Evaluation of the Queensland Road Safety Initiatives Package

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Abstract

This paper presents an evaluation of the Queensland Road Safety Initiatives Package (RSIP) developed by Queensland Transport (QT) and the Queensland Police Service (QPS). The RSIP is a continuation of the Holiday Period Road Safety Enforcement and Education Campaign that was trialled between 13th December 2001 and 8th February 2002, and re-implemented from 13th December 2002 to 27th April 2003. The RSIP commenced on 28th April 2003 and continued into 2004. The RSIP aimed to target the road toll through increased hours of speed camera operation, increased hours of on-road Police enforcement to target the "Fatal Four" behaviours (drink driving, speeding, fatigue, and non-seat belt wearing), increased mass-media publicity to target the "Fatal Four" and increased hours of Police educative activities.

This study has evaluated the effectiveness of the Road Safety Initiatives Package implemented in Queensland over the period December 2002 to January 2004. The evaluation has examined the crash effects of the program and their associated economic worth for both the program as a whole as well as for specific program elements. It has also assessed changes in speeding behaviour and general attitudes through analysis of speed monitoring data and attitudinal surveys respectively.

Key Words

Evaluation, Accident, Police, Enforcement, Publicity, Statistical Analysis,

Background and Aims

To address the Queensland road toll, Queensland Transport (QT) and the Queensland Police Service (QPS) have developed the Road Safety Initiatives Package (RSIP). The RSIP is a continuation of the Holiday Period Road Safety Enforcement and Education Campaign (HPRSEEC) that was trialled between 13th December 2001 and 8th February 2002, and re-implemented from 13th December 2002 to 27th April 2003. The RSIP commenced on 28th April 2003 and continued into 2004.

The RSIP involved the following measures to target the road toll:

1. Increase in the hours of operation of speed cameras, from five to eight hours per camera per day.
2. Increase in the hours of on-road Police enforcement to target the "Fatal Four" behaviours – drink driving, speeding, fatigue, and non-seat belt wearing:
    2.1. To target drink driving: increase in RBTs by buses and other stationary or mobile vehicles.
    2.2. To target speeding: increase in the hours of operation of moving mode radar (MMR) and LIDAR speed detectors.
    2.3. To target non-seat belt wearing and fatigue: increase in Police hours of "Stop and inspect" operations for seat belts, mobile phones and fatigue.
3. Increase of mass-media publicity (planned TARPs) to target the "Fatal Four":
4. Increase in hours of Police educative activities: For example, educating motorists who have been pulled over about the Fatal Four and publicising analysis of crashes on the previous day.

The aim of this study was to examine the effects of the RSIP on crash outcomes in Queensland for the program as a whole as well as for specific program elements including estimation the economic worth of the program. For the purposes of the study, the RSIP period has been defined to include both the re-implementation of the HPRSEEC as well as the formal RSIP period due to the compatibility of the programs in terms of structure. This has resulted in a total program evaluation period from 13th December 2002 to the end of January 2004, the latest month for which complete crash data was available for analysis at the time of the study.

Evaluation Design

The number of initiatives included in the RSIP (enforcement operations of various types, and mass media public education), and the reach of these program components over the crash population did not lend itself to a crash-based evaluation employing an experimental or quasi-experimental design framework. The coverage of crashes throughout Queensland by the components of the package across all times of day and all road users, did not result in any crash type which could be considered unaffected by the package and hence potentially useful for taking into account the influence of "other factors" as a "control" group in a quasi-experimental setting. Nor could crashes at any specific time of the year be considered to be unaffected. Furthermore, use of a control outside of Queensland, say crashes in New South Wales for example, was considered inappropriate due to fundamental differences in road safety strategy and socio-economic factors between Queensland and other Australian states.

As the best alternative design, the evaluation of RSIP crash effects sought to identify relationships between measures of the RSIP and crash outcomes in terms of a time trend in observed monthly crashes through statistical regression modelling. The success of such an approach relies on the ability to effectively represent the majority of factors other than the RSIP that have influenced observed crash counts over an extended time period in order to be able to measure the pure effects of the RSIP. To do this, it was necessary to have accurate measures of the other influential factors and to model the crash data for a period sufficiently long to allow accurate associations between the available measures and the crash outcomes to be firmly established. This required crash trends to be modelled over a time period including the RSIP implementation period but also for a significant time period before the introduction of the RSIP. The basic premise of the modelling approach was to accurately represent crash trends in the pre-RSIP period by the non-RSIP factors included in the regression model and then measure the perturbation from the pre-implementation crash trends once the RSIP program was in place. The perturbation is then inferred to represent the effect of the program on crashes.

In designing the analysis in the way described, there is always a danger of confounding of the RSIP program crash effects with the effects of other unidentified factors not included in the modeling process. However, the possibility of confounding factors affecting the assessment of the RSIP crash effects has been minimized by including general trend and seasonal terms in the model (see below). This means that any confounding factor that would significantly bias the estimated crash effect of the RSIP program intervention would have to have been entirely co-incident with the RSIP program introduction. No such factor was identified and it is considered unlikely that one exists that would affect the broad crash population in Queensland in a substantial enough way to bias the estimates obtained in the study greatly.

A two stage approach to the regression modelling was used in this evaluation. The first approach models the perturbation on the crash series attributed to a program effect as a single global effect. This model estimates the overall crash effects of the RSIP and is referred to as the "intervention model". The second stage measures the perturbation as a function of measures of key RSIP component activity measures, aiming to measure the crash effects of each of the key RSIP activities. It is referred to here as the "program component effects model".

Evaluation Time Period and Analysis Stratification

The evaluation of the crash effects covers both the re-implementation of the HPRSEEC as well as the formal RSIP period, a time frame December 2002 to January 2004 inclusive. The period from January 1998 to November 2002 was used as the pre RSIP intervention period from which general trends in the crash data were estimated. The length of this period was dictated largely by the available data on key factors influencing the observed crash trends.

