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AN EVALUATION OF THE DEFAULT 50 KM/H SPEED LIMIT IN VICTORIA

by

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Title:
An evaluation of the default 50 km/h speed limit in Victoria

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Abstract:

Victoria introduced a state-wide default 50 km/h speed limit in built-up areas (except where otherwise signed), on January 22, 2001. The purpose of this legislation was to reduce the incidence and severity of crashes involving unprotected road users. The effectiveness of the initiative has been evaluated under a quasi-experimental design framework at various intervals with the last covering a period of almost three years. Results of the final evaluation are presented in this report.

Results of the evaluation demonstrate that implementation of the Victorian default 50km/h urban speed limit was associated with reduced casualty crashes in aggregate by around 12% with the reductions sustained over the entire post implementation study period. However, the results also indicate that the program has been more successful in reducing minor injury crashes than in reducing fatal and serious injury crashes. Whilst there was some suggestion of the program being effective in reducing the high severity crashes in the 5 months immediately after program implementation, analysis was unable to identify these effects being sustained over the longer term. Reasons for the lack of measured program effects on high severity crashes were not able to be established from analysis of the limited speed monitoring data available for the evaluation.

Assessment of program crash reduction effects for particular road user sub-groups was also carried out in the evaluation. They showed that the change in default speed limit was associated with a sustained reduction in fatal and serious injury crashes involving pedestrians of between 25% and 40%. Effects on crashes involving young drivers were consistent with the overall crash analysis results whilst no significant effects on crashes involving older drivers were measured.

Key Words:
Evaluation, default speed limit, crash analysis,
speed, statistics, Poisson regression.

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Preface

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EXECUTIVE SUMMARY

Introduction

On 22 January 2001, a state-wide 50km/h default urban speed limit was introduced in Victoria. This limit was applied principally on residential streets, and on a proportion of collector roads. The remainder of collector roads and road network have remained zoned 60 km/h or higher, with additional signage erected where warranted. The primary objective of this initiative was to reduce the incidence and severity of casualty crashes, in particular in casualty crashes involving the more vulnerable users of this road class such as pedestrians.

To determine the initiative's effectiveness, the Monash University Accident Research Centre (MUARC) was commissioned to undertake a comprehensive evaluation of the program to ascertain its effects following implementation.

The evaluation was undertaken in two stages. Both stages utilised a quasi-experimental design comparing before and after program implementation crash trends on roads that became zoned 50km/h under the default limit with those on roads that remained at 60km/h. The first evaluation phase covered the period up to five months after the default speed limit change and employed a conventional evaluation design. The second evaluation phase covered the period up to 35 months from default speed limit change. It employed a modified quasi experimental design where the control crash series was adjusted for the effects of a large increase in speed camera enforcement that was not seen in the areas affected by the default speed limit change.

Evaluation History

The first interim evaluation conducted and published in 2002 (Hoareau, Newstead, Cameron, 2002), assessed the effectiveness of this legislation via a comprehensive analysis of crash data covering the first five months post implementation. Results showed a statistically significant net percentage reduction of 13% for all types of casualty crashes and a 22% reduction for casualty crashes involving pedestrians.

A second interim evaluation was attempted when seventeen months of post implementation data became available. In the period following the first interim evaluation and leading up to the commencement of the second, a number of new speed enforcement initiatives were introduced. The package included flash-less camera operation, reduced enforcement tolerances and an increase in speed camera hours, phased in from August 2001 to February 2002, which took the number of hours worked from 4200 to 6000 hours per month. A significant proportion of this increase was directed to 60 km/h speed zones. A previous separate evaluation of the effects of the components of the new speed enforcement initiatives package showed the increased camera hours had the strongest identified association with observed reduced crash frequencies.

This operational policy change presented a methodological problem in the course of conducting the second interim evaluation, which covered the first seventeen months post implementation. The quasi-experimental design employed in the first evaluation, used as a comparison group crashes that had occurred in 60 km/h zones. However, increases in speed camera enforcement were largely targeted at 60km/h roads meaning the new speed initiatives had not influenced trends in the crash data in 50 km/h zones in the same way as crashes in the comparison areas, thus compromising the study design. To overcome this design issue, an alternative design was devised and utilised in this third and final evaluation. The alternative study design accounted for the effect of the increased enforcement hours by pre-adjusting the control crash data for this factor by using it as a covariate in an appropriately formulated statistical model. The formulation of the statistical analysis model used was derived from the methods used and experience gained in the prior evaluation of the new speed enforcement initiatives package.

Post hoc validation of the adjustment approach was carried out through a comparison of the first and final evaluations which showed the crash analysis results to be of a similar order of magnitude over the time period for which they could be compared. This indicated that the alternative study design was able to effectively account for the effects of the increased speed camera hours on the comparison group thus enabling the estimation of the net effect of the default speed limits.

Results and Conclusions of Final Evaluation

The results of the final evaluation for all crash types are summarised in the table below including estimated percentage crash reductions and their 95% confidence limits, statistical significance values and confidence limits for the estimated absolute monthly crash savings where the crash reduction estimates were statistically significant.

	Crash Effects Associated with the Default Urban 50 km/h Speed Limit in Victoria			
Crash Severity	**Estimate of Monthly Net Percentage Reduction**	**95% Confidence Interval of Net Percentage Reduction**	**Statistical Significance**	**95% Confidence Interval of Estimated Crash Savings**
Fatal Crashes				
Feb 2001 – Jun 2001	50.8%	(-7.6%, 77.5%)	0.0758	NE
Jul 2001 – Dec 2003	9.5%	(-64.8, 50.3%)	0.7437	NE
Feb 2001 – Dec 2003	21.4%	(-37.6%, 55.1%)	0.3991	NE
Serious Injury Crashes				
Feb 2001 – Jun 2001	7.3%	(-7.4%, 20.0%)	0.3128	NE
Jul 2001 – Dec 2003	0.1%	(-12.1%, 10.9%)	0.9905	NE
Feb 2001 – Dec 2003	2.8%	(-8.1%, 12.7%)	0.5989	NE
Fatal and Serious Injury Crashes				
Feb 2001 – Jun 2001	8.8%	(-5.2%, 21.0%)	0.2068	NE
Jul 2001 – Dec 2003	0.2%	(-11.7%, 10.8%)	0.9710	NE
Feb 2001 – Dec 2003	3.3%	(-7.3%, 12.9%)	0.5267	NE
Other Injury Crashes				
Feb 2001 – Jun 2001	11.8%	(3.9%, 18.9%,)	0.0039	(9, 42)
Jul 2001 – Dec 2003	17.6%	(11.5%, 23.3%)	<0.0001	(22,47)
Feb 2001 – Dec 2003	15.7%	(9.8%, 21.1%)	<0.0001	(26, 52)
All Casualty Crashes				
Feb 2001 – Jun 2001	10.9%	(3.7%, 17.6%)	0.0036	(12, 55)
Jul 2001 – Dec 2003	12.7%	(7.3%, 17.9%)	<0.0001	(23, 56)
Feb 2001 – Dec 2003	12.1%	(7.0%, 16.9%)	<0.0001	(22, 53)

NE: Not estimated due to the percentage crash reduction estimate not being statistically significant

Results of the evaluation demonstrate that implementation of the Victorian default 50km/h urban speed limit was associated with reduced casualty crashes in aggregate by around 12% with the reductions sustained over the entire post implementation study period. However, the results also indicate that the program has been more successful in reducing minor injury crashes than in reducing fatal and serious injury crashes. Whilst there was some suggestion of the program being effective in reducing the high severity crashes in the

5 months immediately after program implementation, no statistically significant reductions were found for the period after this. Possible reasons for the lack of identified program effects in this later period were not able to be established from analysis of the limited speed monitoring data available for the evaluation.

Assessment of program crash reduction effects for particular road user sub groups was also carried out in the evaluation. They showed that the change in default speed limit was associated with a sustained reduction in fatal and serious injury crashes involving pedestrians, a primary target of the program, of between 25% and 40%. Effects on crashes involving young drivers were consistent with the overall crash analysis results whilst no significant effects on crashes involving older drivers were measured.

1 INTRODUCTION AND BACKGROUND

On 22 January 2001, a state-wide 50km/h default urban speed limit was introduced in Victoria. This limit has been applied principally on residential streets, and on a proportion of collector roads. The balance of the collector roads and the remainder of the road network have remained zoned 60 km/h or higher, with additional signage erected where warranted. The primary objective of this initiative was to reduce the incidence and severity of casualty crashes, in particular in casualty crashes involving the more vulnerable users of this road class such as pedestrians.

To determine the effectiveness of the initiative, the Monash University Accident Research Centre (MUARC) Baseline Research Program Committee commissioned an evaluation to estimate the net effect of the introduction of the 50km/h speed limit on crash frequency in Victoria following the implementation. An interim evaluation, published in 2002 (Hoareau, Newstead, Cameron, 2002), assessed the effectiveness of this legislation via a comprehensive analysis of crash data covering the first five months post implementation. Results showed a statistically significant net percentage reduction of 12% to 13% for all types of casualty crashes and a 19% to 22% reduction for casualty crashes involving pedestrians. Analyses for crashes involving the young driver group also revealed significant reductions while statistically reliable results were not achieved for older drivers.

A second interim evaluation was considered when seventeen months of post implementation data became available. However, in the period following that covered by the first interim evaluation, a number of new speed enforcement initiatives were introduced. The most significant of these was the increase in hours of mobile speed camera enforcement, phased in from August 2001 to February 2002. The increase took the number of hours worked from 4200 to 6000 hours per month. The greatest proportion of this increase was directed to 60 km/h speed zones with relatively little effort occurring in streets adopting the default 5-km/h speed limit.

This operational policy change presented a methodological problem in the course of attempting to conduct a second interim evaluation using crash data up to 17 months after program implementation. The quasi-experimental design employed in the first evaluation used as a comparison group crashes that had occurred on roads remaining at 60 km/h after the default limit change. Ideally, crash trends in the control area should represent the effect of non treatment factors on crashes in the treatment (default 50km/h) areas. This desired property of the control group implies that the density of enforcement effort from speed cameras should be the proportional in treatment and control areas over time. Examination of the data on hours of speed camera enforcement for the treatment and control groups showed significant differences in the trends between areas during the period after the first interim evaluation. To overcome this design issue, an alternative design was devised and utilised in a final evaluation phase detailed in this report. This alternative method has been applied to the entire study period.

The final evaluation of the default 50km/h speed limit in Victoria detailed in this report covers thirty-five months of post implementation data. It estimates average crash effects over the entire post implementation period covered as well as in six-monthly periods after implementation. This length of time was considered sufficient to establish the long-term effectiveness of the initiative. In addition an analysis is presented on the estimated effects of the initiative on vehicular speed, which are available only for the period immediately following the first five months after implementation.

For comparative purposes, this report details the study designs employed in both the initial and final evaluations as well as the results emanating from each design.

While the 50km/h default urban speed limit has been adopted for local streets in built-up metropolitan areas and in country towns, the crash analysis has been limited to crashes whose sites could be linked to the electronic speed zone map from the TAC SafeCar project. The coverage of this electronic map extends to the geographical locations covered in the Melway street directory. Therefore, the crash analysis extends beyond metropolitan Melbourne to cover only limited areas of regional Victoria.

2 SOME PRIOR EVALUATIONS OF 50 KM/H IMPLEMENTATIONS

2.1 EVALUATION OF THE 50 KM/H SPEED LIMITS IN NEW SOUTH WALES

New South Wales was one of the first states in Australia to introduce an urban 50km/h speed limit on a wide selection of roads across the state. Implementation of the 50km/h limit in NSW was approached differently to Victoria in that it was carried out as a partnership between local councils, their communities and the NSW Roads and Traffic Authority. In the first instance, a three-month trial of the 50km/h limit was undertaken including 26 local government areas (LGAs). The program was staggered in its implementation across the 26 participating LGAs over a period of 7 months commencing 1st October 1997. Of the 26 local councils, four removed the lower speed limit signs at the end of the trial period whilst 22 councils left the signs in place until at least the end of 1999. Subsequent to the trial, all local government areas were invited to participate in the program. A further characteristic of the 50km/h implementation in NSW was the extensive use of signage to identify the 50km/h roads along with education campaigns to inform the public of the change.

ARRB Transport Research conducted an extensive evaluation of the 50km/h speed limit implementation in NSW for the NSW Roads and Traffic Authority (RTA 2000). It covered effects on crashes and speed along with assessment of changes in community attitudes and effectiveness of public education campaigns, media monitoring and analysis of insurance claims data. With respect to crash reductions, the study revealed sizeable reductions in all crash types with an overall 22% decrease in casualty crashes and 25% decrease in all reported crashes (including non-injury) estimated in the two years after the 50km/h introduction. Much greater reductions were estimated in reported crashes involving pedestrians, cyclists and older drivers that fell by 50%, 30% and 50% respectively. Fatal crashes were estimated to have decreased by over 44%.

As well as crash effects, evaluation of the 50km/h limit in NSW also focused extensively on changes in speeding behaviour. Analysis of speed survey data showed relatively small reductions in mean and 85th percentile speeds on streets with the 50km/h limit following its introduction. Effectiveness of the program, however, appeared to stem from large reductions in the number of drivers exceeding 60, 70 and 80km/h, which were in the order of 38%, 70% and 74% respectively.

Prior to the implementation of the 50km/h speed limit in Victoria, uncertainty existed as to whether the results obtained in NSW would be indicative of the likely effects in Victoria. This is because the Victorian model for implementation differed significantly from that used in NSW.

