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EVALUATION OF THE QUEENSLAND RANDOM ROAD WATCH PROGRAM

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Abstract:

This report describes the results of an evaluation of the crash effects of Random Road Watch, a traffic policing program currently in operation in Queensland. The difference between Random Road Watch (RRW) and conventional traffic policing is the resource management technique used for scheduling Police enforcement in a manner intended to maximise road safety benefits. Extensively developed from the original model used in the U.S.A., the technique involves dividing each Police jurisdiction into a number of sectors, and the week into a number of time blocks. The sector to be visited and the time at which it is to be visited are assigned randomly with the whole week being enforced. Enforcement involves conspicuous stationing of a marked police vehicle in the chosen sector for the allocated time block to undertake general road safety enforcement duties.

Analysis of the effects of the Queensland Random Road Watch program on crash frequency has shown the program to be effective overall in producing a significant 11% reduction in crashes in aggregate. Further, the program was effective in producing a significant reduction in crashes of all severities in all police regions except Metropolitan South, where reductions consistent with the rest of Queensland were observed but were not generally statistically significant. In the areas outside metropolitan Brisbane, the estimated program effects were largest on fatal crashes, with an estimated reduction of 31%. Estimated aggregate program crash effects reduced with crash severity from 13% for serious injury crashes to 9% for property damage only crashes. Crash reductions attributable to the program were estimated to increase with time after program introduction with fatal, serious injury and property damage only crash reductions estimated to have risen to 33 percent, 25 percent and 22 percent, respectively, in the third year of the program. Whilst crash effects of the program were estimated to be uniform on fatal crashes across areas of Queensland outside of Brisbane, there was significant variation in program effects on non-fatal crashes between Police regions and urban and rural areas.

Translation of the estimated RRW program crash effects into crash cost savings showed the Queensland program to have saved an estimated $109m in the first 12 months after full implementation rising to an estimated saving of $163m in the third year after full implementation. These crash costs savings correspond to an estimated saving of 1266 crashes in the first year of program implementation rising to a saving of 2749 crashes in the third year after program implementation.

Key Words: (IRRD except when marked*)
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EVALUATION OF THE QUEENSLAND RANDOM ROAD WATCH PROGRAM

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EXECUTIVE SUMMARY

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In the areas outside metropolitan Brisbane, the estimated program effects were largest on fatal crashes, with an estimated reduction of 31%. Estimated aggregate program crash effects reduced with crash severity from 13% for serious injury crashes to 9% for property damage only crashes. The evaluation estimated total crash savings of 11% due to the RRW program. Crash reductions attributable to the program were estimated to increase with time after program introduction with fatal, serious injury and property damage only crash reductions estimated to have risen to 33 percent, 25 percent and 22 percent, respectively, in the third year of the program. Whilst crash effects of the program were estimated to be uniform on fatal crashes across areas of Queensland outside of Brisbane, there was significant variation in program effects on non-fatal crashes between Police regions and urban and rural areas.

Crash effects of the RRW program in metropolitan Brisbane appeared to be generally consistent with those estimated for the rest of Queensland. However, results of the analysis were insufficient to draw firm conclusions about the magnitude of the program effects in this area, except for property damage crashes and all crashes combined in urban areas where significant crash reductions were found.

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EVALUATION OF THE QUEENSLAND RANDOM ROAD WATCH PROGRAM

1.0 INTRODUCTION

The Queensland Department of Transport commissioned the Monash University Accident Research Centre (MUARC) to carry out an independent evaluation of the Random Road Watch program currently in operation in Queensland. The difference between Random Road Watch (RRW) and conventional traffic policing is the resource management technique used for scheduling Police enforcement in a manner intended to maximise road safety benefits. Extensively developed from the original model of Edwards and Brackett (1978), the technique involves dividing up each Police jurisdiction into a number of sectors, and the week up into a number of time blocks. The sector to be visited and the time at which it is to be visited are assigned randomly with the whole week being enforced. Enforcement involves conspicuous stationing of a marked police vehicle in the chosen sector for the allocated time block to undertake general road safety enforcement duties.

RRW in Queensland commenced during December 1991 in the rural areas of the Southern Police Region. Since then, implementation of the program has spread to cover the whole state. Similar programs had previously been used in Tasmania, New South Wales and New Zealand. The broad aim of RRW is to maximise the dispersed effects of enforcement by (I) explicitly deploying units over time across larger parts of the road network than conventional policing and (II) by minimising the road users' ability to predict Police enforcement location and timing. The mechanism to achieve this is the randomised operations schedule.

This report outlines the results of the evaluation of the implementation of RRW in Queensland. Evaluation has followed the structure outlined in the proposal to Queensland Transport by MUARC.

1.1 Previous Implementations and Evaluations of RRW

Queensland is not the first jurisdiction to implement a program of low-level, randomized Police enforcement as a road safety countermeasure. The approach was initiated in Texas, USA (Edwards and Brackett, 1978). In Australia, both New South Wales and Tasmania have used such programs in the past, whilst New Zealand has also used such an approach to optimize Police enforcement effectiveness. Evaluation of the performance of each of these programs has been carried out with a review of each carried out below.

1.1.1 Tasmania

The first trial of low intensity randomly scheduled Police enforcement in Australia took place over two years in Tasmania and is reported and evaluated in Leggett (1988). The Tasmanian trial was implemented on three rural highway sections, each between 12 and 16 kilometres in length. Each road length was divided into 1km sections, with the section to be enforced and the 2-hour time block for enforcement assigned randomly. Enforcement took the form of stationing a marked Police vehicle on the chosen road segment at the chosen time to undertake general enforcement duties. Potentially enforced times were between 3pm and 11pm each day of the week with the program running from December 1984 to December 1986.

Evaluation of the Tasmanian random enforcement program by Leggett (1993) showed many benefits. Comparison of travel speeds at sites covered under the program with observations at a set of matched control sites showed significant reductions in mean travel speeds at the treated sites relative to the control sites, as well as a reduction in the travel speed variance at treated sites. Comparison of crash rates between treatment and control sites showed a significant 60% reduction in crash rates at the treated sites relative to the control sites leading to a high benefit to cost ratio for the program. A high compliance with the randomised enforcement schedule by Police was also noted in the Tasmanian program.

1.1.2 New Zealand

Based on the Tasmanian experience, a program of random schedule enforcement was also trialed in New Zealand on three 20km stretches of rural roads, which had been designated as accident black spots, over the period December 1988 to March 1990. Like Tasmania, enforcement in the form of operation of a marked Police vehicle was carried for one and 2-hour periods 2 or 3 times a week on each highway, with the time and placement selected randomly.

Description and evaluation of the New Zealand random enforcement program is reported in Graham et al (1992). The evaluation measures the program effects on travel speeds and crash rates by again comparing trends at the enforced sites with trends at suitably matched control sites. Results of the evaluation found a reduction in both mean and 85th percentile speeds on the enforced roads relative to the control roads. They also noted that effects on speed appeared to diminish with reduced Police compliance with the random schedule. The evaluation also provided statistics showing a 25% decrease in fatal and injury crashes at enforced sites relative to the control sites but conceded that the number of crashes on which these estimated were based was small. It was also reported that whilst the overall effectiveness of the program was as described, there was significant variation in performance of the program between the three sites used.

1.1.3 New South Wales

The final example of application of the random enforcement schedule in Australasia prior to the Queensland program evaluated here has been in New South Wales (NSW). Here, the approach was used on a 385km section of the Pacific Highway in northern NSW over the period June 1990 to May 1991. The highway was divided into 6 program sectors for enforcement, with hours of the day between 8am and 8pm being divided into 2-hour segments for enforcement on all days of the week. Again, highly visible Police patrols were operated once or twice a week at times and places on the highway chosen randomly. Evaluation of the NSW program is described in AGB (1991) again using comparison of speeds and crash frequency at the enforced sites to those observed at selected control sites. The evaluation found no significant changes in either travel speeds or crash rates attributable to the random schedule program.

Possible reasons for the lack of effectiveness found in the NSW program relative to the Tasmanian and New Zealand program put forward were the lower intensity of enforcement, greater length of road covered, different hours of operation and different type of road and road user. Subsequent analysis of the NSW program of random enforcement scheduling by Leggett (1992) has been critical of the analysis methods used in the evaluation of AGB(1991). Analysing data from a greater time period before implementation of the NSW program, Leggett (1992) has identified crash reductions due to the program consistent with those found in the Tasmanian program.

1.1.4 Analysis Methods

The analysis technique used in assessing the crash effects of randomised enforcement schedules using control comparison site crashes, such as in Leggett (1993) and Leggett (1997), is a control chart method making use of simple linear regression techniques. Application of this method is described by Frith (1987) and is based on analysing the ratio of treatment site crashes to control site crashes, typically in an annual time series. A linear regression is fitted to the series of ratio data over the time period before the introduction of the randomised enforcement program. This is then extrapolated forward to give a prediction of the expected value of the ratio had the random enforcement program not been implemented. Two-sigma[1] limits are placed on the estimated regression line to reflect the accuracy of estimation of the pre-intervention trend. Observed values of the ratio after program implementation are then compared to those predicted from the extrapolated linear regression to measure program effectiveness. Significant changes in the ratio due to the program are declared if the observed ratio lies outside the two-sigma limits of the extrapolated regression.

Control Chart Method

The control chart method of analysis addresses a number of key requirements for analysis of a pseudo experimental study design, as outlined by Council et al (1980). Further, comparison of the estimated crash effects of the Queensland RW program produced by the control chart method and the methods used in this study show close similarity in the point estimates of effect size. As well, both methods agreed in broad terms on the statistical significance of the overall program results. When turning to the precise quantum of statistical significance, however, some assumptions made by the control chart method are questionable and remain to be precisely assessed. Whilst not suggesting that these issues cannot be positively resolved, a more complex and rigorous statistical analysis method was developed for use in this evaluation.

1.2 Implementation of RRW in Queensland

For the purposes of policing, the state of Queensland is divided into eight Police regions. Each region is further divided into Police Districts that cover groups of individual Police Divisions, each Division containing a single Police station. RRW in its initial form was progressively introduced into all Police regions across Queensland apart from the

[1] Two-sigma limits are a form of confidence band on the regression line calculated using the standard error of the estimated regression dependent variable and assuming a t distribution with degrees of freedom equal to the number of regression points minus 2. The two-sigma limits are parallel to the regression line.

Metropolitan North region. Table 1 details the seven Police regions in Queensland that implemented a RRW program, along with the month of RRW implementation.

Table 1: *Date of RRW implementation by Queensland Police region*

Police Region	Date of RRW implementation
Southern	December 1991
North Coast	October 1992
Central	November 1992
South Eastern	December 1992
Far North	February 1993
Northern	January 1994
Metropolitan South	February 1994

The process of scheduling Police operations under the Queensland RRW program can be found described broadly in Leggett (1997) and in greater detail in Queensland Transport (1994) and can be summarized as follows. Each of the participating Police Divisions (some 303 by 1998) has selected a number of road segments within it (typically 40) for enforcement, such that routes covering some what over 50 percent of all road crashes which had occurred in the Division were included in the program. Hours of the day between 6am and 12 midnight are divided into two-hour segments for enforcement. A schedule of Police enforcement operations is then devised by randomly selecting a series of sites and times of day for enforcement. The number of hours per week required per Division is tailored to match the Police strength available at each Division. Based on previous studies of best practice at sites (see Leggett 1988 for review), enforcement comprises stationing a marked police vehicle in static mode at the selected site for the chosen two-hour duration to undertake general traffic enforcement duties.

This program structure results in areas of the state being logically divided into four strata resulting from the product of division of both time and space into two segments each. Space is divided into those selected roads that are potentially enforced under the program and those which are never enforced under the program whilst time is divided into potentially enforced times (6am to 12 midnight) and times where enforcement is never placed (midnight to 6am). These time and space divisions have been referred to as enforced and un-enforced areas and enforced and un-enforced times from here on and define the way in which the crash data is segregated for analysis. One Police region that is an exception to this time and space division is Metropolitan South where all roads in the region are potentially enforced. This creates some difficulty in the analysis procedure proposed as will be discussed below.

