Crash effects of the Queensland Camera Detected Offence Program

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Abstract

The Queensland Camera Detected Offence Program (CDOP) covers all modes of camera based traffic enforcement in Queensland including the mobile speed camera program, fixed intersection red light and speed cameras, fixed midblock speed cameras and point to point cameras. This project aimed to develop an evaluation framework for CDOP which measured the overall crash effects of the program as well as the crash effects associated with each enforcement type. An evaluation framework was developed measuring the performance of CDOP in terms of its effect on crashes by considering the likely spatial and temporal effects of each CDOP enforcement type based on the international literature. Efficacy of the developed framework was shown through its application to existing data to estimates of the effects of the CDOP during 2008. It was estimated that the CDOP was associated with an overall 23% reduction in all police reported crashes and 24% reduction in fatal and hospitalisation crashes across Queensland in 2008. This represents a saving of over 5,700 crashes of all severities and over 1,100 fatal and serious injury crashes. Over 95% of the savings associated with the program derive from the mobile speed camera program which is the CDOP element that covers by far the largest proportion of the crash population. Implementation of the CDOP in Queensland was associated with substantial road trauma reductions. Evaluation results highlight the particular importance of a wide-reaching mobile speed camera program in achieving these savings.

Introduction & Aims

The Queensland Camera Detected Offence Program (CDOP) covers management and operation of all modes of camera based traffic enforcement in Queensland. Currently this includes the mobile speed camera program, the red light camera program and fixed speed cameras, and has recently been expanded to include point to point cameras and combined speed and red light cameras. The objective of this study was to measure the effects on crash frequency, severity and social costs to the community in Queensland associated with the CDOP through development of a comprehensive evaluation framework. The evaluation framework was required to incorporate the impacts of different camera types, both existing and future. The framework was then applied to estimate the effects of the CDOP during 2008.

To meet these objectives, the study included the following stages:

1. Review of the types of traffic enforcement cameras in operation in Queensland and their likely modes and scope of effectiveness
2. Develop and specify the CDOP evaluation framework to estimate effects on crash frequency, severity and costs related to all elements of the CDOP.
3. Run the framework to estimate CDOP effectiveness during 2008

Methods

Review of CDOP Components

Each CDOP camera type was reviewed with respect to its likely sphere of influence on crashes and speeds in both time and space. The likely mechanism of effectiveness, such as visual presence at the site, time of operation, or number of infringements issued, was also considered. Estimation of likely camera effects was informed by a review of previous evaluations of each camera technology, where available, and of like technologies for new camera types. A summary of each technology, the likely sphere of influence, and mechanisms of effectiveness derived from the literature review is presented in Table 1. Literature sources are indicated in the table.

Table 1. Hypothesised Sphere and Mechanism of Influence for each CDOP Element

CDOP Element	Sphere of Influence	Mechanism of Influence
Red Light (Retting, Ferguson, & Hakkert, 2003)	Localised to intersection where camera is placed	Primary: placement of camera and associated signage Secondary: infringement notice issue
Combined Speed and Red Light (intersection) (ARRB, 2005; Cameron & Delaney, 2006; Elvik, 1997; Gains, 2005; Wilson, Willis, Hendrikz, Le Brocque, & Bellamy, 2010)	Localised to intersection where camera is placed	Primary: placement of camera and associated signage Secondary: infringement notice issue
Spot Speed (midblock) (Brinson, 2002)	Localised to site of camera location within a 1-3 km radius	Primary: placement of camera and associated signage Secondary: infringement notice issue
Point to point average speed (A77SG, 2007, 2008; Keenan, 2002)	Localised to the road length covered by the point to point system up to 1km upstream of the start of the length and up to 10km downstream of the length	Primary: placement of camera and associated signage Secondary: infringement notice issue
Mobile Speed (overt) (S. Newstead & Cameron, 2003a; S. V. Newstead, 2006)	Localised to the site of operation (1km in urban areas, 5km in rural areas*) with possible secondary effects generalised over space	Primary: definition of a site of operation and placement of camera Secondary: infringement notice issue
Mobile speed (covert) (Cameron, Cavallo, & Gilbert, 1992; S. V. Newstead, Mullan, & Cameron, 1995; Rogerson, Newstead, & Cameron, 1994)	Generalised in space over the region of operation, with some secondary localised effects around the camera site	Primary: infringement notice issue Secondary: definition of a site of operation and placement of camera

