crash characteristics of collisions with fixed roadside objects in metropolitan Melbourne and regional areas of Victoria is the object struck in a collision. Whilst trees are the most commonly struck object throughout Victoria, poles do not play as great a role in collisions occurring in regional Victoria. This result is not unexpected given the differences in roadside environment between the two areas. In regional Victoria, trees are the most frequently hit object (45%) followed by embankments (16%), fences or walls (10%) and poles (10%) (Figure 5).

[1] Crashes occurring in poor weather conditions include those that occur on wet, muddy or icy road surfaces and when there is rain, fog or strong winds at the time of the crash.

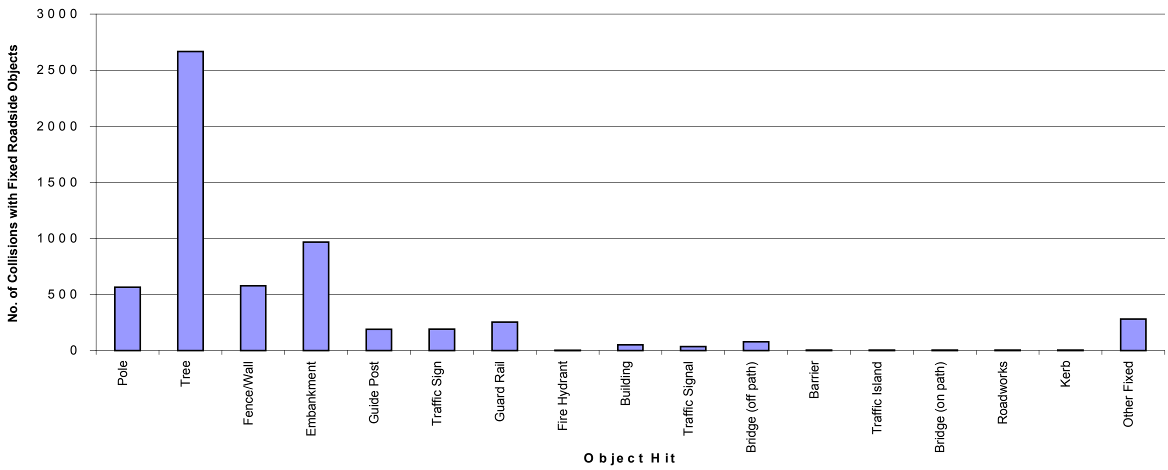

Figure 5. Objects hit in collisions with fixed roadside objects from 1996 to 2000 in regional Victoria.

However, the analysis of the crash severity of these collisions supports the results found in the analysis for metropolitan Melbourne. Collisions with trees were found to result in a fatality in 6.5% of cases and in 4.4% of cases, collisions with roadside poles resulted in a fatality. Collisions with other roadside objects resulted in a fatality in only 3.6% of cases. Therefore, in both metropolitan Melbourne and regional Victoria it appears that the relative risk of suffering a fatal injury is greater when the object struck is a tree or a pole.

The second key distinction between collisions with fixed roadside objects occurring in metropolitan Melbourne and regional areas is the speed zone in which the crash occurs. In regional Victoria 67% of crashes occurred on roads with speed limits of 100 km/h (Figure 6). This is in contrast to collisions in metropolitan areas where the majority of collisions occurred on roads with speed limits of 60 km/h. This result is not unexpected given the greater exposure to 100 km/h roads in regional Victoria.