With the development of RRW in Queensland, the methodology for selection of enforced areas has changed. Over the period July to December 1996, enforced area selection was changed from using manual methods to using graphical information systems (GIS) based area selection based on crash densities. A major change that came with this shift in methodology was that all areas of the state were potentially enforced meaning the stratification of the state collapsed into two; enforced times and un-enforced times. Due to potentially heightened problems concerned with regression-to-the-mean (RTM) bias due to GIS based selection procedures and the necessity of modifying analysis methods to cope with the changes in stratification, this evaluation focuses only on assessing the effectiveness of RRW before the introduction of GIS based site selection methods.

1.3 Evaluation Aims

This evaluation aims to estimate the effect the RRW program in Queensland has had on crash frequency in the period up to the introduction of GIS based enforcement site selection. Differences between the effectiveness of the program in different areas of the state as well as changes in effectiveness of the program over time will also be investigated. In addition, economic value will be placed on observed crash changes due to the RRW program.

2.0 DATA

Comprehensive crash data was supplied by Queensland Transport covering all casualty and reported property damage crashes in Queensland over the period January 1986 to June 1997. Monthly crash data was supplied in aggregate format with separate series for each of the four combinations of enforced and unenforced areas and enforced and unenforced times. The data was also stratified by the 7 participant Queensland Police regions and urban or rural zones within each Police region as well as broken down by the five crash severity levels (fatal, hospitalisation, medically treated, first aid and property damage only). Rural and urban zones were defined as those with speed zones greater than 60 km/h and less than or equal to 60 km/h respectively. Data was collapsed into four severity levels for analysis, with medically treated and first aid crashes combined into a single category ("other injury crashes").

Queensland Transport also supplied information on the exact implementation dates of RRW in each region of the state. Data detailing Police compliance with the RRW schedule in each district along with number and type of offences detected during enforcement has also been supplied.

3.0 METHODS

Evaluation of the Queensland RRW program has been carried out in a number of stages. Crash frequency changes due to the RRW program have been analysed using an integrated log-linear modelling approach. The model has been applied to all Queensland crash data simultaneously to give estimates of program effectiveness not only by Police region and level of urbanisation but also region wide and state wide as well. Stemming from the crash frequency analysis, statistical tests of the homogeneity of the effect of RRW within and between regions have been carried out as well as statistical tests of the homogeneity of crash data from areas and times outside the influence of RRW. Finally, estimates of RRW program effectiveness obtained from modelling have been converted into estimates of the change in the number of crashes and subsequently into cost savings to society.

The following sections describe the design and analysis methodology used in each section of the evaluation described above.

3.1 Crash Frequency Analysis

The evaluation framework used here to analyse the influence of the RRW program on crash frequency is fundamentally a pseudo experimental design. Certain modifications to the standard pseudo experimental design framework traditionally used have been made to suit the particular nature of the data available for analysis. A pseudo experimental design was considered to be the most appropriate because of its potential to control for the effects of other factors besides RRW on crash frequency at the enforced sites through the use of crash trends at control sites. Other factors affecting crash frequency might include socio-economic effects or effects of other road safety programs which may have been present in Queensland during the study period.

As described above, Queensland is stratified into 7 Police regions, each of which is further divided into urban and rural areas (making 14 strata in all). The implementation strategy for RRW divides crashes within each of the Police region by urban/rural strata into four series. These are: crashes at enforced times in enforced areas (EA/ET), crashes at un-enforced times in enforced areas (EA/UT), crashes at enforced times in un-enforced areas (UA/ET) and crashes in un-enforced areas at un-enforced times (UA/UT). It is most convenient in describing the analysis methodology to consider the use of these four data series in one of the Police region by urban/rural strata and then generalise this to simultaneous analysis of data in all strata.

One of the key issues in adopting a pseudo experimental design framework is the appropriate choice of control or comparison groups for use in the analysis. Of the four data series defined in each strata, the EA/ET series corresponds to the 'treatment' data in the analysis design whilst the remaining three series are all potentially 'controls' within the design. To maximise the statistical power of the analysis, it was considered desirable to be able to use all three potential control series simultaneously in the analysis. An analysis method was designed to achieve this.

Within each stratum, the monthly crash data series for each of the four crash groups was modeled. A log-linear model form with Poisson error structure was used, a model form commonly used for modeling crash data series (see Bruhning and Ernst (1985), Hakim et al (1991)). The exact form of the model for data within an individual stratum is given by equation 1.

$$\ln(y) = a + b_1(Road \times Time) + b_2(Month \times Road \times Time) + b_3(program) \ldots(1)$$

where

y	is the monthly crash count
Road	is and indicator for enforced or un-enforced road
Time	is an indicator for enforced or un-enforced time
Month	is a linear month indicator variable (ie. 1,2,3,…..)
program	is the RRW program indicator

AxB indicates an interaction effect between variable A and B, and

a, b_1, b_2 **and** b_3 are parameter of the model

The RRW program indicator was parameterised in the following way.

program ***= 0*** if month was before introduction of RRW program
= 1 if month was after introduction of RRW program and crash series was EA/ET
=2 if month was after introduction of RRW program and crash series was not EA/ET

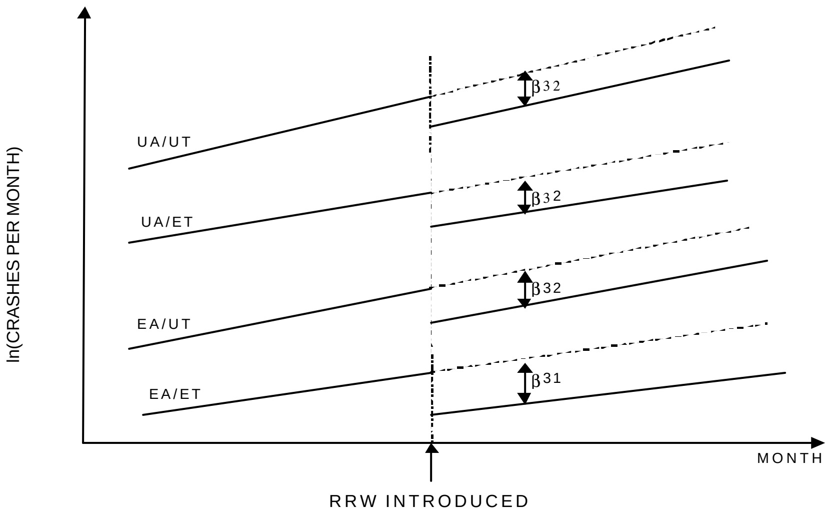
Defined in this way, the product term b_3***program*** expands to give

$$b_3\,program = b_{30}\,program_0 + b_{31}\,program_1 + b_{32}\,program_2 \qquad ...(2)$$

Where ***program$_i$*** is the indicator function for the ***program*** variable level ***i*** in the regression equation design matrix.

Figure 1 shows the model structure used in graphical representation. Each of the four crash series in Figure 1 has unique intercept and linear trend components in the model structure as represented by the solid lines. The dotted lines in Figure 1 represent the projection of the pre RRW implementation crash trends in each series into the post RRW implementation period. The changes in both treatment and control series after the implementation of RRW are measured by the model parameters b_{32} and b_{31} respectively. In specifying the model so far it has been assumed that the parallel changes in each of the control series after the introduction of the RRW program are equal (b_{32} for each control series). A statistical test of the equality of this change in each of the control series is discussed in Section 3.2.2 below.

Figure 1 : *Analysis design for RRW data within each defined strata*



The net effect of the RRW program after adjustment for the control is simply the difference between the model parameters b_{32} and b_{31}. A measure of the percentage change in crash frequency due to the RRW program, after adjustment for corresponding changes in the three control series is then

$$\Delta RRW = (1 - \exp(b_{31} - b_{32})) \times 100\% \qquad ...(3)$$

Whilst discussion so far has centered on defining a model structure to estimate the effect of the RRW program in one of the Police region by urban/rural stratum, the model structure is easily extended to simultaneously estimate program effects in all 14 strata. The generalized model structure for simultaneous program effect estimation is given by Equation 4.

$$\ln(y) = a + b_1(region) + b_2(Month \times region \times Metro \times Road \times Time) + b_3(region \times Metro \times Road \times Time) + b_4(program \times region \times Metro) \quad ...(4)$$

where terms are as defined above, and

Region	is an indicator for Police region
Metro	is an indicator of metro or rural area, and
a, b_i ***,i=1,..,4***	are model parameters

Parameter estimates from the model of the structure of Equation 4 give individual estimates of RRW program effects in each stratum. Average program effects across combinations of the strata can be obtained by modification of the last regression term in Equation 4. A hierarchy of combined program effect estimates used in this evaluation is described in Table 2 along with the form of the final term in Equation 4 necessary to obtain the appropriate estimates.

Table 2 : *Hierarchy of program effect estimate models*

Program effect estimate	Form of final term in Equation 4
Program effect within each police region and urban / rural division	b_4***(Program x Region x Metro)***
Program effect within each Police region, urban and rural areas combined	b_4***(Program x Region)***
Program effect across all Police regions combined, by urban and rural areas separately	b_4***(Program x Metro)***
Program effect across all regions combined and urban and rural regions combined	b_4***(Program)***

The model structures described above give estimates of the average effectiveness of the RRW program in the whole post implementation period under study. A small modification to the model described in equation 4 was also fitted to the data to produce estimates the effect of RRW in each twelve-month period after its introduction. Equation 5 shows the modification to the model required

$$\ln(y) = a + b_1(region) + b_2(Month \times region \times Metro \times Road \times Time)$$
$$+ b_3(region \times Metro \times Road \times Time) +$$
$$b_4(program \times region \times Metro \times progyear) \quad ...(5)$$

where

progyear is a vector indicating the post RRW implementation 12 month period

Similar modification of the hierarchical model structures detailed in Table 2 can be made to estimate yearly program effects for regions and urban and rural areas combined.

Whilst Table 1 shows that each of the Police regions in Queensland introduced the RRW program in a different month, this does not pose a complexity for setting the *progyear* variable as it is defined separately for each region in the integrated analysis structure. The interpretation of *progyear* at an aggregate region or urban/rural level when parameterised in this way is not the net effect of the RRW program in any particular calendar year, which would depend on the number of regions operating the program at the time. Rather, it is the average effectiveness of the program in the first, second and subsequent year of operation showing how program effectiveness might increase with factors such as cumulative exposure of drivers to the program.

Of the seven Police regions implementing a RRW program and described in Table 1, data from six was analysed using the simultaneous modelling techniques described above. The one Police region that did not fit this analysis framework was the Metropolitan South Police region. This was because all roads in Metropolitan South region were potentially enforced, leaving only two data series for analysis, EA/ET and EA/UT. Consideration was given to using data from Metropolitan North region, which had no RRW program during the study period, for the UA/ET and UA/UT series allowing the metropolitan Brisbane area to be included in the combined analysis. Queensland Transport staff, however, advised that data from Metropolitan North was unsuitable as a control for Metropolitan South region because of substantial differences in demographic and growth patterns between the two regions, both factors thought to influence crash trends.

Because of this, analysis of the crash effects of the RRW program implementation in Metropolitan South Police region was undertaken separately with only the remaining 12 Police region by urban/rural strata included in the integrated model. A reduced model of the form given by equation 6 was fitted to the Metropolitan South region data using only a single control crash series, the EA/UT series for Metropolitan South.

$$\ln(y) = a + b_2(Month \times Metro \times Time) + b_3(Metro \times Time) + b_4(program \times Metro) \quad ...(6)$$

Similar modifications to those described above can be made to the model of equation 6 to estimate program effects for urban and rural areas combined as well as yearly program effects in Metropolitan South region.

The models described for both the grouping of six non-metropolitan regions and Metropolitan South region were fitted separately to crash data of four severities. The groupings of crash severity used were: fatal crashes, serious injury crashes (crashes involving hospital admission), other injury crashes (medically treated and first aid injury crashes), and property damage only crashes.