* urban areas were defined as those with speed limit of 80kph or less and rural with speed limits greater than 80kph

Evaluation Framework

Based on the results of the literature review and review of likely CDOP sphere and mechanism of crash effects, an evaluation framework was developed. The evaluation framework developed for the CDOP was based on the quasi-experiment but treated fixed elements of the CDOP differently to the mobile speed camera program. In this context, quasi-experiment refers to the comparison of crash rates at 'treated' sites from before to after camera implementation compared against parallel changes at a suitably chosen set of 'comparison' sites. The aim of the comparison sites is to reflect the effect of all other factors, other than the countermeasure being studied, on the outcome of interest.

The evaluation framework for the fixed CDOP elements was similar to a traditional accident black-spot evaluation design due to the likely predominating localised effects of the fixed cameras. For each CDOP element a hypothesised sphere of influence was defined specifying the likely geographical reach in crash effects associated with the camera placement. The spheres of influence were informed by both the literature review and the geographical characteristics of the sites where the cameras were placed. A set of one or more comparison sites were then specified to be matched to each camera site based on a set of criteria including physical characteristics of the camera location and proximity to other camera sites. The proximity to other camera sites was specified in order to control for overlapping camera effects. The sphere of influence defined for each CDOP camera type and the corresponding comparison site matching criteria are summarised in Table 2. Matching of comparison sites by SLA was intended to control for localised influence on crash rates such as population and travel growth as well as local economic influences.

For each analysis model a minimum of 3 but ideally 5 years crash data prior to camera installation were specified for analysis to minimise regression to the mean bias (Nicholson, 1986). Negative Binomial regression analysis was used to estimate the net crash effect of the CDOP at camera sites relative to the chosen comparison sites (Hilbe, 2007). Data for analysis at each camera and corresponding control site was aggregated into a single count of crashes in the before and after camera installation period at both treatment and comparison sites. Analysis of data at each site as a time series was not possible due to the available quantities of before and after camera installation data available at camera sites. This dictated the need for analysis of aggregated crash counts. The analysis models specified considered data on a site by site basis to avoid Simpson's Paradox (Simpson, 1951). Separate models were specified for each crash severity level.

Results of each of the analysis models specified were estimates of the net percentage reduction in crashes associated with each camera type considered. Using the observed after installation crash data, the percentage crash savings were converted into absolute crash savings. The absolute crash savings were then converted in to social cost savings to the broader Queensland community using "human capital" based social costs for road crashes by crash severity level estimated by the Commonwealth Government Bureau of Transport, Infrastructure and Regional Economics (BITRE, 2010).

Table 2. Sphere of Influence and Comparison Site Matching Criteria for Each CDOP Fixed Camera Element

CDOP Fixed Element	Hypothesised Sphere of Influence	Matching Criteria for Comparison Sites
Red Light & Combined Speed and Red Light (intersection)	At the intersection of installation Secondary restriction to target crash DCA types	1. Statistical Local Area (SLA) 2. Intersection control 3. Intersection geometry 4. Speed Limit 5. Divided or undivided Road 6. Number of lanes 7. Matching by overlay of mobile camera sites (within the same proximity of mobile speed camera sites)
Spot Speed (midblock)	Same road as the camera is installed on within a 1km distance from the camera site	1. Statistical Local Area (SLA) 2. Speed Limit 3. Divided or undivided Road 4. Number of lanes 5. Proximity of mobile speed camera sites
Point to Point average speed	Primary: the length of road within the PtP camera system Secondary: the length of road from each end of the PtP site to 5km from this point (for divided roads the halo only include the lanes outbound from the PtP site in each direction)	1. Statistical Local Area (SLA) 2. Speed Limit 3. Divided or undivided Road 4. Number of lanes 5. Proximity of mobile speed camera sites