2.2 EVALUATION OF THE 50 KM/H SPEED LIMIT IN SOUTH EAST QUEENSLAND

A 50km/h local street speed limit was introduced in 11 local government areas in south-east Queensland from March 1st, 1999. Like Victoria, the 50km/h limit in Queensland operates as a default limit in built up areas and is generally not accompanied with the use of signage to indicate the 50km/h areas. However, an extensive media campaign was undertaken before the introduction of the default limit to inform the community of the impending change. A three month amnesty period was also imposed during which drivers detected exceeding the new default limit were issued with a warning rather than being issued with a traffic offence notice.

Results of the evaluation found that the implementation was associated with statistically significant average yearly reductions of 88%, 23% and 22% for fatal crashes, all casualty crashes and all reported crashes, respectively. Crash reductions appeared to have increased with time after program implementation for each crash severity level considered. Like in New South Wales, analysis of speed survey data associated with the program implementation suggested that these crash reductions stemmed largely from a reduction in excessive speeding in 50km/h zones rather than large reductions in mean speeds at the affected sites.

2.3 EVALUATION OF THE 50 KM/H SPEED LIMIT IN WESTERN AUSTRALIA

The default 50 km/h built-up area speed limit was introduced in Western Australia on December 1, 2001. The initiative involved extensive education activities which included advertising and informational campaigns both pre and post introduction. Signage informing motorists of the 50 km/h speed limits was limited to courtesy signs at state borders, reminder signs on major arterials and on a small number of roads where the speed limits were possibly unclear. Although a one-month moratorium on enforcement was announced, due to operational policy, limited enforcement of these speed limits was actually undertaken post implementation.

The crash effects of the initiative were measured for metropolitan Perth and regional Western Australia for various target groups and severity categories. Results of the metropolitan analysis showed a 20% net reduction in all crashes, a 51% net reduction for all crashes involving pedestrians, and a 19% and 18% net reduction for all crashes involving young and older drivers, respectively. Although no statistically significant results were obtained for fatal or serious injury crashes in any of the analyses, a statistically reliable net reduction of 21% was obtained for all casualty crashes. All major and minor property damage crashes were also reduced by 19% and 29%, respectively. Very few statistically significant results associated with the introduction of the program were obtained for the regional analyses.

An examination of speed monitoring surveys provided evidence that the intervention was associated with a positive effect on speeding behaviour, achieving statistically significant reductions in excessive speeding in 50 km/h zones in both metropolitan Perth and regional Western Australia. Furthermore, an examination of community attitude surveys conducted in the period prior to and post implementation, showed that support for the initiative had increased throughout this period. Both these findings were consistent with the crash analysis outcomes.

3 DATA AND METHOD

3.1 INITIAL DESIGN

To measure the effect of the introduction of the initiative on crashes, a quasi-experimental design was applied to crash data covering the period January 1996 to December 2003. This type of analytical framework, which utilises a treatment and control design, is appropriate for measuring the net effects of an intervention such as the default 50 km/h speed limit, and has been used to evaluate the 50 km/h speed limits programs in New South Wales, South East Queensland and Western Australia. Under this design strategy, ideally a control (or comparison) group characteristically similar to the treatment group (but not subject to the intervention) is chosen to represent the influence of factors other than those related to the intervention have on crashes at the treated sites. Net program crash effects are then estimated by comparing crash history at the treated sites from before to after program implementation with those at the control sites. Use of the control group in this context has an advantage in that it reflects the influence of both measurable and un-measurable confounding factors other than the treatment on crashes at treated sites. This is in contrast to simply conducting a time series analysis of the crash data at the treated site and adjusting for confounding factors in the analysis which presumes the confounding factors are all known and measurable.

Under the initial study design, the treated area was defined as those roads that became zoned 50km/h after introduction of the default speed limit. The ‘control’ area for the initial study was chosen as those roads that were zoned at 60km/h both before and after the introduction of the default 50km/h speed limit. These roads were considered the best possible control for the study as they were the most similar to the treatment area roads in land use and traffic characteristics. In addition, over the period covered by the initial evaluation, traffic enforcement regimes, and in particular speed camera enforcement, remained consistent in both the treatment and control areas. The net difference in before to after 50 km/h implementation crash frequency between the treatment and control sites gave the estimated effect of the 50km/h implementation.

3.2 FINAL DESIGN

Design of the first interim analysis was unaffected by changes in the speed camera enforcement hours. However, in the period after six months from default 50km/h implementation, a package of new speed enforcement initiatives were introduced that were likely to affect crashes differentially between the defined treatment and control areas of the initial evaluation. Key aspects of the new speed initiatives package included flash-less camera use, revised enforcement tolerances and significantly increased hours of operation. In order to develop a final evaluation design for this study that eliminated the potential confounding effects of the new speed enforcement initiatives, it was necessary to establish the relative effect of each component of the program on crash outcomes. It was also necessary to consider differential effects of the speed enforcement program components between the defined treatment and control areas selected for this study.

A recent separate study by Bobevski, Hosking, Oxley and Cameron (2004) has examined the crash effects of the components of the Victorian speed enforcement initiatives package. Using crash and enforcement data similar to that used in this evaluation, the Bobevski et al (2004) study found that, of all the components of the package, the dramatic increase in hours of speed camera use was the one that was associated with by far the largest identified crash reductions under the program. Furthermore, it also showed that hours of speed camera enforcement had increased at different rates across different speed zones. In particular, it found that the largest proportionate increase in speed camera hours had occurred on roads zoned at 60km/h, the roads corresponding to the control area selected for the default 50km/h speed limit study reported here. From these results, it was evident that the default 50km/h speed limit extended evaluation needed to compensate for the differential growth in hours of speed camera enforcement between defined treatment and control areas to ensure a valid quasi-experimental evaluation design was maintained through the extended evaluation period.

Bobevski et al (2004) put some effort into establishing the most appropriate functional relationship between hours of speed camera enforcement and observed crash outcomes. After considering a number of alternatives, they found that a model relating the log of the observed crashes in a month to the hours of speed camera enforcement in the previous month gave the strongest statistical association between the two measures. This model was similar to one used in prior research carried out by Cameron, Newstead, Diamantopoulou and Oxley (2003) where it was found that an increase in traffic infringement notices issued was associated with a reduction in casualty crashes in the following month.

Based on these previous findings, the approach adopted in the current study to ensure a valid quasi-experimental design was to adjust the observed monthly crash frequencies in 60 km/h control areas for the effect of speed camera hours lagged by one month. The adjustment process, which is described in detail shortly, essentially estimates the expected value of the control series had the additional speed camera enforcement not been undertaken. This adjusted crash series was then used as the control data series to measure the net effect of the introduction of the default speed limits uninfluenced by speed camera hours. This adjustment process was carried out for each of the crash severity levels examined within each target crash group and for each of the crash severity levels for all crash types combined.

In statistical terms the following Poisson regression model, similar to that used by Bobevski et al (2004), was fitted to the monthly control series with lagged speed camera hours as a covariate,

$$\ln(y_i) = \beta_0 + \beta_1 x_i$$

where

y_i is the crash count in the control group for time period i

x_i is the speed camera hours from time period $i-1$ (i.e. lagged 1 month)

β_0, β_1 are parameters of the model[1].

If x_{av} denotes the average number of speed camera hours per month enforced in the study pre implementation period, the adjusted monthly control series crash counts, $y_{i(adj)}$, are calculated as follows:

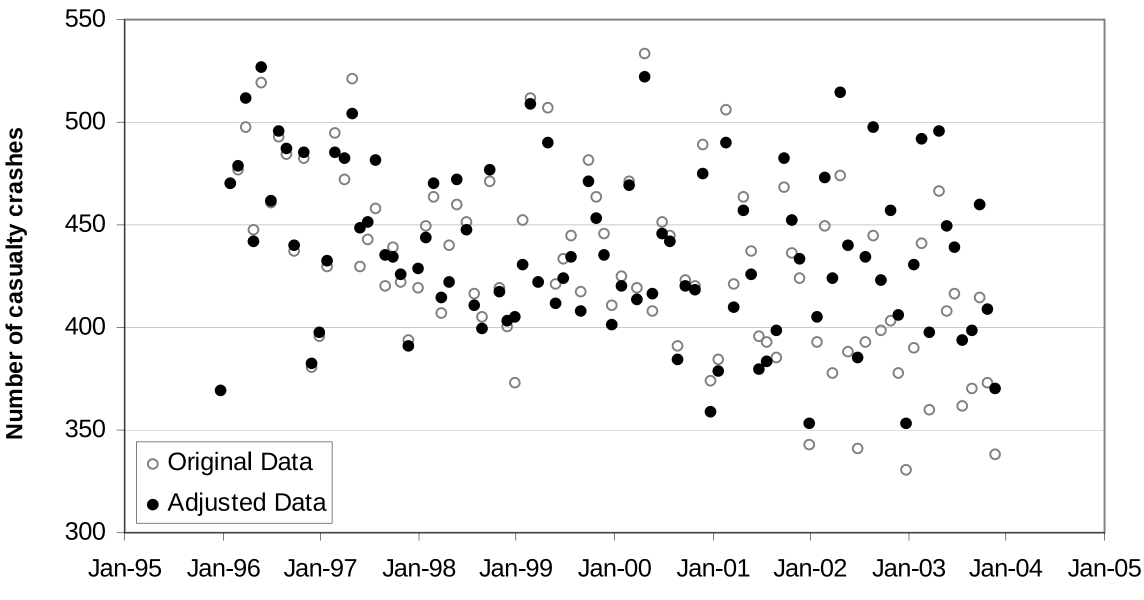
[1] The β coefficients of each variable are regression coefficients allowing comparison of the relative contribution of each independent variable in the prediction of the crashes.

$$\ln\left(y_{i(adj)}\right) = \ln(y_i) + \beta_1(x_{av} - x_i)$$

As an example, the effect of adjusting casualty crash frequency for all casualty crashes combined on the 60 km/h control roads for lagged speed camera hours can be seen in Figure 3-1 for all casualty crashes. The distances between the adjusted and original data in the graph widen after August 2001, indicating the magnitude of adjustment required to remove the effect of increased speed camera hours.

Before implementation of the default 50km/h speed limit in Victoria, there was almost no speed limit enforcement on local roads using speed cameras. In response to the default limit introduction, some speed camera operations were carried out on local roads from about 6 months after implementation. Since the increase in speed camera operation in the treatment areas were in response to the program and not co-incidental through other road safety programs or activity, the speed camera activity has been considered to be part of the default speed limit change being evaluated. Consequently, no adjustment of the treatment data series for the introduction of speed camera operations has been made even though it would have been possible to do so using the same methods applied to the control data series. This means that the crash and speed effects of the default 50km/h speed limit estimated in this evaluation reflect not only the effects of the default limit change but also the accompanying speed camera enforcement on these roads as a combined program. This has been borne in mind in interpreting the analysis results.

Figure 3-1 Adjusted control series (casualty crashes on 60 km/h roads)



3.3 IDENTIFICATION OF TREATMENT AND CONTROL GROUPS

As noted, the treatment area of the study design was designated as those roads changing to 50km/h with the introduction of the new default limit whilst the closest matching available control area were those roads remaining at 60km/h. Ideally, all such treatment and control roads existing across the state would have been included in the study. However, identifying treatment and control roads was not straight forward due to a lack of a state-wide road inventory giving set speed limits at relevant time points for the study. Two practical options were available for identification of treatment and control crashes. The first was an electronic map coverage generated for use in the Transport Accident Commission funded SafeCar project (Healy et al, 2002) giving the current speed zoning of all roads in Metropolitan Melbourne and certain regional centre in Victoria. The second was the Melway map reference coverage that identifies all roads in Metropolitan Melbourne and its fringes by road hierarchy level including local road, collector road, arterial road and freeway.

A major flaw in using the Melway map coverage to define the treated area in this study pertained to the uncertainty of whether all local roads had been changed to 50km/h and to the unknown proportion of 60km/h collector roads changed to 50km/h. Using the Melway road hierarchy levels to identify the 50km/h roads for crash analysis would have resulted in identifying collector roads remaining at 60km/h as treated sites, thereby compromising the accuracy of the study. It was also difficult to identify the control set of roads remaining at 60km/h from the road hierarchy alone. Consequently, it was decided to use the speed zone coverage generated for the TAC SafeCar project to identify crashes on those roads currently zoned 50km/h assuming all the current 50km/h roads became so because of the default speed limit change. This decision was further justified by the greater precision offered by the SafeCar coverage in identifying areas from which to draw control crashes for the analysis.

Using the TAC SafeCar project speed zone coverage, it was possible to identify crashes occurring on all other roads that did not change to 50km/h along with the speed zoning of these other roads. Although this presented a number of options for selection of areas from which to draw control crashes for use in the analysis, the most appropriate area was considered to be those roads that had remained at 60km/h after the 50km/h change was implemented. As noted, these roads were likely to be most comparable to the 50km/h roads amongst those available in terms of physical and traffic characteristics.

Because the TAC SafeCar coverage is limited to metropolitan Melbourne and some regional areas of Victoria, labelling of speed zones was also limited to these areas; hence a state-wide evaluation of the initiative could not be conducted. The Local Government Areas encompassing these regional or part regional areas and included in this evaluation were Bass Coast, Golden Plains, Macedon Ranges, Mitchell, Moorabool, Murrindindi and Nillumbik.

3.4 CRASH DATA

Data on all crashes reported to Police in Victoria for the period January 1996 to December 2003 was supplied to MUARC by VicRoads, for use in this evaluation. This data contained all Police reported casualty crashes occurring in both regional and metropolitan Victoria although, as noted above, only crash data covered by the TAC SafeCar system was utilised.

