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Accident Research Centre

**EVALUATION OF THE CRASH
EFFECTS OF THE QUEENSLAND
MOBILE SPEED CAMERA PROGRAM
IN THE YEARS 2006-2007**

by

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Abstract:

This study extends the evaluation of the Queensland mobile speed camera program reported in Newstead and Cameron (2003) and the update studies of Newstead (2004), Newstead (2005), Newstead (2006) and Newstead (2007) to estimate the crash effects of the program during the whole of 2006 and the first 6 months of 2007. It adds a further period of 12 months post program experience to that covered in the previous evaluations to cover the period up to June 2007. Full year 2007 program effectiveness estimates have been imputed from the half yearly results assuming the operations and effectiveness of the Queensland mobile speed camera program were constant over the year. Methods of evaluation and generic hypotheses tested are the same as in the previous evaluations.

Results of analysis showed the Queensland mobile speed camera program resulted in sustained large crash reductions over 2006 and the first half of 2007. Crash effects within 2km of a defined speed camera zone give the best indication of program performance with this area covering 85% of reported crashes in Queensland based on speed camera zones used up until June 2007. Analysis in this study estimated a reduction in fatal to medically treated crashes in this area of 47% during 2006 and the first half of 2007 with a corresponding reduction in all reported crashes, including non-injury crashes, of 32% and 30% for the 2 years assessed respectively. These translate to half year savings of around 8,250 fatal to medically treated severity crashes and 9,500 crashes of all severity levels in 2006 with imputed corresponding savings of 8,100 fatal to medically treated and 8,000 total crashes across the whole of 2007. Based on these estimated reductions, total savings in costs to society associated with the program were estimated to be in the order of \$1.85 billion for 2006 and \$1.68 billion imputed across the whole of 2007.

Key Words:

Speed camera, speed enforcement, statistical analysis, road trauma, injury, collision, evaluation, research report

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EVALUATION OF THE CRASH EFFECTS OF THE QUEENSLAND MOBILE SPEED CAMERA PROGRAM IN THE YEARS 2006-2007

1. BACKGROUND AND STUDY AIMS

During 2003, the Monash University Accident Research Centre (MUARC) completed a comprehensive evaluation of the crash effects of the Queensland mobile speed camera program. The evaluation estimated significant crash reductions due to the implementation and growth of the program in areas local to zones where speed cameras operated over the period from program commencement in May 1997 to the end of the evaluation period at June 2001. Full details of the evaluation and its findings appear in Newstead and Cameron (2003).

Since the end of June 2001, the period covered by the initial evaluation, the Queensland mobile speed camera program has continued to grow in terms of its coverage of the Queensland crash population and in its hours of operation. In order to establish the effectiveness of the program in the period from June 2001 to June 2007, Queensland Transport commissioned MUARC to undertake four extensions of its original evaluation to cover this later period. The results of this study are reported in Newstead (2004), Newstead (2005), Newstead (2006) and Newstead (2007) and estimated sustained large crash effects of the Queensland mobile speed camera program from June 2001 through to June 2007.

The broad aim of this research was to establish the effect of the mobile speed camera program on crash frequency in Queensland over a further extended program post implementation than had previously been evaluated. Specifically, the study focused on the effects of the program in 2006 and the first 6 months of 2007 in terms of:

- Percentage crash savings
- Absolute crash savings
- Social costs of the estimated absolute crash savings

2. EVALUATION DESIGN AND HYPOTHESES

2.1 EVALUATION DESIGN

The evaluation design used in this study is the same as that used in the original evaluation of the Queensland mobile speed camera program by Newstead and Cameron (2003) and in the updated evaluations of Newstead (2004), Newstead (2005), Newstead (2006) and Newstead (2007). It is a quasi-experimental design, comparing crash history at sites influenced by the hypothesised speed camera effects against that at appropriately chosen control sites. The treatment area of the quasi-experimental design is the area within 6km of speed camera zones operational within the time frame of the evaluation data. As in the original study, the hypothesised treatment area has been broken into three separate annuli, 0km to <2km, 2km to <4km and 4km to <6km, in order to examine the possibility of different program effects as distance from the camera zones increased. All areas outside of the 6km hypothesised area of influence of the mobile speed camera program served as the control area.