The evaluation framework specified for the mobile camera program was a refinement of the evaluation framework previously applied to the mobile camera program in Queensland (S. Newstead & Cameron, 2003b). It also followed a quasi-experimental design but using different treatment and comparison site definitions to the fixed camera elements in Table 2. The mobile camera evaluation design is specified as follows:

- Treatment areas were defined as areas within a 1km radius of the centre of the speed camera zone in built up areas (roads with speed limits up to 80km/h) and within a 4km radius from the camera zone centre in open road areas (roads > 80km/h speed limit). Crashes were then labelled as in a treatment area if they are within the defined radius of influence from any camera site.

- Comparison areas were those remaining areas outside the defined radius of influence of the speed camera zone centres. They were matched for analysis by police region of operation and broad speed zone of location (=<80km/h, >80km/h).

- Crashes were aggregated for analysis within the police region, speed zone and treatment and comparison area classification in a yearly time series.

- Assessment of the crash effects of the mobile camera program are made by comparing time series trends in crash outcomes in the treatment areas with those in the corresponding comparison areas using Negative Binomial Generalised Estimating Equation (GEE) statistical modelling methods (Liang & Zeger, 1986). The GEE is an extension of the standard Negative Binomial regression model which accommodates the inherent inter-correlation between observations in the time series of crash data used in this analysis.

Each of the component evaluations for CDOP elements produces estimates of crash and crash cost savings associated with the camera installation, categorised by police region and crash severity. The final stage of the evaluation framework for crashes and crash costs specifies the mechanism for combining the estimates by police region and crash severity to produce state-wide estimates of the crash and crash cost effects associated with the CDOP.

Data

Crash Data

The Data Analysis Unit within Queensland Transport and Main Roads (TMR) supplied MUARC with complete crash data covering the period from January 1992 to December 2008 inclusive. The data covered all crashes reported to police in Queensland with each unit record in the data representing a unique crash. A total of 357,931 crash records were contained in the data. The data included the following fields pertaining to the crash: unique identification number, date of occurrence, severity (fatal, hospitalisation, medically treated injury, other injury, no injury), police region, Statistical Local Area, speed limit, street crash on, intersecting street, traffic control, DCA code (Definition for Classifying Accidents), Roadway feature (intersection geometry, bridge, etc.), divided/undivided carriageway, number of lanes, speed related crash indicator, number of traffic units involved in crash, distance from 5 closest mobile speed camera sites and the unique site identifiers for the 5 closest mobile speed camera sites, distance from the 3 closest fixed spot speed camera sites and the unique site identifiers for the 3 closest fixed spot speed camera sites, distance from the closest red light camera site and the unique site identifier for the closest red light camera site. These variables allowed each crash in the data to be labelled according to the analysis framework cells to which it belonged.

Camera Operations Data

TMR supplied data on key aspects of traffic camera operations required to apply the evaluation framework. Red light camera data was supplied for the 142 installations across Queensland including: site identification number, road and intersecting road on which camera was placed, suburb of location, local region name, direction camera faces, number of lanes on road, speed limit at camera site, date camera became operational. Data on the 10 existing fixed spot speed camera installations was provided including: camera type (film/digital), camera identifier number, street name, suburb, police region, activation date. Data on the mobile speed camera program was provided for each of the 2144 zones of camera operation used up to the date of the study and included: mobile speed camera zone identifier, date zone was proposed and date zone was approved. Dates at which fixed cameras became operational were used to define the before and after data periods in the study design.