Since elements of the RSIP were targeted specifically at crashes occurring in certain regions or at certain times of the day and because Queensland is such a geographically and socially diverse state, it was considered likely that the key factors considered in this study influence road trauma trends differently in different parts of the state. To accommodate this in the crash analysis, the monthly crash data series was stratified for modelling. The first level of stratification was by the 8 Queensland Police Regions. Within each Police Region the monthly crash frequencies were then further stratified into two times of week (High versus Low Alcohol Hours as defined by Harrison [1]) and two road environments (urban, <

80km/h, versus rural, >= 80km/h) defining 32 crash strata (8x2x2). For each of the 32 strata, the monthly crash counts from January 1998 to January 2004 were assembled for analysis.

Data

Crash Data and Outcome Measures

Queensland Transport supplied crash data covering the period January 1997 to April 2004. It included all reported crashes in Queensland over that period with each unit record in the data representing a reported crash. Each record in the crash data contained information on the crash severity, date, time of day, police region and speed limit. These fields allowed crashes to be allocated to each of the 32 analysis strata defined above. Injury outcome in the data is classified into one of five levels based on the injury level of the most seriously injured person involved, being fatal, serious injury (requiring hospital admission), medically treated injury, other injury and non-injury. The data was collapsed into 3 crash severity levels for analysis: fatal and serious injury crashes, medically treated injury crashes and other injury and non-injury crashes. Figure 1 plots the monthly crash data counts for the three highest crash severity levels for the whole of Queensland as an indication of the general trend over the study period. Figure 1 is included to illustrate the general road safety trends in Queensland and the relative numbers of crashes in each of the 3 most severe crash categories. It was beyond the scope of the study to illustrate the crash trends in each of the 32 analysis strata.

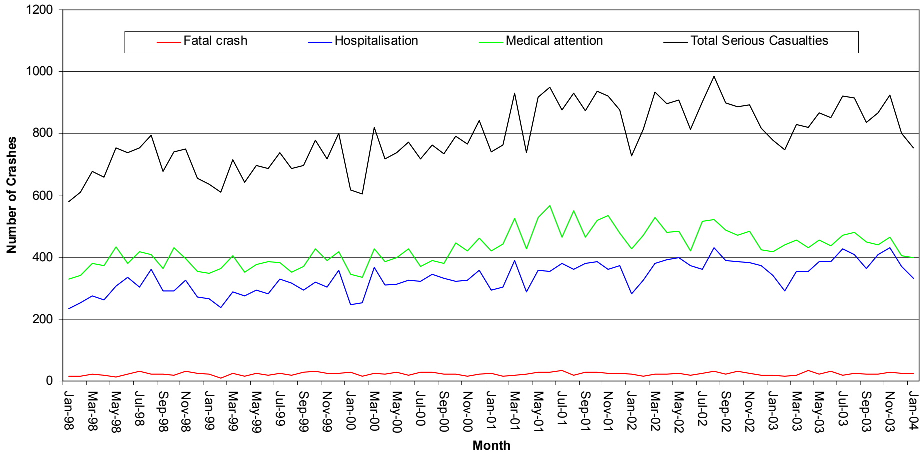

Figure 1: Queensland Crash Data: Fatal, Hospitalisation, Medical Attention, and Total Serious Casualty Crashes; January 1998 to January 2004

RSIP Measures

Measures of RSIP activity were collected under a number of broad program component areas with the data chosen for use largely dictated by what was reliably collected by the relevant authorities. The component areas and the specific component activities along with variable name abbreviations within each area are summarised as follows.

1. Speed Camera Activity: hours of operation, number of sites used and compliance with randomised schedular
2. On-road (non speed camera) Police Enforcement: Moving Mode Radar (MMR) and Laser Speed Detection (LIDAR) operations, Random Breath Testing (RBT) operations, seat belt offences detected and mobile phone offences detected.
3. Mass Media Publicity: Monthly awareness levels of mass media television advertising (AdStock) with the following themes; speed, fatigue, seat belts, and drink driving (see Broadbent [2], [3] for the definition of AdStock)

Non-RSIP Road Safety Measures

A number of other road-safety related initiatives were introduced during the RSIP evaluation period, but which were not the central focus of this evaluation. In addition, there was also a change in crash reporting levels in Queensland in late 2000 associated with changes in the rules for making injury compensation claims following a motor vehicle crash. The factors included were as follows.

- Introduction of the default 50km/h local street speed limit in south-east Queensland in June 1999 (enforcement amnesty period from March to May 1999)
- The Holiday Period Road Safety Trial from December 2001 to end of January 2002
- Introduction of the regional 50km/h local street speed limit from May 2003 (enforcement amnesty period from February to April 2003)
- the increase in speeding penalties from April 2003
- the increase in penalties for use of hand-held mobile phones while driving from December 2003
- the change in crash reporting levels from October 2000

Each of the above factors was represented in the statistical model as a step function.

Socio-Economic Factors

Like the non-RSIP related road safety initiatives, it was necessary to include measures of socio-economic effects in the statistical models to accurately describe trends in the crash data driven by factors other than the RSIP. Measures of several socioeconomic factors were included in the statistical models on a monthly and regional basis. These were: population size, unemployment rate, and fuel sales.

Effects Targeted to Particular Crash Strata

As noted in describing the stratification of the crash data for analysis, the motivation for the data stratification was to be able to relate certain measures used in the statistical models to those crash sub-populations to which they most directly relate. The measures considered only relating to certain crash strata and the strata to which they relate are as follows: Number of RBTs - High Alcohol Hour crashes, Moving mode radar hours - Crashes on rural roads, LIDAR speed detector hours - crashes on urban roads during Low Alcohol Hours, Seat-belt and mobile phone penalties - Crashes on urban roads during Low Alcohol Hours, Road safety publicity AdStock with drink-driving theme -High Alcohol Hour crashes, South-east Queensland 50km/h local street speed limit - Police regions in south-east Queensland, Regional Queensland 50km/h local street speed limit - Police regions outside of south-east Queensland.

Analysis Methods

In order to build statistical regression models that are robust and easily interpreted the first step in the statistical modelling process was to test for co-linearity between the regression input (independent) variables. The presence of potential co-linearity between independent variables in the regression models has been investigated through analysing the correlations between the variables. Variables having a raw correlation co-efficient higher than 0.5 were considered to have a co-linearity high enough to be of concern to the analysis interpretation. In order to eliminate the co-linearity problem, one of each pair of highly correlated input variables was removed from the regression equation. The remaining variable could be considered to represent the effect of both itself as well as the removed highly correlated variable.