Like the original evaluation, the 'before' period in the evaluation design was defined as January 1992 to December 1996. Five years before treatment crash history was used in order to minimise possible regression-to-the-mean effects caused by the non-random selection of the speed camera operation sites (Nicholson, 1986). Complete reported crash data was available up to June 2007 giving a maximum post-implementation period from January 1997 to June 2007. Although the camera program was only implemented in May 1997, January to April 1997 was included in the post implementation period because of the presence of intensive publicity prior to the program launch.

2.3 EVALUATION HYPOTHESES TESTED

The generic null hypothesis tested in this evaluation is that the introduction of the mobile speed camera program in Queensland had no effect on crash frequency in areas within a 6km radius of speed camera zones that had been used up to June 2006. This has been assessed against the two-sided alternative hypothesis that the introduction of the mobile speed camera program has led to a change in crash frequency in the defined areas of influence. As a result of the study design, the alternative hypothesis also allows for differential crash effects of the mobile speed camera program within each 2km annulus around the speed camera zones. A two sided alternative hypothesis used in this evaluation makes no presumption about the direction of the crash effects of the mobile speed camera program and hence gives the most conservative statistical significance values on the program crash effect estimates. If a one sided alternative hypothesis is considered more appropriate by the reader (for example, if it is hypothesised that the program only reduces crashes of each severity level), statistical significance values presented should be halved, whilst the point estimates of crash effects will remain the same.

3. DATA

3.1 CRASH DATA

Queensland Transport provided data on all reported crashes in Queensland over the period January 1992 to June 2007 in unit record format. Each crash record had information in the following fields:

- Crash number
- Crash date
- Crash severity (fatal, serious injury (hospital admission), medically treated injury, other injury, no injury)
- Police region of crash
- Speed zone of crash
- Distance of crash from nearest operational speed camera zone centroid (km)

Data was defined as belonging to treatment or control groups using the distance of the crash from the centroid of the nearest approved speed camera zone. In the original study of Newstead and Cameron (2003), it was thought that the crash data had been labelled according to the distance of the crash from the nearest operational speed camera site. Since then, it has been established that the distance was actually relative to the nearest speed camera zone centroid, a labelling convention also used for the data in this update study and the previous update studies of Newstead (2004), Newstead (2005), Newstead (2006) and

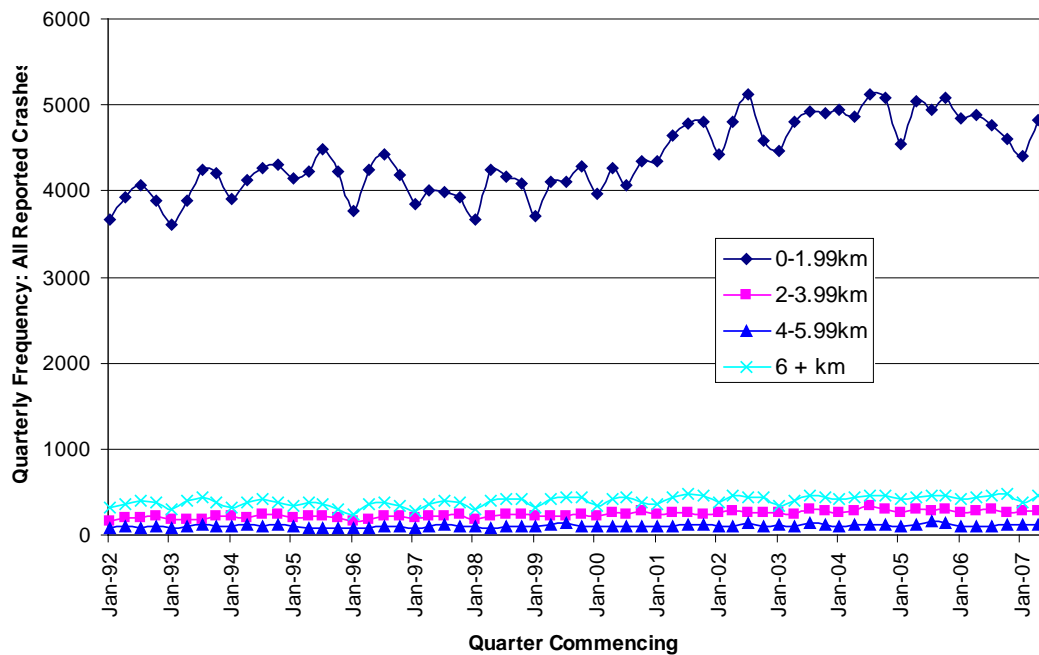
Newstead (2007). Because most speed camera zones only have between 1 and 2 operational sites on average (see Newstead and Cameron, 2003), the change in definition of the distance labelling made essentially no difference to the interpretation of the original study outcomes.