One issue, which has not been addressed in this evaluation, is the potential problem of regression-to-the-mean (RTM). RTM problems potentially exist when treatment sites for a road safety countermeasure are not chosen at random but rather based on prior crash history. Queensland Transport staff advised that enforced sites chosen for the RRW program were potentially chosen on prior crash history using crash analysis or by Police expert knowledge of local accident black spots. In order to minimise RTM effects in the analysis, a suitably long (5 year) pre intervention crash history has been analysed whilst the analysis method incorporates trend analysis rather than using simple before after comparisons. The analysis method used in this evaluation, however, provides no direct estimate of potential RTM effects and none of the existing methods for estimating RTM would adapt easily to the study design. Consequently, no estimates of RTM effects have been given.

3.2 Homogeneity Analyses

Two types of homogeneity analyses have been considered in the evaluation of the Queensland RRW program. The first is the equivalence of the crash effects of the RRW program across the 12 strata into which the data has been divided for analysis using the integrated model structure. The second homogeneity analysis tests an assumption that the analysis procedure makes concerning the equivalence of the comparison information of each of the three control series available in each analysis stratum. Statistical test procedures for each type of homogeneity analysis are developed here.

3.2.1 Treatment effect homogeneity

One convenient feature of the integrated model structure simultaneously estimating the RRW program effects in six Police regions is the ability to test for treatment effect homogeneity under the model structure. The measure used to test for program effect homogeneity is the model scaled deviance[2]. Scaled deviance of a log linear model is a measure of the level of model fit to the observed data and has a chi-squared distribution with degrees of freedom equal to the difference between the number of data points and the number of model parameters.

When increasing model complexity by adding extra parameters, the difference in scaled deviance of the model before and after the inclusion of the extra parameters can be examined to assess the value of the extra parameterisation in improving model fit. The difference in scaled deviance between the two model complexities also has a chi-squared distribution with degrees of freedom equal to the number of extra parameters added to the model. Large changes in scaled deviance indicate the additional parameterisation has been effective in explaining more of the variation observed in the data.

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[2] Scaled deviance is a measure of how close the current model fit is to the optimum possible. In statistical terms it is equal to -2 times the natural log of the ratio of the current model likelihood to the likelihood of the fully specified model.

The hierarchical model structure detailed in table 2 represents a series of increasing model parameterisation complexities and hence provides the basis on which to test the homogeneity of RRW program effects across Police regions and urban and rural areas of the state. In general, model complexity increases from the bottom to the top of table 2. Tests of RRW program effect homogeneity have been carried out between all levels of model complexity detailed in Table 2 by testing changes in model scaled deviance between levels.

3.2.2 Control series homogeneity

One assumption the integrated model structure for the six non-metropolitan regions makes, as depicted in figure 1, is that the crash changes in each of the three control data series after RRW implementation are equal. This assumption can be tested statistically in a convenient manner similar to the testing of treatment effect homogeneity described above.

A test of control series homogeneity can be made by re-parameterisation of the last term of the model shown in equation 1. Instead of using a three-level parameterisation, as shown in equation 2, a five-level parameterisation is used where the RRW program indicator vector is re-parameterised in the following way.

program	***= 0*** if month was before introduction of RRW program
	= 1 if month was after introduction of RRW program and crash series was EA/ET
	=2 if month was after introduction of RRW program and crash series was EA/UT
	=3 if month was after introduction of RRW program and crash series was UA/ET
	=4 if month was after introduction of RRW program and crash series was UA/UT

Defined in this way, the product b_3***program*** of equation 1 expands to give

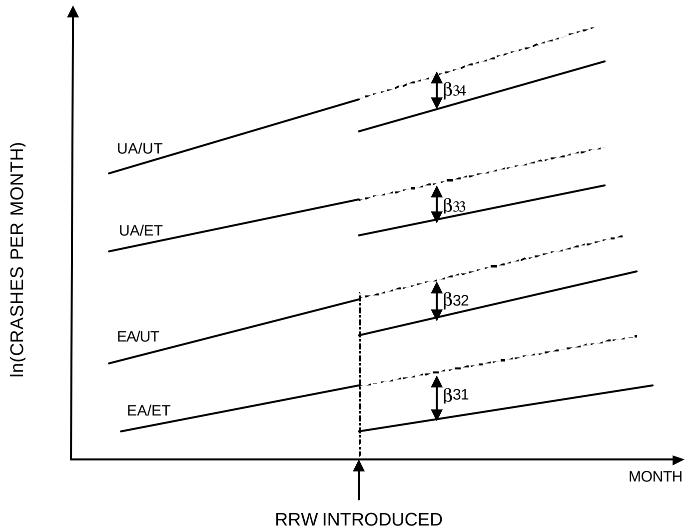
$$b_3\,program = b_{30}\,program_0 + b_{31}\,program_1 + b_{32}\,program_2 + b_{33}\,program_3 + b_{34}\,program_4 \qquad ...(7)$$

Where ***program*** is the indicator function for the ***program*** variable level ***i*** in the regression equation design matrix. The more general model parameterisation of the program variable given in equation 7 is depicted in figure 2.

A test of control series homogeneity within an analysis stratum can be made by comparing the scaled deviances of the model given by equation 1 using the program variable parameterisation given by equation 2 and that given by equation 7. The difference in scaled deviance between the models using the two different program variable parameterisations will have a chi-squared distribution on two degrees of freedom allowing statistical significance testing. A large chi-squared value indicates non-homogeneous control series information.

The described test of control series homogeneity has been carried out individually for each of the twelve crash strata included in the integrated analysis. It is possible using the model structure of equation 4 to simultaneously test control series homogeneity in all twelve strata. This is, however, of limited use as it does not indicate in which of the twelve strata, in particular, any homogeneity problems have arisen, hence the need for individual analyses.

Figure 2 : *Extended model parameterisation for testing control series homogeneity*



3.3 Crash Cost Savings

The final stage of the evaluation was to obtain estimates of the economic value of the crash changes estimated to be attributable to the Queensland RRW program. To achieve this, firstly the estimated percentage crash changes were transformed into actual number of crashes saved by using the expected crash series generated from the model of equation 6 for Metropolitan South region and equation 4 for the other six regions in conjunction with the estimated percentage crash changes. This was carried out for each of the four crash severity levels analysed.

Estimates of numbers of crashes saved were then transformed into economic value by multiplying the number of crashes saved at each severity level by the estimated average cost of a crash to society by crash severity. Queensland Transport staff provided estimates of the average cost to society of a crash, by severity of crash, that they use for evaluation studies. These cost estimates are summarised in Table 3 and are given in 1997 Australian dollars.

Table 3 : *Estimated cost of crashes to society by crash severity*

Crash severity	Estimated cost to society ($A, 1997)
Fatal	805,000
Serious Injury	167,000
Other Injury	23,000
Property Damage Only	11,000

Queensland Transport staff advised that the crash cost figures presented in Table 3 are based on those derived by Andreassen (1992). Dollar values have been inflated to 1997 levels using the overall Consumer Price Index figures for Queensland.

4.0 RESULTS

4.1 Crash Frequency Analysis

A set of integrated models of the form given by equation 4 was fitted to the Queensland crash data over the period January 1987 to June 1996 using the hierarchical structure described in Table 2. Separate model sets were fitted to each of the four levels of crash severity considered. Estimates from these models give the average net effect of the RRW program in Queensland on crash frequency over this period.

Non-Metropolitan Regions

Appendix A, Tables 1 and 2(a)-(d) give the full results of the integrated model analyses performed. Table 1 in Appendix A summarises the estimated percentage crash changes for each region, urbanisation level and crash severity level attributable to the RRW program. The columns shown in Table 1, Appendix A are the estimated crash change attributable to RRW (bracketed numbers indicate crash increases whilst numbers with no brackets indicate a crash decrease), the statistical significance probability of the estimated crash change and the upper and lower 95% confidence limits. Table 2, parts A to D, in Appendix A show the estimated crash effects of the RRW program aggregated across regions and across the state by crash severity. Again, the estimated crash change, statistical significance probabilities and upper and lower 95% confidence limits are shown in the same format as for Table 1.

Table 4 summarises the key results of the analyses presented in Appendix A. Estimated overall crash effects of the RRW program in all non-metropolitan Police regions are shown for each crash severity considered, along with the same information broken down by urban and rural areas. The information given in table 4 is the estimated percentage crash reduction due to the RRW program along with the significance probability of this estimate. Small significance probabilities indicate statistically significant crash changes.

Table 4 shows statistically significant reductions in crash frequency at all severity levels due to the RRW program when considering all areas of non-metropolitan Queensland, with the estimated crash effect size diminishing with diminishing crash severity. When considering urban and rural areas separately, table 4 shows some marked differences. In rural areas, only fatal crashes showed a statistically significant reduction in frequency due to the RRW program with all other severities showing no significant change. In contrast to this, results in urban areas showed statistically significant crash reductions due to RRW at all crash severities but fatal, although the point estimate of fatal crash reduction in urban areas is similar order of magnitude to that in rural areas. This suggests the lack of statistical significance is a result of insufficient data.

Table 4 : Estimated average crash effects of Queensland RRW program November 1991 – June 1996 : Non Metropolitan Regions

		Estimated crash reduction (%)	Statistical Significance Probability
Rural Areas			
	Fatal	34.3	0.0094
	Serious	4.1	0.5472
	Other	4.9	0.4475
	Property Damage	1.3	0.8037
	All Crashes	4.78	0.1513
Urban Areas			
	Fatal	25.7	0.2006
	Serious	20.6	0.0004
	Other	14.7	0.0007
	Property Damage	13.1	0.0003
	All Crashes	15.0	0.0001
All Areas			
	Fatal	31.0	0.0051
	Serious	13.2	0.0030
	Other	11.5	0.0013
	Property Damage	8.9	0.0028
	All Crashes	11.2	0.0001

Table 4 has shown the estimated aggregate effect of the RRW program across all non-metropolitan regions. The results of the analysis presented by Police region in Appendix A, table 2 show consistent results across all severities and regions in the sense that 21 of the 24 categories (6 regions by 4 severity levels) show crash decreases after program inception. However, the size of the estimated reduction varies between regions and crash severities, particularly at lower crash severities. It should be noted though that the confidence limits on program effectiveness, even at the level of Police region, are relatively wide with few results achieving statistical significance. The consistency in crash reduction, noted above, suggest this lack of statistical significance is due to insufficient data. Similar observations can be made of the estimates of program effect by urban/rural area within Police region shown in table 1 of Appendix A. The consistency of the estimated program effects across Police regions and by urban and rural areas will be further investigated in the analysis of treatment effect homogeneity presented below.

Metropolitan South Region

Table 5 shows the analogous information to table 4 for Metropolitan South Police region. Results suggest that the program has been more effective in urban areas than in rural areas of metropolitan South, with the aggregate result in all areas being driven largely by the urban estimate due to the high percentage of urban area crashes in the region. It is, however, difficult to draw conclusions from the results in table 5 given that the only estimates which reach statistical significance are the crash reductions for property damage only crashes in urban areas and all areas combined. Analysis of all crash severities combined also showed statistically significant reductions in urban areas as well as all areas combined.

Table 5 : Estimated average crash effects of Queensland RRW program February 1994 – June 1996: Metropolitan South Region

		Estimated crash reduction (%)	**Statistical Significance Probability**
Rural Areas			
	Fatal	-133.5	0.3361
	Serious	7.8	0.8541
	Other	31.8	0.2512
	Property Damage	-33.9	0.2605
	All Crashes	-5.1	0.7848
Urban Areas			
	Fatal	62.0	0.2272
	Serious	4.1	0.8394
	Other	4.2	0.8017
	Property Damage	32.3	0.0008
	All Crashes	20.8	0.0070
All Areas			
	Fatal	14.3	0.7831
	Serious	5.3	0.7736
	Other	12.2	0.3887
	Property Damage	24.8	0.0074
	All Crashes	17.4	0.0140

Change in effects of RRW over time

The model of the form given by equation 5 was fitted to the data from non-metropolitan regions to produce estimates of RRW program effectiveness by year after program introduction. Separate models were fitted to crashes of each of the four severity groups. It should be noted that the yearly estimates derived from the model refer to the effect of the program in 12-month intervals staring from the exact month of introduction of the program in each region rather than corresponding directly to particular calendar years. Hence, in the all region summaries, the results are reflecting the average effects of the program in its first, second and subsequent years after introduction, independent of actual introduction date by region. This is in contrast to measuring effects in particular calendar years (such effects were dependent on the number of regions having implemented the program in a particular year).