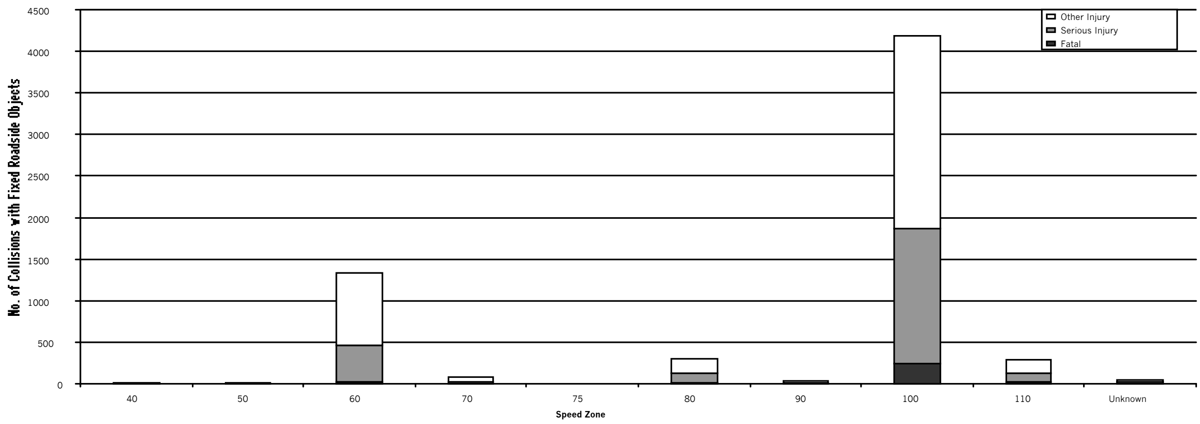

Figure 6. The number of collisions with fixed roadside objects in regional Victoria by speed zone and crash severity from 1996 to 2000.

As was the case in metropolitan Melbourne, the proportion of fatal collisions with fixed roadside objects within each speed zone increased as the speed zone of the crash increased. Of the crashes occurring in 60 km/h speed zones, 2.1 percent resulted in a fatality. In contrast, in 100 km/h speed zones, 5.8 percent of all fixed-object crashes were fatal.

The results of the analysis with respect to the number and type of vehicles involved in fixed-object crashes demonstrate that 95% of collisions involved one vehicle only. Further, cars hit roadside objects more frequently than any other vehicle type. However, station wagons, utilities and motor cycles did feature more prominently in crashes occurring in regional Victoria, perhaps due to the increased exposure of these vehicle types in these areas.

4.1. Driver Characteristics

The characteristics of drivers involved in collisions with fixed roadside objects in regional Victoria were similar to those involved in collisions in metropolitan Melbourne. It was found that approximately 23% of drivers involved in collisions with fixed roadside objects were aged between 18 and 21 years. A further 22% were aged between 26 and 35 and approximately 25% were aged between 36 and 55 (Figure 7).

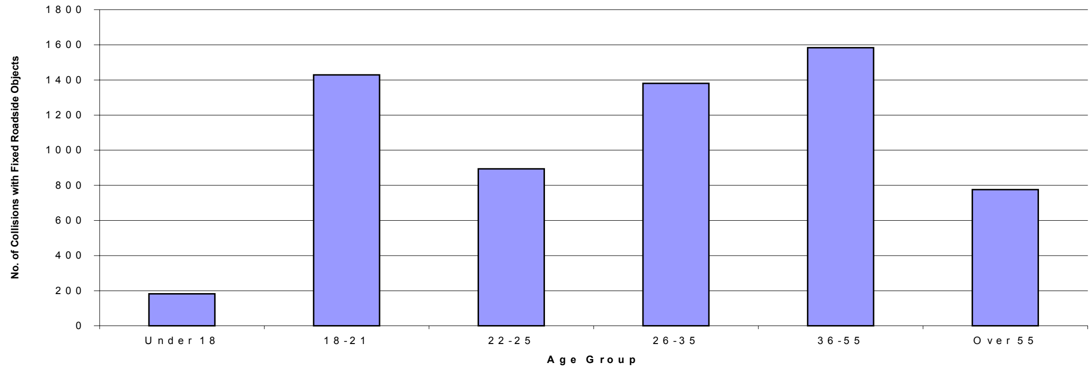

Figure 7. The number of collisions with fixed roadside objects in regional Victoria from 1996 to 2000 by age group.

