A STATISTICAL EVALUATION OF THE DEFAULT 50 KM/H SPEED LIMITS IN VICTORIA

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ABSTRACT

Victoria introduced a statewide 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. The first evaluation, covering the first five months of the initiative, showed that the program was associated with statistically significant reductions for all casualty crashes. Results of the second evaluation were unable to show continuing crash reductions for the six to seventeen month post implementation period. Closer inspection of the data suggested that this was not necessarily an indication that the 50 km/h speed limit was no longer effective in reducing crashes, but an issue relating to the study design used. Specifically, it was believed that contamination of the comparison group (as defined by the study design) had occurred due to the introduction of a number of new speed enforcement initiatives. To overcome this issue, an alternative methodology was devised and applied to data covering a 35-month post implementation period allowing the effects of the 50 km/h speed limits to be estimated separately. This alternative methodology is described in detail, as well as the results derived from this study design.

INTRODUCTION AND BACKGROUND

A statewide 50km/h default urban speed limit was introduced in Victoria on 22 January 2001 applying principally to residential streets, and on a proportion of collector roads. The remainder of the road network 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 an evaluation was conducted 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, conducted in March 2002 (Hoareau, Newstead and 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 relative to crashes on 60 km/h roads.

A second interim evaluation was conducted 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 most significant of these was the 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. The greatest proportion of this increase was directed to 60 km/h speed zones. Other initiatives introduced during this period included flashless cameras (phased in from December 2000) and reduced speed tolerances.

This operational policy change presented a methodological challenge 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. Under this design framework, analysis showed that statistically significant crash reductions were achieved during a period where the only change over the study period had been the introduction of the default speed limits. Using the same design, the results of the second interim evaluation, showed the default speed limits to no longer be effective in the six to seventeen months after the introduction of the default limits. However, an examination of the monthly crash data series showed sustained crash reductions in the seventeen-month period after implementation in the order of that observed in the first five months post implementation.

In comparison, monthly crash numbers in the comparison group used in the study showed large reductions in the period from six to seventeen months post implementation. This finding suggested that 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 the third and final evaluation. This alternative method has been applied to the entire study period covering 35 months of post implementation data and the results reported in this paper. This length of time was considered sufficient to establish the long-term effectiveness of the initiative.

METHOD

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 (NSW RTA 2000), South East Queensland (Hoareau, Newstead, Oxley, Cameron 2003) 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.

Crash history on those roads that became 50km/h was compared from before the change to after the change. This was then compared to changes in crash history at a suitably comparable ‘control’ site over the same before and after time periods. The net difference in the before to after 50 km/h implementation crash frequency change between the treatment and control sites was the estimated effect of the 50km/h change. It was necessary to use a control group in this study, rather than simply comparing crash history before and after change on the 50 km/h roads, to represent the influence of other factors, besides the 50 km/h introduction, on crash frequency.

Final Design

The first interim analysis results, obtained using the initial study design, showed statistically significant crash reductions had been achieved during the first five months following implementation, a period during which the control series had remained relatively stable. However, in the period six to seventeen months post implementation, new speed enforcement initiatives were introduced, the effects of which became apparent in the second interim evaluation. Large crash reductions in 60 km/h zones were found and were thought to be largely associated by the phased increases in speed camera hours from August 2001 to February 2002. The association between these increases in speed camera hours and crash frequency reduction has been confirmed in a number of studies and more recently in Bobevski, Hosking, Oxley and Cameron (2004) where crash and enforcement data used was similar to that used in this evaluation.

The above finding and the fact that the largest proportion of the increase in hours was targeted at 60 km/h roads provided sufficient grounds to alter the initial design by statistically adjusting for the increase in speed camera hours on 60 km/h roads only, to remove their effect. The Bobevski et al (2004) study also assumed a one-month lag between the detection of a speeding offence and the potential behaviour change leading to a reduction in casualty crashes in their analysis. This decision was based on prior research carried out by Cameron, Newstead, Diamantopoulou and Oxley (2003) where it was found that an increase in traffic infringement notices issued resulted in a reduction in casualty crashes in the following month.