The analysis model used in this evaluation to relate measures of RSIP effort and other factors to observed monthly crash counts was a Poisson Regression model which has been widely used to model accident count data (Nicholson, A.J. [4], Nicholson, A.J. [5], Maher and Summersgill [6], Newstead, Cameron & Leggett [7]). An advantage of the Poisson regression analysis model was the ability to conveniently measure the average RSIP crash effects over all 32 analysis strata through application of single regression model to the entire data stratified data. The overall purpose of the Poisson regression analysis models is to measure the level and statistical significance of association between RSIP program measures and observed crash outcomes.

Table 1: Summary of modelling variable shorthand names and structures

Variable Grouping	Variable Description	Shorthand Name	Structure in Modelling Process
Crash data	Monthly fatal and serious injury crash counts	FATHOSP	Count variable
	Monthly medically treated injury crash counts	MEDICAL	Count variable
	Monthly other and non injury crash counts	MINPROP	Count variable
Stratification Variables	Police Region	REGION	Categorical (8 level)
	Urban or Rural speed zone	METRUR	Categorical (1=Urban, 2=Rural)
	Alcohol Hours	ALCHOUR	Categorical (1=LAH, 2=HAH)
	Month of Crash	MONTH	Categorical Numeric (1-12)
	Year of Crash	YEAR	Continuous Numeric(1998-2004)
Socio-Economic Variables	Population	POP	Continuous Numeric
	Unemployment	UNEMPLOY	Continuous Numeric
	Fuel Sales	FUELSALES	Continuous Numeric
Other Road Safety Initiatives	S.E. QLD 50km/h local street speed limit	SEQLD50	Categorical (1=Post, 2=Pre)
	Initial Holiday Period Road Safety Trial	HOLTRIAL	Categorical (1=During, 2=Not During)
	Change in Crash Reporting Levels	CRASHREP	Categorical (1=Post, 2=Pre)
	Regional QLD 50km/h local street speed limit	REGQLD50	Categorical (1=Post, 2=Pre)
	Change in Speeding Penalties	SPDPEN	Categorical (1=Post, 2=Pre)
	Increase in Mobile Phone Use Penalties	MOBPEN	Categorical (1=Post, 2=Pre)
RSIP Measures	Drink-Driving AdStock	AD_DRINK	Continuous Numeric
	Speed AdStock	AD_SPEED	Continuous Numeric
	Belt Use AdStock	AD_BELT	Continuous Numeric
	Fatigue AdStock	AD_FATIGUE	Continuous Numeric
	Total AdStock	AD_ALL	Continuous Numeric
	Number of Random Breath Tests	BT	Continuous Numeric
	Hours of LIDAR Enforcement	LASHRS	Continuous Numeric
	Hours of Moving Mode Radar Enforcement	MOBHRS	Continuous Numeric
	Mobile Phone Offences	MOB	Continuous Numeric
	Seat Belt offences	BELT	Continuous Numeric
	Number of Hours of LIDAR and MR enforcement combined	NOCAMHRS	Continuous Numeric
	Hours of Speed Camera use	CAMHRS	Continuous Numeric
	Number of Active Speed Camera Sites	ACTSITE	Continuous Numeric
	Hours of Speed Camera Enforcement per Active Site	HRSACT	Continuous Numeric
Non-RSIP Controlled Speed Camera Variables	Compliance with Randomised Schedular	COMPLY	Continuous Numeric
	Monthly Difference in Active Site Numbers	ACTDIFF	Continuous Numeric
	Monthly Difference in Hours of Operation	HRSDIFF	Continuous Numeric

In the output from the statistical modelling included in the results section and in the following descriptions of the precise forms of the statistical models fitted, a shorthand notation for each variable included in the models has been used. A summary of the shorthand notations as well as an indication of the structure and treatment of the variable in the models is given in Table 1.

Assessment of Total Program Effects: The Intervention Model

The intervention model was specified to include all relevant factors aside from those associated with elements of the RSIP. By not using the RSIP program element measures, the model was designed to measure the total effect of the RSIP over its implementation period, without regard to the mechanisms producing the effect. The specification of the model is given by Equation 1.

$$\begin{aligned}\ln(crash_{asrm}) = {} & \alpha_{asr} + \beta_r^{Pop} Pop + \beta_r^{Unemploy} Unemploy + \beta_{mr}^{Month} Month_m + \beta_r^{year} Year \\ & + \beta^{SEQLD50} I_{SEQLD50} + \beta^{REGQLD50} I_{REGQLD50} + \beta^{HOLTRIAL} I_{HOLTRIAL} \\ & + \beta^{SPDPEN} I_{SPDPEN} + \beta^{MOBPEN} I_{MOBPEN} + \beta^{CRASHREP} I_{CRASHREP} \\ & + \beta^{RSIP} I_{RSIP}\end{aligned} \quad \text{...Equation 1}$$

In Equation 1, a is the index for alcohol hours, s is the index for urban or rural speed zone, r is the index for region, m is the index for month, α and β are parameters of the model and I is an indicator function being 1 if the program/factor is active and 0 otherwise. The RSIP intervention term is the final term in Equation 1. It is defined as 1 for the RSIP period and 0 before the RSIP program was implemented and is included as a categorical variable in the analysis model. It is the key term for assessing the intervention effect of the RSIP on crash outcomes.

The long term trend and seasonal terms were included in the intervention model to describe underlying long term and seasonal trends in the data series due to factors not explicitly represented in the model including population levels, unemployment rate and the effect of non-RSIP related road safety program interventions. Different underlying trends and seasonal effects were allowed for in each police region of Queensland as well as different relationships between crash outcome and population and unemployment rate. To assess the robustness of the estimate of the RSIP intervention parameter in Equation 1, a number of different forms of the model were fitted. These included allowing for separate seasonal and yearly trend terms for each of the 32 crash strata rather than just by region and similar modifications for effects of population, unemployment and other road safety programs. The modifications made essentially no difference to the estimated RSIP effect showing the result was robust to fine detail of model specification. There were too many possible permutations to consider lagged effects of all continuous variables in the model so it was assumed that effects of each variable in each month were associated only with crash outcomes in the same month. There was no a-priori reason to question this assumption based on the use of a number of these factors in prior related evaluation studies. Separate analysis models were fitted to the monthly data series of each of the three crash severity levels considered in the evaluation. All models were fitted using the SAS statistical software.