Only 3 of the 11 fixed spot speed camera locations were active before 2009 with the remaining 7 activated after the period for which crash data were available for analysis. No Point to Point sites were operational in the period for which crash data were available, nor were any combined speed and red light cameras so these CDOP elements were not reflected in the analysis.

Results

Each of the analyses presented in this section were conducted in SPSS Version 20. For the fixed camera analysis Negative Binomial Regression and for the mobile camera analysis a Negative Binomial Generalised Estimating Equation was used. In both instances the software produces direct estimates of relative risks and their standard errors from which it computes statistical significance values and 95% confidence limits presented in Table 3, 4 and 5.

Estimated crash reductions associated with the red light camera component of the CDOP are presented in Table 3 by crash severity level. Estimates are given as relative risks which measure the risk of having a crash at the red light camera site relative to the crash risk at the comparison site. Relative risks less than 1 indicate a crash reduction effect associated with camera operation. A net percentage crash reduction associated with camera can be obtained by subtracting the relative risk from 1 and multiplying by 100%. For example, the relative crash risk estimate for all crash severities across all police regions in Table 3 is 0.66 which translates to a 34% net crash reduction. Table 3 also shows the statistical significance of the estimated relative risk along with a 95% confidence limit. Table 3 shows statistically significant estimated crash reductions associated with red light camera operations for all crash severity levels considered. There was some indication of slightly greater reductions associated with injury crashes although this observation should be treated with caution given the width and overlap of the confidence limits on each estimate.

Table 3 Estimated Crash Risks at Red Light Camera Sites Relative to Sites without Red Light Cameras

		Relative Risk (Camera Sites vs Non Camera Sites)		
	Statistical Significance	**R.R.**	**Lower 95% C.L.**	**Upper 95% C.L.**
Effects Across the Whole of Queensland by Crash Severity				
All severities	<0.001	**0.66**	0.573	0.76
Serious Casualty (fatal + SI)	0.015	**0.682**	0.501	0.930
Minor Injury	0.000	**0.613**	0.498	0.754
Non Injury	0.001	**0.702**	0.574	0.858

An estimate of the average relative risk of crashes at fixed spot speed camera sites relative to the comparison sites across all crash severity levels is presented in Table 4. Results are interpreted the same as for the red light camera results in Table 3. Crash effects by specific crash severity level were not able to be estimated due a lack of data resulting from only 3 camera installations being active during the periods of crash data available for analysis. Results in Table 4 show an average estimated net 16.6% crash reduction associated with the fixed spot speed camera sites although this result was not statistically significant due to the limited quantities of data. Longer periods of after treatment crash data, most likely another 2-3 years, will be required to obtain statistically robust estimates of fixed spot speed camera crash effects in Queensland as will installation of additional spot speed camera sites. Although the result for this CDOP element is not statistically significant, the point estimate has been used in the comparison of total road trauma effects of each camera type as an indicative estimate.

Table 4 Estimated Crash Risks at Fixed Spot Speed Camera Sites Relative to Sites without Fixed Spot Speed Cameras

	Statistical Significance	Relative Risk (Camera Sites vs. Non Camera Sites) R.R.	Lower 95% C.L.	Upper 95% C.L.
Average Crash Effect Across All Sites				
All Crashes - All severities	.473	.834	.508	1.370

Estimated crash effects of the mobile speed camera program in Queensland by year after program introduction and crash severity level are given in Table 5 along with statistical significance values and 95% confidence limits. Interpretation of the information in Table 5 is the same as for analogous tables presented in the evaluation results for red light and fixed spot speed cameras. Estimates are given by year to reflect the significant growth in mobile speed camera crash coverage and hours enforced over time.