On the basis of these rationales, crash frequency in 60 km/h zones was adjusted for the effect of speed camera hours lagged by one month. This adjusted crash series was then used 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 severity levels examined within each target group and for each of the severity levels for all crashes combined. The effect of lagged speed camera hours on casualty crash frequency (all casualty crashes combined) on 60 km/h roads can be seen in the adjusted control series (casualty crashes on 60 km/h roads). The distances between 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.

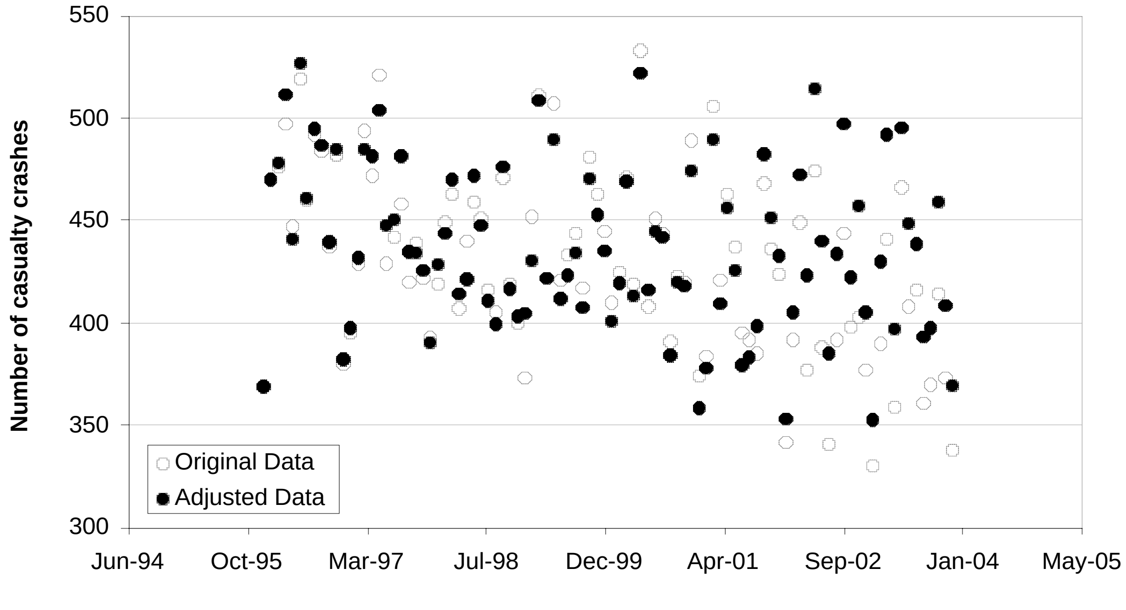

Figure 1 Adjusted casualty crash series on roads that remained 60 km/h

In statistical terms the following Poisson regression model was fitted to the monthly control series with lagged speed camera hours as a covariate,

$$\ln(y) = \beta_0 + \beta_{1x}$$

where

y is the monthly crash count in the control group

x is the lagged speed camera hours

β are parameters of the model[1].

Identification of Treatment and Control Groups

The ideal choice of treatment group would be to consist of all those roads in the state that had been re-zoned to 50 km/h with the introduction of the new default speed limit. Identification of these crashes was enabled through the use of an electronic map coverage generated for use in the Transport Accident Commission funded Safe-car project (Healy 2002). The treatment group, based on the speed zone map coverage, were crashes on those roads that had a current speed zoning of 50 km/h, while crashes that had occurred on roads that had a current speed zone of 60 km/h comprised the comparison group.

A major flaw in using the Melway map coverage (local street directory coverage for metropolitan Melbourne) to define the treated area in this study pertained to the uncertainty of whether all local roads had been changed to 50 km/h and to the unknown proportion of 60 km/h roads changed to 50 km/h. Using the Melway road hierarchy levels to identify the 50 km/h roads for crash analysis would have resulted in identifying 60 km/h collector roads as treated sites, thereby compromising the accuracy of the study. Consequently, the option to use the speed zone coverage generated for the TAC safe car project to identify crashes on those roads changing to 50 km/h, was deemed most suitable. This decision was further justified by the greater precision offered by the Safe-car coverage in identifying areas from which to draw control crashes for the analysis.