Table 6 shows the yearly program effect estimates for all non-metropolitan Police regions in all areas combined and in urban and rural areas separately. Negative values indicate an estimated crash increase due to the RRW program whilst the bracketed numbers below each estimate are the statistical significance probability of the estimated reduction (low probabilities indicating significant crash changes). Appendix A, table 3 parts (a) to (d) give estimates of yearly RRW program effectiveness broken down by Police region and urban and rural areas. Corresponding statistical significance levels of these results are also given in appendix A. Only results for years 1 to 3 after full program implementation are given in table 6 because 3 years is the maximum amount of post program implementation experience which has been gained across all regions.

Table 6 : Estimated crash reductions attributable to Queensland RRW program by year after implementation : Non Metropolitan Regions.

		Year after program introduction		
Rural Areas		**1**	**2**	**3**
	Fatal	42.24% *(0.319)*	25.18% *(0.597)*	37.94% *(0.388)*
	Serious	0.54% *(0.980)*	6.27% *(0.759)*	12.53% *(0.528)*
	Other	5.65% *(0.766)*	1.08% *(0.956)*	10.90% *(0.558)*
	Property Damage	-2.11% *(0.893)*	3.17% *(0.837)*	10.79% *(0.468)*
	All Crashes	3.13% *(0.7623)*	4.69% *(0.6509)*	13.00% *(0.2127)*
Urban Areas				
	Fatal	15.88% *(0.820)*	37.66% *(0.533)*	24.38% *(0.713)*
	Serious	16.66% *(0.343)*	20.49% (0.233)	34.51% (0.029)
	Other	9.80% *(0.423)*	15.94% *(0.177)*	26.29% *(0.018)*
	Property Damage	3.28% *(0.743)*	17.57% *(0.058)*	26.35% *(0.003)*
	All Crashes	8.01% *(0.2736)*	17.71% *(0.0157)*	27.50% *(0.0002)*
All Areas				
	Fatal	34.17% *(0.347)*	28.78% *(0.444)*	33.41% *(0.362)*
	Serious	9.35% *(0.488)*	14.02% *(0.287)*	24.78% *(0.046)*
	Other	8.41% *(0.414)*	11.19% *(0.268)*	21.49% *(0.025)*
	Property Damage	1.25% *(0.882)*	12.45% *(0.118)*	21.11% *(0.006)*
	All Crashes	6.09% *(0.3071)*	12.86% *(0.0311)*	22.31% *(0.0002)*

Results presented in Table 6 suggest a general increase in the crash reduction effect of the RRW program in all areas over time for all crash severities apart from fatalities. Statistically significant reductions in all crash severities combined were observed in the second and third year of full program implementation in both urban areas and all areas combined. The effect of the program on fatal crash numbers appears to have been roughly consistent since the introduction of the program. Similar trends in program effectiveness over time can be seen in the results separated by urban and rural areas, also shown in table 6. It should be noted, however, that many of the estimated crash changes in table 6 fail to reach statistical significance. Only crash severities other than fatal in all areas combined and urban areas showed statistically significant reductions in the third year after implementation of the RRW program. The general lack of statistical precision in the estimated crash effects by year of program operation are even more marked when considering results at the level of Police region or below, as shown in appendix A, table 3.

Table 7 shows estimated yearly RRW program crash effects for metropolitan south Police region with the information presented analogous to that in table 6. Statistical significance levels have only been shown in table 7 for all crash severities combined for simplicity of presentation. None of the results in table 7 achieved statistical significance even for all crashes combined which is the analysis with the most statistical power. This is expected given the general lack of statistical significance of the results for the overall crash effects in Metropolitan South in table 5, which is a more aggregate analysis than in table 7. Nonetheless, reductions are seen in 11 of the 12 cells of the part of table 7 showing results for all areas of Metropolitan South combined.

Table 7 : Estimated crash reductions attributable to Queensland RRW program by year after implementation : Metropolitan South Region

		Year after program introduction		
		1	**2**	**3**
Rural Areas				
	Fatal	-181.7%	-198.1%	6.9%
	Serious	-49.5%	38.0%	36.1%
	Other	30.8%	37.0%	14.8%
	Property Damage	-84.7%	-12.1%	12.2%
	All Crashes	-30.6% *(0.4426)*	11.7% *(0.7604)*	16.2% *(0.5773)*
Urban Areas				
	Fatal	68.7%	55.5%	35.1%
	Serious	7.1%	2.7%	-11.0%
	Other	6.5%	-15.1%	33.6%
	Property Damage	37.1%	24.3%	25.6%
	All Crashes	26.1% *(0.1649)*	10.8% *(0.5720)*	22.2% *(0.1126)*
All Areas				
	Fatal	25.6%	0.0%	9.7%
	Serious	1.3%	11.6%	0.9%
	Other	13.4%	1.6%	32.5%
	Property Damage	27.3%	20.1%	24.6%
	All Crashes	19.6% *(0.2487)*	12.4% *(0.4656)*	22.0% *(0.0815)*

Further, results of the analysis by year after program introduction in Metropolitan South Police region presented in table 7 show broad consistency in outcome to the rest of the state for property damage crashes, the highest crash frequency category. There is a lack of clear trends in the yearly crash change estimates at other severity levels.

4.2 Homogeneity Analyses

4.2.1 Treatment Effect Homogeneity

Analysis of treatment effect homogeneity test for statistically significant differing RRW program effectiveness between areas within a region and between regions has been carried out here using the methods described in section 3.2.1. Figures 1 to 4 in Appendix B show the treatment effect homogeneity test trees derived from the integrated models fitted to the non metropolitan Queensland crash data. The four nodes on the tree represent the four levels of model complexity described in table 2. Model complexity increases moving down the tree.

The numbers on each node of the tree give the statistical measure of model fit for that model complexity, the first number being the model scaled deviance, the second number the degrees of freedom for the model and the third number the statistical significance probability of the scaled deviance figure. Low scaled deviances relative to the degrees of freedom give rise to numerically high significance probabilities indicating satisfactory model fit whilst low significance probabilities indicate poor model fit.

Also given on the tree are the scaled deviance and degrees of freedom changes resulting in moving from one model complexity (node) to the another along with the statistical significance probability of this change. High deviance changes relative to the change in degrees of freedom lead to low significance probabilities indicating moving to the higher degree of model complexity has lead to a statistically significant improvement in model fit (ie. the extra factor introduced into the model is statistically significant). Statistical significance of the change in scaled deviance upon moving from one model complexity to the next is the measure of program effect homogeneity with the program effect being deemed homogeneous at the complexity concerned if moving to the next higher model complexity does not significantly improve the model fit. Levels of program effect homogeneity that are tested by moves down the tree are:

- equivalent program effect in all regions urban and rural combined
- equivalent program effect in combined urban and rural areas across all regions
- equivalent program effect in urban and rural areas within regions and
- equivalent program effect in all regions within urban and rural areas.

Examination of the homogeneity tree for fatal crashes shown in appendix B, figure 1, shows the model fits the data well at each level of the tree. The tree also shows the estimated RRW program effect on fatal crashes to be homogeneous between all nodes. Figure 2, appendix B shows the effects of the RRW program were homogeneous on serious injury crashes between urban and rural areas across all non-metropolitan regions. Similarly, figure 3 in appendix B shows homogeneous program effects across urban and rural areas on other injury crashes both within regions and across all regions combined. No homogeneous program effects on property damage only crashes were observed across regions or urban and rural areas, as shown in figure 4, appendix B.

In summary, the homogeneity test performed here showed the Queensland RRW program to have homogeneous effects on fatal crashes in all Police regions and urban and rural areas of non-metropolitan Queensland. When considering crashes of a severity less than fatal, however, variation in RRW program effectiveness was generally observed either between Police region, between urban and rural areas or both.

4.2.2 Control Series Homogeneity

As described in section 3.2, the integrated modelling approach compares changes in the RRW treated time and area crash series to corresponding changes in the three control crash series before and after program implementation to estimate the net effect of RRW in the treated area. Testing of control series homogeneity assesses whether the relative before to after program implementation change in each of the three control crash series is the same and hence that each is providing the same control information. Methodology for testing control series homogeneity is described in section 3.2.2.

Appendix C shows the summary of the control group homogeneity tests by region, urbanisation and crash severity for the six non-metropolitan regions for which the test is appropriate. For each region, urbanisation level and crash severity, appendix C shows the scaled deviance statistic for the model presuming the changes in each control series are the same and the scaled deviance statistic for the model where each is allowed to change independently. The scaled deviance change between the two models gives the homogeneity chi-squared test statistic for which the statistical significance probability is also given in appendix C.

Appendix C shows a number of strata where the 3 control series are non-homogeneous. Six strata, marked with a double asterisk, had control series that were statistically significantly non-homogeneous at the 5% level. A further eight strata had control series which were non-homogeneous at the marginal statistical significance level of 10%. These are marked with a single asterisk in appendix C. There appears to be no particular pattern in terms of injury level, Police region or level of urbanisation that the strata with non-homogeneous control series follow.

Implications for Further Evaluation

Whilst the issue of control series homogeneity has been investigated here, it has little bearing on the program effects estimated so far here. It will however be important in future evaluation of the RRW program in Queensland in the period after June 1996, the point up to which the program is evaluated in this study. As described in section 1.2, after June 1996, scheduling of Police operations under the RRW program changed to utilise the technology of Geographical Information Systems (GIS). Under these new scheduling methods, all areas of each Police region are potentially enforced hence reducing stratification of crash data to a dichotomy; enforced and un-enforced times. If using a similar pseudo experimental design to evaluate the RRW program in the period after June 1996, there would only be two of the three original control series remaining for use in the analysis. In strata where the control series have been found to be non-homogeneous in the control information they are supplying, this could mean the RRW program estimates obtained for the period after June

1996 could be inconsistent with those obtained for the period before June 1996. A method of dealing with this problem is not immediately obvious and has not been further investigated here. The homogeneity analysis results presented here point to the need to consider this problem in future work.

4.3 Crash Savings

Using the model fitted values to the observed crash series data and the estimated percentage crash changes, the number of crashes saved in each year after RRW program implementation year attributable to the program have been estimated at each crash severity level. This was carried out separately for Metropolitan South Police region and the six non-metropolitan regions. The model giving program effect estimates in each 12-months after implementation, fitted to data at each crash severity aggregated by police region and urbanisation level was used to obtain the crash savings estimates. These models are given by equation 5 for non-metropolitan areas and a modification of equation 6 for Metropolitan South region. These models were used because they were considered the most statistically reliable, as demonstrated by the results presented in tables 6 and 7, although the results for Metropolitan South region should be interpreted with care given their lack of statistical precision.

Table 8 : *Estimated annual crash savings attributable to RRW program (if the program had been implemented state-wide simultaneously)*

	Year after program implementation		
	Year 1	**Year 2**	**Year 3**
6 Non-Metropolitan Regions			
Fatal Crashes	54	52	66
Serious Injury Crashes	105	173	353
Other Injury Crashes	162	243	551
Property Damage Only Crashes	33	359	653
Totals : Non Metro Regions	***354***	***827***	***1624***
Metropolitan South Region			
Fatal Crashes	40	31	14
Serious Injury Crashes	7	48	-3
Other Injury Crashes	134	-62	645
Property Damage Only Crashes	731	390	469
Totals : Metro South	***912***	***407***	***1125***
All Regions			
Fatal Crashes	94	83	80
Serious Injury Crashes	112	221	350
Other Injury Crashes	296	181	1196
Property Damage Only Crashes	764	749	1122
Total : All Regions	***1266***	***1234***	***2749***

Table 8 shows the estimated number of crashes saved by severity level in each of the first three years after program implementation. Results are given by metropolitan and non-metropolitan regions as well as added to give an overall program figure for the state. Negative values in table 8 indicate estimated crash increases. It should be noted, however, that the instances of negative values in table 8 correspond to non-statistically significant crash change estimates.