Each crash was labelled according to the speed zone that existed at the crash site at the time of labelling (December 2001) regardless of the date the crash occurred. This allowed identification of crashes that occurred in sites zoned 50km/h in December 2001 which were previously zoned 60km/h (the ‘treatment’ crashes) along with crashes occurring in areas that have remained zoned at 60km/h (the ‘control’ crashes). This speed zone labelling process required the linking of the electronic speed zone map from the TAC SafeCar project with the map of all crash locations using the geographical information system (GIS) package ARCINFO. VicRoads Information and Application Support Department carried out the linking.

Crashes were labelled as occurring before or after the implementation of the 50km/h speed limit using the recorded date of the crash. The before treatment period was defined as January 1996 to January 2001, a period of 61 months. A before treatment period of this duration was chosen in order to give a precise as possible estimate of pre-treatment crash trends over a period where road trauma in Victoria was relatively stable. Regression to the mean was not considered a problem for this study given the treatment area was not chosen on the basis of crash history but on the basis of road type. The after treatment period was chosen as February 2001 to December 2003.

3.5 SPEED CAMERA ENFORCEMENT DATA

Speed camera enforcement data used in this evaluation has been provided by the Traffic Intelligence Unit of Victoria Police. This data comprised summary information on each speed camera session conducted from January 1996 to December 2003. Details on the number of hours of operation, location, and speed zone were provided. Hours of operation were not available for some months throughout the study period. In those cases, the average number of hours was estimated using the available data for the year of interest. The enforcement data selected for analysis also encompassed the same geographical areas used in the crash analysis. A table containing the number of hours of speed camera operation for each speed zone can be found in Table A4 1 and Table A4 2 in Appendix 4. Charts also accompany these tables.

It can be seen from these charts that increases in speed camera hours appear to have occurred in all speed zones but have been predominantly concentrated in 60 km/h zones. The chart depicting the monthly percentage distribution of operational hours, however, shows that relative all other speed zones, speed camera hours in 60 km/h zones appear to have been decreasing since approximately January 2000. This reflects that speed camera use in speed zones above 60km/h have grown progressively over the study period.

3.6 SPEED MONITORING DATA

The primary purpose of this study was to identify the crash effects of the 50km/h speed limit introduction. However, it was also of interest to see if any crash changes estimated due to the 50km/h introduction are supported by changes in speeding behaviour.

Ratio Consultants, a consulting company commissioned by VicRoads, has evaluated mass speed survey data collected by both metropolitan and regional Local Government Authorities (LGAs). Survey sites were limited to local and collector roads with data collected at some sites for a period of up to 12 months prior to the implementation. The report does not explicitly state at what time the post implementation data collection ended, although estimates put it around June 2001.

In the initial stages of the evaluation, a review of speed survey data provided by various Local Government Areas (LGAs) indicated that data with sufficient detail and quality for meaningful analysis was available in only a select number of LGAs. Data from 26 LGAs proved suitable for analysis. Of these, only 17 LGAs were able to accommodate the request, providing data for 104 sites in total. Through various filtering processes, a total of 29 test sites and 5 control sites were deemed suitable for inclusion. Only 1 test site was in a rural LGA. Four of the 29 test sites, however, displayed 50km/h signage, leaving a total of 25 sites being regulated solely by the default 50km/h limit. The four sites with signage were analysed separately.

In the period to June 2001, the study concluded that there had been an overall 2-3 km/h reduction in both mean and 85th percentile speeds since the 50 km/h speed limit implementation. All but 3 of the 29 test sites showed a decrease in 85th percentile speeds while 24 of the 29 test sites showed a decrease in mean speeds. Two test sites showed an increase in both mean and 85th percentile speeds. The control sites also showed an overall net reduction in vehicular speed but only in the order of 1 km/h.

Due to the small number of test sites analysed in the study, it was not possible to establish statistical significance. No further collection of speed monitoring data has taken place for the purposes of this evaluation.

3.7 STATISTICAL ANALYSIS

Poisson regression models were used to assess statistically the crash effects of the 50 km/h implementation on local roads. They are appropriate for use in this context for a number of reasons. First, they reflect the widely established finding that crash data counts generally follow a Poisson distribution (Nicholson, 1985; Nicholson, 1986). The theoretical basis for this finding is that crashes are rare events that occur randomly and independently of other crashes, and that the measurable quantity is a count taking non-negative integer values. These characteristics are common to all Poisson distributed data.

Another appropriate property of Poisson regression models is that the model form includes a log transformation of the crash count data. This ensures predicted values are non-negative as well as to account for the high degree of skewness typically present in crash count data. Furthermore, a log transformation assumes that the relationship between the dependent and independent variables in the regression model is multiplicative rather than additive. A multiplicative relationship is thought to be appropriate to describe the relationship between crash counts and road safety countermeasures because it acknowledges that the absolute reductions in crashes achieved by a countermeasure will be dependent on the crash base to which it applies. It also ensures that the estimated reductions will not leave a predicted residual crash population less than zero which can be the case when using standard linear regression models assuming additive effects.

A Poisson regression model of the following general form was fitted to the monthly series of crash frequency data from the treatment (50 km/h) area and the data adjusted for speed camera hours from the control (60 km/h) areas,

$$\ln\left(y_{mtb}\right) = \beta_0 + \beta_{1t} + \beta_{2b} + \beta_{3t}m + \beta_{4tb}$$

where

y is the monthly crash count in either treatment or control group

t is an indicator for treatment or control crash series

b is an indicator of before or after 50 km/h implementation

m is the sequential month of the crash data count (1,2,..)

tb indicates the interaction between treatment/control and before/after factors.

β are parameters of the model.

A maximum likelihood method was used to estimate the coefficients of the explanatory variables. The parameterisation of the model allowed direct estimation of the program effect estimate and its statistical significance. Statistical significance of the program effect estimate is assessed against the corresponding probability value that indicates the likelihood of obtaining the estimate of program effectiveness by chance given no real underlying reduction in crash frequency.

The final form of the Poisson regression model chosen is relatively simple including only intercept and exponential trend terms for each of the treatment and control data series as well as an intervention effect term at the time of program implementation. Investigation of appropriate model formulations to apply to the observed treatment and control data series was based on the observation that the data series were very regular in form. Investigations showed that these regular trends were able to be adequately represented by a simple exponential term in the model (see Figure 4-1 and Figure 4-2). Adding higher order trend terms to the model to represent additional curvature in the trend proved to not improve the model fit significantly further indicating the adequacy of the simple exponential trend. The need to include seasonal factors in the model was also investigated. Although including seasonal factors in the model improved its fit to the data, it did not alter the point estimates of net program crash effects nor did it change the level of statistical significance for the estimate. Furthermore, examination of model residual behaviour showed appropriate random dispersion and stationarity of the residuals without the seasonal terms being included. Hence, for ease and clarity of model presentation, it was decided to use the model formulation without seasonal terms, as illustrated in Figure 4-1 and Figure 4-2 of the Results section.

The analysis of overall average program crash effects defines the after treatment period in a single block. The second analysis considers the after treatment period in two time blocks. These are February 2001 to June 2001 (the initial study period) and July 2001 to December 2003 (the long term effects). Consequently, the before or after index in the regression model, *b*, takes three levels: one for the before treatment period and two for the after treatment time periods.

Separate models were fitted to crashes at each severity level as well as to all casualty crashes. The severity levels investigated included: fatal crashes, serious injury crashes, fatal and serious injury crashes pooled, and 'other' injury crashes. Crashes involving three key target groups of road users have also been analysed to assess the effect of the default 50km/h speed limit on crashes involving these drivers. The three crash sub-groups analysed are

- Crashes involving at least one pedestrian (pedestrian crashes)
- Crashes involving at least one driver aged 55 or over (older driver crashes)
- Crashes involving at least one driver aged 25 or under (young driver crashes)

3.8 ANALYSIS OF COLLECTOR AND LOCAL ROADS

Although the first evaluation showed statistically significant crash reductions associated with the introduction of the default speed limit, it was not known on which road type the initiative had had the greatest effect. It was desirable therefore to determine whether collector or local roads had benefited most from the legislation. For this analysis to proceed, crashes that had occurred on roads which were previously primary or secondary arterial roads, collector or local roads and had been reclassified into either collector or local roads since the change to the default speed limits, needed to be identified and labelled in a similar way to that used for retrospectively labelling crashes with current speed zones. It was not possible to carry out this identification process and hence this analysis was not pursued in this evaluation.

4 RESULTS

4.1 ANALYSIS OF CASUALTY CRASHES

This section presents the results of the Poisson regression analysis performed for all crash types. Regression results for each of the three target crash sub-groups can be found in the Appendices 1-3. Statistically significant findings for these target groups, however, are summarised at the end of this section.

In Sections 4.2 and 4.3, program effect estimates, measured by the net percentage change in crashes, by severity on 50 km/h roads relative to crashes on 60 km/h roads are presented from the initial evaluation design, and the final evaluation design, respectively. These results were obtained using the Poisson regression analysis described and are presented with their corresponding confidence intervals and statistical significance values. Statistical significance values give the probability of obtaining the estimated crash reduction by chance given the null hypothesis that the implementation has had no real underlying effect on crashes. Low significance probabilities indicate a likely crash effect. Shaded regions in the tables indicate statistically significant results less than 0.05, a threshold value commonly considered to represent a reliable finding. Negative results indicate an estimated net increase in the crash type being considered.

Statistically significant point estimates have been translated into actual crash numbers to provide an indication as to the savings achieved and give an indication of the significance of the countermeasure in contributing to road trauma reductions. These were calculated by multiplying the net percentage change by the average monthly number of crashes in the pre-implementation period for the corresponding severity and target group considered, and then multiplied by the number of months in the analysis period. Confidence intervals were similarly translated. This process was carried out only where statistically significant results were obtained.

Confidence intervals have been calculated with a 95% confidence coefficient. The confidence interval gives an indication of how much uncertainty there is in the point estimate provided; the narrower the interval, the more precise the estimate. A very wide interval is an indication that the data is highly variable and more data is required to produce a more certain estimate. Wide confidence intervals commonly result when analysing fatal crash data as this type of data is proportionally highly variable because the number of observations is relatively few.

4.2 RESULTS FROM INITIAL STUDY DESIGN: ALL CRASH TYPES

The following results, which cover the period February 2001 to June 2001, were obtained using the initial study design incorporating unadjusted control area crash data series. This design did not utilise speed camera hours to adjust the control series.

Table 4-1 Estimated net percentage and absolute crash savings in 50 km/h zones relative to 60 km/h zones for all crash types for the period February 2001 to June 2001.

	50 km/h zones versus 60 km/h zones in Victoria			
Crash Severity	**Estimate of Monthly Net Percentage Reduction**	**95% Confidence Interval of Net Percentage Reduction**	**Statistical Significance**	**95% Confidence Interval of Estimated Monthly Crash Savings**
Fatal Crashes	52.9%	(-24.05%, 82.11%)	0.1276	-
Serious Injury Crashes	12.6%	(-2.80%, 25.75%)	0.1036	-
Other Injury Crashes	13.0%	(3.36%, 21.61%)	0.0093	(5, 8)
All Casualty Crashes	13.2%	(5.33%, 20.54%,)	0.0014	(9, 11)

Results in Table 4-1 show a statistically reliable reduction in all casualty crashes of 13.2%, associated with the introduction of the 50km/h default speed limit. The estimated net reduction is the change in the crashes in the current 50km/h zones after implementation of the default speed limit, relative to the change in the comparison group over the same period. The statistically reliable reduction in all casualty crashes translates to an estimated absolute crash saving of between 9 and 11 casualty crashes per month in the area considered by the study (essentially metropolitan Melbourne).

Similar reductions to those estimated for all casualty crashes were observed for serious and other injury crashes, although the result for serious injury crashes was not statistically reliable. Fatal crash reduction associated with the 50km/h introduction was estimated to be 53% in comparison to crashes in 60km/h zones although this result is also not statistically reliable.

Figure 4-1 shows the monthly time series data for all casualty crashes of all types in both 50km/h (treatment) and 60 km/h (control) speed zones. To illustrate the model fitted to the data, Figure 4-1 also shows the estimated Poisson regression model predicted values. The estimated step change in the monthly level of crashes in both the 50km/h and 60 km/h speed zones at the time of introduction of the default 50km/h limit is visible in the fitted model. The difference in the two step changes represents the net crash effect of the 50km/h change (i.e. 13.2% reduction, from Table 4-1). Visually, Figure 4-1 shows little deviation in the control series at the time of treatment implementation compared to a significant downward deviation in the treatment group indicating the suitability of the control series in reflecting general crash trends. Noteworthy is the relatively flat trend in the control series, further indicating the suitability of the chosen control series in representing the baseline crash frequency trend.

