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EVALUATION OF THE CRASH EFFECTS OF THE QUEENSLAND SPEED CAMERA PROGRAM IN THE YEARS 2001-2003

by

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Abstract:

This study extends the evaluation of the Queensland speed camera program reported in Newstead and Cameron (2003) to estimate the crash effects of the program to the end of September 2003, adding a further period of 27 months post program experience to that covered in the initial evaluation. Methods of evaluation and generic hypotheses tested are the same as in the initial evaluation.

Results of analysis showed the Queensland speed camera program resulted in sustained large crash reductions over the period from 2001 to 2003. No statistically significant trend to reduced crash savings were estimated over this period. Point estimates of program performance suggest some of the greatest crash reductions since program commencement occurred during the 2001-2003 period. Crash effects within 2km of a defined speed camera zone give the best indication of program performance with this area covering 83% of reported crashes in Queensland based on speed camera zones used up until February 2004. Analysis in this study estimated a reduction in fatal and hospitalisation crashes in this area of between 32% and 37% during 2001-2003 with a corresponding reduction in all reported crashes, including non-injury crashes, of between 26% and 29%. These translate to annual savings of over 1,800 fatal and hospitalisation crashes and 7,000 to 7,300 crashes of all severities. Total savings in costs to society corresponding to these estimated crash savings were in the order of $1.2 to $1.4 billion in each year from 2001 to 2003.

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 SPEED CAMERA PROGRAM IN THE YEARS 2001-2003

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 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 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 December 2003, Queensland Transport commissioned MUARC to undertake an extension of its original evaluation to cover this later period.

The broad aim of this research was to establish the effect of the speed camera program on crash frequency in Queensland over the extended program post implementation in May 1997 to December 2003. In particular, Queensland Transport wished to establish the effectiveness of the Queensland speed camera program over the full calendar years 2001 to 2003 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 speed camera program by Newstead and Cameron (2003). 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 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). Reported crash data was available up to December 2003 giving a maximum post-implementation period from January 1997 to December 2003. 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 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 February 2004. This has been assessed against the two-sided alternative hypothesis that the introduction of the 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 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 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 staff provided data on all reported crashes in Queensland over the period January 1992 to December 2003 in unit record format. Each crash record had information in the following fields:

- Crash number
- Crash date
- Crash severity (fatal, serious injury, 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 operation 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. 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 will make 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. Before and after implementation periods were defined 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), 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 matching the data (February 2004). 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 the end of February 2004. It shows that around 83% 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 8% of crashes happened a distance of 6km or more from the nearest speed camera zone (that became operational sometime during May 1997 to February 2004). 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 February 2004.

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

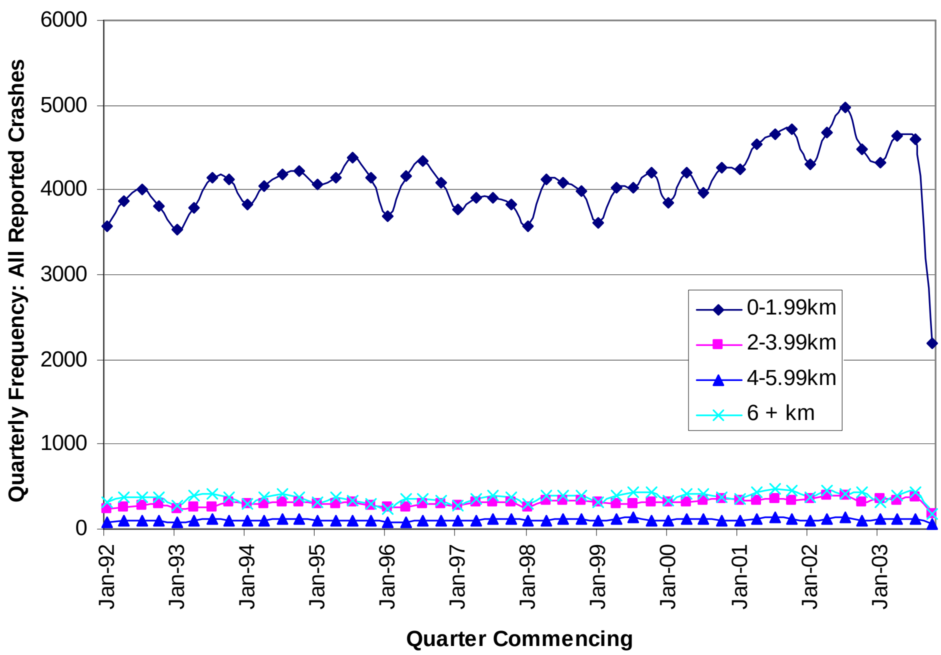


Figure 1 shows a sharp drop in reported crash numbers in the last quarter of 2003. This is most likely to do with crashes from this period not being completely reported in the Queensland Transport crash database at the time of extraction for use in the analysis in this report. As a result of the observed under reporting of crashes in the last quarter of 2003, it was decided not to include data from this period in the analysis. Consequently, the period of post program implementation data used in this study was January 1997 to September 2003.

4. METHODS

Net crash effects of the Queensland 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). 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). It is also constrained to be non-negative as well as often being highly skewed in distribution, both factors accommodated by the log transformation in the log-linear model. Furthermore, the log-linear model structure assumes external factors, 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.

…(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 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 speed camera program indicator, j, has been defined for annual program estimates as follows.

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

The net effect of the 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.

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.