4.4 Crash Cost Savings

Using the crash cost estimates shown in table 3, the estimated crash savings in table 8 have been converted into monetary savings to society by multiplying the number of crashes saved at each severity level by the average cost of a crash to society at each severity level. Crash cost savings derived in this way are presented in table 9 separately by Metropolitan south region and the six non-metropolitan regions for each crash severity level and for the state as a whole. Again, negative values result from an estimated crash increase associated with the RRW program and represent an extra crash cost to society in table 9.

As shown in table 9, estimates of crash cost savings attributable to the RRW program grew from $109m in the first twelve months after program implementation to $163m in the third year after implementation. Again, it is stressed that the crash cost saving estimates for Metropolitan South region should be treated with caution given the lack of statistical precision of the crash change estimates from which they are derived. Precision of the crash cost saving estimates for the non-metropolitan Police regions is far better with these results showing clear increases in the effectiveness of the RRW program in terms of crash cost savings over the first three years after program implementation.

Table 9 : *Estimated annual economic worth of crash savings attributable to RRW program (if the program had been implemented state-wide simultaneously)*

	Economic Savings (1997 $A, millions) Year after program implementation			
	Year 1	**Year 2**	**Year 3**	**Total**
6 Non-Metropolitan Regions				
Fatal Crashes	43.41	41.91	53.00	138.32
Serious Injury Crashes	17.55	28.93	59.04	105.52
Other Injury Crashes	3.65	5.49	12.46	21.60
Property Damage Only Crashes	0.38	4.06	7.38	11.82
Totals : Non Metro Regions	**64.99**	**80.39**	**131.88**	**277.26**
Metropolitan South Region				
Fatal Crashes	31.95	24.92	11.98	68.85
Serious Injury Crashes	1.17	7.99	-0.52	8.64
Other Injury Crashes	3.04	-1.39	14.58	16.23
Property Damage Only Crashes	8.26	4.40	5.30	17.96
Totals : Metro South	**44.42**	**35.92**	**31.34**	**111.68**
All Regions				
Fatal Crashes	75.36	66.83	64.98	207.17
Serious Injury Crashes	18.72	36.92	58.52	114.16
Other Injury Crashes	6.69	4.10	27.04	37.83
Property Damage Only Crashes	8.64	8.46	12.68	29.78
Total : All Regions	**109.41**	**116.31**	**163.22**	**388.94**

5.0 DISCUSSION

Overall, the foregoing evaluation of the Queensland Random Road Watch program has shown significant reductions in crash frequency due to the program at all severity levels in areas outside of Metropolitan Brisbane. Highest crash reductions have been estimated for fatal crashes with effects decreasing with crash severity. For fatal crashes, the effects appear to have been relatively consistent over time. Program effects, however, appear to have been increasing with time for other crash severities to reduction levels closer to those for fatal crashes. Increasing effect sizes with time are possibly an indication of cumulative awareness of the program amongst the public following continuous exposure. Analysis of the homogeneity of program effects between non-metropolitan Police regions and urban and rural areas showed that, whilst the program effects on fatal crashes were equivalent across these areas, there was significant variation in the effects on lower severity crashes between the areas. This will be further discussed below.

Results of analysis of program effects in Metropolitan South Police region, part of metropolitan Brisbane, are generally indicative of the same overall effects as in the rest of the state, showing reductions both overall and in individual program year and crash severity divisions. However, there is insufficient data to draw conclusions with a high degree statistical certainty. Data insufficiency is particularly highlighted when looking at yearly program effect estimates or effect estimates in rural areas in Metropolitan South region.

Implementation of random enforcement scheduling in the form of the RRW program in Queensland has been far more extensive than other random schedule implementations that have been evaluated. Consequently there was no particular expectation prior to evaluation regarding how the Queensland RRW program would perform in relation to previous implementations of random enforcement scheduling. This is particularly the case in urban areas where there has been little documented history of the performance of this type of program. In rural areas, the Queensland program has produced a significant reductions in fatal crashes estimated to be 34% which is not as great as that reported by Leggett (1993) in Tasmania but perhaps more encouraging than reported for the program in either New Zealand or NSW. Computation of the effect of the Queensland RRW program on fatal and serious injury crashes combined in rural areas showed an estimated overall 25 percent reduction. This is comparable to the reductions observed for these severities combined in previous program implementations in Tasmania, New Zealand and NSW (37% reduction), as shown in table 10. The effect on the Queensland program on rural crashes of a lesser severity is less clear. In urban areas, however, the Queensland program has shown significant reductions in crash frequency at all severities other than fatal, with the result for fatal crashes pointing to good program performance but not being significant most likely due to data insufficiency. This suggests programs of random enforcement scheduling are potentially as valuable in lower speed areas as on open highways.

Table 10 : *Comparison of the effects of randomised enforcement scheduling on fatal and serious injury crashes between different programs*

Location of program implementation	**Estimated reduction in fatal and serious injury crashes due to the program**
Queensland	25%
Tasmania	37%
New Zealand	25%
New South Wales	37%

Variation in the performance of the RRW program between non-metropolitan Police regions and urban and rural areas found in this evaluation point to further research that could be undertaken. Whilst some analysis of estimated program effectiveness against measures such as compliance with program scheduling by Police has been carried out, the results were generally uninformative and have not been presented here. A detailed investigation of the specific factors affecting program performance would be worthwhile. Factors investigated might include issues such as traffic or population density versus enforcement density, offence rates prior to program implementation, offence rates detected by the program or other such measures. Results of such a study would be useful in further fine tuning program implementation and hence optimising the program benefits.

Whilst the current study has been able to measure the general effects of the program on crash frequency, it has not been able to identify specific mechanisms of program effectiveness. Further study would be necessary to determine whether the crash effects were uniform across treated region or were localised in time and space around the sites where Police patrols have been operating. There has been no attempt in this study to link observed crash changes to changes in travel speed, as has been attempted in previous evaluations of random enforcement scheduling programs, such as Leggett (1988) and Graham et al (1992). Investigating such links would be worthwhile in Queensland.

Whilst the analysis technique used here has been developed to suit the available data as well as possible, assumptions are still made about data structures and distributions, as well as the appropriateness of the fundamental study design. It has been assumed that the form of the model given by equation 4 adequately describes the data and that the error structure of the model is Poisson. Tests of over dispersion of the Poisson error term were carried out and revealed no problem. The assumption of the model structure appropriateness could be checked using some form of sensitivity analysis but it is believed that this would probably not reveal any major deficiency in the analysis structure.

In using a pseudo experimental design, it is assumed that the control crash series represents all other factors affecting crash rates at the treated sites other than the RRW program itself and that the control sites are unaffected by the RRW program. No attempt to precisely match characteristics of treatment and control sites has been made in this study beyond the broadest level. Matching treatment and control sites at a closer level would be difficult, however, due to the magnitude of the program and hence the analysis task in doing so. Using only broadly matched control crashes does, however, maximise statistical analysis power and probably adequately reflects the effects of other factors than the RRW program on crash frequency. There is also a possibility in this study that the effects of the RRW program may breach the boundaries of those sites considered as treated to also affect areas used for control crashes given that the driver population is unaware of the exact locations of the program. In terms of estimated program effect, contamination of the control series with treatment effects would only serve to produce an underestimate of program effectiveness.

For reasons described in section 4.2.2, further evaluation of the RRW past the period considered here would pose some challenges because of the move to using GIS based systems for operations scheduling. Further development of the modelling procedures used in the work described here would be necessary to be able to accurately evaluate RRW program effects in the post GIS implementation period. Further to this, a number of other issues should be considered in extending the evaluation. These issues include regression to the mean effects (that could possibly be magnified by GIS scheduling methods) along with possible inconsistency of the results with those presented here due to the heterogeneity identified in some of the sets of control series. Analysis of RRW in the post GIS period would, however, provide the opportunity to examine the effects of varying enforcement densities across regions, an operational development which has been made with the use of GIS based scheduling techniques.

6.0 CONCLUSIONS

Analysis of the effects of the Queensland Random Road Watch program on crash frequency has shown the program to be effective overall in producing a significant reduction in crashes in aggregate. Further, the program was effective in producing a significant reduction in crashes of all severities in all police regions but Metropolitan South where reductions were observed but were not statistically significant.

In the areas outside metropolitan Brisbane, the estimated program effects were largest on fatal crashes, with an estimated reduction of 31%. Estimated aggregate program crash effects reduced with crash severity from 13% for serious injury crashes to 9% for property damage only crashes. Crash reductions attributable to the program were estimated to increase with time after program introduction with fatal, serious injury and property damage only crash reductions estimated to have risen to 33 percent, 25 percent and 22 percent respectively in the third year of the program. Whilst crash effects of the program were estimated to be uniform on fatal crashes across areas of Queensland outside of Brisbane, there was significant variation in program effects on non-fatal crashes between Police regions and urban and rural areas.

Crash effects of the RRW program in metropolitan Brisbane appeared to be generally consistent with those estimated for the rest of Queensland, however, results of the analysis were insufficient to draw firm conclusions about the magnitude of the program effects in this area.

Translation of the estimated RRW program crash effects into crash cost savings showed the Queensland program to have saved an estimated $109m in the first 12 months after full implementation rising to an estimated saving of $163m in the third year after full implementation. These crash costs savings correspond to an estimated saving of 1266 crashes in the first year of program implementation rising to a saving of 2749 crashes in the third year after program implementation.

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APPENDIX A

Results of analysis of crash effects of Queensland RRW program

Estimated Crash Effects of QLD RRW Program by Region, Urbanisation and Injury level **Table 1**

			Significance Probability	*%Reduction*	*Lower 95% CL*	*Upper 95% CL*
Central	R	Fatal	0.6857	16.0%	63.8%	(95.1%)
		Serious	0.517	10.7%	36.5%	(25.7%)
		Other	0.0785	25.7%	46.7%	(3.4%)
		PDO	0.5729	(8.2%)	17.7%	(42.3%)
	U	Fatal	0.4184	53.3%	92.6%	(195.7%)
		Serious	0.175	27.8%	54.9%	(15.6%)
		Other	0.2261	18.3%	41.1%	(13.4%)
		PDO	0.0591	23.2%	41.6%	(1.0%)
Far North	R	Fatal	0.9936	(0.4%)	59.6%	(149.6%)
		Serious	0.3998	14.7%	41.1%	(23.5%)
		Other	0.9862	0.3%	30.2%	(42.4%)
		PDO	0.0099	(45.8%)	(9.5%)	(94.2%)
	U	Fatal	0.8807	10.0%	77.3%	(256.2%)
		Serious	0.7898	(5.6%)	29.2%	(57.6%)
		Other	0.2708	15.0%	36.4%	(13.6%)
		PDO	0.8011	2.9%	22.6%	(21.8%)
North Coast	R	Fatal	0.0453	49.3%	74.0%	1.4%
		Serious	0.7228	4.9%	28.0%	(25.5%)
		Other	0.8347	(2.9%)	21.1%	(34.2%)
		PDO	0.8037	2.5%	20.4%	(19.4%)
	U	Fatal	0.6762	(24.3%)	55.2%	(244.7%)
		Serious	0.215	16.3%	36.8%	(10.9%)
		Other	0.0609	(21.1%)	0.9%	(48.0%)
		PDO	0.5564	4.9%	19.4%	(12.3%)
Northern	R	Fatal	0.8614	7.4%	61.1%	(120.1%)
		Serious	0.022	36.9%	57.4%	6.4%
		Other	0.1937	22.2%	46.6%	(13.6%)
		PDO	0.0009	41.3%	57.2%	19.7%
	U	Fatal	0.0034	87.0%	96.7%	49.0%
		Serious	0.0106	36.4%	55.0%	10.0%
		Other	0.0055	28.0%	43.0%	9.2%
		PDO	0.0245	21.2%	36.0%	3.0%
South Eastern	R	Fatal	0.3375	34.3%	72.2%	(55.0%)
		Serious	0.2161	(27.1%)	13.1%	(85.8%)
		Other	0.1654	(25.8%)	9.1%	(74.2%)
		PDO	0.8679	(2.3%)	21.4%	(33.1%)
	U	Fatal	0.8307	8.1%	57.9%	(100.3%)
		Serious	0.0017	30.7%	44.9%	12.9%
		Other	0.0646	15.2%	28.7%	(1.0%)
		PDO	0.032	15.0%	26.7%	1.4%
Southern	R	Fatal	0.0299	55.5%	78.5%	7.6%
		Serious	0.5291	(10.6%)	19.1%	(51.1%)
		Other	0.4381	11.6%	35.3%	(20.8%)
		PDO	0.4866	7.7%	26.5%	(15.8%)
	U	Fatal	0.8552	11.9%	77.3%	(242.5%)
		Serious	0.1341	29.3%	55.1%	(11.3%)
		Other	0.0173	33.2%	52.1%	6.9%
		PDO	0.0042	30.3%	45.6%	10.8%