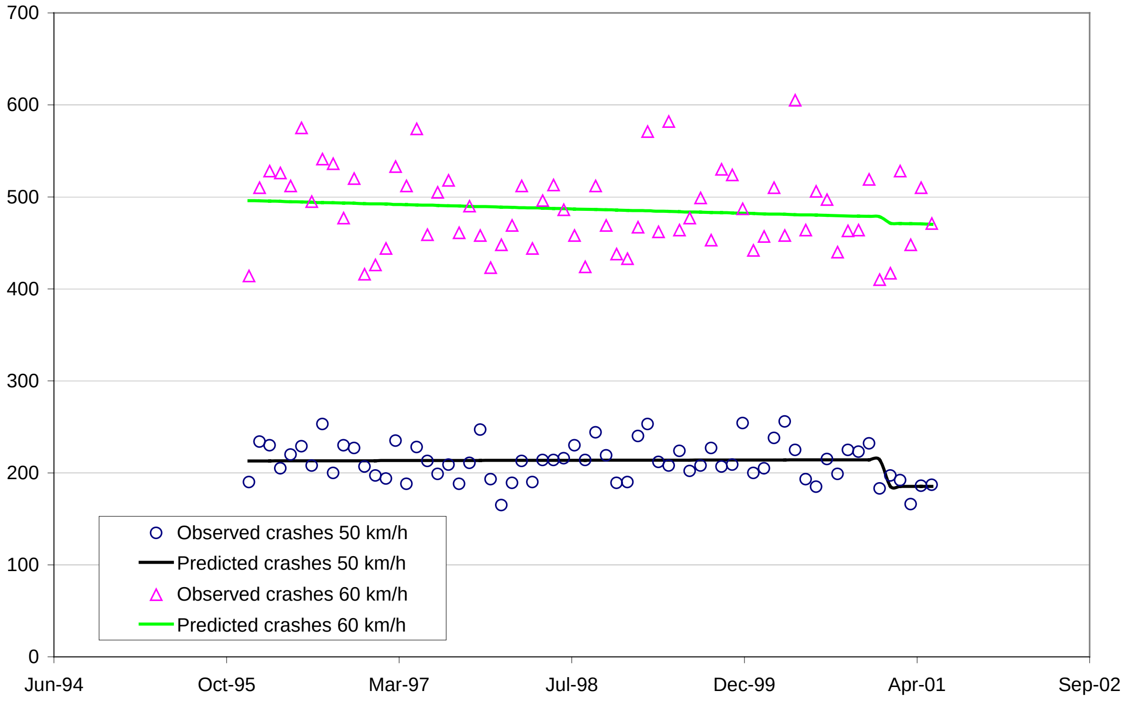


Figure 4-1 Observed and modelled monthly crash frequency in 50 km/h zones and 60 km/h zones for all crash types for the period February 2001 to June 2001

4.3 RESULTS FROM FINAL STUDY DESIGN: ALL CRASH TYPES

This section details the results of the analyses conducted on all crash types using the final study design incorporating adjustment of the control crash data series for growth in speed camera enforcement. Total and average numbers of crashes of all types in zones that became 50km/h are shown in Table 4-2 for the 61 months prior to the initiative, for the first 5 months after implementation covered by the initial evaluation and for the additional 30 months covered by the final evaluation. The table shows that the monthly average crash counts after implementation in the treatment area were lower for all crash severity levels considered were lower in the 5 months period immediately post implementation. However, in the period after June 2001, apart from other injury crashes, average monthly crash frequencies seem to have rebounded towards pre program levels with average monthly serious injury crash frequencies actually higher in this period than pre program implementation. It should be noted, however, that Table 4-2 presents only raw crash frequencies that have not been adjusted for general crash trends reflected in the chosen control series using the full evaluation framework. Hence the numbers quoted in Table 4-2 should be considered as purely descriptive.

Table 4-2 Total and average monthly crash numbers in current 50km/h speed zones before and after the introduction of the default 50 km/h speed limit

	Total Crash Numbers Before and After Introduction of the Default 50 km/h Speed Limit			Average Monthly Crash Numbers Before and After Introduction of the Default 50 km/h Speed Limit		
Crash severity & current speed zone	**Before (Jan-96 to Jan-01)**	**After (Feb-01 to Jun-01)**	**After (Jul-01 to Dec-03)**	**Before (Jan-96 to Jan-01)**	**After (Feb-01 to Jun-01)**	**After (Jul-01 to Dec-03)**
Fatal Crashes	188	8	75	3.1	1.6	2.5
Serious Injury Crashes	5,229	408	2619	85.7	81.6	87.3
Fatal + Serious Injury Crashes	5,417	416	2694	88.8	83.2	89.8
Other Injury Crashes	13,626	1,005	5727	223.4	201.0	190.9
All Casualty Crashes	19,043	1,421	8421	312.2	284.2	280.7

Results of the formal evaluation analysis of program crash effects estimated using Poisson regression analysis are shown below in Table 4-3. Presentation of the results is in the same format as those in Table 4-1. Estimates of program crash effects have been calculated for the period covered by the initial evaluation design, the remainder of the after implementation study period as well as the whole after implementation period.

Table 4-3 Estimated net percentage and absolute crash savings in 50 km/h zones relative to 60 km/h zones for all crash types.

	50 km/h zones versus 60 km/h zones in Victoria			
Crash Severity	**Estimate of Monthly Net Percentage Reduction**	**95% Confidence Interval of Net Percentage Reduction**	**Statistical Significance**	**95% Confidence Interval of Estimated Crash Savings**
Fatal Crashes				
Feb 2001 – Jun 2001	50.8%	(-7.6%, 77.5%)	0.0758	NE
Jul 2001 – Dec 2003	9.5%	(-64.8, 50.3%)	0.7437	NE
Feb 2001 – Dec 2003	21.4%	(-37.6%, 55.1%)	0.3991	NE
Serious Injury Crashes				
Feb 2001 – Jun 2001	7.3%	(-7.4%, 20.0%)	0.3128	NE
Jul 2001 – Dec 2003	0.1%	(-12.1%, 10.9%)	0.9905	NE
Feb 2001 – Dec 2003	2.8%	(-8.1%, 12.7%)	0.5989	NE
Fatal and Serious Injury Crashes				
Feb 2001 – Jun 2001	8.8%	(-5.2%, 21.0%)	0.2068	NE
Jul 2001 – Dec 2003	0.2%	(-11.7%, 10.8%)	0.9710	NE
Feb 2001 – Dec 2003	3.3%	(-7.3%, 12.9%)	0.5267	NE
Other Injury Crashes				
Feb 2001 – Jun 2001	11.8%	(3.9%, 18.9%,)	0.0039	(9, 42)
Jul 2001 – Dec 2003	17.6%	(11.5%, 23.3%)	<0.0001	(22,47)
Feb 2001 – Dec 2003	15.7%	(9.8%, 21.1%)	<0.0001	(26, 52)
All Casualty Crashes				
Feb 2001 – Jun 2001	10.9%	(3.7%, 17.6%)	0.0036	(12, 55)
Jul 2001 – Dec 2003	12.7%	(7.3%, 17.9%)	<0.0001	(23, 56)
Feb 2001 – Dec 2003	12.1%	(7.0%, 16.9%)	<0.0001	(22, 53)

NE: Not estimated due to the percentage crash reduction estimate not being statistically significant

Results of the formal evaluation analysis of program crash effects estimated using Poisson regression analysis are shown below in Table 4-3. Presentation of the results is in the same format as those in Table 4-1. Estimates of program crash effects have been calculated for the period covered by the initial evaluation design, the remainder of the after implementation study period as well as the whole after implementation period.

Table 4-3 shows a statistically significant estimated average reduction in all casualty crashes of 12.1% across the entire 35 month after implementation study period associated with implementation of the default 50km/h speed limit. This represents and average monthly saving of between 22 and 53 casualty crashes across the area of metropolitan Melbourne covered by the study. Although not shown, analysis by time period for all casualty crashes showed specific trends over time.

Examination of the results of analysis by crash severity show substantial differences in program crash effects between crash severity levels. The majority of effect measured on all casualty crashes combined appears to have stemmed largely from effects of the program on other (minor) injury crashes. The program was associated with a statistically significant average net decrease in minor injury crashes of 16% over the post implementation study period. In contrast, the estimated average reduction in fatal and serious injury crashes combined associated with the program over the same period was in the order of 3% and was not statistically significant.

There was some indication of associated crash effects for fatal crashes alone in the period up to 6 months after program implementation with the estimated crash reductions in this period achieving marginal statistical significance. However, relatively wide confidence limits on the fatal crash estimates and a lack of statistical significance on the analysis results in the later post implementation period and for the entire post implementation period make it difficult to draw conclusions about fatal crash effects. Lack of statistical significance in the analysis results for fatal crashes are most likely a result of the limited numbers of fatal crashes occurring in the treatment area. In contrast, lack of data is not likely an issue for the lack of statistical significance in the analysis of fatal and serious injury crashes combined or serious crashes alone. Statistical power calculations suggest data on fatal and serious injury crashes combined should be able to detect a crash reduction of 10% or more. The point estimates of program effectiveness of only 3% suggests the default 50km/h speed limit has had little effect in reducing higher severity crashes in Victoria in the longer term.

Figure 4-2 illustrates the fit of the Poisson regression model to the observed monthly crash count in 50 and 60 km/h speed zones, for all crash types with the model estimating crash effects in 6-monthly periods. The estimated step changes in the 6-monthly level of crashes in the 50 and 60 km/h zones in the post implementation period are visible in the fitted model. The differences in the two step changes at a particular point in the post implementation period represent the net crash effect of the default speed limit change when compared to the pre implementation period. For example, the first step change representing crashes that occurred on 50 km/h roads in the six months following implementation is equivalent to an 11% reduction in crashes. Noteworthy again is the relative consistency of trend observed in the adjusted control data series (predicted and observed 60km/h) showing it is apparently unaffected by the default speed limit change as desired hence confirming its suitability as a control in the evaluation design.

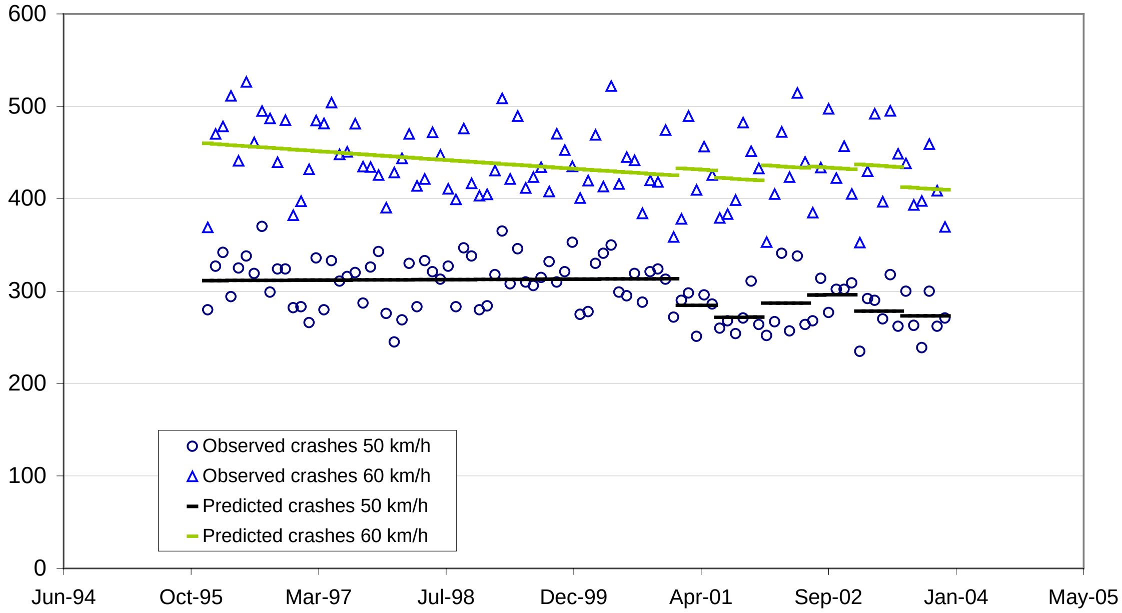


Figure 4-2 Observed and modelled monthly crash frequency in 50 km/h zones and 60 km/h zones for all crash types

4.4 SUMMARY OF RESULTS FOR CRASH SUB-GROUPS

Six monthly effect estimates for crashes involving each of the target groups can be found in Appendices 1-3. Following is a summary of the main findings based on 35 months of post implementation crash data.

4.4.1 Crashes involving pedestrians

Several statistically significant estimates were detected in the Poisson regression analysis of crashes involving pedestrians. Results showed that overall, crashes involving pedestrians decreased by 20% in the first five months following implementation, relative to crashes in 60 km/h areas. This result is similar in magnitude to that achieved using the initial study design where a net decrease of 22% was found. No statistically significant reduction in all pedestrian involved casualty crashes was estimated for the period from July 2001 to December 2003. However, results in Appendix 1 show the 50km/h default speed limit was associated with large statistically significant reductions in high severity crashes. When examining fatal and serious injury crashes combined, the lower speed limit was associated with an average 41% decrease in fatal and serious injury pedestrian related crashes over the entire post implementation study period. There was some evidence of slightly higher effects of the program on serious pedestrian crashes in the first 5 months after program implementation although the differences between the program crash reduction estimates was not statistically significant.

The estimated percentage savings in fatal and serious injury pedestrian related crashes corresponds to a saving of between 4 and 12 crashes of this type per month.

4.4.2 Crashes involving older drivers

Analysis of crashes involving drivers aged 55 years and over generally did not find statistically significant reductions in crashes involving this target group associated with the introduction of the default 50km/h speed limit.

4.4.3 Crashes involving young drivers

Analysis of crashes involving drivers aged 18 to 25 estimated that the 50km/h speed limit introduction was associated with a statistically significant average reduction in all casualty crashes of 14% over the entire post implementation period. Analysis of program effects by crash severity for this target group suggested the reductions estimated for all casualty crashes combined stemmed largely from statistically significant reductions in minor injury crashes rather than for higher severity crashes. A statistically significant average post implementation minor injury crash reduction of 25% was estimated, In contrast, no statistically significant average crash effects across the same period were estimated for fatal and serious injury crashes.

5 DISCUSSION

5.1 INITIAL VERSUS FINAL STUDY DESIGN

Analysis presented in this report has been able to quantify the crash effects of the default 50km/h speed limit introduced in Victoria on January 22, 2001. The evaluation has been undertaken in two stages, the results of each being reported separately. Although the initial and final study designs were undertaken separately in response to the historical progression of the evaluation, comparison of the two designs is useful with respect to assessing both the robustness of the analysis results as well as the validity of the final analysis design.

The first interim analysis of the Victorian default 50 km/h speed limits covered a period of five months – a period during which no changes to existing road safety programs were made and no new programs introduced. This provided a relatively stable period in which to assess the crash effects of the default speed limit using a quasi-experimental design that was as pure as possible with respect to control information. The results of analysis using the initial evaluation design represent a benchmark against which to compare the modified final study design used to assess program effects in the full after treatment study period.