Formal testing of the distribution of age groups for collisions with fixed roadside objects and the distribution of age groups for non-fixed-object collisions showed that younger drivers aged 25 or less were over-represented in collisions with fixed roadside objects in comparison to non-fixed-object crashes. This reinforces the result found in the metropolitan Melbourne analysis that the risks posed by roadside objects are particularly relevant to younger drivers. The results relating to the licence type of drivers again confirm this. That is, drivers who are yet to obtain a standard licence were over-represented in collisions with fixed roadside objects.

In relation to the BAC of drivers, the proportion of drivers recording BACs less than the legal limit (18%) was slightly higher than for metropolitan Melbourne. In contrast, the proportion of drivers recording BACs in excess of the legal limit was lower than for metropolitan Melbourne. The BAC was not recorded in 67 percent of cases. The results of the chi-squared test indicate, with 95% confidence, that drivers who recorded positive BACs were all over-represented in collisions with fixed roadside objects. This supports the suggestion that drivers involved in collisions with fixed roadside objects are more likely to have a recorded BAC than drivers involved in other types of collision in both metropolitan Melbourne and regional Victoria. However, this may be due to the higher severity outcomes of this crash type. In addition, drivers who recorded a zero BAC were under-represented in collisions with fixed roadside objects. That is, the proportion of drivers who recorded a zero BAC was smaller for collisions with fixed roadside objects than for non-fixed-object collisions.

4.2. Environmental Conditions

An analysis of the environmental conditions at the time of the crash revealed that in 73% of cases, collisions with fixed roadside objects occurred on dry roads. Further, 80% of collisions occurred in clear weather conditions and only 15% of collisions occurred in the rain. The chi-squared test of the distributions of crashes with respect to road conditions found that crashes occurring on wet, muddy and icy roads were over-represented in comparison to non-fixed-object collisions. Similarly, collisions with fixed roadside objects occurring in poor weather conditions were over-represented in comparison to non-fixed-object collisions. In particular, a greater proportion of collisions with fixed roadside objects occurred in the presence of rain, snow, dust, fog or strong winds in comparison to non-fixed-object collisions.

The results as they relate to the light conditions however, were dissimilar to those obtained for metropolitan Melbourne. Approximately 59% of collisions with fixed roadside objects in regional Victoria occurred during the day. However, 23% of collisions occurred in the dark on streets with no street lights. In metropolitan Melbourne collisions occurring in these conditions represented only 9% of all collisions with fixed roadside objects. In contrast, the proportion of collisions occurring in the dark with street lights on was only 10% in regional Victoria compared to 33% for metropolitan Victoria. This is confirmed by the results of the formal testing of the distribution of collisions with respect to light conditions. The results reveal that collisions occurring during the day were under-represented in collisions with fixed roadside objects in comparison to non-fixed-object crashes. Further, collisions occurring at dusk, dawn and in dark conditions were all over-represented in comparison to non-fixed-object crashes. It is expected that these differences are due to the greater level of street lighting infrastructure in metropolitan Melbourne.

5. Discussion

The analysis of collisions with fixed roadside objects presented above highlights a number of key characteristics of these crash types. It is noted that although dissimilarities between crashes occurring in metropolitan Melbourne and regional areas of Victoria do exist, the problem of collisions with fixed roadside objects is substantial in size and not restricted to a particular geographic area. In addition, the evidence of an increased risk of fatal and serious injuries in collisions with fixed roadside objects demonstrates the added cost of these collisions to the community in both economic and social terms. Therefore, a reduction in road trauma resulting from these crash types would contribute substantially to a reduction in the overall level of road trauma in Victoria.

In examining ways in which road trauma resulting from these crashes can be reduced it is necessary to consider the characteristics particular to collisions with fixed roadside objects.

First, the objects most frequently hit in collisions with fixed roadside objects are trees, poles, fences and embankments. Given the location and spatial distribution of such objects, linear treatments (i.e. whole route or section treatments) may be needed to reduce the risk of hitting these objects, more so than discrete, highly localised treatments. In addition, it is noteworthy that in both metropolitan Melbourne and regional Victoria, the vast majority of vehicles colliding with fixed objects are cars and car derivatives. This suggests that to provide the greatest reductions in road trauma, appropriate roadside treatments should be targeted at vehicles of this type, while still accommodating the needs of occupants of other vehicle types where possible.