Table 5: Estimated Net Relative Crash Risks Associated with the Queensland Mobile Speed Camera by Year after Introduction

	Serious Casualty (fatal + SI)				Minor Injury			
Year	**Stat Sig.**	**R.R.**	**95% LCL**	**95% UCL**	**Stat Sig.**	**R.R.**	**95% LCL**	**95% UCL**
1997	.459	.967	.885	1.057	.127	1.036	.990	1.083
1998	.224	.961	.902	1.024	.641	.985	.926	1.048
1999	.049	.931	.867	1.000	.011	.911	.847	.979
2000	.899	.995	.925	1.071	.000	.931	.894	.969
2001	.054	.929	.861	1.001	.027	.915	.846	.990
2002	.015	.904	.834	.981	.166	.942	.866	1.025
2003	.009	.920	.865	.980	.113	.942	.875	1.014
2004	.001	.900	.847	.957	.000	.892	.851	.935
2005	.001	.873	.805	.947	.000	.836	.783	.892
2006	.000	.876	.822	.934	.000	.850	.805	.897
2007	.000	.789	.722	.863	.000	.846	.799	.896
2008	.000	.775	.717	.837	.000	.856	.796	.921

	Non Injury				All Crashes			
Year	**Stat Sig.**	**R.R.**	**95% LCL**	**95% UCL**	**Stat Sig.**	**R.R.**	**95% LCL**	**95% UCL**
1997	.087	.964	.923	1.005	.272	0.984	0.957	1.012
1998	.002	.886	.820	.957	.001	0.929	0.888	0.971
1999	.000	.879	.818	.944	.000	0.893	0.846	0.943
2000	.000	.906	.863	.951	.000	0.927	0.893	0.963
2001	.020	.935	.884	.989	.000	0.917	0.875	0.96
2002	.000	.907	.865	.952	.000	0.907	0.866	0.951
2003	.000	.897	.855	.942	.000	0.911	0.87	0.955
2004	.005	.913	.857	.973	.000	0.896	0.861	0.932
2005	.263	.957	.887	1.033	.000	0.884	0.837	0.934
2006	.000	.838	.778	.902	.000	0.847	0.81	0.886
2007	.002	.849	.764	.943	.000	0.822	0.777	0.869
2008	.000	.798	.724	.878	.000	0.797	0.756	0.84

Using observed crash numbers affected by each CDOP element along with the estimated crash reductions associated with each program element, absolute crash savings associated with the program during 2008, the latest year of available data, have been estimated. In the absence of crash severity specific estimates, estimates for the fixed spot speed cameras have been derived assuming the crash effect measured in Table 4 to be uniform over all crash severity levels. Table 6 shows that the CDOP was estimated to be associated with savings of nearly 5800 police reported crashes during 2008 with an estimated value to the community of nearly $580M. The vast majority of these crash savings have been derived from the mobile speed camera program and the vast majority of the crash cost savings have derived from reductions in serious casualty (fatal and hospitalisation) crashes. It should be noted that the estimates for all crashes in Table 6 do not tally with the estimates by crash severity since the all crash estimates were obtained from separate analysis models within each CDOP component. Since the all crash estimates are based on larger data quantities than the individual crash severity estimates they are likely to be more accurate than a simple tally across crash severity levels.

Table 6: Aggregate Absolute Crash Savings and Crash Cost Savings Associated with the CDOP in Queensland During 2008

Crash Severity	CDOP Element	Absolute Crash Savings	Crash Cost Saving
Serious Casualty	Red Light Camera	35.9	$14,366,665
	Fixed Spot Speed Camera	0.6	$61,788
	Mobile Speed Camera	1071.4	$429,262,065
	Total	**1107.9**	**$443,690,518**
Minor Injury	Red Light Camera	97.9	$1,567,318
	Fixed Spot Speed Camera	1.6	$162,720
	Mobile Speed Camera	1580.7	$25,302,079
	Total	**1680.2**	**$27,032,117**
Non Injury	Red Light Camera	51.4	$556,337
	Fixed Spot Speed Camera	1.7	$182,068
	Mobile Speed Camera	2677.1	$29,004,535
	Total	**2730.2**	**$29,742,940**
All Crashes	Red Light Camera	185.1	$16,490,321
	Fixed Spot Speed Camera	3.9	$406,576
	Mobile Speed Camera	5599.6	$578,784,824
	Total	**5788.6**	**$595,681,721**