Table 5-1 shows a comparison of estimated crash reductions associated with introduction of the 50km.h default speed limit obtained using both the initial and final study designs. Point estimates are given from both analyses along with 95% confidence limit estimates and statistical significance values. The estimates summarised in Table 5-1 apply to the first five months after program implementation (February-June 2001), the period covered by both evaluation designs.

Table 5-1 Comparison of estimated crash reductions from the initial and final study designs

	50 km/h zones versus 60 km/h zones in Victoria			
Crash Severity	**Estimate of Monthly Net Percentage Crash Reduction and 95% CI: Initial Design**	**Statistical Significance: Initial Design**	**Estimate of Monthly Net Percentage Crash Reduction and 95% CI: Final Design**	**Statistical Significance: Final Design**
Fatal Crashes	52.9% (-24.05%, 82.11%)	0.1276	50.8% (-7.6%, 77.5%)	0.0758
Serious Injury Crashes	12.6% (-2.80%, 25.75%)	0.1036	7.3% (-7.4%, 20.0%)	0.3128
Other Injury Crashes	13.0% (3.36%, 21.61%)	0.0093	11.8% (-5.2%, 21.0%)	0.0039
All Casualty Crashes	13.2% (5.33%, 20.54%)	0.0014	10.9% (3.7%, 17.6%)	0.0036

Comparison of the estimated program effects, their confidence limits and statistical significance values shows a high degree of concordance between the two study designs. Whilst point estimates of program effectiveness are slightly lower for the final study design, the differences are well within the bounds expected through the effects of random variation in the data. This is illustrated by the high degree of overlap in the confidence limits on comparable pairs of estimates obtained from the two designs. Importantly, inferential testing of the null hypothesis of no program crash effect associated with the program yields the same conclusion from each study design. Under both designs, statistically significant crash reductions were estimated for all casualty crashes combined and for other injury crashes whilst no significant crash effects were estimate for fatal or serious injury crashes under either design.

The high compatibility between results from the two study designs indicate that the alternative methodology used for the final study design was able to effectively account for the effects of the increase in speed camera hours on 60 km/h roads on crash frequency in the control areas. The comparison showed robust estimates of program crash effects during the initial five months post implementation and indicated that program crash effects obtained for the full after implementation study period estimated using the final study design would also be robust.

The key feature of the final study design used in this evaluation was that it removed the effects of increased speed camera enforcement hours from the control group. The basis of the modified design was that the change in speed camera enforcement was different between treatment and control areas with additional speed camera enforcement being targeted primarily at 60km/h arterial roads. However, speed camera enforcement also increased on the 50km/h roads after introduction of the default 50km/h speed limit. Despite this it was not considered necessary to apply this same adjustment procedure to the treatment group. This was because any significant speed camera activity directed to 50km/h roads was introduced to support the implementation and was considered to be part of the 'treatment' effect in this study. Hence the net treatment effects estimated using the final study design reflect the effectiveness of both the default speed limit change and accompanying speed camera enforcement in reducing crashes.

5.2 INTERPRETATION OF THE FINAL ANALYSIS RESULTS

The principal focus in evaluating the effects of the Victorian default 50km/h speed limit is on the effects of the initiative on crashes overall. Table 4-3 summarises the crash reductions associated with program implementation estimated using the final study design reductions for the entire post implementation study period as well as broken down by the initial study post implementation period and subsequent period only covered by the final evaluation. Table 4-3 shows the program has been associated with a reduction in casualty crashes in aggregated by an average of around 12% over the post implementation study period. Comparison of initial effects in the first five months with longer term effect shows estimated program casualty crash reductions in the first 5 months have been maintained in the longer term. Different patterns of estimated long term crash effects were estimated when considering each crash severity level individually.

Estimated effects of program implementation associated with other injury crashes show an apparent increase in estimated associated crash reductions following the initial five months after program implementation although the increase is not statistically significant as indicated by the overlapping confidence limits on the estimates. The estimated program crash effect on other injury crashes over the entire post implementation study period, at 16%, was slightly higher than for all casualty crashes aggregated. This suggests the program has been slightly more effective in reducing minor injury crashes than those at higher levels of severity. This is borne out by examining the estimated program effects on serious injury crashes, which make up the bulk of the higher severity crashes. This crash severity level averaged a reduction of only 3% over the entire post implementation period and was not statistically significant. There was some evidence of reducing program effects on serious injury crashes over time in the results presented in Table 4-3 through comparing the two post implementation periods considered, however this observation should be treated with caution given none of the estimates for serious injury crashes achieved statistical significance. Lack of statistical significance in the estimated serious injury crash effects is not likely to be from a lack of sufficient data for analysis. It is more likely a reflection of no real program effects given the point estimate of percentage crash reduction of only 3%.

Similar program effects over time to those estimated for serious injury crashes were estimated for fatal crashes. A marginally statistically significant short term program fatal crash effect of 51% was estimated although this reduced to only 9% in the period following the initial 5 months after program implementation. Interpretation of fatal crash effects should always be made with care due to the low average monthly fatal crash counts on 50km/h roads (see Table 4-2).

In summary, the results presented in Table 4-3 suggest that the Victorian default 50km/h urban speed limit has been successful in reducing casualty crashes in aggregate by around 12% with the reductions sustained over the entire post implementation study period. However, the results also suggest that the program has been more successful in reducing minor injury crashes that in reducing fatal and serious injury crashes. Whilst there was some suggestion of the program being effective in reducing the high severity crashes in the period immediately after program implementation, it appears that these effects were not sustained over the longer term.

It should be noted that the above results, although presented as representing the effect of the 50km/h default speed limit in Victoria as a whole, are only derived from analysis of crashes in metropolitan Melbourne. It is not clear whether the crash effects of the program were the same outside of Melbourne. A different data preparation and analysis strategy to that used for Melbourne in this study would be required to assess program effectiveness in regional Victoria.

5.3 COMPARISON OF OVERALL RESULTS WITH SPEED TRENDS AND OTHER STATES AND GENERAL DISCUSSION

Victoria has not been the only jurisdiction in Australia to introduce a 50km/h speed limit on urban local roads. Indeed, all states in Australia now have an urban 50km/h speed limit implemented in some form, many of which have been formally evaluated in terms of effects on crashes and travel speeds. Table 5-2 provides a comparison of the results obtained from the published evaluations of 50 km/h urban speed limits in other Australian states. In general, the study designs used in each evaluation were similar and considered after-implementation periods ranging from 24 months to 35 months. The results presented are representative of the average effects over the study period in the metropolitan region of each state. The NSW and Victorian evaluations, however, contain a small proportion of regional crashes.

Table 5-2 Summary of Estimated Casualty Crash Effects and Speed Behaviour Measures for Urban 50km/h Speed Limit Implementations in Different Australian States.

State	Reduction estimates for casualty crashes (%)	Reduction in Mean Speed (km/h)	Red in 85^{th} %ile speed (km/h)	Reduction in prop>60km/h and <70km/h (%)	Red in prop ≥ 70km/h and < 80km/h (%)	Red in prop ≥ 80km/h (%)	Enforce-ment
Victoria	13	1.0*	1.0*	n/a	n/a	n/a	yes
NSW[1]	22	1.0	1.2	38	70	74	yes
SE Qld[2]	23	2.2	1.5	53	68	62	yes
WA[3]	21	0.3	0.8	16	15	15	no

- *Applicable to period covering May 2001 to June2001.*

[1] NSW RTA (2000)

[2] Hoareau, Newstead, Oxley and Cameron (2003)

[3] Hoareau and Newstead (2004)

The effect sizes presented in the table show that the magnitude of the crash reductions associated with the introduction of the 50 km/h speed limits were similar in NSW, South East Queensland and Western Australia. The effect size computed for Victoria, however, is almost half that of the other states, suggesting the default 50km/h urban speed limit was less successful in reducing crashes than in other states. There could be a number of reasons for this outcome.

Table 5-2 shows a summary of the estimated effects of the 50kmh urban speed limit on travel speeds in each state. Results from NSW, Queensland and WA show the initiative made very little difference to mean and 85^{th} percentile travel speeds. They show that the majority of program crash reduction effects seem to have been generated by large reductions in the proportion of excessive speeders on local roads. In both Queensland and NSW, the proportion of vehicles travelling at more than 70km/h on these roads was reduced by over 60%. Whilst reduction in excessive speed was not so great in WA, it still represented the principal change in the speed profile associated with the countermeasure. Large changes in excessive speeding in response to the reduced speed limit in each of these evaluations have also correlated with findings in each of generally larger crash reductions for higher severity crashes. This is as expected given the well established power relationships between speed and injury severity outcome.

Minimal changes in mean and 85^{th} percentile speeds were measured in Victoria in response to the default 50km/h speed limit introduction, consistent with the other states studies. Unfortunately the speed monitoring data available for the Victorian evaluation did not include measures of the number of vehicles travelling at excessive speed. Consequently it was not possible to assess changes in this critical speed measure in relation to program implementation. It is possible that the proportion of excessive speeders on Victorian local roads may have been less prior to introduction of the 50km/h limit possibly due to the long established intensive speed enforcement regime across the state. This would result in less potential for program effectiveness which would reflect in the lower estimated crash reduction in Victoria, particularly for the higher severity crashes. Access to longitudinal speed monitoring data with the full range of required parameters may also have shed light on the reason crash effects of the Victorian 50km/h program were not sustained in the longer term for higher severity crashes.

Clearly, the lack of detailed and longitudinal speed monitoring data has made this evaluation less definitive than it might have been in establishing the mechanisms of program effectiveness and understanding why effectiveness might have been less than observed in other states. It is strongly recommended that implementation of all future speed based road safety initiatives in Victoria be accompanied by comprehensive and targeted speed monitoring both before implementation and for the full period after implementation for which evaluation will be required.

A further reason for the lack of sustained high severity crash reductions in Victoria following the default 50km/h implementation may be related to issues of traffic congestion in conjunction with low levels speed enforcement effort on local roads. Anecdotal evidence from one Melbourne Council area in the south eastern suburbs suggests many local roads are used as alternative routes to the arterial roads, or ‘rat runs’, during peak travel periods when arterial road congestion is high. Because these routes are being used to reduce travel times, it is also reported that compliance with posted speed limits is poor. In response to complaints by residents, the Council has undertaken traffic volume and speed surveys. These confirm that traffic volume in many of the local roads with through access is very high. Data collected as recently as 2004 also show mean and 85th percentile travel speeds on many of the roads well in excess of 60km/h, with some near 70km/h even though the roads surveyed are zoned under the default 50km/h limit.

This limited sample of data supports the hypothesis that high end speeding on local roads in metropolitan areas may still be prevalent despite the default limit change, particularly amongst those using local roads as alternative routes to congested arterial roads. It is also possible that enforcement on local roads might be somewhat ineffective at deterring this behaviour in the longer term. Appendix 4 shows that enforcement in 50km/h zones, although increasing after the default limit change, is still relatively limited compared enforcement on 60km/h roads in terms of hours enforced. Given the relative length of local road and arterial road network, the density of enforcement on local roads per kilometre of network is very low. Police report difficulty in using automated enforcement methods such as speed cameras on local roads due to geometry restrictions and sources of potential interference such as parked cars. Furthermore, resource availability to undertake manual enforcement in these areas reported to be limited at peak traffic times when it is most needed.

It is evident that further investigation of speed compliance and particularly high end speeding on Victorian local roads needs to be undertaken to examine this potential reason for the relatively smaller overall crash effects of the 50km/h program in Victoria and the lack of sustained high severity crash reductions. If speed compliance is found to be a problem on local roads, an effective method of speed enforcement for these roads needs to be established. Given the diffuse nature of the crash problem and length of local road to be enforced, proven effective low enforcement density methods using schedule randomisation such as demonstrated in the Queensland Random Road Watch Program (Newstead et al, 2001) might be applicable in this context.

5.4 RESULTS FOR SPECIFIC ROAD USER GROUPS

Like the initial evaluation of the Victorian default 50km/h speed limit presented in Hoareau et al (2002), the final evaluation has also shown significant reductions in crashes involving pedestrians associated with the default 50km/h implementation. Importantly, the largest reductions in pedestrian related crashes were estimated for fatal and serious injury crashes and these reductions where reductions between 25% and 40% were estimated. Encouragingly, these reductions were also estimated to be sustained over the whole post implementation study period unlike the results for all road user groups combined. This result further enforces the value that road safety countermeasures involving speed reduction have for the safety of the pedestrians. It also underlies the potential for further gains in serious pedestrian road trauma reduction through consideration of extending speed reduction programs to other areas of high pedestrian exposure.

Unlike the NSW 50km/h speed limit evaluation, the Victorian evaluation was not able to identify benefits of the default limit change in reducing crashes associated with older drivers. In the NSW evaluation, it was argued that older drivers would be expected to benefit from the speed limit change because of their increased difficulty with speed perception and their greater susceptibility to injury. The reason why similar reduction were not estimated in Victoria is unclear but may be related to the general issues related to the relatively smaller estimated effects of the Victorian program discussed previously.

Estimated effects associated with the program on crashes involving younger drivers were generally in line with those for all crashes. Significant reductions were estimated for all casualty crashes. However, analysis by crash severity showed these stemmed largely from reductions in minor injury crashes. No statistically significant reductions in fatal and serious injury crashes involving young drivers were estimated at any stage during the post implementation period. Disturbingly, serious crash increases for this road user group were actually associated with the program in the few months immediately after implementation. It is not possible to relate these results to observed speed compliance behaviour of young drivers on local roads from the available speed monitoring data although this should perhaps be a priority for future research given the results of this evaluation.