Within the 6km radius treatment group area, treatment group annuli were defined as: less than 2km from a speed camera zone; 2km or more but less than 4km from a speed camera zone and 4km or more but less than 6km from a speed camera zone. Control areas were all those outside the defined treatment annuli. Crashes were assigned as being in the before or after implementation periods using the date of the crash.

Queensland Transport assigned the distance of each crash in the data from the nearest approved speed camera zone centroid using Geographical Information System (GIS) software that related the physical location of crash sites and speed camera zone centroids. As in the original evaluation of Newstead and Cameron (2003) and the update studies of Newstead (2004), Newstead (2005), Newstead (2006) and Newstead (2007), the labelling of crash data with respect to the distance to the nearest speed camera zone, referred to any speed camera zone that had been used up to the time of taking the speed camera operations snapshot (June 2007). This was irrespective of whether the camera zone had been used operationally or not at the time of the crash. Implications for the interpretation of analysis are as for the original study.

Figure 1 shows quarterly trends in all reported crashes in Queensland by distance from the nearest speed camera zone that had been operational to June 2007. It shows that around 85% of reported crashes in Queensland have occurred within 2km of a (eventual) speed camera zone centroid, rising to 90% when considering up to 4km from a speed camera zone. It also shows that around 7.8% of crashes happened a distance of 6km or more from the nearest speed camera zone (that became operational sometime during May 1997 to June 2007). These proportions are higher than found in the original study of Newstead and Cameron (2003), reflecting increased coverage of the Queensland crash population through continued growth in the number of speed camera zones utilised over the period July 2001 to June 2007. However, they are consistent with the proportions identified in the update studies of Newstead (2006) and Newstead (2007) suggesting geographical coverage of the program has not grown significantly over the period from January 2006 to June 2007.

Figure 1: Number of police reported crashes in Queensland by distance from speed camera zone



Data has been analysed at the following individual and aggregated levels of crash severity:

- Fatal and hospitalisation crashes combined
- Medically treated crashes
- Fatal, hospitalisation and medically treated crashes combined
- Other injury crashes
- Non-injury crashes
- All reported crashes combined.

Fatal crashes were not analysed on their own since there were insufficient monthly fatal crash counts to produce statistically reliable estimates of mobile speed camera program effects.

4. METHODS

Net crash effects of the Queensland mobile speed camera program under the quasi-experimental study design have been estimated using a Poisson regression statistical model. The analysis approach used here is the same as that used in the original study of Newstead and Cameron (2003) and the update studies of Newstead (2004), Newstead (2005), Newstead (2006) and Newstead (2007). A Poisson regression model was felt to be appropriate for analysing the crash data for a number of reasons. Firstly, crash count data is widely considered to follow a Poisson distribution (Nicholson, 1986). Fitted values from the Poisson regression model are also constrained to be non-negative whilst assumed Poisson distribution of the count data reflects its often highly skewed distribution. Furthermore, the log-linear model structure assumes factors affecting crash outcomes, such as road safety campaigns, affect crash numbers in a proportionate way. This is in contrast to a linear model that assumes additive affects of external factors and can hence predict

negative crash numbers under certain circumstances. Poisson regression models are also commonly used in the analysis of experimental designs in medical research (Breslow and Day, 1987).