Second, two key driver groups are over-represented in collisions with fixed roadside objects: younger drivers and drivers with positive BACs. The over-representation of collisions involving drivers with these characteristics demonstrates that the proportion of accidents in which these characteristics were present was greater for collisions with fixed roadside objects than for non-fixed-object collisions. Therefore, road safety countermeasures aimed at the behaviour of these two driver groups would be expected to reduce road trauma due to fixed roadside objects in particular. A number of such safety countermeasures already operate in Victoria and include extensive enforcement and publicity related to both drink-driving and the behaviour of learner and newly licensed drivers.

Third, serious injuries and fatalities are over-represented in collisions with fixed roadside objects. That is, collisions with fixed roadside objects are more likely to result in serious and fatal injuries than non-fixed-object crashes. Given that the severity of fixed-object collisions increased with the speed zone in which the crash occurred, effective speed management initiatives could be expected to impact on the severity of collisions with roadside objects. In addition to speed enforcement programs, recent reductions in urban speed limits may also impact on the severity, if not necessarily the frequency, of collisions with fixed roadside objects.

Finally, it was found that collisions with fixed roadside objects were over-represented in comparison to non-fixed-object collisions in poor weather and road surface conditions. Whilst little can be done to avert poor weather conditions, improvements in road surfaces such as increasing skid resistance and improvements to sight distances are likely, among other things, to reduce the frequency of collisions with fixed roadside objects. Improved lane marking and delineation treatments may also provide some benefit. Further, collisions with fixed roadside objects occurring in the dark were also over-represented in comparison to non-fixed-object collisions. It is noted that the over-representation of fixed-object collisions was found in dark conditions regardless of the use of street lights. This suggests that factors other than lighting may influence collisions occurring at night-time. Such factors may include alcohol consumption, fatigue and speed. Addressing these issues may also result in reductions in the frequency of collisions with fixed roadside objects.

In planning future programs to reduce the frequency and/or severity of collisions with fixed roadside objects, it is necessary to consider the success of previous efforts to reduce collisions with fixed roadside objects in Victoria in conjunction with the characteristics of these crashes discussed above. In an evaluation of treatments aimed at this crash type, some of the most successful countermeasures in reducing the frequency and severity of these crash types were found to be shoulder sealing, improved horizontal road alignment and skid resistant pavements (Corben et al, 1997). Further, an evaluation of the TAC funded Accident Black Spot Program implemented during 1992 to 1996 found that the program had been effective overall in reducing reported casualty crashes (Newstead et al, 2001). While this program did not focus exclusively on reducing collisions with fixed roadside objects, treatments aimed at these crash types such as shoulder sealing and edge line marking were effective in reducing casualty crash frequency and the casualty crash cost of all collisions. More recent research examining the possible use of flexible barrier systems along high-speed routes indicates that dramatic reductions in road trauma resulting from vehicles leaving the roadway are readily achievable (Corben et al, 2001). That is, the extensive use of flexible barrier systems offers potential for long-term, sustained reduction in this form of trauma. In addition to these results, further work on the spatial distribution of collisions with fixed roadside objects may assist in determining those sites or routes which can be most cost-effectively treated in future.

6. Conclusion

The analysis of collisions with fixed roadside objects conducted here highlights a number of key characteristics of these crashes. However, two primary results demonstrate the importance of this issue in road safety and the potential benefits to be gained by addressing the particular factors influencing these crash types. First, from 1996 to 2000, collisions with fixed roadside objects represented between 16 and 19% of all casualty crashes and between 29 and 37% of fatal crashes. Second, in both metropolitan Melbourne and regional Victoria, fixed-object collisions resulted in higher levels of fatal and serious injuries than non-fixed-object crashes. It is clear therefore, that attention to the factors influencing the frequency and severity of these collisions may results in substantial reductions in road trauma in Victoria.

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