To put the results of Table 6 in the context of total Queensland reported crashes during 2008, Table 7 presents total police reported crashes in Queensland during 2008, estimated 2008 crash savings due to the CDOP and the imputed reduction in total police reported crashes due to the CDOP. Once again, the all crash estimates do not tally with the individual crash severity estimates since they were obtained from separate analysis models based on more data and are hence more accurate than a simple tally. It is estimated that the CDOP was responsible for a 22.9% reduction in police reported crashes in Queensland during 2008 with crash reductions relatively uniform across crash severity levels. From another angle, without the CDOP being in operation the total number of police reported crashes in Queensland during 2008 would have been in excess of 25,000 or nearly 5,800 more than that actually observed.

Table 7: Overall Percentage Crash Savings Attributable to the Queensland CDOP

Crash Severity	Total 2008 Crashes Observed (A)	Estimated 2008 CDOP Crash Savings (B)	Number of Crashes Expected in 2008 Without the CDOP (=A+B)	% of Expected Total 2008 Crashes Saved by CDOP =B/(A+B)
Serious Casualty	3590	1107.9	4697.9	23.6%
Minor Injury	7165	1680.2	8845.2	19.0%
Non Injury	8702	2730.2	11450.2	23.9%
All Crashes	19457	5788.6	25245.6	22.9%

Discussion

Application of the CDOP evaluation framework involved separate evaluation of each of the CDOP elements over the history of their installation and then utilisation of the results of these specific evaluations to infer the required crash effects of each during 2008. The evaluation design employed ensured that the evaluation elements in the framework were mutually exclusive meaning the individual results could be readily combined to give a picture of the effects of the CDOP as a whole in crashes in Queensland. Each individual element evaluation represents a rigorous scientific evaluation of the overall crash effects of that technology.

The red light camera element of the CDOP has been in operation in Queensland for over 20 years meaning there was a large number of sites and extensive crash data on which to base the analysis. Consequently, the evaluation results for the red light cameras are highly robust. ARRB Group had completed a previous evaluation of red light camera effectiveness in Queensland and the results of the CDOP evaluation are generally consistent with the results of that earlier study, albeit based on somewhat different methods. Despite the large number of sites on which the red light camera evaluation was based, the data were insufficient to allow estimation of change in crash effects associated with the program over time. Consequently, only average crash effects over the post implementation period have been estimated and it has been assumed that the average crash effects apply equally over each post intervention year in estimating 2008 crash effects associated with the red light cameras. This assumption is probably not unreasonable given red light cameras are a static and generally highly visible technology which should achieve stable crash effects after an initial short familiarisation period.

Only 3 fixed spot speed cameras could be included in the evaluation test run due to the relatively recent introduction of this technology in Queensland. The limited number of sites and the short after installation period of crash data available meant the associated crash estimates obtained were not statistically reliable. Further evaluation of the effectiveness of fixed spot speed cameras is recommended in the future after more post implementation crash data have accumulated and additional planned sites have been installed. Future evaluation will have to consider crash effects of fixed spot speed cameras installed on new road segments from their time of opening (such as the Clem7 tunnel) using a different evaluation methodology, possibly based on a cross sectional comparison of relative crash rates across similar roads in the locality. Timing of the installation dates of the Clem7 fixed spot speed cameras meant they could not be considered this study. The study was also unable to evaluate point to point average speed camera systems as the installations in Queensland occurred after the available crash data period. Effects of this technology will also need to be considered in the future.