Using the TAC safe car 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 50 km/h change was implemented. These roads were likely to be most comparable to the 50 km/h roads in terms of physical and traffic characteristics.

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

Crash data

Crash data 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

[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.

occurring in both regional and metropolitan Victoria although, as noted above, only crash data covered in the Melway coverage 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 currently zoned 50km/h which were previously 60 km/h along with crashes occurring in areas that have remained zoned at other speeds (the 'control' crashes). This speed zone labelling process required the linking of the electronic speed zone map from the TAC safe car 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 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. The after treatment period was chosen as February 2001 to December 2003.

Speed Camera 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. Detail 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.

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 were supported by changes in speeding behaviour. VicRoads commissioned Ratio Consultants to undertake a collection and analysis of speed data associated with the introduction of the 50km/h limit. A report on the analysis of data collected was released, however, this covered only the first five months following implementation. Results of this report showed that there had been a net decrease of 1 km/h in 50 km/h roads relative to 60 km/h roads. No further collection of speed monitoring data has taken place for the purposes of this evaluation.

Statistical Analysis
Poisson regression models were used to assess statistically the crash effects of the 50 km/h implementation on local roads. This technique assumes that crash data follow a Poisson distribution, a distribution commonly assumed for crash data (Nicholson, 1985; Nicholson , 1986). The theoretical basis for this assumption 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. 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. A maximum likelihood method is

used to estimate the coefficients of the explanatory variables while suitable parameterisation of the model allows direct estimation of the program effect estimate. 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.

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) and control (60 km/h; or 60 km/h and above) areas,

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

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.

The after period variable consists of six time periods. These are February 2001 to June 2001, July 2001 to December 2001, January 2002 to June 2002, July 2002 to December 2002, January 2003 to June 2003 and July 2003 to December 2003. Consequently, the before or after index in the regression model, b, takes seven levels: one for the before treatment period and one for each of the six 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. The effect of the initiative on specific road user groups was also examined at various severity levels. These groups included pedestrians, young drivers and older drivers.

RESULTS

All Casualty Crashes

This section presents the results of the Poisson regression analysis performed for all crashes that occurred on 50 km/h roads and 60 km/h roads. Only statistically significant findings for each of the specific road user groups analysed are summarised at the end of this section.

Table 1 presents the six-monthly 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. These results were obtained using Poisson regression analysis 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 table 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. Confidence intervals have been calculated with a 95% confidence coefficient.

Results of the analysis of fatal and serious injury crashes, below, do not show any statistically significant results. An analysis of these two injury categories combined also did not produce any statistically reliable estimates. This outcome is most likely due to the relatively small crash numbers in these categories. Statistically reliable estimates, however, were obtained for the 'other' injury severity category analysed. Over the 35 month period point estimates ranged from 12% in the first five months to 23% in the January to June 2003 period, with the trend towards greater crash reductions over time. Effect estimates for all casualty crashes combined ranged from 10% to 16%. Like 'other' injury crashes, the greatest gains were also achieved during the January to June 2003 period.