6 CONCLUSIONS

This report presents the results of an evaluation of the crash effects of the default urban 50km/h speed limit introduced in Victoria on January 22nd 2001. Due to confounding effects of other speed related initiatives introduced after the default 50km/h speed limit, two different study designs were employed in the evaluation. The first was a pure quasi-experimental design that considered the first 5 months after program implementation where the confounding influences were not present. It compare crash trends on those roads in Metropolitan Melbourne affected by the default speed limit change with those on roads that remained zoned at 60km/h. The second design adjusted for the large increase in speed camera enforcement hours in the study control area that was the key effective element of the confounding speed enforcement initiatives program. Estimated crash reductions from each study design were consistent over the post implementation period common to each. Hence it was concluded that the study design employing adjustment for the confounding crash effects of the speed initiates was viable. Key results of the evaluation presented cover the period to December 2003 and are based on the adjusted study design.

Results of the evaluation estimated that implementation of the Victorian default 50km/h urban speed limit was associated with statistically significantly reduced casualty crashes in aggregate by around 12% with the reductions sustained over the entire post implementation study period. However, analysis was unable to identify statistically significant reductions in fatal and serious injury crashes. Whilst there was some suggestion of the program being effective in reducing the high severity crashes in the period immediately after program implementation, it appears that these effects were not sustained over the longer term. An explanation of the apparent lack of program effects on higher severity crashes was not able to be established from analysis of the limited speed monitoring data available for the evaluation.

Assessment of program crash reduction effects for particular road user sub groups was also carried out in the evaluation. They showed that the change in default speed limit was associated with a sustained and statistically significant reduction in fatal and serious injury crashes involving pedestrians of between 25 and 40 percent. Effects on crashes involving young drivers were consistent with the overall crash analysis results whilst no significant effects on crashes involving older drivers were measured.

7 RECOMMENDATIONS

Two major recommendations stem from the outcomes of the evaluation of the Victorian default 50km/h speed limit.

1. Speed monitoring data was not collected specifically for the specific purpose of evaluating the effects of the default 50km/h speed limit in Victoria both before and after program implementation. The lack of a reliable intermediate measure of program effectiveness has limited the ability of this evaluation to be able to fully understand and describe the mechanisms leading to the program crash effects estimated. This has led to a much weaker and less conclusive evaluation. It is recommended that speed monitoring data be collected specifically for the purposes of evaluating any future road safety programs or countermeasures aimed at reducing crash frequency or severity through changing driver speed behaviour. Design and content of the speed data collection should be carried out in consultation with experienced evaluation researchers to ensure to speed data collected is the most appropriate for the evaluation task.

2. Further comprehensive investigation of speed compliance on Victorian local roads needs to be undertaken on a wide basis to identify whether speeding on local roads is a problem and , if so, the characteristics of the problem. If speed compliance is found to be a problem on local roads, an effective and appropriate speed management program for these roads needs to be developed reflecting the nature and extent of the problem identified.

8 ASSUMPTIONS AND QUALIFICATIONS

The validity of the results shown in this report is based on the following assumptions:

- The crash data supplied by VicRoads contains accurate crash severity and that the definition of crash severity used by police over the study period has remained consistent

- Labelling of the current speed zoning of crash locations by VicRoads through the use of the TAC SafeCar speed zone coverage was accurate.

- The statistical models employed to estimate the net effect of the initiative have been adequately specified.

- The error structure of the models follows the Poisson distribution.

- The hypothesis tested was based on a two-tailed test of significance hence no assumption about the direction of change has been made. To obtain a one-tailed level of significance, the significance levels should be halved.

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APPENDIX 1

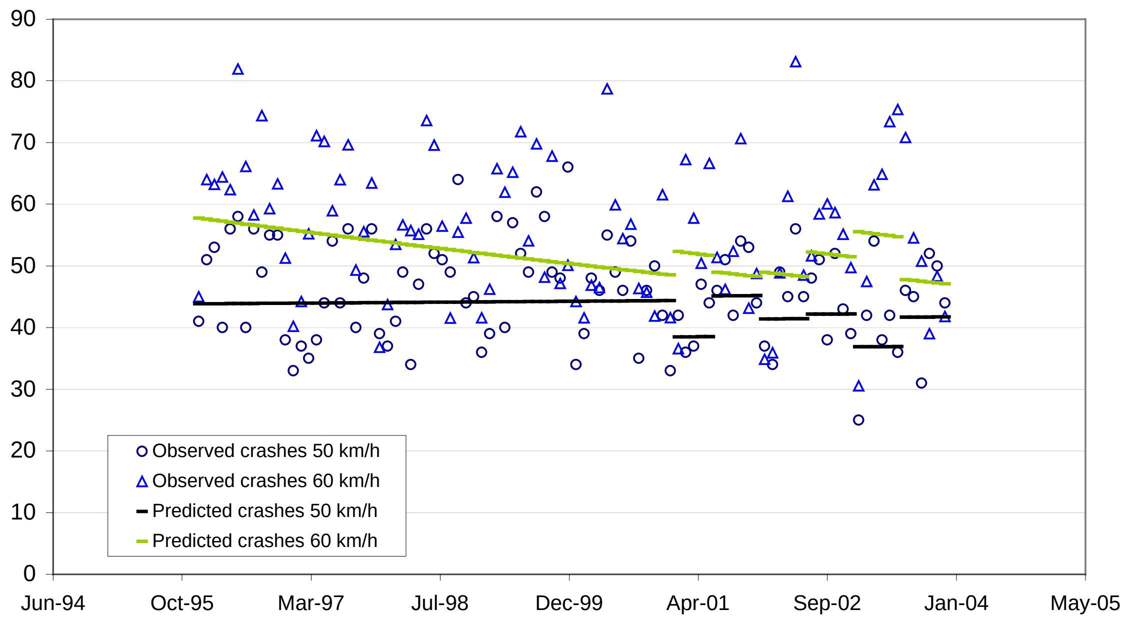
CRASHES INVOLVING PEDESTRIANS

Estimated net percentage change in crashes in 50 km/h zones relative to 60 km/h zones for crashes involving PEDESTRIANS resulting from initial study design

	50 km/h zones versus 60 km/h zones in Victoria	
Crash Severity	**Estimate of Monthly Net Percentage Reduction**	**Statistical Significance**
Fatal Crashes	44.8%	0.4225
Serious Injury Crashes	46.2%	0.0005
Fatal + Serious Injury Crashes	46.1%	0.0003
Other Injury Crashes	-4.3%	0.7719
All Crashes	22.2%	0.0229

Estimated net percentage change in crashes in 50 km/h zones relative to 60 km/h zones for crashes involving PEDESTRIANS resulting from final study design

	50 km/h zones versus 60 km/h zones in Victoria			
Crash Severity	Estimate of Monthly Net Percentage Reduction	95% Confidence Interval of Net Percentage Reduction	Statistical Significance	95% Confidence Interval of Estimated Crash Savings
Fatal Crashes				
Feb 2001 – Jun 2001	53.6%	(-74.6%, 87.7%)	0.2559	-
Jul 2001 – Dec 2003	27.9%	(-108.4%, 75.1%)	0.5453	-
Feb 2001 – Dec 2003	53.4%	(-75.3%, 87.6%)	0.2589	-
Serious Injury Crashes				
Feb 2001 – Jun 2001	41.5%	(57.9%, 18.7%)	0.0014	(4, 11)
Jul 2001 – Dec 2003	26.8%	(5.8%, 43.2)	0.0153	(1, 8)
Feb 2001 – Dec 2003	30.8%	(16.8%, 56.6%)	0.0021	(3, 11)
Fatal and Serious Injury Crashes				
Feb 2001 – Jun 2001	42.5%	(58.2%, 20.9%)	0.0007	(4, 12)
Jul 2001 – Dec 2003	26.9%	(6.6%, 42.8%)	0.0124	(1, 9)
Feb 2001 – Dec 2003	41.0%	(19.2%, 57.0%)	0.0010	(4, 12)
Other Injury Crashes				
Feb 2001 – Jun 2001	-5.1%	(20.5%, 39.1%)	0.7256	-
Jul 2001 – Dec 2003	-2.9%	(-27.4%, 16.9%)	0.7946	-
Feb 2001 – Dec 2003	-8.7%	(-43.4%, 17.6%)	.05557	-
All Crashes				
Feb 2001 – Jun 2001	19.8%	(34.9%, 1.2%)	0.0383	(1, 16)
Jul 2001 – Dec 2003	11.5%	(-3.9%, 24.7%)	0.1361	-
Feb 2001 – Dec 2003	17.4%	(-1.6%, 32.8%)	0.0698	-



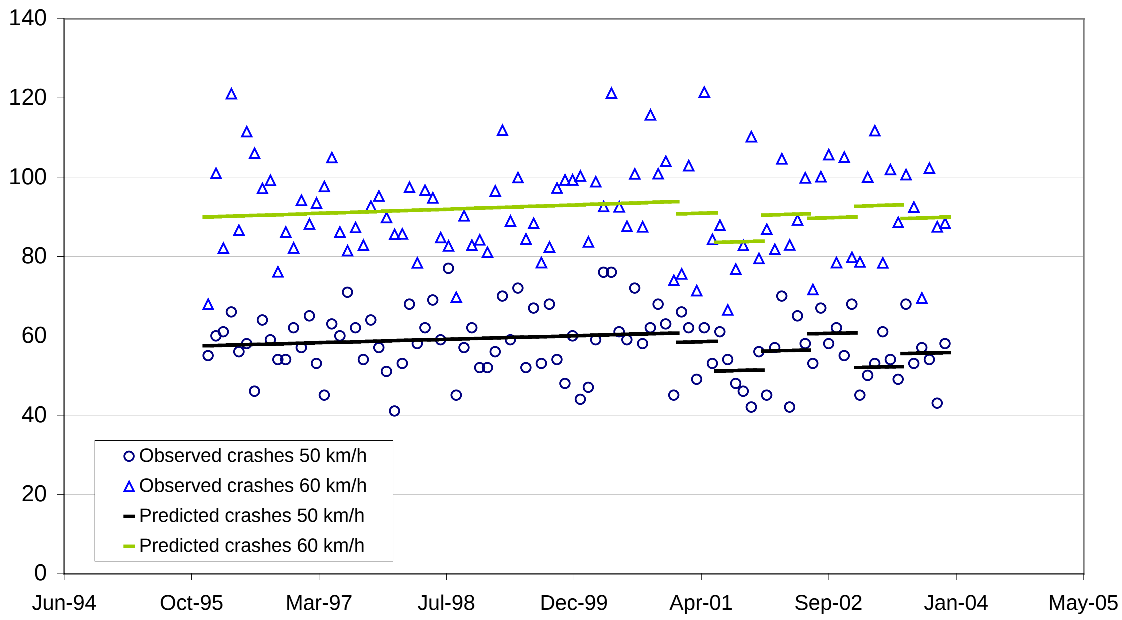
Observed and modelled monthly crash frequency in 50 km/h zones and 60 km/h zones for all casualty crashes involving pedestrians

APPENDIX 2

CRASHES INVOLVING OLDER DRIVERS

Estimated net percentage change in crashes in 50 km/h zones relative to 60 km/h zones for crashes involving OLDER DRIVERS

	50 km/h zones versus 60 km/h zones in Victoria			
Crash Severity	Estimate of Monthly Net Percentage Reduction	95% Confidence Interval of Net Percentage Reduction	Statistical Significance	95% Confidence Interval of Estimated Crash Savings
Fatal Crashes				
Feb 2001 – Jun 2001	-60.8%	(77.9%, -1069.4%)	0.6387	-
Jul 2001 – Dec 2003	-180.7%	(-1150.2%, 37.0%)	0.1756	-
-Feb 2001 – Dec 2003	-103.7%	(-1381.3%, 72.0%)	0.4822	-
Serious Injury Crashes				
Feb 2001 – Jun 2001	8.6%	(34.6%, -27.6%)	0.5970	-
Jul 2001 – Dec 2003	-23.0%	(-25.8%, 35.0%)	0.1273	-
Feb 2001 – Dec 2003	9.6%	(-60.5%, 5.7%)	0.5495	-
Fatal and Serious Injury Crashes				
Feb 2001 – Jun 2001	6.8%	(32.9%, -29.6%)	0.6766	-
Jul 2001 – Dec 2003	-26.4%	(-64.2%, 2.7%)	0.0796	-
Feb 2001 – Dec 2003	7.1%	(-28.6%, 32.9%)	0.6575	-
Other Injury Crashes				
Feb 2001 – Jun 2001	-2.2%	(16.4%, -24.9%)	0.8335	-
Jul 2001 – Dec 2003	13.9%	(-0.9%, 26.5%)	0.0641	-
Feb 2001 – Dec 2003	-3.0%	-25.7%, 15.6%)	0.7717	-
All Crashes				
Feb 2001 – Jun 2001	0.6%	(16.2%, -18.0%)	0.9482	-
Jul 2001 – Dec 2003	4.2%	(-9.7%, 16.3%)	0.5355	-
Feb 2001 – Dec 2003	0.1%	(-18.4%, 15.7%)	0.9933	-