The form of the model fitted to the monthly crash data frequencies of treatment and control data for each crash severity considered is given by equation 1.

$$\ln(y_{ijm}) = \alpha + \beta_i + \delta_i m + \gamma_j + \phi_{ij} \dots (\text{Equation 1})$$

where

- y is the monthly crash count
- i is an indicator for treatment annulus or control series
- m is a linear month indicator variable
- j is the mobile speed camera program indicator
- $\alpha, \beta, \delta, \gamma, \phi$ are parameters of the model

The indicators in the model take the following values.

- m = 1 in the first quarter of data
- = 2 in the second quarter of data etc.
- i = 0; control series (crashes 6km or greater from a speed camera zone)
- = 1; outer treatment annulus (crashes less than 6km but 4km or greater from a speed camera zone)
- = 2; middle treatment annulus (crashes less than 4km but 2km or greater from a speed camera zone)
- = 3; inner treatment annulus (crashes less than 2km from a speed camera zone)

The mobile speed camera program indicator, j , has been defined for annual program estimates as follows.

- j = 0 if month was before introduction of mobile speed camera program
- = 1 if month was in the first year after introduction of mobile speed camera program
- = 2 if month was in the second year after introduction of mobile speed camera program
- etc.*

The net effect of the mobile speed camera program in treatment annulus i in time period j after program implementation measured as a net percentage reduction in crash frequency is given by Equation 2.

$$\Delta SpeedCamera_{ij} = (1 - \exp((\phi_{ij} - \phi_{i0}) - (\phi_{0j} - \phi_{00}))) \times 100\% \quad \dots(2)$$

Equation 2 is measuring the change in treatment area crash frequency from before treatment to time period j after treatment, adjusted for corresponding changes in crash frequency in the control areas over the same time period.

In practice, parameterisation of the factors in the model given by Equation 1 leaves parameters being 'aliased'. 'Aliased' parameters refer to those that are unable to be estimated because they are a linear product of other parameters in the regression design matrix. Aliased parameters are set to zero in the regression equation. With careful parameterisation and fitting of the model in equation 1, it is possible to alias the parameters ϕ_{0j} and ϕ_{i0} for all values of i and j . This leads to a reduction in Equation 2 to give Equation 3.

$$\Delta SpeedCamera_{ij} = (1 - \exp(\phi_{ij})) \times 100\% \quad \dots(3)$$

The form of Equation 3 is much more convenient in practice as statistical testing of the difference in ϕ_{ij} from zero tests directly the significance of the change in crash frequency in speed camera annulus of influence i in time period j after program implementation. Similarly, the variance of ϕ_{ij} can be used to compute confidence limits on the estimated change in crash frequency.

All Poisson log-linear regression models were fitted using the GENMOD procedure in the SAS statistical analysis software (SAS, 1993).

5. RESULTS

5.1 CRASH EFFECT ESTIMATES

Percentage Crash Reductions

Table 1: *Estimated percentage crash reductions attributable to the Queensland mobile speed camera program for 2006 and January-June 2007.*