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Estimated Crash Effects of QLD RRW Program
Regionwide and Satewide Summaries Excluding Metro South

Fatalities

Table 2 (A)

Regionwide : Urban and Rural combined

	Coeff	*SE*	*Chisq*	*Sig Prob*	***%Reduction***	*LCL*	*UCL*
Central	-0.3044	0.389	0.6124	0.4339	26.2%	65.6%	(58.1%)
Far North	0.0188	0.3856	0.0024	0.961	(1.9%)	52.1%	(117.0%)
North Coast	-0.4091	0.284	2.0746	0.1498	33.6%	61.9%	(15.9%)
Northern	-0.6683	0.3676	3.3055	0.069	48.7%	75.1%	(5.4%)
South Eastern	-0.2527	0.2939	0.7394	0.3899	22.3%	56.3%	(38.2%)
Southern	-0.4588	0.3106	2.1823	0.1396	36.8%	65.6%	(16.2%)

All regions by Urban and Rural

	Coeff	*SE*	*Chisq*	*Sig Prob*	***%Reduction***	*LCL*	*UCL*
All regions - Rural	-0.42	0.1617	6.7441	0.0094	34.3%	52.1%	9.8%
All regions - Urban	-0.2964	0.2316	1.6377	0.2006	25.7%	52.8%	(17.1%)

All regions : Urban and Rural Combined

	Coeff	*SE*	*Chisq*	*Sig Prob*	***%Reduction***	*LCL*	*UCL*
All regions	-0.371	0.1324	7.8472	0.0051	31.0%	45.8%	10.6%

Serious Injuries

Table 2 (B)

Regionwide : Urban and Rural combined

	Coeff	*SE*	*Chisq*	*Sig Prob*	***%Reduction***	*LCL*	*UCL*
Central	-0.2051	0.1402	2.1379	0.1437	18.5%	38.1%	(7.2%)
Far North	-0.061	0.1388	0.1932	0.6602	5.9%	28.3%	(23.5%)
North Coast	-0.111	0.1008	1.2135	0.2706	10.5%	26.6%	(9.0%)
Northern	-0.4425	0.1325	11.1527	0.0008	35.8%	50.5%	16.7%
South Eastern	-0.1975	0.0996	3.9343	0.0473	17.9%	32.5%	0.2%
Southern	-0.0576	0.1205	0.2285	0.6326	5.6%	25.5%	(19.6%)

All regions by Urban and Rural

	Coeff	*SE*	*Chisq*	*Sig Prob*	***%Reduction***	*LCL*	*UCL*
All regions - Rural	-0.0416	0.0691	0.3623	0.5472	4.1%	16.2%	(9.8%)
All regions - Urban	-0.2306	0.0657	12.3295	0.0004	20.6%	30.2%	9.7%

All regions : Urban and Rural Combined

	Coeff	*SE*	*Chisq*	*Sig Prob*	***%Reduction***	*LCL*	*UCL*
All regions	-0.1411	0.0476	8.7997	0.003	13.2%	20.9%	4.7%

Estimated Crash Effects of QLD RRW Program
Regionwide and Satewide Summaries Excluding Metro South

Other Injuries

Table 2 (C)

Regionwide : Urban and Rural combined

	Coeff	*SE*	*Chisq*	*Sig Prob*	*%Reduction*	*LCL*	*UCL*
Central	-0.256	0.1182	4.6885	0.0304	22.6%	38.6%	2.4%
Far North	-0.1024	0.1144	0.802	0.3705	9.7%	27.9%	(13.0%)
North Coast	0.1254	0.0815	2.3658	0.124	(13.4%)	3.4%	(33.0%)
Northern	-0.312	0.1007	9.608	0.0019	26.8%	39.9%	10.8%
South Eastern	-0.0723	0.0781	0.8575	0.3544	7.0%	20.2%	(8.4%)
Southern	-0.294	0.1044	7.9345	0.0049	25.5%	39.3%	8.5%

All regions by Urban and Rural

	Coeff	*SE*	*Chisq*	*Sig Prob*	*%Reduction*	*LCL*	*UCL*
All regions - Rural	-0.0499	0.0656	0.577	0.4475	4.9%	16.3%	(8.2%)
All regions - Urban	-0.1594	0.0468	11.5848	0.0007	14.7%	22.2%	6.5%

All regions : Urban and Rural Combined

	Coeff	*SE*	*Chisq*	*Sig Prob*	*%Reduction*	*LCL*	*UCL*
All regions	-0.1224	0.0381	10.3107	0.0013	11.5%	17.9%	4.7%

Property Damage Only

Table 2 (D)

Regionwide : Urban and Rural combined

	Coeff	*SE*	*Chisq*	*Sig Prob*	*%Reduction*	*LCL*	*UCL*
Central	-0.103	0.0984	1.0959	0.2952	9.8%	25.6%	(9.4%)
Far North	0.0964	0.09	1.1471	0.2841	(10.1%)	7.7%	(31.4%)
North Coast	-0.0428	0.0655	0.4282	0.5129	4.2%	15.7%	(8.9%)
Northern	-0.3312	0.0883	14.0588	0.0002	28.2%	39.6%	14.6%
South Eastern	-0.1092	0.0658	2.7513	0.0972	10.3%	21.2%	(2.0%)
Southern	-0.1058	0.0775	1.8611	0.1725	10.0%	22.7%	(4.7%)

All regions by Urban and Rural

	Coeff	*SE*	*Chisq*	*Sig Prob*	*%Reduction*	*LCL*	*UCL*
All regions - Rural	-0.0128	0.0516	0.0618	0.8037	1.3%	10.8%	(9.2%)
All regions - Urban	-0.1403	0.0389	13.0059	0.0003	13.1%	19.5%	6.2%

All regions : Urban and Rural Combined

	Coeff	*SE*	*Chisq*	*Sig Prob*	*%Reduction*	*LCL*	*UCL*
All regions	-0.093	0.0311	8.9651	0.0028	8.9%	14.3%	3.2%

Esimated Crash Effects of QLD RRW Program : Yearly Effects

Fatalities

Table 3 (A)

Region	Urb/Rur	Year After Introduction 1	2	3	4	5
C	R	45.64%	(4.48%)	(28.45%)	29.26%	
	U	100.00%	40.23%	44.44%	(242.60%)	
FN	R	(36.32%)	19.23%	18.11%	59.73%	
	U	(95.19%)	51.56%	1.91%	69.41%	
NC	R	63.81%	54.97%	16.37%	51.85%	
	U	(14.89%)	(70.85%)	(24.33%)	(63.56%)	
N	R	19.35%	(46.08%)	66.32%		
	U	84.18%	88.77%	91.43%		
SE	R	32.01%	22.70%	55.88%	69.07%	
	U	(26.28%)	36.11%	4.97%	0.57%	
S	R	66.49%	31.81%	66.59%	26.60%	89.31%
	U	(8.47%)	69.54%	(36.26%)	(124.84%)	(51.60%)

Summary by region : Urban and Rural Combined

Region	1	2	3	4	5
C	57.49%	8.99%	(12.21%)	(13.69%)	
FN	(56.83%)	27.88%	13.39%	49.04%	
NC	42.82%	36.52%	8.48%	28.49%	
N	47.81%	41.27%	76.08%		
SE	10.15%	30.25%	35.23%	28.07%	
S	46.02%	15.79%	49.46%	(38.44%)	71.64%

Summary by Urban and Rural

		1	2	3	4	5
All regions	R	42.24%	25.18%	37.94%	31.93%	86.14%
	U	15.88%	37.66%	24.38%	(17.49%)	(1.98%)

Summary by Metro South and all other regions : Urban and rural combined

	1	2	3	4	5
All regions	34.17%	28.78%	33.41%	17.37%	74.62%

QLD RRW Program : Yearly Effect Significance Probabilities

Fatalities

Table 3 (A)

Region	Urb/Rur	Year After Introduction 1	2	3	4	5
C	R	0.402	0.951	0.716	0.665	
	U	0.999	0.737	0.712	0.356	
FN	R	0.708	0.796	0.816	0.269	
	U	1.000	1.000	1.000	1.000	
NC	R	0.088	0.145	0.745	0.181	
	U	0.864	0.535	0.797	0.537	
N	R	0.802	0.661	0.191		
	U	0.186	0.093	0.080		
SE	R	0.646	0.763	0.349	0.230	
	U	0.740	0.512	0.943	0.993	
S	R	0.137	0.602	0.153	0.680	0.008
	U	0.943	0.402	0.781	0.537	0.745
Summary by region : Urban and Rural Combined						
C		0.203	0.882	0.852	0.842	
FN		0.555	0.662	0.850	0.378	
NC		0.234	0.322	0.847	0.451	
N		0.371	0.448	0.045		
SE		0.839	0.494	0.425	0.515	
S		0.299	0.772	0.260	0.600	0.061
Summary by Urban and Rural : all regions combined						
All regs	R	0.319	0.597	0.388	0.498	0.006
	U	0.820	0.533	0.713	0.837	0.984
All regions : Urban and rural combined						
All regs		0.347	0.444	0.362	0.677	0.016

Esimated Crash Effects of QLD RRW Program : Yearly Effects
Serious Injuries

Table 3 (B)

Region	Urb/Rur	Year After Introduction 1	2	3	4	5
C	R	1.57%	6.97%	34.62%	47.25%	
	U	12.58%	22.87%	65.08%	44.69%	
FN	R	11.26%	17.91%	18.63%	10.37%	
	U	2.96%	(20.57%)	(5.69%)	6.32%	
NC	R	(1.78%)	12.13%	12.24%	15.39%	
	U	16.45%	7.79%	33.50%	34.71%	
N	R	29.25%	40.84%	50.66%		
	U	34.94%	44.82%	13.60%		
SE	R	(16.59%)	(42.19%)	(16.94%)	(59.94%)	
	U	27.92%	28.73%	43.82%	50.50%	
S	R	(13.26%)	(2.07%)	(0.92%)	21.59%	9.38%
	U	12.16%	45.13%	45.37%	9.28%	36.00%

Summary by region : Urban and Rural Combined

Region	1	2	3	4	5
C	5.75%	15.41%	49.75%	47.14%	
FN	7.42%	2.95%	8.25%	10.41%	
NC	7.46%	10.11%	23.00%	25.61%	
N	31.96%	42.59%	27.96%		
SE	17.16%	13.13%	30.78%	31.81%	
S	(2.26%)	17.50%	8.85%	14.90%	9.14%

Summary by Urban and Rural

		1	2	3	4	5
All regions	R	0.54%	6.27%	12.53%	21.31%	16.67%
	U	16.66%	20.49%	34.51%	34.88%	37.69%

Summary by all regions : Urban and rural combined

	1	2	3	4	5
All regions	9.35%	14.02%	24.78%	29.12%	21.62%

QLD RRW Program : Yearly Effect Significance Probabilities

Serious Injuries

Table 3 (B)