The new evaluation framework for the mobile speed camera program developed in this study is somewhat different to the one used in evaluating the mobile camera program previously (S. Newstead & Cameron, 2003b). Overall, the estimates of percentage crash reductions associated with the mobile speed camera program are similar in this study compared to previous evaluations. What do differ are the estimates of absolute crash savings and the associated community worth of these savings. This is partly due to the major revision in the BITRE derived costs of crashes in its latest crash cost updates, where the cost of serious injury in particular has been revised to be much lower. It also reflects the smaller localised zone of influence of the mobile cameras in urban areas which now align more closely with the way in which zones are selected for enforcement (1km urban areas, 5km in non-urban areas). It is possible this definition now results in some contamination of the defined comparison areas by mobile speed camera effects which will lead to conservative estimates of crash reductions. Despite this, the study still offers strong evidence of localised mobile speed camera crash effects which can be considered a minimum bound. In addition, it is also considered that the mobile speed camera crash effect estimates are now more robust due to the closer comparison area matching.

It is also possible that the mobile speed camera program has produced generalised effects over space that cannot be readily detected by the evaluation framework proposed. Indeed it would be difficult to detect these effects reliably by any methodology since only weak analysis designs are available which give estimates confounded with many other factors. Existence of a generalised effect in space would also lead to conservative crash estimates reinforcing the need to consider the estimates derived in this study as potentially lower bounds on effectiveness. It is possible that appropriately designed speed surveys could measure localised versus generalised mobile speed camera program effects but would need to be carried out discretely to avoid observation bias and are outside the scope of the framework used here.

The final stage in applying the evaluation framework was to aggregate the results of applying the framework for individual CDOP technologies to give a state-wide estimate of CDOP crash effects. There are two different approaches to estimating absolute crash savings from the percentage crash savings derived from the statistical analysis models. The first projects the pre-treatment crash history forward and applies the estimate percentage crash savings to the projection to determine the absolute crash savings. The second applies the percentage saving in reverse to the observed after period crashes to estimate expected crash counts in the absence of the countermeasure from which the absolute savings can be derived. The first method is considered more problematic as projecting prior crash history forward required assumptions about the continuation of past trends that may be inaccurate. The second approach eliminated the need for assumptions but generally produces more conservative estimates of crash savings. On balance the second approach was considered less problematic and was adopted for this study.

The evaluation framework developed to assess the crash effects of the CDOP has a number of strengths and some potential weaknesses. The quasi-experimental evaluation framework design is the strongest available to estimate crash effects from each CDOP element controlling for confounding influences of other factors affecting crash risk and severity. Definition of camera spheres of influence from all available international evidence and close matching of comparison sites for each camera type made the best use of the available data in formulating the evaluation design. There is always strong debate in the literature about how to best choose comparison sites. In developing the matching protocol for the fixed camera part of the evaluation framework a reasonably specific matching criteria was adopted where control sites were taken in the same locality as the camera site, on the same road type and geometry with the same speed limit. Additionally, proximity to mobile camera sites was also used as a matching key to represent overlay effects. It is considered that these matching criteria should identify control sites that are highly similar in characteristic to the camera sites and hence should accurately represent the influence of confounding factors at the camera site. Furthermore, the control matching criteria generally identified a number of control sites for each camera location. This strategy minimised the potential effects of unintended contamination of the control site during the study period due to say local road works or non-automated police enforcement that could not be readily identified from the information available. Since the likelihood that such contamination would affect all control sites simultaneously or even a significant number of the control sites for long time durations were small, the potential bias in the analysis was correspondingly small.

One issue that could affect the evaluation design is if the treatment sites are contaminated by other influences specific to that site. These might include local road works at the treatment site, speed limit changes or non-automated police enforcement activity targeted specifically at treatment sites. Ideally such events should be recorded against the camera information and data for that period excluded from the analysis. Given the evaluation framework is designed to estimate the broad effects of the CDOP across all sites rather than just the effects at a specific site and it is unlikely that a significant proportion of the camera sites will be affected by such problems simultaneously, it is unlikely that the form of contamination will cause a major bias in the estimated effects. The exception to this is speed limit changes which should be noted in the camera data used for the evaluation although speed limit changes are unlikely to happen at a significant number of sites.