Crash Severity	Distance From Camera Zone	Estimated Crash Reduction (Statistical Significance)	
		2006	Jan-Jun 2007
Fatal and Hospital Admission	0-1.99km	41.20% (0.0047)	39.01% (0.0109)
	2-3.99km	22.36% (0.4049)	11.44% (0.6974)
	4-5.99km	-22.97% (0.5951)	-47.80% (0.3286)
Medically Treated	0-1.99km	47.56% (0.0047)	49.07% (0.0043)
	2-3.99km	48.12% (0.062)	46.10% (0.0886)
	4-5.99km	2.58% (0.9561)	-8.97% (0.8601)
Fatal to Medically Treated	0-1.99km	47.13% ($<.0001$)	46.83% ($<.0001$)
	2-3.99km	36.20% (0.0501)	29.97% (0.1317)
	4-5.99km	-11.29% (0.7218)	-30.10% (0.3947)
Other Injury	0-1.99km	16.11% (0.5731)	25.02% (0.3657)
	2-3.99km	-32.37% (0.579)	-21.36% (0.7076)
	4-5.99km	58.64% (0.1836)	78.58% (0.0272)
No Injury	0-1.99km	15.39% (0.2959)	1.18% (0.9436)
	2-3.99km	16.78% (0.4645)	0.61% (0.9814)
	4-5.99km	-5.37% (0.8783)	-54.94% (0.2156)
All Severity Levels	0-1.99km	32.37% (0.0001)	30.05% (0.0007)
	2-3.99km	23.39% (0.0968)	16.26% (0.2848)
	4-5.99km	1.08% (0.9592)	-13.58% (0.5632)

NB: Negative crash reduction estimates indicate an estimated crash increase

Results presented in Table 1 give the estimated crash reductions associated with the introduction of the Queensland mobile speed camera program for all of 2006 and the first 6

months of 2007. The table presents both the estimated percentage crash reduction, where negative results indicated an estimated crash increase, as well as the statistical significance of each estimate. Low statistical significance values indicate the estimated crash reduction is not likely to have been obtained by chance variation in the quarterly crash data counts when no real crash reduction occurred. The information presented in Table 1 is an extension of that presented in Table 2 of Newstead and Cameron (2003) and in Table 1 of Newstead (2004), Newstead (2005), Newstead (2006) and Newstead (2007).

Table 1 shows sustained crash reductions attributable to the mobile speed camera program in Queensland in both 2006 and the first half of 2007 and is particularly evident when examining results for higher severity crashes within 2km of speed camera zones. Estimated reductions in fatal and hospital admission crashes within 2km of speed camera zones are estimated to be 41% in 2006 and 39% in the first half of 2007, with both estimates being highly statistically significant. Because the 95% confidence limits on both the 2006 and 2007 estimates overlap with those on estimates for recent prior years, it is not possible to say crash effects in 2006 and 2007 are significantly different from the recent prior years.

Table 1 further confirms two general trends in the speed camera crash effects observed in Newstead and Cameron (2003) and in the update analyses (Newstead, 2004, 2005, 2006, 2007). Results show a continued differential effect of the mobile speed camera program on crashes by crash severity level. Estimates of fatal to medically treated crash effects within 2km of speed camera zones are in the order of 47% in both 2006 and the first half of 2007, compared to other injury and non-injury crashes where estimated crash reductions within the same radius are less than 26%. This point is illustrated in Figure 2 which plots estimated crash reductions in 2006 and 2007 by annulus of influence for all crashes combined and for fatal, hospital and medically treated crashes combined. Figure 2 shows the clear differential of crash effects in the more severe crash severities in the 0-2km and 2-4km annuli compared to when the minor crash severities are included. This is particularly the case in the inner most annulus. The differential is sustained in the outer annulus, however, it should be noted that the estimated crash effects for both these crash groupings are not statistically significant in the outer annulus (see Table 1). Results in Table 1 also show the continuing trend of estimated crash reductions being greatest nearest the camera zone (0-2km) and least in the furthest annulus (4-6km). This is also clearly illustrated in Figure 2.

Figure 2a: *Percentage crash reduction by injury severity and distance from speed camera zone: 2006*