Assessment of Program Component Effects

Assessment of the association between specific measure of RSIP program activities and observed monthly crash outcomes was made through a modification of the Poisson regression model described in Equation 1. The formal definition of the program components effect analysis model is given by Equation 2.

$$\begin{aligned}\ln(crash_{asrm}) = {} & \alpha_{asr} + \beta_r^{Pop} Pop + \beta_r^{Unemploy} Unemploy + \\ & + \beta^{SEQLD50} I_{SEQLD50} + \beta^{REGQLD50} I_{REGQLD50} + \beta^{HOLTRIAL} I_{HOLTRIAL} \\ & + \beta^{SPDPEN} I_{SPDPEN} + \beta^{MOBPEN} I_{MOBPEN} + \beta^{CRASHREP} I_{CRASHREP} \\ & + \beta^{COMPLY} COMPLY + \beta^{ACDIFF} ACDIFF + \beta^{HRSDIFF} HRSDIFF \\ & + \beta^{AD\_ALL} AD\_ALL + \beta^{BT} BT + \beta^{CAMHRS} CAMHRS \\ & + \beta^{HRSACT} HRSACT + \beta^{NOCAMHRS} NOCAMHRS + \beta^{BELT} BELT\end{aligned} \quad \text{...Equation 2}$$

Interpretation of the components of Equation 2 is the same as for Equation 1. As before, separate models were fitted to the monthly crash counts for each crash severity level considered using the SAS software. It should be noted that general trend and seasonal effects were no longer significant in Model 2 when the specific RSIP program measures were included. Removing the trend and seasonality terms from the model made no difference to the estimated associations between the specific program measures and crash outcomes, hence for simplicity of presentation it was decided to present the results with these terms removed from the models.

Estimation of Percentage and Absolute Crash Savings

Estimates of percentage crash change attributable to a factor included in the Poisson regression were derived directly from the model parameter associated with that factor via Equation 3.

$$\%Change = (1 - \exp(\beta)) \times 100\% \quad \ldots\text{Equation 3}$$

For a binary categorical variable, such as the RSIP intervention variable in the intervention model, Equation 3 gives the net percentage crash change due to the introduction of the program. For the parameter estimates associated with continuous measures, Equation 3 gives the estimated percentage crash change associated with a unit increase in the continuous measure. To calculate the percentage crash change associated with a change in a continuous variable from level a_0 to level a_1, Equation 4 was is applied.

$$\%Change = (1 - \exp(\beta(a_1 - a_0))) \times 100\% \quad \ldots\text{Equation 4}$$

Equation 4 was used in assessing the effect of RSIP project components on crash outcomes during the RSIP period. For this assessment, a_0 was assigned as the average of the RSIP program component in the period before the RSIP was implemented (January 1998 to November 2002) whilst a_1 was the average of the RSIP program component after RSIP implementation.

In the above, positive percentage change estimates indicate crash reduction, whilst negative percentage change estimates indicate a crash increase. Statistical confidence limits can be placed on the estimated percentage changes by using the parameter standard error to estimate confidence limits on the parameter and then transforming the confidence limits into percentage changes using Equation 3 or 4. Estimates of absolute monthly crash savings attributed to the RSIP or its components have been derived from the percentage crash savings through multiplying the estimated percentage crash savings by the average monthly crash count in the pre RSIP implementation period (January 1998 to November 2002). Annual crash savings or crash savings for the entire 14 months post RSIP implementation period were then derived by multiplying the average monthly savings by 12 or 14 respectively. Confidence limits have been estimated for the absolute crash savings by converting the confidence limits on the estimated percentage crash savings into absolute crash savings in the same way.

Estimation of Crash Cost Savings and Benefit to Cost Ratio

Estimates of crash cost savings attributable to the RSIP have been obtained by multiplying the estimates absolute crash savings by standardised crash costs by crash severity estimated by the Australian Bureau of Transport Economics (BTE [8]). Crash costs savings have been estimated both for the program as a whole using the results from the intervention analysis, as well as for individual program components showing a significant association with crash outcomes in the analysis of program component effects. Confidence limits on the estimated crash cost savings have also been derived through conversion to costs of the confidence limits on the absolute crash savings. Program benefit to cost ratio estimates have been calculated by dividing the estimated cost savings by figures on RSIP program costs supplied by Queensland Transport. This has been done again for the program as a whole and for specific program components.

Results

Elimination of Input Measure Co-Linearity

In order to build statistical regression models that were robust and could be easily interpreted, it was first necessary to test for co-linearity between the regression input (independent) variables. The presence of potential co-linearity between independent variables in the regression models has been investigated through analysing the Pearson correlations between the variables over the months for which data was available. Variable pairs having a raw correlation co-efficient higher than 0.5 were considered to have a co-linearity high enough to be of concern to the analysis interpretation. Variable pairs with high correlations were as follows with the level of correlation indicated: Fuel sales with unemployment rate (-0.500); Laser enforcement hours with seat belt offences (0.912), mobile phone offences (0.755); Mobile phone offences with seat belt offences (0.555); All AdStock with belt AdStock (0.704), drink driving AdStock (0.637), fatigue AdStock (0.737), speeding AdStock (0.807); Fatigue AdStock with belt AdStock (0.583); Speed camera hours with fuel sales (0.540); Active speed camera sites with speed camera hours (0.727), fuel sales (0.539), hours per active speed camera site (-0.585)

To overcome the model co-linearity problems, a number of variables were excluded from the analysis. Because of the high correlation, the effect of the excluded variables is represented by the correlated variable included in the analysis. The following variables were excluded, whilst the variable representing the effect of each excluded variable is indicated in brackets: Fuel sales (in favour of unemployment rate), All individual AdStock themes (in favour of total AdStock), Active speed camera sites (in favour of speed camera hours), Mobile phone offences (in favour of seat belt offences)

Results of Crash Frequency Analysis

Total Program Effects

Estimates of the overall crash effects of the RSIP resulting from fitting the regression model described in Equation 1 are given in Table 2. Given along with the estimated crash reduction attributable to the program are 95% confidence limits on the estimate as well as the statistical significance of the estimate. Low statistical significance values indicate the crash effect is unlikely to have arisen through chance variation in the data.