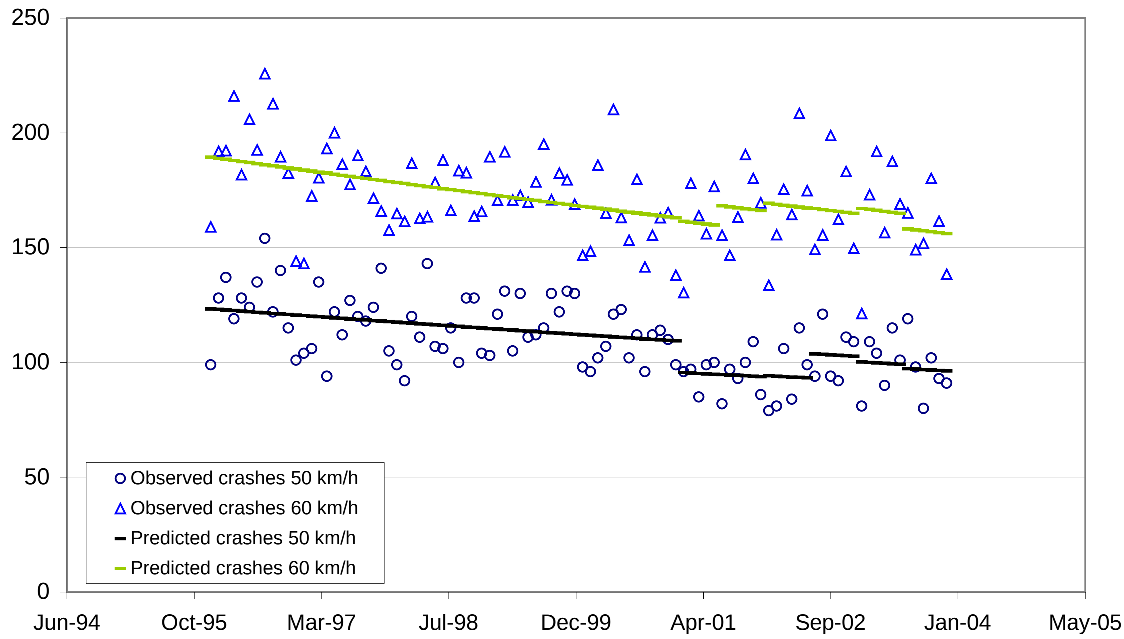
Observed and modelled monthly crash frequency in 50 km/h zones and 60 km/h zones for all casualty crashes involving older drivers

APPENDIX 3

CRASHES INVOLVING YOUNG DRIVERS

Estimated net percentage change in crashes in 50 km/h zones relative to 60 km/h zones for crashes involving YOUNG DRIVERS

	50 km/h zones versus 60 km/h zones in Victoria			
Crash Severity	**Estimate of Monthly Net Percentage Reduction**	**95% Confidence Interval of Net Percentage Reduction**	**Statistical Significance**	**95% Confidence Interval of Estimated Crash Savings**
Fatal Crashes				
Feb 2001 – Jun 2001	79.3%	(97.6%, -81.9%)	0.1556	-
Jul 2001 – Dec 2003	-4.7%	((-200.2%, 63.5%)	0.9318	-
Feb 2001 – Dec 2003	12.8%	(-87.6%, 97.5%)	0.1642	-
Serious Injury Crashes				
Feb 2001 – Jun 2001	-37.4%	(-7.2%, -76.2%)	0.0122	(-22, -2)
Jul 2001 – Dec 2003	-9.6%	(-33.2%, 9.6%)	0.3581	-
Feb 2001 – Dec 2003	-32.1%	(-69.0%, -3.3%)	0.0263	-
Fatal and Serious Injury Crashes				
Feb 2001 – Jun 2001	-32.4%	(-3.7%, -69.2%)	0.0246	(-21, -1)
Jul 2001 – Dec 2003	-9.5%	(-32.7%, 9.6%)	0.3531	
Feb 2001 – Dec 2003	-27.7%	(-62.7%, -0.2%)	0.0482	(-19,0)
Other Injury Crashes				
Feb 2001 – Jun 2001	24.7%	(35.5%, 12.1%)	0.0003	(10, 30)
Jul 2001 – Dec 2003	21.7%	(12.1%, 30.2%)	<0.0001	(10, 26)
Feb 2001 – Dec 2003	24.8%	(12.4%, 35.5%)	0.0003	(11, 30)
All Crashes				
Feb 2001 – Jun 2001	11.8%	(22.6%, -0.5%)	0.0587	-
Jul 2001 – Dec 2003	14.1%	(5.2%, 22.2%0	0.0025	(6, 26)
Feb 2001 – Dec 2003	12.8%	(0.7%, 23.3%)	0.0386	(1, 27)



Observed and modelled monthly crash frequency data in 50 km/h zones and (speed camera hours) adjusted monthly crash frequency in 60 km/h zones for all casualty crashes involving young drivers

APPENDIX 4

SPEED CAMERA ENFORCEMENT DATA

Table A4 1 Number of speed camera hours in metropolitan Melbourne[2] by speed zone

Month/ year	Speed Zone							Total hours per month	Average per speed zone	
	50	60	70	80	90	100	110		50 km/h	60 km/h
Jan-96	282.4	1822.7	249.4	196.4	12.0	103.5	13.1	2679.4		
Feb-96	214.1	1842.5	355.7	137.1	6.0	52.9	20.1	2628.4		
Mar-96	229.8	1925.2	285.3	168.5	26.2	109.4	13.0	2757.4		
Apr-96	239.4	1757.7	279.1	104.9	19.5	121.0	15.0	2536.5		
May-96	285.2	1873.1	357.4	121.2	-	96.3	15.0	2748.1		
Jun-96	199.4	1746.8	275.4	157.0	4.9	145.9	15.0	2544.3		
Jul-96	241.7	1828.0	300.4	147.5	13.7	104.8	15.2	2651.3		
Aug-96	241.7	1828.0	300.4	147.5	13.7	104.8	15.2	2651.3		
Sep-96	241.7	1828.0	300.4	147.5	13.7	104.8	15.2	2651.3		
Oct-96	241.7	1828.0	300.4	147.5	13.7	104.8	15.2	2651.3		
Nov-96	241.7	1828.0	300.4	147.5	13.7	104.8	15.2	2651.3		
Dec-96	241.7	1828.0	300.4	147.5	13.7	104.8	15.2	2651.3	241.7	1838.5
Jan-97	182.8	1848.2	319.2	169.7	16.9	122.9	-	2659.6		
Feb-97	176.3	1679.9	293.4	127.4	15.0	136.7	10.2	2438.8		
Mar-97	368.1	1942.9	557.1	274.6	30.5	259.2	20.3	3452.8		
Apr-97	202.4	1659.3	346.8	214.8	1.1	121.9	-	2546.1		
Jun-97	147.9	1853.6	364.5	328.1	11.3	140.9	8.7	2854.9		
Jul-97	157.2	2063.0	279.0	157.8	-	150.7	10.0	2817.7		
Aug-97	179.1	1982.4	332.8	183.3	-	119.5	15.0	2812.2		
Sep-97	208.5	1712.3	304.7	197.8	5.0	71.6	15.0	2514.8		
Oct-97	226.1	1801.0	309.3	201.0	5.0	114.6	10.0	2666.9		
Nov-97	146.3	1793.7	254.4	232.5	14.2	81.8	-	2523.0		
Dec-97	170.5	1887.9	271.4	141.3	10.0	163.2	23.9	2668.1	196.8	2002.5
Jan-98	217.1	1749.2	277.6	153.8	5.0	166.5	29.9	2599.2		
Feb-98	146.0	1833.9	326.2	123.3	10.0	72.3	10.0	2521.7		
Mar-98	178.5	1861.9	261.3	163.7	-	122.0	25.0	2612.4		
Apr-98	142.7	1600.0	369.6	174.6	12.5	123.1	15.1	2437.6		
May-98	178.2	1940.4	335.8	177.7	-	68.6	25.2	2725.8		
Jun-98	150.0	1718.4	305.7	206.5	6.0	74.6	25.0	2486.1		
Jul-98	171.2	1734.6	330.3	83.2	10.4	56.7	28.3	2414.7		
Aug-98	176.1	1697.1	337.9	204.9	7.8	148.3	28.2	2600.3		
Sep-98	172.4	1843.7	288.0	152.8	15.0	125.6	38.1	2635.5		
Oct-98	176.7	1767.6	275.8	103.0	18.5	127.8	18.0	2487.4		
Nov-98	201.2	1843.4	279.3	148.8	14.1	136.7	32.0	2655.6		
Dec-98	280.3	2228.0	410.6	327.2	31.5	261.0	20.0	3558.7	179.4	1824.5
Jan-99	159.4	1551.0	252.1	196.2	5.1	187.6	33.0	2384.3		
Feb-99	171.3	1738.8	197.1	180.7	10.0	96.5	4.0	2398.5		
Mar-99	207.5	1769.5	242.0	95.2	5.0	70.0	14.0	2403.2		
Apr-99	178.4	1605.8	188.4	141.3	22.0	203.1	5.0	2344.0		
May-99	179.2	1666.2	219.9	153.4	10.5	139.3	14.0	2382.5		
Jun-99	179.2	1666.2	219.9	153.4	10.5	139.3	14.0	2382.5		
Jul-99	179.2	1666.2	219.9	153.4	10.5	139.3	14.0	2382.5		
Aug-99	179.2	1666.2	219.9	153.4	10.5	139.3	14.0	2382.5		
Sep-99	179.2	1666.2	219.9	153.4	10.5	139.3	14.0	2382.5		
Oct-99	179.2	1666.2	219.9	153.4	10.5	139.3	14.0	2382.5		
Nov-99	179.2	1666.2	219.9	153.4	10.5	139.3	14.0	2382.5		
Dec-99	179.2	1666.2	219.9	153.4	10.5	139.3	14.0	2382.5	179.2	1666.2

[2] In accordance with Victoria Police regional and divisional boundaries

Jan-00	249.5	1649.4	297.9	129.9	12.0	124.5	7.0	2470.2		
Feb-00	194.2	1722.9	296.5	113.1	0.0	147.9	5.0	2479.6		
Mar-00	234.3	1671.7	266.0	156.2	5.0	134.1	6.5	2473.7		
Apr-00	228.7	1632.2	282.3	140.2	0.0	151.7	32.0	2467.0		
May-00	205.3	1840.6	328.4	101.1	12.0	78.6	6.0	2572.1		
Jun-00	244.3	1662.1	333.5	178.5	12.0	99.0	9.0	2538.4		
Jul-00	239.1	1727.7	355.4	225.0	6.0	91.6	25.5	2670.3		
Aug-00	240.9	1670.6	329.5	229.9	12.0	94.8	22.0	2599.7		
Sep-00	224.2	1717.3	354.4	265.6	10.0	93.6	16.0	2680.9		
Oct-00	207.0	1725.6	346.5	170.8	10.0	120.0	26.0	2605.9		
Nov-00	227.7	1599.8	417.8	217.9	5.0	107.7	16.0	2591.9		
Dec-00	231.9	1534.2	309.4	252.2	32.0	123.7	5.0	2488.4	225.2	1682.2
Jan-01	251.1	1661.9	308.8	287.3	11.0	114.1	17.0	2651.1		
Feb-01	115.5	1592.1	304.8	291.4	19.7	96.8	9.3	2429.6		
Mar-01	76.0	1636.5	351.6	265.7	29.0	92.7	24.4	2475.9		
Apr-01	51.5	1687.9	360.8	242.0	18.0	66.5	25.6	2452.4		
May-01	85.3	1633.8	387.6	284.0	46.2	76.0	10.0	2522.9		
Jun-01	247.0	1553.7	341.7	229.6	43.4	67.5	10.0	2492.8		
Jul-01	211.6	1653.2	322.3	253.0	23.0	70.8	7.4	2541.3		
Aug-01	254.7	1954.4	416.1	249.8	24.0	80.4	16.0	2995.5		
Sep-01	223.7	1937.3	375.6	329.0	21.0	130.3	10.0	3026.9		
Oct-01	259.1	1955.2	413.4	270.6	24.0	116.1	16.0	3054.4		
Nov-01	232.0	1892.0	345.6	368.6	25.4	148.6	10.0	3022.1		
Dec-01	212.0	1940.9	345.7	420.9	26.0	156.0	35.2	3136.6	178.9	1767.0
Jan-02	273.8	1949.1	355.7	448.1	24.3	167.6	68.0	3286.6		
Feb-02	330.1	2002.6	460.2	344.5	22.0	146.5	31.9	3337.8		
Mar-02	334.9	2349.1	408.3	336.4	24.9	89.8	19.0	3562.3		
Apr-02	288.7	2183.7	520.9	300.4	24.0	161.4	44.1	3523.1		
May-02	342.0	2402.1	501.9	289.7	37.0	112.3	17.0	3702.1		
Jun-02	399.2	2384.4	511.1	268.7	39.5	85.4	15.1	3703.4		
Jul-02	444.9	2269.0	526.2	311.0	32.1	87.4	12.0	3682.5		
Aug-02	394.7	2341.6	522.9	322.4	30.1	100.2	15.0	3726.9		
Sep-02	366.2	2022.1	475.3	335.5	26.0	120.3	16.0	3361.4		
Oct-02	398.7	2368.9	504.9	335.1	28.0	74.4	9.0	3719.0		
Nov-02	381.0	2125.8	463.4	360.1	26.6	72.5	18.0	3447.4		
Dec-02	380.5	2097.4	473.9	352.4	46.2	140.5	27.0	3517.8	369.2	2231.5
Jan-03	379.2	2278.1	502.2	326.8	25.0	112.1	17.0	3640.4		
Feb-03	350.5	2311.6	498.4	346.3	17.0	108.7	15.0	3647.4		
Mar-03	375.4	2272.9	461.6	234.4	16.5	166.6	48.0	3575.3		
Apr-03	505.4	2082.7	516.9	232.5	27.0	136.5	36.0	3537.0		
May-03	429.1	2283.4	472.3	263.2	20.0	169.5	30.0	3667.4		
Jun-03	374.8	2076.1	486.9	307.0	37.3	178.9	49.0	3510.0		
Jul-03	456.2	2240.3	457.3	322.0	21.0	163.6	37.0	3697.3		
Aug-03	395.7	2168.1	485.1	395.5	17.0	191.3	43.0	3695.6		
Sep-03	496.6	2320.0	412.1	351.5	19.0	216.8	35.0	3850.9		
Oct-03	531.1	2256.3	461.9	312.6	50.0	182.5	31.1	3825.4		
Nov-03	559.4	2242.5	449.9	340.8	30.1	159.9	18.0	3800.6		
Dec-03	549.9	2206.2	396.9	299.6	17.1	260.1	59.6	3789.3	456.7	2223.6

NB: For the months where data on speed camera hours was not available, the average for the period for which this information is available in a given year was used as a substitute for the missing data.