Table 1 Estimated net percentage change in casualty crashes 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 Change**	**95% Confidence Interval of Net Percentage Reduction**	**Statistical Significance**
Fatal Crashes			
Feb 2001 – Jun 2001	50.8%	(77.5%, 7.6%)	0.0758
Jul 2001 – Dec 2001	-26.5%	(27.0%, 119.2%)	0.4022
Jan 2002 – Jun 2002	47.9%	(74.5%, 6.2%)	0.0728
Jul 2002 – Dec 2002	5.4%	(53.2%, 91.2%)	0.8762
Jan 2003 – Jun 2003	6.9%	(55.4%, 94.5%)	0.8495
Jul 2003 – Dec 2003	37.5%	(75.8%, 61.5%)	0.3321
Serious Injury Crashes			
Feb 2001 – Jun 2001	7.3%	20.0%, 7.4%	0.3128
Jul 2001 – Dec 2001	8.5%	20.9%, 5.8%	0.2300
Jan 2002 – Jun 2002	-1.4%	12.7%, 17.8%	0.8515
Jul 2002 – Dec 2002	-11.6%	4.4%, 30.2%	0.1643
Jan 2003 – Jun 2003	-1.3%	14.2%, 19.5%	0.8817
Jul 2003 – Dec 2003	-8.1%	9.2%, 28.6%	0.3824
Fatal and Serious Injury Crashes			
Feb 2001 – Jun 2001	8.8%	21.0%, 5.2%	0.2068
Jul 2001 – Dec 2001	7.1%	19.3%, 6.9%	0.3023
Jan 2002 – Jun 2002	0.3%	13.8%, 15.3%	0.9673
Jul 2002 – Dec 2002	-11.1%	4.4%, 29.1%	0.1693
Jan 2003 – Jun 2003	-1.1%	13.9%, 18.7%	0.8930
Jul 2003 – Dec 2003	-7.0%	9.6%, 26.8%	0.4306
Other Injury Crashes			
Feb 2001 – Jun 2001	11.8%	18.9%, 3.9%	0.0039
Jul 2001 – Dec 2001	15.9%	22.7%, 8.5%	<0.0001
Jan 2002 – Jun 2002	16.7%	23.6%, 9.1%	<0.0001
Jul 2002 – Dec 2002	17.8%	24.9%, 9.9%	<0.0001
Jan 2003 – Jun 2003	22.8%	29.9%, 15.0%	<0.0001
Jul 2003 – Dec 2003	21.5%	29.1%, 13.0%	<0.0001
All Crashes			
Feb 2001 – Jun 2001	10.9%	(17.6%, 3.7%)	0.0036
Jul 2001 – Dec 2001	13.5%	(19.8%, 6.6%)	0.0002
Jan 2002 – Jun 2002	12.2%	(18.8%, 4.9%)	0.0013
Jul 2002 – Dec 2002	9.9%	(17.1%, 2.2%)	0.0131
Jan 2003 – Jun 2003	16.4%	(23.4%, 8.8%)	<0.0001
Jul 2003 – Dec 2003	13.8%	(21.5%, 5.5%)	0.0016

Figure 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. The estimated step changes in the six-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 a 11% reduction in crashes.

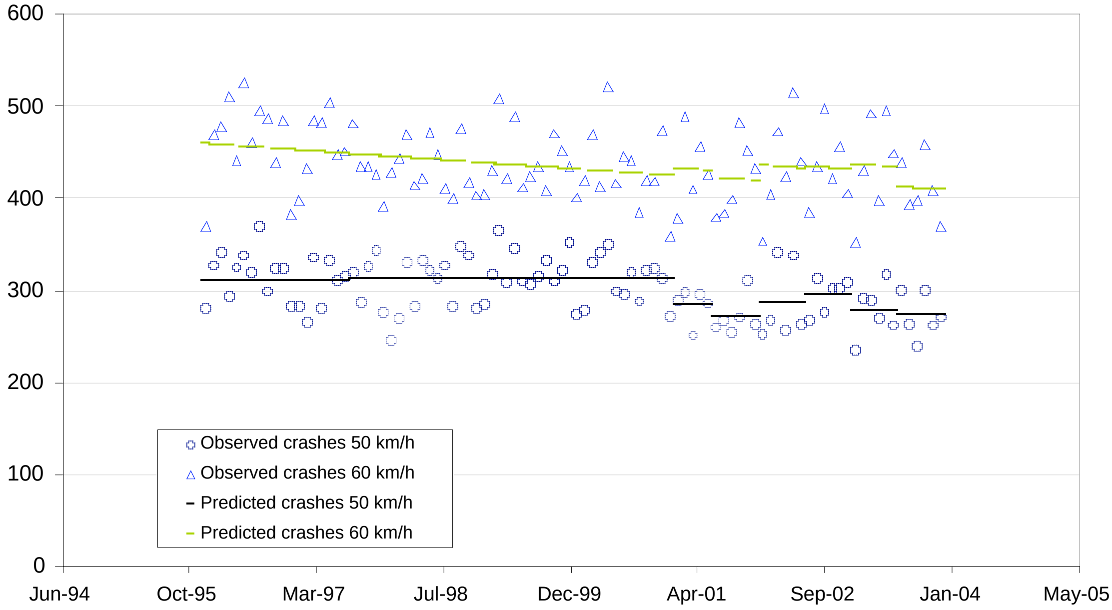

Figure 2 Observed and modelled monthly crash frequency in 50 km/h zones and 60 km/h zones for all casualty crash types