Table 2: Estimated Total Crash Reductions Attributable to the RSIP

Crash Severity	Estimated Crash Reduction	Upper 95% Confidence Limit	Lower 95% Confidence limit	Statistical Significance
Fatal + Hospital	13.12%	6.09%	19.62%	0.0004
Medically Treated	14.20%	7.91%	20.06%	<.0001
Other Injury + Non-Injury	4.34%	-0.36%	8.83%	0.0693
All Crashes	8.80%	5.52%	11.96%	<.0001

NB: Negative percentage crash reduction estimates indicate an estimated percentage crash increase.

Table 2 shows that the estimated overall reduction in fatal and hospitalisation crashes attributable to the introduction of the RSIP was 13.12%. The estimate was highly statistically significant. A similar estimate of program effectiveness was also obtained for medically treated crashes. In contrast, the estimate for the more minor crash severity levels, other injury and non-injury crashes, was a crash reduction of only 4.34% which was marginally statistically significant. The results suggest that the RSIP was much more effective in reducing higher severity crashes than lower severity crashes although some caution is warranted in making this observation given the confidence limits for each crash reduction estimate overlap.. The estimated reduction in all crashes due to the program was a highly statistical significant 8.8%.

Effects of Specific Program Elements

This analysis aimed to identify those program components principally responsible for the intervention effect measured in the previous analysis. Given the co-linearity problems between input variables had been largely solved by the process of pre conditioning described above, it was considered unnecessary to undertake a model building process. Instead, a single model described by Equation 2 was fitted including all the factors remaining after the process of removing co-linearity. As there were no variable co-linearity problems, leaving non-significant factors in the model had little bearing on the coefficient estimates or significant levels of the other factors in the model. Model parameter estimates for the RSIP program elements are summarised in Table 3 for each of the models by crash severity.

Table 3:.Parameter Estimates of RSIP Component Crash Effects

Crash Severity Level	RSIP Program elements	Regression Co-efficient	Standard Error	Statistical Significance
Fatal + Hospital	AD_ALL	-0.000012	0.000003	0.0003
	BT	0.000000	0.000002	0.7477
	CAMHRS	-0.000204	0.000101	0.0429
	HRSACT	0.000156	0.005524	0.9774
	NOCAMHRS	0.000023	0.000021	0.2731
	BELT*	-0.000236	0.000141	0.0937
Medical	AD_ALL	-0.000008	0.000003	0.0168
	BT	-0.000003	0.000002	0.023
	CAMHRS	-0.000074	0.000092	0.4212
	HRSACT	0.000103	0.004759	0.9827
	NOCAMHRS	-0.000014	0.000019	0.4686
	BELT	-0.000441	0.000112	<.0001
Other Injury and Non-Injury	AD_ALL	-0.000011	0.000002	<.0001
	BT	-0.000001	0.000001	0.1932
	CAMHRS	-0.000018	0.000062	0.7714
	HRSACT	-0.002599	0.003178	0.4135
	NOCAMHRS	0.000027	0.000012	0.0316
	BELT	-0.000263	0.000079	0.0009
All Crashes	AD_ALL	-0.000011	0.000002	<.0001
	BT	-0.000001	0.000001	0.0481
	CAMHRS	-0.000071	0.000046	0.1218
	HRSACT	-0.001553	0.00238	0.5142
	NOCAMHRS	0.000017	0.000009	0.0747
	BELT	-0.000317	0.000059	<.0001

** Seat belt offences is only marginally significant for fatal crashes*

A number of RSIP program elements were significantly associated with crash outcome in each of the models considered by crash severity level. RSIP program elements of road safety advertising AdStock (AD_ALL), speed camera program activity (represented by camera hours - CAMHRS) and number of seat belt and mobile phone offences detected (represented by the belt offences - BELT) were estimated to be statistically significantly associated with crash outcomes when considering the more severe crash levels (fatal and hospitalisation). Seat belt and mobile phone offences only showed marginally statistical significance for fatal crashes. The negative coefficient of the parameter estimates also shows that an increase in these measures was associated with a decrease in observed crash numbers. For the lower crash severity levels (medically treated and below), AdStock and number of seat belt and mobile phone offences were again significant along with the number of breath tests carried out (BT). It should be recalled that the high correlation between mobile phone and seat belt offences means that the BELT factor in the model is representing the effect of both these factors. It should be noted that a lack of measured association between a program component measure and crash outcome does not imply that the component is ineffective. It is still possible that program components not found to be significantly related to crash outcomes here had a significant and enduring effect on crash outcomes at the time of their initial introduction. It is also possible that the relationship between their variation and crash outcomes is more subtle than can be measured using the analysis design and techniques employed here.

Effects of the significant RSIP program components were translated into percentage crash effects following implementation of the RSIP using Equations 3 and 4 in conjunction with average program component effort both before and after the implementation of the RSIP. In doing so, AdStock figures were disaggregated by south-east and the rest of Queensland so the averages represent the average monthly AdStock across the two television regions. Data on speed camera enforcement, alcohol breath tests and belt and mobile phone offences were available by Police region so the averages represent the monthly average of each measure across all eight regions. Because of the high correlation between the seat belt and mobile phone measures, the pre and post RSIP seat belt offence measure is an average of both seat belt and mobile phone offence data. Program effort levels are shown in Table 4 along with the estimated percentage crash reductions derived from the regression parameter and change in average monthly program component effort level. The 95% confidence limits on the estimated percentage crash reductions are also shown.

One notable feature of Table 4 is that average AdStock levels were actually higher in the pre RSIP period than after the program was implemented, by a factor of almost 3 times. This is despite increased road safety television advertising levels being one of the key RSIP features. The net effect of this drop in advertising levels was a 2-3 percent increase in crashes associated with this program component during the RSIP period.