Hypothesising the likely geographic area of influence for any CDOP technology is a difficult task. In developing the evaluation framework presented here, the hypothesised areas of influence were proposed as far as possible based on previous evaluations of similar technology as well as being informed by the geography of the camera location and the geographical basis on which the sites were selected for placement of the camera. There is always potential that the areas of influence hypothesised are either too small or too large which will bias the associated crash effect estimates to some degree. This is most likely a problem for mid-block and mobile camera placements where the frame of reference for a motorist may not be so precise rather than intersection cameras where the frame of reference is tightly fixed. As a general rule, the definition of the likely zones of influence used in this framework has been conservatively small. If the real zone of influence is larger than that hypothesised there is potential for contamination of the control areas with camera effects. This will generally lead to under estimates of camera crash effects.

Two notable issues that must be considered in adopting a quasi-experimental analysis framework are regression to the mean (RTM) and crash migration. RTM effects were minimised as far as possible in the evaluation framework by ensuring adequately long pre camera activation crash histories were considered. A further option proposed in the framework was to choose control sites with a similar pre activation prior crash history as a means of equalising the potential RTM bias. In practice this proved to be difficult using the crash data available due to problems in consistently identifying individual control sites. This strategy still could be an enhancement for future applications of the framework. RTM bias is likely to be minimised in the framework since the pre activation data period used in the framework is unlikely to be co-incident with the data period on which each camera site was selected. Traffic migration issues in the evaluation framework proposed were difficult to assess as they require detailed data on all road network traffic flows around the camera site both before and after activation of the camera. Such data were not available for the evaluation but could be included in the future. Traffic migration effects associated with camera use are considered unlikely as the placement of a camera is not considered likely to cause major traffic congestion (or other time delay) problems which are the most likely motivator for drivers to change their route around a site.

A key outcome of this study is the quantification of the relative effectiveness of the different CDOP elements in reducing road trauma in Queensland. In 2008, the CDOP program was estimated to have saved nearly 5800 crashes including around 1100 fatal or serious injury crashes. The vast majority of these savings have stemmed from the mobile speed camera element of the CDOP showing the high impact an effective mobile speed camera program can have on road trauma levels relative to fixed speed enforcement. As demonstrated in previous studies of automated speed enforcement technologies, the sphere of influence of fixed cameras and hence the proportion of the crash population covered by these is necessarily small. This does not suggest that fixed camera enforcement is not effective, this and other studies demonstrate it can be highly effective and cost beneficial, but that it is more suitable for localised treatment of speeding or red light running black-spots rather than creating wide-spread generalised deterrence. Results from this study indicate that planned expansions of the fixed camera program in the future are warranted but their aggregate effect on road trauma even with significant expansion will still be an order of magnitude lower than what can be achieved by the mobile program.

The relative value of the various CDOP elements in reducing serious road trauma is underlined by the crash cost estimates. The vast majority of savings to the community in reduced crash costs have stemmed from the mobile speed camera program and in particular its influence on high severity crashes. This further highlights the mobile speed camera program as being the centrepiece of speed enforcement in Queensland with the fixed camera elements of the CDOP playing a peripheral supporting role at sites of localised speeding and red light running problems.

Conclusions

This study has estimated the effects of the Queensland Camera Detected Offence Program on crash frequency and costs. It was estimated that the CDOP was associated with an overall 23% reduction in all police reported crashes and 24% reduction in fatal and hospitalisation crashes across Queensland in 2008, the latest year of available data. This represents a saving of over 5,700 crashes of all severities and over 1100 fatal and serious injury crashes, translating to savings to the community of nearly $600M and $450M, respectively. Over 95% of the savings associated with the program derive from the mobile speed camera program, which is the CDOP technology that covers by far the largest proportion of the crash population in Queensland.

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