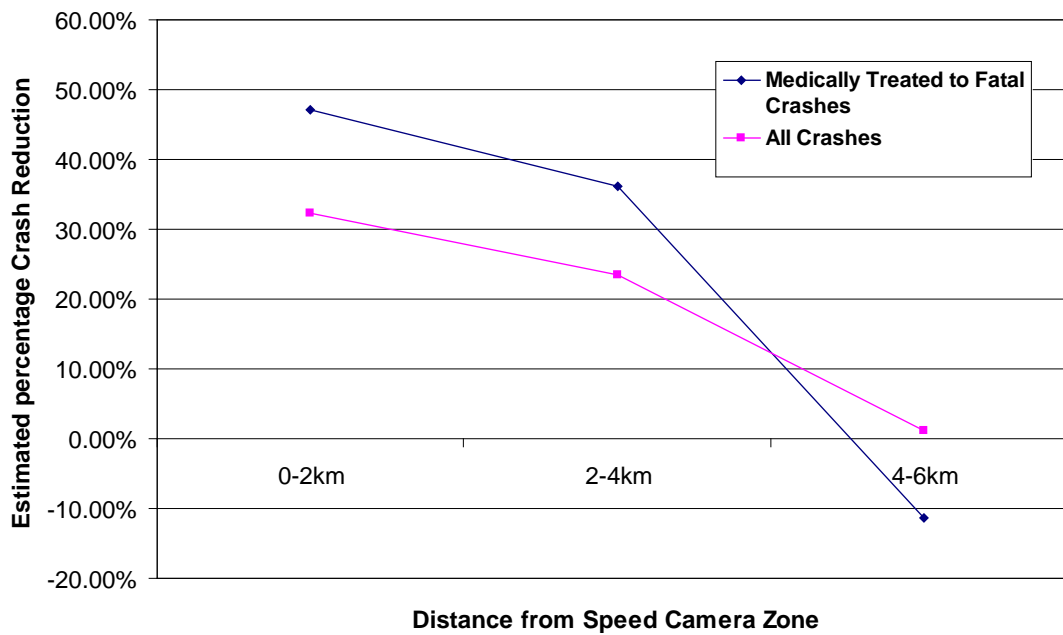
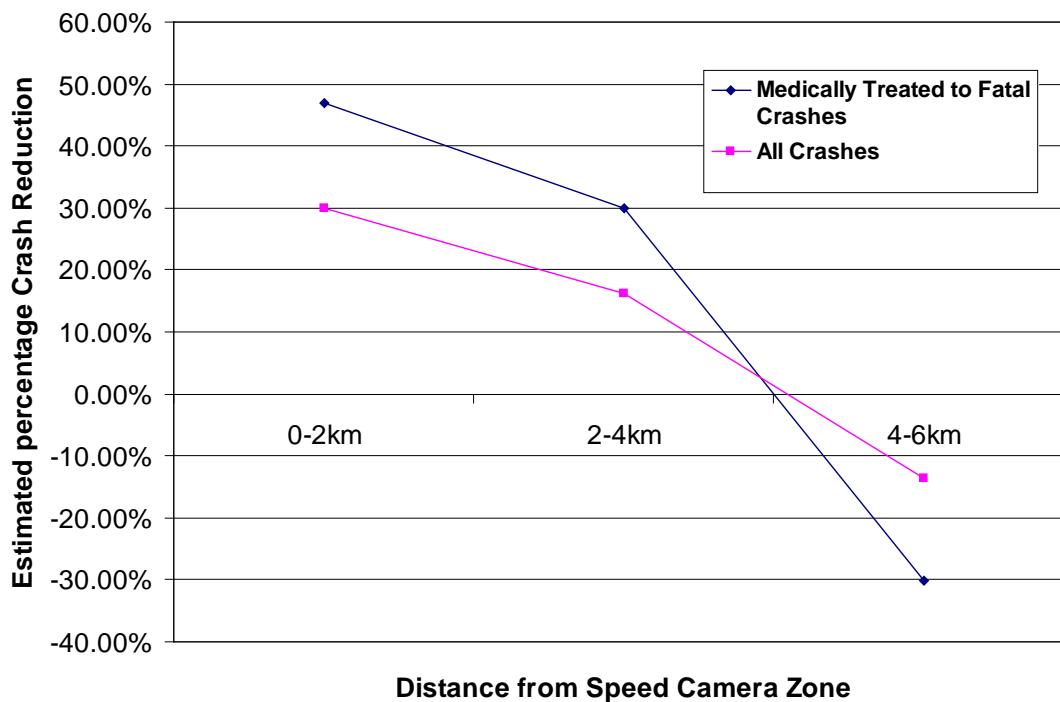