Of the other RSIP component measures that were significantly associated with crash outcomes, the increase in speed camera enforcement was estimated to be associated with the largest crash savings. Table 4 shows that an estimated doubling of the speed camera enforcement was associated with a reduction in fatal and hospitalisation crashes of around 9 percent. This represents over half the total effect of the RSIP on these crash severity levels estimated in the intervention analysis. Increased detection of mobile phone and seat belt offences under the RSIP was estimated to have been associated with a 2-3 percent crash reduction. Increases in random breath testing were estimated to have reduced crashes by only around 1 percent during the RSIP period.

Table 4: Parameter Estimates of RSIP Component Crash Effects

Crash Severity Level	Significant RSIP Component	Average Pre RSIP Level	Average Post RSIP Level	Estimated Crash Reduction	Lower 95% CL	Upper 95% CL
Fatal + Hospital	AD_ALL	3126	939	-2.66%	-1.35%	-3.99%
	CAMHRS	417	856	8.58%	0.27%	16.20%
	BELT	306	390	1.95%	-0.34%	4.19%
Medical	AD_ALL	3126	939	-1.76%	-0.46%	-3.08%
	BT	20333	24390	1.21%	-0.37%	2.77%
	BELT	306	390	3.62%	1.83%	5.37%
Other Injury & Non-Injury	AD_ALL	3126	939	-2.43%	-1.56%	-3.32%
	BELT	306	390	2.17%	0.90%	3.43%
All Crashes	AD_ALL	3126	939	-2.43%	-1.56%	-3.32%
	BT	20333	24390	0.40%	-0.39%	1.19%
	BELT	306	390	2.62%	1.67%	3.55%

NB: Negative percentage crash reduction estimates indicate an estimated percentage crash increase.

Tallying the estimated crash reductions associated with each significant RSIP component leads to a total crash reduction associated with these components which is far less than the overall program crash effects measured in the intervention analysis. This implies that there were other components of the RSIP not identified amongst those above that were also effective in reducing crashes. These could include components for which explicit measures were available and included in the model but which did not show significant association with monthly crash counts. If this was the case, the contributing program components must have produced crash effects in a way that was inconsistent with the relationship assumed by the analysis model structure. Further specific evaluation of each program component beyond the scope of this evaluation would be needed to identify such effects. It is also possible that there have been other effects from the RSIP for which no explicit measure was available but which have produced crash savings. One such example is general community awareness of the RSIP generated through media interest in the general implementation of the program. Queensland Police Service indicated this is highly likely, as their officers aimed to get significant media coverage of events such as enforcement blitzes. Unlike scheduled road safety advertising, there is no direct measure of audience exposure to the media coverage generated. Consequently, the evaluation process cannot assess the effect of this unscheduled publicity.

<u>*Absolute Crash Savings*</u>

Total Program

Estimates of the overall percentage crash reduction attributable to the RSIP have been converted to absolute crash savings by multiplying the percentage crash effect estimate by the average monthly crash frequency in the pre-RSIP implementation evaluation period (January 1998 to November 2002). The resulting average monthly absolute crash savings by severity level are summarised in Table 5 along with the average pre implementation period monthly crash counts on which they are based. Also presented are 95 percent confidence limits on the estimated absolute crash savings derived directly from the 95 percent confidence limits on the percentage crash savings.

Table 5:. Estimated Absolute Monthly Crash Savings Attributable to the RSIP

Crash Severity	Average Monthly Crashes Pre RSIP	Estimated Monthly Crash Savings	Upper 95% Confidence Limit	Lower 95% Confidence limit
Fatal + Hospital	342	45	21	67
Medically Treated	422	60	33	85
Other Injury + Non-Injury	963	42	-3	85
Total	1727	147	51	237

NB: Negative crash reduction estimates indicate an estimated percentage crash increase.

Table 5 shows the RSIP was estimated to have saved 147 reported crashes per month, including 45 fatal and hospitalisation crashes and 60 medically treated crashes. Estimates of average monthly crash savings for the RSIP as a whole have been converted into estimated absolute crash savings across the whole 14 month period following RSIP implementation. These estimates, along with corresponding 95 percentage confidence limits are shown in Table 6.

Table 6: Estimated Total Absolute Crash Savings across the Entire RSIP Period

Crash Severity	Estimated Total Crash Savings	Upper 95% Confidence Limit	Lower 95% Confidence limit
Fatal + Hospital	627	291	938
Medically Treated	839	468	1185
Other Injury + Non-Injury	586	-49	1191
Total	2052	710	3314

NB: Negative crash reduction estimates indicate an estimated percentage crash increase.

Specific Program Elements

Estimates of total crash savings over the entire 14 month RSIP evaluation period have been obtained for the program component measures that were statistically significantly related to crash outcomes in the Poisson regression analysis and are summarised in Table 7 along with the corresponding 95 percent confidence limits. Results are grouped by RSIP component with total crash savings shown for those program elements that produced significant effects across more than one crash strata. Rather than using the factor name used in the model, the tables from here on present the name of the full program component represented by the model factor after consideration of the co-linearity between program elements identified earlier (for example speed camera hours represents total effort on the speed camera program from both hours spent and number of active sites).

Table 7: Estimated Absolute Crash Savings of the RSIP Components across the Entire RSIP Period

Significant RSIP Component	Crash Severity Level	Estimated Crash Savings	Lower 95% CL	Upper 95% CL
Road Safety Advertising AdStock	Fatal + Hospital	-127	-64	-191
	Medical	-104	-27	-182
	Other Injury + Non-Injury	-328	-210	-447
	All Crashes	-560	-302	-820
Speed Camera Program	Fatal + Hospital	410	13	775
Random Breath Testing	Medical	24	-8	56
Belt Use and Mobile Phone Enforcement	Fatal + Hospital	34	-6	74
	Medical	112	57	166
	Other Injury + Non-Injury	129	53	203
	All Crashes	275	104	443

NB: Negative crash savings indicate an estimated crash increase.

Of the significant program components, the increase in speed camera program activity during the RSIP produced the biggest savings in high severity crashes, reducing the number of fatal and serious injury crashes by an estimated 410 across the RSIP evaluation period. Estimated savings in medically treated crashes from increased random breath testing were modest. Increased detection of seat belt and mobile phone offences resulting from the RSIP was estimated to have reduced all reported crashes by 275 over the evaluation period although only 34 of these crashes saved were fatal or hospitalisation crashes. Lower levels of road safety television advertising were estimated to have led to 560 more crashes during the RSIP period, with 127 of these being fatal or hospitalisation crashes.