Region	Urb/Rur		Year After Introduction 1	2	3	4	5
	C	R	0.950	0.782	0.128	0.025	
		U	0.685	0.438	0.005	0.108	
	FN	R	0.758	0.608	0.600	0.767	
		U	0.935	0.611	0.883	0.852	
	NC	R	0.937	0.569	0.571	0.450	
		U	0.422	0.719	0.079	0.054	
	N	R	0.355	0.165	0.045		
		U	0.196	0.076	0.605		
	SE	R	0.653	0.305	0.659	0.143	
		U	0.097	0.090	0.004	0.000	
	S	R	0.682	0.946	0.975	0.429	0.731
		U	0.693	0.095	0.107	0.799	0.295
Summary by region : Urban and Rural Combined							
	C		0.766	0.414	0.002	0.004	
	FN		0.770	0.909	0.748	0.663	
	NC		0.624	0.505	0.110	0.058	
	N		0.121	0.027	0.132		
	SE		0.268	0.411	0.035	0.018	
	S		0.914	0.365	0.663	0.469	0.663
Summary by Urban and Rural : all regions combined							
All regs	R		0.980	0.759	0.528	0.272	0.381
	U		0.343	0.233	0.029	0.032	0.116
All regions : Urban and rural combined							
All regs			0.488	0.287	0.046	0.019	0.128

Esimated Crash Effects of QLD RRW Program : Yearly Effects

Other Injuries

Table 3 (C)

Region	Urb/Rur	Year After Introduction 1	2	3	4	5
C	R	22.66%	28.62%	26.46%	43.16%	
	U	12.66%	13.41%	53.91%	43.72%	
FN	R	(12.03%)	12.39%	7.39%	(17.12%)	
	U	5.20%	24.65%	23.43%	42.96%	
NC	R	5.32%	(10.16%)	(15.13%)	2.03%	
	U	(24.52%)	(14.95%)	(17.74%)	(4.24%)	
N	R	1.91%	26.70%	64.92%		
	U	26.07%	20.63%	51.70%		
SE	R	(1.89%)	(61.19%)	(35.43%)	(30.38%)	
	U	4.68%	20.63%	34.03%	24.41%	
S	R	9.03%	(0.79%)	21.43%	(6.42%)	(0.06%)
	U	25.23%	29.23%	10.26%	(16.92%)	(33.86%)

Summary by region : Urban and Rural Combined

Region	1	2	3	4	5
C	17.78%	21.09%	41.59%	43.85%	
FN	(0.88%)	20.20%	17.35%	24.13%	
NC	(12.39%)	(12.20%)	(15.48%)	(0.53%)	
N	20.44%	22.45%	55.15%		
SE	3.10%	6.03%	21.27%	12.63%	
S	18.00%	23.47%	28.48%	4.97%	1.67%

Summary by Urban and Rural

Region	Urb/Rur	1	2	3	4	5
All regions	R	5.65%	1.08%	10.90%	6.70%	2.17%
	U	9.80%	15.94%	26.29%	21.92%	(10.22%)

Summary by all regions : Urban and rural combined

Region	1	2	3	4	5
All regions	8.41%	11.19%	21.49%	16.95%	(1.03%)

QLD RRW Program : Yearly Effect Significance Probabilities

Other Injuries

Table 3 (C)

Region	Urb/Rur	Year After Introduction 1	2	3	4	5
C	R	0.297	0.189	0.245	0.038	
	U	0.539	0.530	0.003	0.027	
FN	R	0.742	0.702	0.828	0.617	
	U	0.852	0.317	0.351	0.033	
NC	R	0.790	0.637	0.502	0.920	
	U	0.160	0.373	0.306	0.787	
N	R	0.954	0.354	0.001		
	U	0.169	0.288	0.000		
SE	R	0.945	0.082	0.288	0.317	
	U	0.753	0.128	0.006	0.044	
S	R	0.755	0.979	0.423	0.838	0.998
	U	0.240	0.183	0.685	0.585	0.339
Summary by region : Urban and Rural Combined						
C		0.231	0.164	0.003	0.002	
FN		0.968	0.301	0.390	0.171	
NC		0.345	0.354	0.257	0.965	
N		0.212	0.162	0.000		
SE		0.812	0.639	0.073	0.270	
S		0.246	0.127	0.062	0.784	0.929
Summary by Urban and Rural : all regions combined						
All regs	R	0.766	0.956	0.558	0.729	0.910
	U	0.423	0.177	0.018	0.064	0.590
All regions : Urban and rural combined						
All regs		0.414	0.268	0.025	0.094	0.935

Esimated Crash Effects of QLD RRW Program : Yearly Effects

Property Damage Only

Table 3 (D)

Region	Urb/Rur	Year After Introduction 1	2	3	4	5
C	R	(18.16%)	(0.10%)	2.94%	36.66%	
	U	9.34%	31.41%	52.49%	55.72%	
FN	R	(22.36%)	(101.64%)	(34.35%)	(16.85%)	
	U	(6.27%)	7.57%	15.68%	21.99%	
NC	R	4.95%	(2.80%)	8.56%	14.19%	
	U	(8.59%)	17.12%	18.62%	22.34%	
N	R	32.67%	52.91%	32.97%		
	U	17.02%	25.20%	25.23%		
SE	R	(11.77%)	14.58%	2.31%	(1.07%)	
	U	11.01%	11.61%	32.81%	36.47%	
S	R	1.83%	7.75%	20.78%	18.77%	5.40%
	U	13.64%	24.16%	19.10%	(44.67%)	(95.44%)

Summary by region : Urban and Rural Combined

Region	1	2	3	4	5
C	(2.32%)	17.23%	33.02%	47.59%	
FN	(8.46%)	(22.35%)	4.09%	12.29%	
NC	(2.53%)	9.91%	14.82%	19.25%	
N	22.37%	35.44%	27.97%		
SE	5.15%	11.24%	25.41%	27.83%	
S	(2.28%)	8.19%	14.03%	(11.43%)	(40.16%)

Summary by Urban and Rural

Region	Urb/Rur	1	2	3	4	5
All regions	R	(2.11%)	3.17%	10.79%	16.02%	(1.41%)
	U	3.28%	17.57%	26.35%	22.06%	(46.24%)

Summary by all regions : Urban and rural combined

Region	1	2	3	4	5
All regions	1.25%	12.45%	21.11%	20.44%	(15.56%)

QLD RRW Program : Yearly Effect Significance Probabilities

Property Damage Only

Table 3 (D)

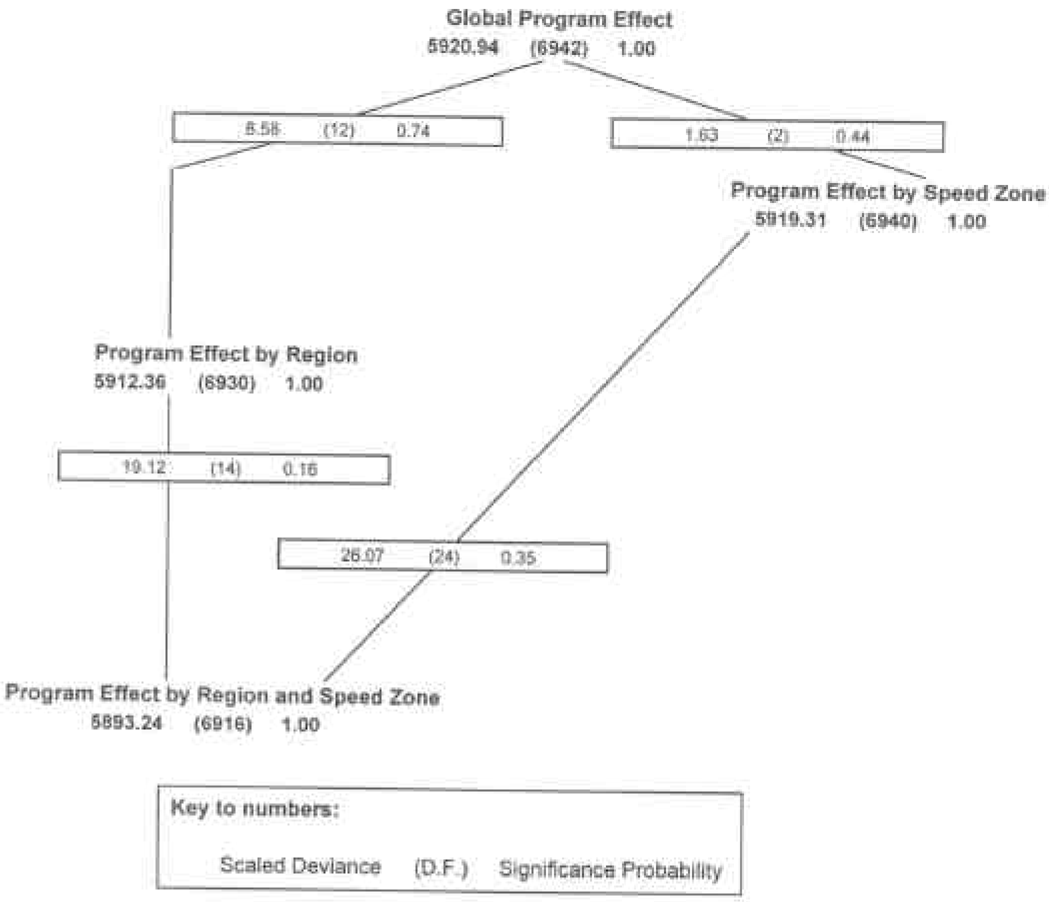
Region	Urb/Rur		Year After Introduction 1	2	3	4	5
	C	R	0.417	0.996	0.893	0.056	
		U	0.593	0.051	0.000	0.000	
	FN	R	0.458	0.011	0.289	0.557	
		U	0.803	0.750	0.493	0.250	
	NC	R	0.751	0.864	0.592	0.342	
		U	0.532	0.153	0.125	0.051	
	N	R	0.231	0.025	0.161		
		U	0.367	0.169	0.095		
	SE	R	0.620	0.499	0.922	0.961	
		U	0.361	0.343	0.003	0.000	
	S	R	0.933	0.714	0.295	0.357	0.791
		U	0.421	0.152	0.296	0.077	0.002
Summary by region : Urban and Rural Combined							
	C		0.866	0.178	0.008	0.000	
	FN		0.652	0.270	0.820	0.429	
	NC		0.806	0.305	0.125	0.034	
	N		0.148	0.014	0.027		
	SE		0.633	0.293	0.011	0.002	
	S		0.859	0.511	0.262	0.436	0.014
Summary by Urban and Rural : all other combined							
All regs	R		0.893	0.837	0.468	0.279	0.926
	U		0.743	0.058	0.003	0.020	0.005
All regions : Urban and rural combined							
All regs			0.882	0.118	0.006	0.010	0.134