Figure 2b: *Percentage crash reduction by injury severity and distance from speed camera zone: January-June 2007*



Absolute Crash Savings

Estimates of the absolute magnitude of crash savings attributable to the mobile speed camera program during 2006 and the first half of 2007, rather than just the percentage reductions shown in Table 1, are shown in Table 2. These have been derived by using the estimated percentage reductions in Table 1 along with the observed post-program crash frequency by crash severity level and annulus of influence. There are a number of ways of deriving actual crash savings from the percentage reduction estimates. This is because the

Poisson log-linear model used to derive the percentage reduction estimates is a multiplicative form, being a product of the change due to non-treatment factors in the treatment group, reflected by the parallel changes in the control group, as well as changes attributed to the treatment itself. The absolute magnitude of crash change attributed to the treatment will depend on whether the control effects (factors other than the mobile speed camera program) or the treatment effects (the mobile speed camera program) are assumed to have influenced the treatment area crashes first. In the figures presented in Table 2, the effects reflected by the control group are assumed to have changed the treatment area crashes first, giving the most conservative estimate of the number of absolute crashes saved by the mobile speed camera program.

Table 2 also shows annualised estimates of absolute crash savings for the whole of 2007. These have been obtained by simple doubling the estimates for the first 6 months of 2007. For the annualised estimates to be representative of the absolute crash reductions associated with the mobile speed camera program across the whole of 2007, it must be assumed that the estimated percentage crash reduction applies for the whole year. This is only likely if the crash coverage of the mobile speed camera program and the hours for which the cameras were operated remained relatively constant throughout 2007. It is not known whether this was the case. Representative annualised estimates also assume that the observed total crash count for the whole of 2007 is twice that observed in the first six months of that year. Examination of historical crash data trends from 1997 to 2005 show crash distribution is approximately 50% across each half of the year suggesting this assumption is tenable.

Table 2: *Estimated total crash savings attributable to the Queensland mobile speed camera program for 2006 and 2007.*

Crash Severity	Distance From Camera Zone	Estimated Absolute Crash Saving 2006	Estimated Absolute Crash Saving January-June 2007	Estimated Annualised Absolute Crash Saving January-December 2007
<i>Fatal and Hospital Admission</i>	0-1.99 km	2887	1324	2649
	2-3.99 km	89	22	44
	4-5.99 km	-26	-26	-52
<i>Medically Treated</i>	0-1.99 km	4380	2248	4495
	2-3.99 km	219	104	209
	4-5.99 km	2	-4	-8
<i>Fatal to Medically Treated</i>	0-1.99 km	7976	3879	7758
	2-3.99 km	309	125	250
	4-5.99 km	-23	-30	-61
<i>Other Injury</i>	0-1.99 km	560	519	1037
	2-3.99 km	-37	-14	-29
	4-5.99 km	221	327	653
<i>No Injury</i>	0-1.99 km	1313	39	78
	2-3.99 km	82	1	2
	4-5.99 km	-8	-32	-63
<i>All Severity Levels</i>	0-1.99 km	9131	3965	7930
	2-3.99 km	335	109	218
	4-5.99 km	5	-28	-57

NB: Negative crash saving estimates indicate an estimated crash increase

It should be noted in Table 2 that the estimates of crashes saved for all severity levels combined and for fatal to medically treated crashes aggregated were not obtained by taking a sum of the estimates from the individual crash severity levels. They were based on specific estimates of crash effectiveness from the statistical procedures applied to data from those severity levels aggregated and, as such, will be more precise than estimates gained from simply summing the savings from the individual crash severity levels.

Table 2 shows the Queensland mobile speed camera program has continued to result in significant estimated crash savings over 2006 and the first half of 2007. Net savings in crashes of all severities were estimated to be in the order of 9,500 for 2006 and 4050 for the first half of 2007 translating to 8,100 for the whole year. Similarly, estimated net savings in medically treated to fatal crashes were around 8250 for 2006 and 4,000 for the first half of 2007 or 8000 for the whole year representing a large proportion of the total savings.