Table A4 2 Percentage of speed camera hours in metropolitan Melbourne by speed zone

	50	60	70	80	90	100	110	Total
Jan-96	10.54	68.02	9.31	7.33	0.45	3.86	0.49	100
Feb-96	8.15	70.10	13.53	5.22	0.23	2.01	0.77	100
Mar-96	8.33	69.82	10.35	6.11	0.95	3.97	0.47	100
Apr-96	9.44	69.30	11.00	4.14	0.77	4.77	0.59	100
May-96	10.38	68.16	13.00	4.41	0.00	3.50	0.55	100
Jun-96	7.84	68.66	10.82	6.17	0.19	5.73	0.59	100
Jul-96	9.12	68.95	11.33	5.56	0.52	3.95	0.57	100
Aug-96	9.12	68.95	11.33	5.56	0.52	3.95	0.57	100
Sep-96	9.12	68.95	11.33	5.56	0.52	3.95	0.57	100
Oct-96	9.12	68.95	11.33	5.56	0.52	3.95	0.57	100
Nov-96	9.12	68.95	11.33	5.56	0.52	3.95	0.57	100
Dec-96	9.12	68.95	11.33	5.56	0.52	3.95	0.57	100
Jan-97	6.87	69.49	12.00	6.38	0.64	4.62	0.00	100
Feb-97	7.23	68.88	12.03	5.22	0.62	5.60	0.42	100
Mar-97	7.00	71.27	10.60	5.23	0.58	4.93	0.39	100
Apr-97	7.95	65.17	13.62	8.44	0.04	4.79	0.00	100
Jun-97	5.18	64.93	12.77	11.49	0.40	4.93	0.30	100
Jul-97	5.58	73.22	9.90	5.60	0.00	5.35	0.35	100
Aug-97	6.37	70.49	11.83	6.52	0.00	4.25	0.53	100
Sep-97	8.29	68.09	12.11	7.86	0.20	2.85	0.60	100
Oct-97	8.48	67.53	11.60	7.53	0.19	4.30	0.37	100
Nov-97	5.80	71.10	10.08	9.22	0.56	3.24	0.00	100
Dec-97	6.39	70.76	10.17	5.30	0.37	6.11	0.90	100
Jan-98	8.35	67.30	10.68	5.92	0.19	6.41	1.15	100
Feb-98	5.79	72.72	12.93	4.89	0.40	2.87	0.40	100
Mar-98	6.83	71.27	10.00	6.26	0.00	4.67	0.96	100
Apr-98	5.86	65.64	15.16	7.16	0.51	5.05	0.62	100
May-98	6.54	71.19	12.32	6.52	0.00	2.52	0.92	100
Jun-98	6.03	69.12	12.29	8.31	0.24	3.00	1.01	100
Jul-98	7.09	71.84	13.68	3.44	0.43	2.35	1.17	100
Aug-98	6.77	65.27	12.99	7.88	0.30	5.70	1.08	100
Sep-98	6.54	69.96	10.93	5.80	0.57	4.76	1.44	100
Oct-98	7.10	71.06	11.09	4.14	0.74	5.14	0.72	100
Nov-98	7.58	69.42	10.52	5.60	0.53	5.15	1.21	100
Dec-98	7.88	62.61	11.54	9.19	0.88	7.33	0.56	100
Jan-99	6.69	65.05	10.57	8.23	0.21	7.87	1.38	100
Feb-99	7.14	72.49	8.22	7.53	0.42	4.02	0.17	100
Mar-99	8.63	73.63	10.07	3.96	0.21	2.91	0.58	100
Apr-99	7.61	68.50	8.04	6.03	0.94	8.66	0.21	100
May-99	7.52	69.94	9.23	6.44	0.44	5.85	0.59	100
Jun-99	7.52	69.94	9.23	6.44	0.44	5.85	0.59	100
Jul-99	7.52	69.94	9.23	6.44	0.44	5.85	0.59	100
Aug-99	7.52	69.94	9.23	6.44	0.44	5.85	0.59	100
Sep-99	7.52	69.94	9.23	6.44	0.44	5.85	0.59	100
Oct-99	7.52	69.94	9.23	6.44	0.44	5.85	0.59	100
Nov-99	7.52	69.94	9.23	6.44	0.44	5.85	0.59	100
Dec-99	7.52	69.94	9.23	6.44	0.44	5.85	0.59	100
Jan-00	10.10	66.77	12.06	5.26	0.49	5.04	0.28	100
Feb-00	7.83	69.48	11.96	4.56	0.00	5.97	0.20	100
Mar-00	9.47	67.58	10.75	6.31	0.20	5.42	0.26	100
Apr-00	9.27	66.16	11.44	5.68	0.00	6.15	1.30	100
May-00	7.98	71.56	12.77	3.93	0.47	3.06	0.23	100
Jun-00	9.63	65.48	13.14	7.03	0.47	3.90	0.35	100
Jul-00	8.95	64.70	13.31	8.43	0.22	3.43	0.95	100

Aug-00	9.27	64.26	12.68	8.84	0.46	3.65	0.85	100
Sep-00	8.36	64.05	13.22	9.91	0.37	3.49	0.60	100
Oct-00	7.94	66.22	13.30	6.55	0.38	4.61	1.00	100
Nov-00	8.79	61.72	16.12	8.41	0.19	4.16	0.62	100
Dec-00	9.32	61.65	12.43	10.14	1.28	4.97	0.20	100
Jan-01	9.47	62.69	11.65	10.84	0.42	4.30	0.64	100
Feb-01	4.75	65.53	12.54	11.99	0.81	3.99	0.38	100
Mar-01	3.07	66.10	14.20	10.73	1.17	3.74	0.98	100
Apr-01	2.10	68.83	14.71	9.87	0.73	2.71	1.05	100
May-01	3.38	64.76	15.36	11.26	1.83	3.01	0.40	100
Jun-01	9.91	62.32	13.71	9.21	1.74	2.71	0.40	100
Jul-01	8.33	65.06	12.68	9.95	0.91	2.78	0.29	100
Aug-01	8.50	65.24	13.89	8.34	0.80	2.69	0.53	100
Sep-01	7.39	64.00	12.41	10.87	0.69	4.30	0.33	100
Oct-01	8.48	64.01	13.54	8.86	0.78	3.80	0.52	100
Nov-01	7.68	62.61	11.43	12.20	0.84	4.92	0.33	100
Dec-01	6.76	61.88	11.02	13.42	0.83	4.97	1.12	100
Jan-02	8.33	59.30	10.82	13.63	0.74	5.10	2.07	100
Feb-02	9.89	60.00	13.79	10.32	0.66	4.39	0.96	100
Mar-02	9.40	65.94	11.46	9.44	0.70	2.52	0.53	100
Apr-02	8.20	61.98	14.79	8.53	0.68	4.58	1.25	100
May-02	9.24	64.89	13.56	7.83	1.00	3.03	0.46	100
Jun-02	10.78	64.39	13.80	7.26	1.07	2.31	0.41	100
Jul-02	12.08	61.62	14.29	8.44	0.87	2.37	0.33	100
Aug-02	10.59	62.83	14.03	8.65	0.81	2.69	0.40	100
Sep-02	10.89	60.16	14.14	9.98	0.77	3.58	0.48	100
Oct-02	10.72	63.70	13.58	9.01	0.75	2.00	0.24	100
Nov-02	11.05	61.66	13.44	10.45	0.77	2.10	0.52	100
Dec-02	10.82	59.62	13.47	10.02	1.31	3.99	0.77	100
Jan-03	10.42	62.58	13.80	8.98	0.69	3.08	0.47	100
Feb-03	9.61	63.38	13.67	9.49	0.47	2.98	0.41	100
Mar-03	10.50	63.57	12.91	6.56	0.46	4.66	1.34	100
Apr-03	14.29	58.88	14.61	6.57	0.76	3.86	1.02	100
May-03	11.70	62.26	12.88	7.18	0.55	4.62	0.82	100
Jun-03	10.68	59.15	13.87	8.75	1.06	5.10	1.40	100
Jul-03	12.34	60.59	12.37	8.71	0.57	4.42	1.00	100
Aug-03	10.71	58.67	13.13	10.70	0.46	5.18	1.16	100
Sep-03	12.90	60.24	10.70	9.13	0.49	5.63	0.91	100
Oct-03	13.88	58.98	12.08	8.17	1.31	4.77	0.81	100
Nov-03	14.72	59.00	11.84	8.97	0.79	4.21	0.47	100
Dec-03	14.51	58.22	10.47	7.91	0.45	6.86	1.57	100

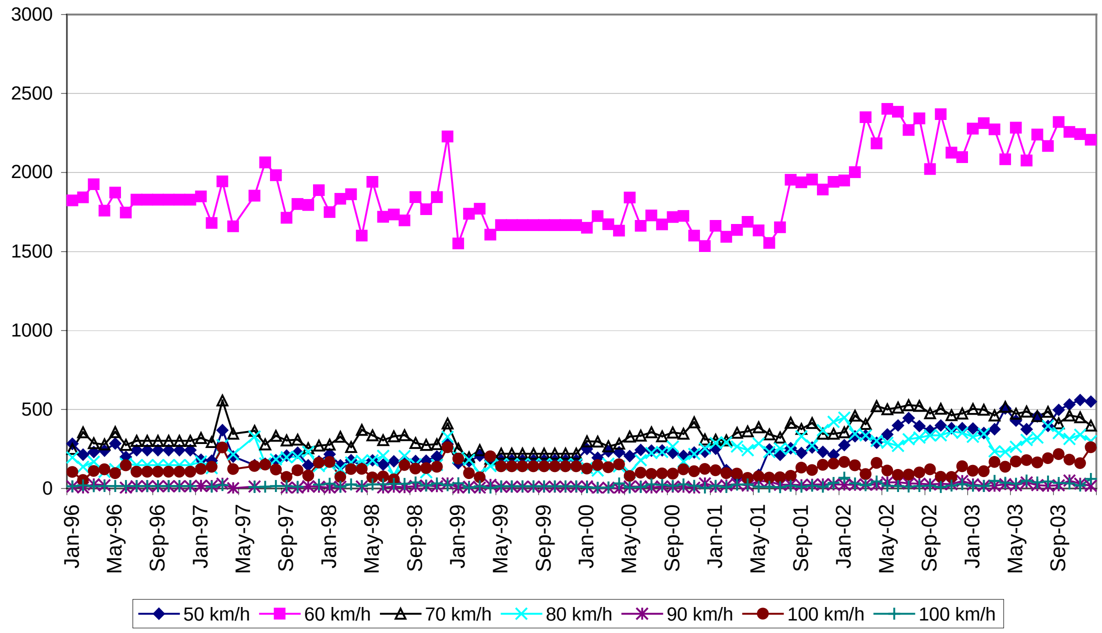


Figure A4 1 Number of speed camera hours in metropolitan Melbourne by speed zone

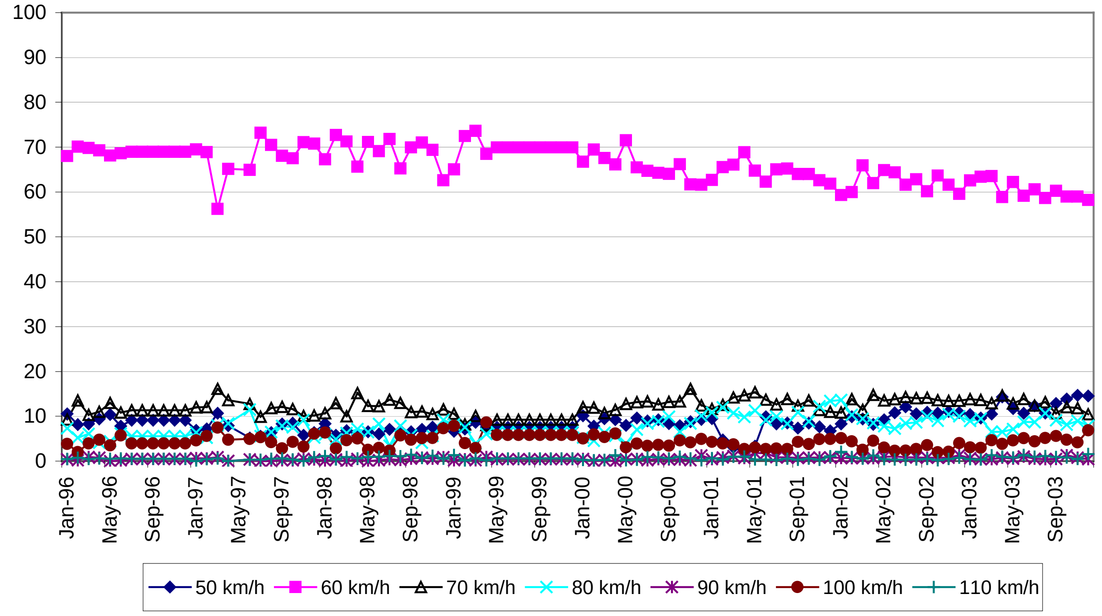


Figure A4 2 Percentage of speed camera hours in metropolitan Melbourne by speed zone