APPENDIX B

Homogeneity analysis of Queensland RRW program effects

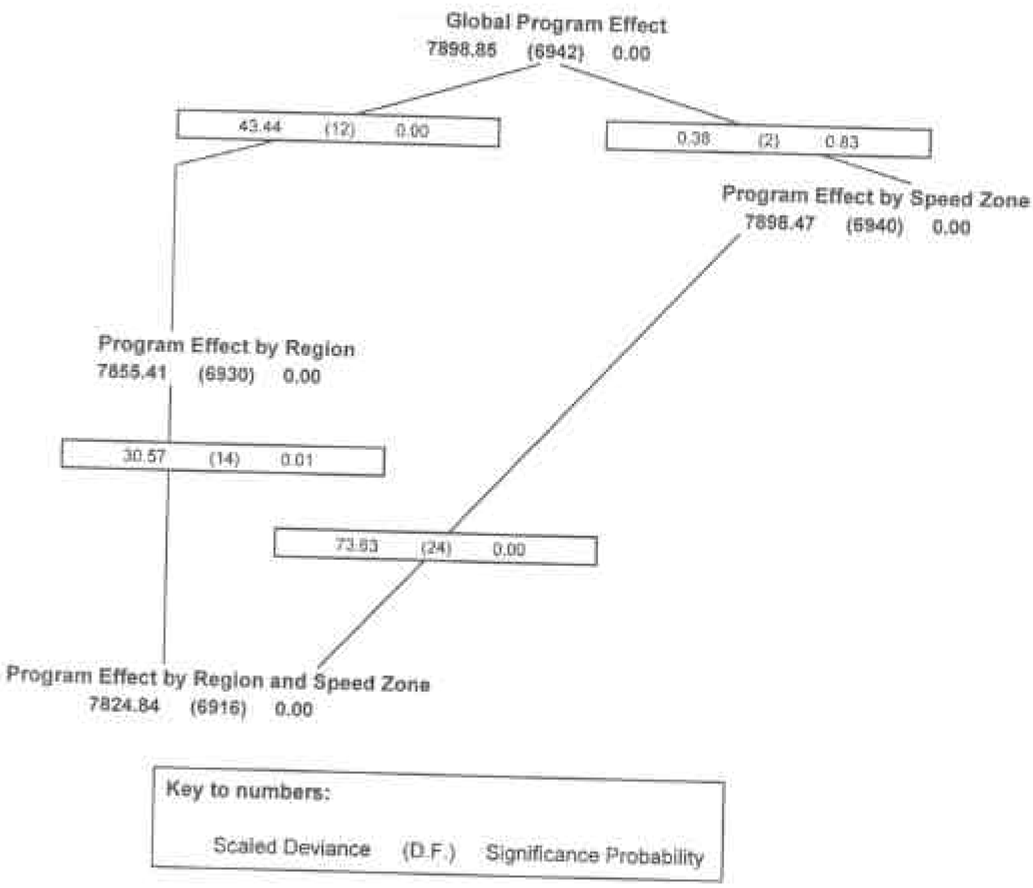
Fatal

Figure 1



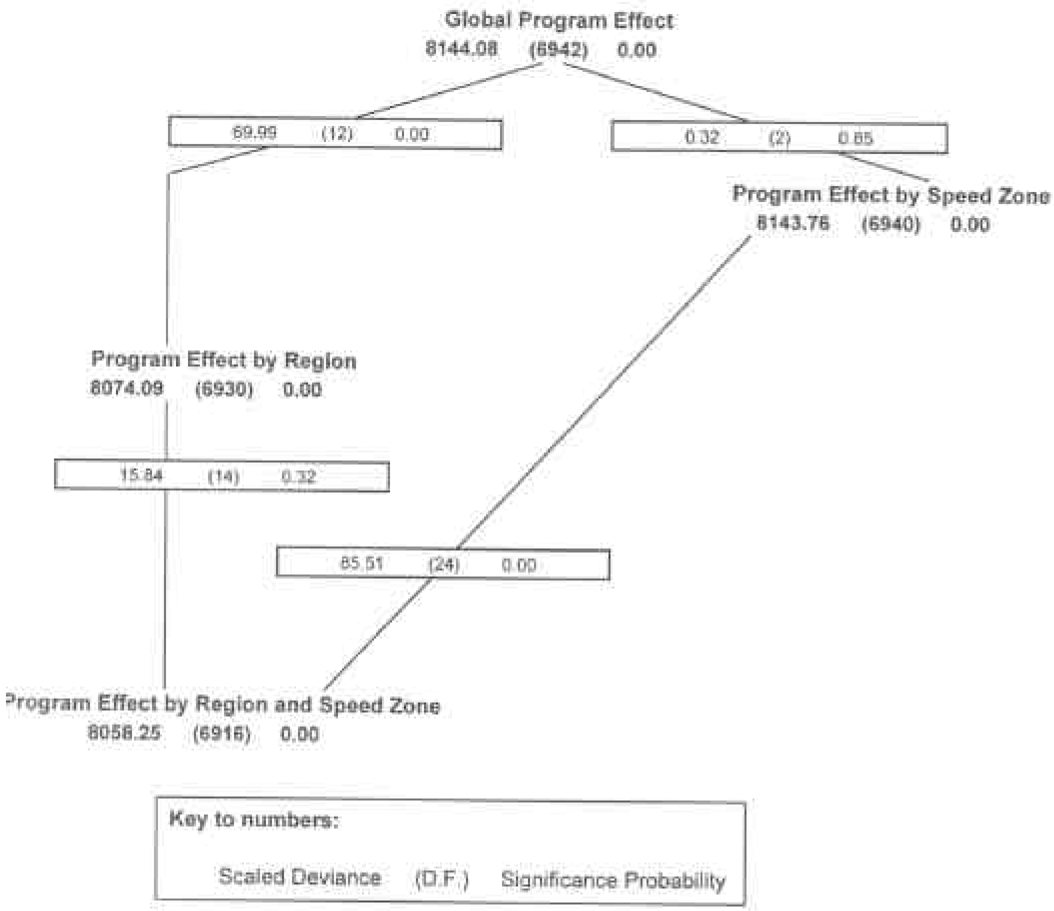
Serious

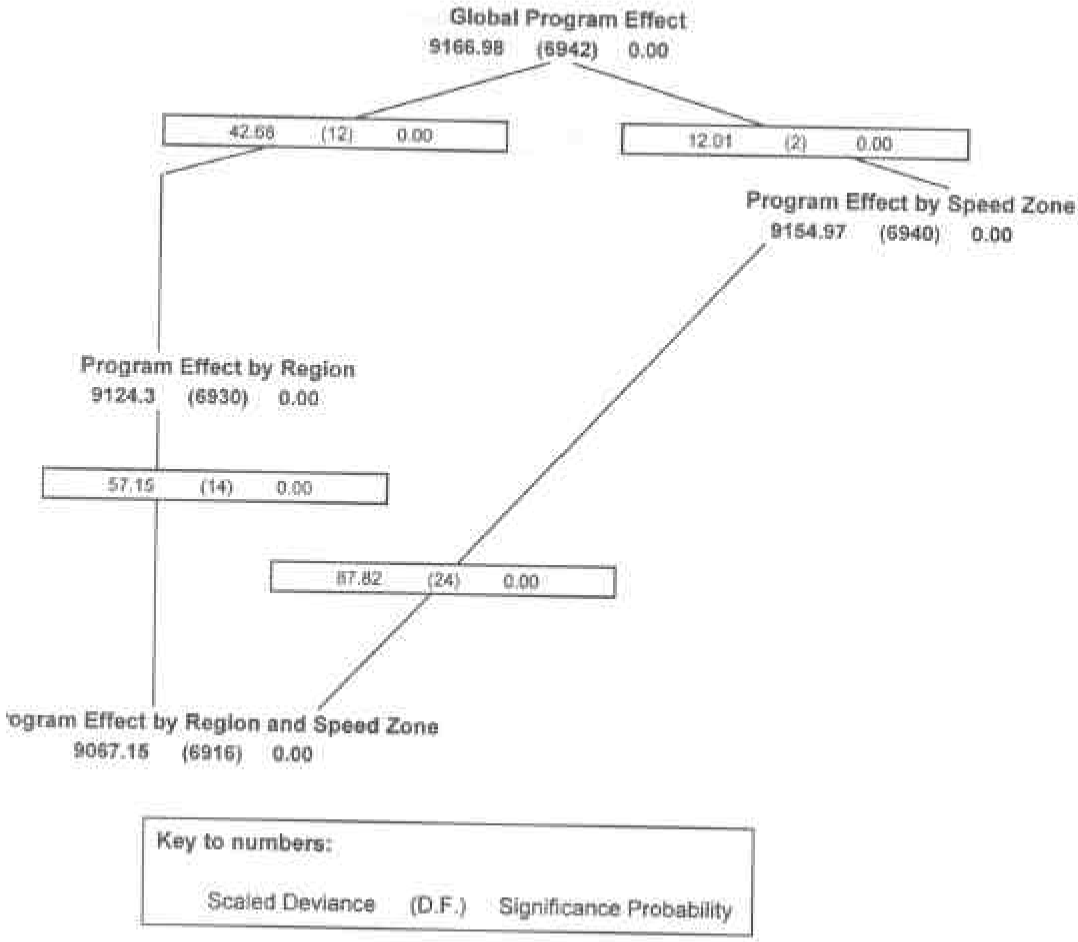
Figure 2



Other Injury

Figure 3




Global Program Effect
9166.98 (6942) 0.00
42.68 (12) 0.00
12.01 (2) 0.00
Program Effect by Speed Zone
9154.97 (6940) 0.00
Program Effect by Region
9124.3 (6930) 0.00
57.15 (14) 0.00
87.82 (24) 0.00
'ogram Effect by Region and Speed Zone
9067.15 (6916) 0.00
Key to numbers:
Scaled Deviance (D.F.) Significance Probability

APPENDIX C

Homogeneity analysis of Queensland RRW program control series information

Test of Control Series Homogeneity

Severity	Region	Zone	Model ChiSq (494df)	Full ChiSq (492df)	Change (2df)	p-value
Fatal	Central	R	465.50	464.31	1.19	0.55
Fatal	Central	U	296.19	293.31	2.88	0.24
Fatal	Far Northern	R	455.87	451.97	3.89	0.14
Fatal	Far Northern	U	296.67	296.13	0.53	0.77
Fatal	North Coast	R	528.70	527.26	1.44	0.49
Fatal	North Coast	U	382.49	380.65	1.84	0.40
Fatal	Northern	R	417.99	413.94	4.05	0.13
Fatal	Northern	U	294.35	293.60	0.75	0.69
Fatal	South Eastern	R	498.29	493.15	5.14	0.08 *
Fatal	South Eastern	U	524.17	513.26	10.91	0.00 **
Fatal	Southern	R	509.02	507.34	1.67	0.43
Fatal	Southern	U	387.25	384.04	3.21	0.20
Serious	Central	R	543.43	538.76	4.67	0.10 *
Serious	Central	U	520.58	510.04	10.54	0.01 **
Serious	Far Northern	R	546.73	545.99	0.74	0.69
Serious	Far Northern	U	556.31	556.19	0.12	0.94
Serious	North Coast	R	628.96	627.52	1.44	0.49
Serious	North Coast	U	558.44	558.28	0.17	0.92
Serious	Northern	R	552.27	550.32	1.95	0.38
Serious	Northern	U	559.17	558.68	0.49	0.78
Serious	South Eastern	R	512.30	510.80	1.50	0.47
Serious	South Eastern	U	612.39	610.12	2.27	0.32
Serious	Southern	R	660.56	659.57	0.99	0.61
Serious	Southern	U	471.53	465.85	5.68	0.06 *
Other	Central	R	585.95	577.07	8.88	0.01 **
Other	Central	U	547.14	546.61	0.53	0.77
Other	Far Northern	R	506.31	501.35	4.95	0.08 *
Other	Far Northern	U	501.20	500.99	0.21	0.90
Other	North Coast	R	601.65	600.23	1.42	0.49
Other	North Coast	U	574.03	569.39	4.64	0.10 *
Other	Northern	R	557.78	552.65	5.13	0.08 *
Other	Northern	U	601.22	594.38	6.84	0.03 **
Other	South Eastern	R	585.94	580.72	5.22	0.07 *
Other	South Eastern	U	595.09	593.20	1.90	0.39
Other	Southern	R	536.33	534.75	1.58	0.45
Other	Southern	U	568.75	566.45	2.30	0.32
PDO	Central	R	614.27	614.07	0.20	0.91
PDO	Central	U	575.94	570.83	5.11	0.08 *
PDO	Far Northern	R	570.50	568.48	2.03	0.36
PDO	Far Northern	U	637.03	634.75	2.27	0.32
PDO	North Coast	R	631.08	627.37	3.71	0.16
PDO	North Coast	U	643.36	634.30	9.06	0.01 **
PDO	Northern	R	614.46	613.81	0.65	0.72
PDO	Northern	U	597.43	595.90	1.53	0.47
PDO	South Eastern	R	642.25	641.21	1.04	0.59
PDO	South Eastern	U	753.38	746.59	6.78	0.03 **
PDO	Southern	R	605.44	605.19	0.25	0.88
PDO	Southern	U	665.24	661.43	3.81	0.15

* = statistically significant at the 10% level
** = statistically significant at the 5% level