As in Newstead and Cameron (2003) and Newstead (2004, 2005, 2006, 2007), translation of percentage crash costs into absolute crash savings by annulus of influence around the speed camera zones shows the majority of crash savings to be made in the 0-2km annulus. This reflects that both the highest percentage crash savings were estimated in this annulus as well as 85% of the Queensland crash population falling within this distance from a speed camera zone (Figure 1). As in the past studies, assessment of the success of the program is best reflected in the crash savings in the 0-2km annulus.

5.2 CRASH COST SAVINGS ESTIMATES

Using the estimates of annual crash savings presented in Table 2 along with estimated crash costs, savings in crash costs attributable to the Queensland mobile speed camera program over 2006, the first half of 2007 and annualised for the whole 2007 year under the stated assumptions have been estimated and are given in Table 3. Crash cost figures used were those estimated by the Bureau of Transport Economics (BTE, 2000) by crash severity based on the human capital approach. In 2006 basis Australian dollars, the crash cost estimates from the BTE were \$2,129,023 for a fatal crash, \$525,583 for a crash resulting in hospital admission, \$17,743 for a minor or other injury crash and \$7,480 for a non-injury crash. Original cost estimates were given by the BTE in 1996 dollars. These have been inflated to 2006 dollars using the CPI difference between June 1996 and June 2006

In the original study of Newstead and Cameron (2003), the crash costs given by the BTE were adjusted by the Consumer Price Index at June of each program year. It was necessary to estimate crash costs using this method in the original study of Newstead and Cameron (2003) in order to compare them to annual program cost estimates to give an overall program Benefit-to-Cost (BCR) ratio estimate. Since a BCR estimate was not required for this study update, all costs have been given in 2006 Australian dollars.

It is clear from the estimates in Table 3 that the Queensland mobile speed camera program has continued to result in substantial savings to the community through reduced crash costs throughout 2006 and 2007.

Table 3: *Estimated total crash cost savings attributable to the Queensland mobile speed camera program for 2006 and 2007.*

Crash Severity	Estimated Crash Cost Saving to Society 2006	Estimated Crash Cost Saving to Society January-June 2007	Estimated Annualised Crash Cost Saving to Society January-December 2007
Fatal + Hospital	\$1,754M	\$785M	\$1,570M
Medical	\$78.5M	\$40.1M	\$80.2M
Other	\$12.7M	\$14.2M	\$28.4M
No Injury	\$9.97M	\$62K	\$126K
Total	\$1,855M	\$839.5M	\$1,679M

6. CONCLUSIONS

Analysis in this study has been able to update estimates of the crash effects of the Queensland mobile speed camera program over 2006 and the first half of 2007 and from this impute the likely effects of the program over the full 2007 year assuming speed camera operations and effectiveness did not change over the second half of 2007. It extends the initial evaluation of the mobile speed camera program reported in Newstead and Cameron (2003) that estimated crash effects of the program only to mid-2001 as well as four update analyses (Newstead, 2004, 2005, 2006, 2007) which extended the period covered until June 2006.

Results of analysis showed the Queensland mobile speed camera program resulted in sustained large crash reductions over 2006 and the first half of 2007. Crash effects within 2km of a defined speed camera zone give the best indication of program performance with this area covering 85% of reported crashes in Queensland based on speed camera zones used up until June 2007. Analysis in this study estimated a reduction in fatal to medically treated crashes in this area of 47% during 2006 and the first half of 2007 with a corresponding reduction in all reported crashes, including non-injury crashes, of 32% and 30% for the 2 years assessed respectively. These translate to half year savings of around 8,250 fatal to medically treated severity crashes and 9,500 crashes of all severity levels in 2006 with imputed corresponding savings of 8,100 fatal to medically treated and 8,000 total crashes across the whole of 2007. Based on these estimated reductions, total savings in costs to society associated with the program were estimated to be in the order of \$1.85 billion for 2006 and \$1.68 billion imputed across the whole of 2007.

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