Program Crash Cost Savings and Benefit to Cost Ratio

The BTE [8] have estimated standardised crash costs in 1996 Australian dollars by the five crash severity levels represented in the Queensland crash data (BTE, 2000). Derivation of the BTE crash costs is based on the human capital approach and takes into account incident costs in property damage and injury treatment as well as loss in human productivity though injury or death. To enable direct comparison with expenditure on the RSIP, which was made mostly in 2003, the BTE crash costs have been converted to 2003 Australian dollars by inflating the figures using Consumer Price Index changes from 1996 to 2003. The resulting cost estimates by crash severity level are given in Table 8.

Table 8: Crash Costs and Their Conversion to Aggregate Severity Levels

Crash Severity Level	BTE Crash Cost Estimate (2003 A$)	Proportion of Crashes at Severity	Weighted Average Crash Cost of Aggregate Categories
Fatal	$1,949,650	1.33%	$576,292
Hospitalisation	$481,210	19.21%	
Medically Treated	$16,248	24.63%	$16,248
Other Injury	$16,248	14.43%	$9,323
Non-Injury	$6,850	40.40%	

Analysis of the RSIP crash effects has focused on crash outcomes aggregated into three levels: fatal and hospital, medically treated, and minor injury and non injury. Average crash costs at each of the three aggregated levels have been obtained by calculating a weighted average of the costs for the component severity levels. The weightings used are the relative proportion of crashes at each severity in the pre RSIP period crash data. The weighting proportions are shown in Table 8 along with the weighted average crash costs for the aggregated severity levels analysed.

Total Program

Estimates of total crash savings associated with the RSIP over the entire 14 month evaluation implementation period shown in Table 7 were converted to crash cost savings by multiplying the estimated crash savings by the BTE crash costs in Table 8 by crash severity. The resulting crash cost savings estimates are summarised in Table 9 along with the corresponding 95 percent confidence limits.

Table 9: Estimated Total Crash Cost Savings Attributable to the RSIP

Crash Severity	Estimated Crash Cost Saving	Lower 95% Confidence Limit	Upper 95% Confidence limit
Fatal + Hospital	$361,529,520	$167,743,396	$540,808,493
Medically Treated	$13,634,867	$7,596,508	$19,260,740
Other Injury + Non-Injury	$5,461,266	-$456,048	$11,101,146
All Crashes	$380,625,653	$174,883,856	$571,170,379

NB: Negative crash cost savings estimates indicate an estimated percentage crash increase.

Total crash costs savings resulting from the RSIP over the 14 months of the evaluation period it was operational were estimated to be around $380M. Relating this figure to total expenditure on the RSIP over the same period leads to an estimated program benefit to cost ratio of 22 with 95 percent confidence limits from 10 to 33. That is, for every dollar spent on the RSIP, resulting savings to the community through reduced road trauma were estimated to be 22 dollars.

Specific Program Elements

Using the same approach as for the total program effects, estimated crash savings associated with the RSIP components were converted into crash cost savings. The resulting crash cost savings estimates are summarised in Table 10.

Table 10: Estimated Total Crash Cost Savings Attributable to Specific RSIP Components

<table>
<tr><th>Significant RSIP Component</th><th>Crash Severity Level</th><th>Estimated Crash Cost Saving</th><th>Lower 95% CL</th><th>Upper 95% CL</th></tr>
<tr><td rowspan="4">Road Safety Advertising AdStock</td><td>Fatal + Hospital</td><td>-$73,280,627</td><td>-$37,132,847</td><td>-$109,896,163</td></tr>
<tr><td>Medical</td><td>-$1,693,926</td><td>-$446,009</td><td>-$2,957,992</td></tr>
<tr><td>Other Injury + Non-Injury</td><td>-$3,061,316</td><td>-$1,961,920</td><td>-$4,170,176</td></tr>
<tr><td>All Crashes</td><td>-$78,035,869</td><td>-$39,540,776</td><td>-$117,024,331</td></tr>
<tr><td>Speed Camera Program</td><td>Fatal + Hospital</td><td>$236,403,487</td><td>$7,308,200</td><td>$446,406,675</td></tr>
<tr><td>Random Breath Testing</td><td>Medical</td><td>$395,842</td><td>-$122,360</td><td>$905,866</td></tr>
<tr><td rowspan="4">Belt Use and Mobile Phone Enforcement</td><td>Fatal + Hospital</td><td>$19,856,397</td><td>-$3,435,185</td><td>$42,615,984</td></tr>
<tr><td>Medical</td><td>$1,814,929</td><td>$919,862</td><td>$2,693,719</td></tr>
<tr><td>Other Injury + Non-Injury</td><td>$1,200,433</td><td>$496,881</td><td>$1,894,935</td></tr>
<tr><td>All Crashes</td><td>$22,871,760</td><td>-$2,018,441</td><td>$47,204,639</td></tr>
<tr><td>Total Non Speed Camera Enforcement</td><td>All Crashes</td><td>$23,267,602</td><td>-$2,140,801</td><td>$48,110,505</td></tr>
</table>

NB: Negative crash cost savings estimates indicate an estimated percentage crash increase.

Reflecting the relative savings in absolute crash numbers, the increase in speed camera program activity under the RSIP led to the largest reduction in crash costs associated with a program component. In fact, the crash savings from the speed camera component represented around 62 percent of the cost savings estimated from the RSIP in its entirety. Relating the estimated crash costs savings from the increased speed camera activity to the cost of the increase enforcement effort gave a program component benefit to cost ratio estimate of 21 for the speed camera component. The 95 percent confidence limits on this estimate were from 1 to 41. Interpretation of the benefit to cost ratio for the program components is the same as for the total program.

The estimated benefit to cost ratio of the additional speed camera enforcement is somewhat smaller than the benefit to cost ratio of 47 estimated in the full evaluation of the program (Newstead and Cameron [9]). This reflects that the additional speed camera hours scheduled under the RSIP reduced crashes from a lower base, the lower base being a result of the large crash reductions resulting from the initial introduction of the speed camera program. For this reason, it is expected that the further the camera hours are increased, the closer the program gets to a point of diminishing returns. However given that the doubling of speed camera hours under the RSIP still produced a benefit to cost ratio of 21, it appears that further increases in speed camera hours of operation could still be justified before the point of diminishing returns is reached.