Specific Road User Groups

The main findings of the six monthly effect estimates for crashes involving specific road user groups are summarised below.

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. Analysis of the following 18 months did not produce any statistically reliable effects, however, a statistically reliable estimate of 33% was detected in the period January to June 2003. The largest statistically significant effects associated with the default limits were found in serious injury crashes involving pedestrians. Relative to crashes in 60 km/h zones, reductions in the order of 41% were found for serious injury crashes in the first five months post introduction. No significant effects were associated with the initiative in the following 12 months, however, from July 2002 to June 2003, crashes decreased by between 37% to 40%. No statistically reliable estimates were obtained for fatal crashes involving pedestrians.

Crashes Involving Older Drivers: Analysis of this road user group (ie, drivers aged 55 years and over) revealed only one statistically significant results. This was associated with ‘other’ injury crashes in the period January 2003 to June 2003 where crashes decreased by 20% relative to crashes in 60 km/h zones.

Crashes Involving Young Drivers: Analysis of crashes involving young drivers, (defined as drivers aged 18 to 25), revealed that the 50 km/h speed limits were associated with a sustained reduction over the entire post implementation period for the severity category of ‘other’ injury crashes. These reductions, all of which were statistically significant, ranged between 19% and 25%, and averaged 22% over the entire post period. When all crashes involving young drivers were examined, statistically reliable estimates in the range of 12% to 18% were found, relative to crashes in 60 km/h, with the trend toward greater reductions over the initial 17 month post introduction period. Statistically reliable effects were not detected after this period for all crashes combined.

DISCUSSION

Validity of alternative study 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. Results using the initial study design showed that a net crash reduction of 13% was achieved, relative to 60 km/h zones, in the first five months of the program following implementation. Analysis using the alternative study design produced a comparable outcome to the initial analysis for the first five-month period following implementation, where a net percentage crash reduction of 11% was estimated.

These comparable results indicate that the alternative methodology was able to effectively account for the effect on crash frequency due to the increase in speed camera hours on 60 km/h roads, thus enabling the estimation of the net effect of the default speed limits. It also showed that the other speed enforcement initiatives introduced throughout the post implementation period, including flashless cameras and reduced speed tolerances, did not have as great an influence on crashes on 60 km/h roads as did the increase in speed camera hours.

Although the effect of the increase in speed camera hours was removed in the comparison group, it was not considered necessary to apply this same procedure to the treatment group. Any significant speed camera activity directed to 50 km/h roads was introduced to support the implementation and was considered to be part of the ‘treatment’ effect in this study.

Specific road user groups

As shown in the first evaluation of this initiative in Hoareau et al (2002), this final evaluation has also shown that the greatest casualty crash reductions were achieved for crashes involving pedestrians. Although statistically significant results were not found in the 18 month period from June 2001 to December 2002, this is not an indication that pedestrians did not benefit from the reduced speed limits during this time only that there is insufficient evidence to suggest the program was effective during this period. This is also the case where only one statistically significant result was found for crashes involving older drivers.

CONCLUSIONS

This study has found that the implementation of the default 50 km/h speed limits was associated with statistically significant crash reductions relative to crashes on 60 km/h roads, which provide reliable evidence in support of the success of the program. The comparable results from the two study designs show that the alternative study design was able to successfully remove the effect of increased enforcement in 60 km/h zones on crash frequency so that the effects of the default limits solely could be determined. This outcome indicates that rationale for choosing the alternative study design appears to be methodologically sound.

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 Safe Car 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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