It was not considered sensible to estimate a benefit to cost ratio for the television advertising component considering that the relative reduction in advertising during the RSIP period led to an estimated crash cost increase to the community of around $78M.

Assessment of the benefit to cost ratio of the increase random breath testing and mobile phone and seat belt enforcement achieved under the RSIP is difficult because the program cost information supplied by Queensland Transport did not break down non speed camera enforcement expenditure by enforcement type. Comparing the crash cost savings from only the increased breath testing and mobile phone and seat belt offence detection with the total cost of non speed camera enforcement activities yields a benefit to cost ratio of 6 with 95 percent confidence limits from -1 to 13. This is a little misleading, however, as comparing total program cost savings in Table 9 to the savings attributable to television advertising (negative savings) and the speed camera program shows a residual of some $222M. This figure is only partly explained by the two significant non speed camera enforcement program components identified, suggesting that there are a number of unidentified program components producing significant crash cost savings under the RSIP

Comparing the non speed camera and advertising residual crash cost savings to the cost of non speed camera enforcement and public education undertaken as part of the RSIP gives and estimated benefit to cost ratio of 43 with 95 percent confidence limits from 40 to 47. This suggests that the effects of the unidentified successful program components of the RSIP have been highly cost beneficial. As discussed above, unidentified successful program components could include those for which explicit measures were available but were not significant in the analysis model as well as unmeasured program effort such as publicity generated through program launches or enforcement blitzes. Unfortunately, the current evaluation cannot identify these components nor can it measure their relative contributions. The benefit to cost ratio estimates for the residual program component effects should be treated with some caution given that the specific mechanisms of producing the effects and hence their net costs to the community are unknown.

Conclusions

Evaluation of the crash effects of the Queensland Road Safety Initiatives Package has shown clear reductions in crashes associated with implementation of the program. Overall the program was associated with a statistically significant estimated 13 to 14 percent reduction in fatal, hospitalisation and medically treated crashes after implementation and a 9 percent average reduction in crashes across all severity levels. This translated to an estimated saving of 627 fatal and hospitalisation crashes, 839 medically treated crashes and 2052 crashes across all severity levels in the 14 months post RSIP implementation period covered by the evaluation. Applying standardised crash cost values to the estimated crash savings yielded an estimated saving in crash cost to the community associated with program implementation of $380M. Of these savings, $361M were savings from reduced fatal and hospitalisation crashes. Comparing total program savings to expenditure incurred in implementing the program gave an estimated overall benefit to cost ratio for the program of 22.

The evaluation also identified a number of RSIP component activities that were significantly associated with crash outcomes. Monthly levels of television road safety advertising awareness, speed camera enforcement, alcohol breath tests conducted and seat belt and mobile phone offences detected were significantly related to monthly variation in observed crash numbers. Comparison of average measures of each program component before and after the RSIP program implementation resulted in estimates of relative program component effects on crashes.

A 100 percent increase in hours of speed camera activity under the RSIP was associated with a statistically significant reduction in fatal and hospitalisation crashes of 9 percent. This represents a saving of 410 fatal and hospitalisation crashes across the 14 month RSIP evaluation period with a value to the community of $236M. The estimated benefit to cost ratio for the speed camera program component of the RSIP was 21. A reduction in crashes of all severity levels of between 2 and 3 percent was associated with the 30 percent increase in seat belt and mobile phone offences detected under the RSIP. This translated to savings of 146 fatal, hospitalisation and medically treated crashes and 275 crashes of all severity levels across the RSIP evaluation period, a saving of $23M to the community. A 20 percent increase in alcohol breath tests was associated with only modest crash reductions of about 1 percent with a value to the community of around $396,000. It was not possible to estimate specific program component benefit to cost ratios for the increased mobile phone and seat belt penalties or the increased alcohol breath tests.

Levels of television road safety publicity achieved after RSIP implementation were only about one third that achieved before program implementation, leading to an estimated increase in crashes. The crash increase associated with the reduced level of advertising during the RSIP period was estimated to be 2 to 3 percent. This represented an increase of 560 crashes across all severity levels with a cost to the community of $78M. The overall effectiveness of the RSIP could have been increased had the publicity levels remained at or increased from pre RSIP levels.

A significant proportion of the total crash savings attributable to the RSIP program was unexplained by the individual program components found to be significantly associated with crash outcomes. This suggests there were one or more RSIP components, other than those identified, that have led to substantial crash savings. The unidentified successful program component could include those for which explicit measures were available but were not significant in the analysis model as well as unmeasured program effort such as publicity generated through program launches or enforcement blitzes.

References

1. Harrison, W. A. (1990). *Update of alcohol times as a surrogate measure of alcohol-involvement in accidents.* Research Note, Monash University Accident Research Centre.
2. Broadbent, S. (1979), One way TV advertisements work. *Journal of the Market Research Society,* Vol. 21, No. 3. London.
3. Broadbent, S. (1984), Modelling with AdStock. *Journal of the Market Research Society,* Vol. 26, No. 4. London.
4. Nicholson, A.J., (1985a). *The Variability of Accident Counts.* Accident Analysis and Prevention 17(1): 47-56.
5. Nicholson, A.J., (1985b). *The Randomness of Accident Counts.* Accident Analysis and Prevention 18(3): 193-198.
6. Maher, M.J., and Summersgill, I., (1996) *A Comprehensive Methodology for the Fitting of Predictive Accident Models.* Accident Analysis and Prevention 28(3) 281-296.
7. Newstead, S., Cameron, M. and Leggett, M. (2001). The crash reduction effectiveness of a network-wide traffic police deployment system. *Accident Analysis and Prevention*, 33 (2001), pp393-406.
8. BTE (2000) *Road crash costs in Australia*, Report No 102, Bureau of Transport Economics, Canberra, Australia.

9. Newstead, S. and Cameron, M. (2003). Evaluation of the crash effects of the Queensland speed camera program: interim analysis of results. Report No. 204, Monash University Accident Research Centre.

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