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 1a: *Estimated percentage crash reductions by crash severity attributable to the Queensland speed camera program by year after program implementation.*

Crash Severity	Distance From Camera Zone	Year 2001	2002	2003*
Fatal	**0-1.99km**	34.5%	26.7%	35.0%
		0.2327	*0.4366*	*0.3283*
	2-3.99km	27.6%	4.9%	38.8%
		0.5393	*0.9318*	*0.4558*
	4-5.99km	-219.8%	-353.1%	-161.4%
		0.1261	*0.0761*	*0.3176*
Hospital Admission	**0-1.99km**	40.1%	38.4%	34.1%
		<.0001	*0.0009*	*0.0103*
	2-3.99km	27.7%	12.8%	15.4%
		0.0942	*0.5254*	*0.4889*
	4-5.99km	20.1%	10.9%	-10.0%
		0.3965	*0.6966*	*0.7715*
Medically Treated	**0-1.99km**	38.4%	41.3%	38.8%
		0.001	*0.0013*	*0.0084*
	2-3.99km	34.1%	31.9%	25.4%
		0.0409	*0.0924*	*0.251*
	4-5.99km	-5.4%	3.7%	-18.3%
		0.8582	*0.9089*	*0.6513*
Other Injury	**0-1.99km**	6.2%	19.5%	8.6%
		0.7507	*0.3397*	*0.7246*
	2-3.99km	-19.6%	-17.0%	-50.6%
		0.5372	*0.6286*	*0.2575*
	4-5.99km	28.6%	49.2%	45.7%
		0.4194	*0.1516*	*0.2489*
No Injury	**0-1.99km**	18.0%	15.9%	15.1%
		0.056	*0.1348*	*0.2053*
	2-3.99km	12.7%	13.3%	15.9%
		0.3523	*0.379*	*0.3376*
	4-5.99km	16.6%	15.8%	11.1%
		0.3975	*0.4686*	*0.6555*

NB: Negative crash reduction estimates indicate an estimated crash increase
**: First 9 months of 2003*

Table 1b: *Estimated percentage crash reductions by aggregated crash severity levels attributable to the Queensland speed camera program by year after program implementation.*

Aggregate Crash Severity Levels	Distance From Camera Zone	Year 2001	2002	2003*
Fatal and Hospital Admission	**0-1.99km**	36.93%	34.18%	32.14%
		0.0002	*0.0023*	*0.0107*
	2-3.99km	25.68%	8.35%	19.51%
		0.1011	*0.6648*	*0.3326*
	4-5.99km	4.30%	-3.28%	-22.91%
		0.8601	*0.9074*	*0.5006*
Fatal to Medically Treated	**0-1.99km**	38.7%	39.7%	38.1%
		<.0001	*<.0001*	*<.0001*
	2-3.99km	31.1%	22.6%	23.0%
		0.0058	*0.0884*	*0.1208*
	4-5.99km	1.3%	-2.1%	-19.4%
		0.9442	*0.9215*	*0.4553*
All Severity Levels	**0-1.99km**	27.6%	28.5%	25.9%
		<.0001	*<.0001*	*0.0003*
	2-3.99km	20.5%	16.2%	14.8%
		0.0141	*0.0913*	*0.1708*
	4-5.99km	10.5%	11.9%	1.7%
		0.4079	*0.3983*	*0.9183*

NB: Negative crash reduction estimates indicate an estimated crash increase
**: First 9 months of 2003*

Results presented in Table 1 give the estimated crash reductions associated with the introduction of the Queensland speed camera program by year after program implementation from 2001 to 2003. Part a of Table 1 gives results by individual crash severity levels whilst part b gives results aggregated across various crash severity levels. 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) for estimates of program effects in full years of 2001 and 2002 and the first 9 months of 2003.

Table 1 shows sustained crash reductions attributable to the speed camera program in Queensland over the years 2001 to 2003. This is particularly evident when examining results for higher severity crashes within 2km of speed camera zones. Estimated reductions in fatal to medically treated severity crashes within 2km of speed camera zones are estimated to be between 38 and 40% in the years 2001 to 2003, with estimates in each year being statistically significant. Results for hospital admission and fatal crashes were also statistically significant and of a similar magnitude.

Table 1 also confirms two general trends in the speed camera crash effects observed in Newstead and Cameron (2003). Results show a differential effect of the 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 39%, compared to other injury and non-injury crashes where estimated crash reductions are less than 20%. This is illustrated in Figure 2 which plots estimated crash reductions in 2002 by annulus of influence and crash severity. Figure 2 shows the clear differential of crash effects in the more severe crash severities compared to the minor crash severities in the 2km annulus.

The differential becomes less clear in the two outer annuli, however, it should be noted that the estimated crash effects for non-injury and other injury crashes in the two outer annuli are generally not statistically significant (see Table 1).

Results in Table 1 also show that crash reductions are greatest nearest the camera zone (0-2km) and least in the furthest annulus (4-6km). This is clearly illustrated in Figure 3 which shows estimated crash reductions by annulus of influence and year after program introduction from 2001 to 2003 for all crash severity levels combined. Similar results presented in Newstead and Cameron (2003) were not so consistent in their patterns of reducing crash reductions by increasing distance from camera zone centroid, with the middle annulus showing greater crash reductions than the outer annulus in later years. This was hypothesised to be indicative of a speed camera site learning effect by the motoring public. It is apparent this hypothesis is not supported by the current data, most likely a result of the re-definition of the study treatment area through the use of more recent speed camera zone coverage information (February 2002 vs June 2001).

Figure 2: *Year 2002 Percentage crash reduction by injury severity and distance from speed camera zone*

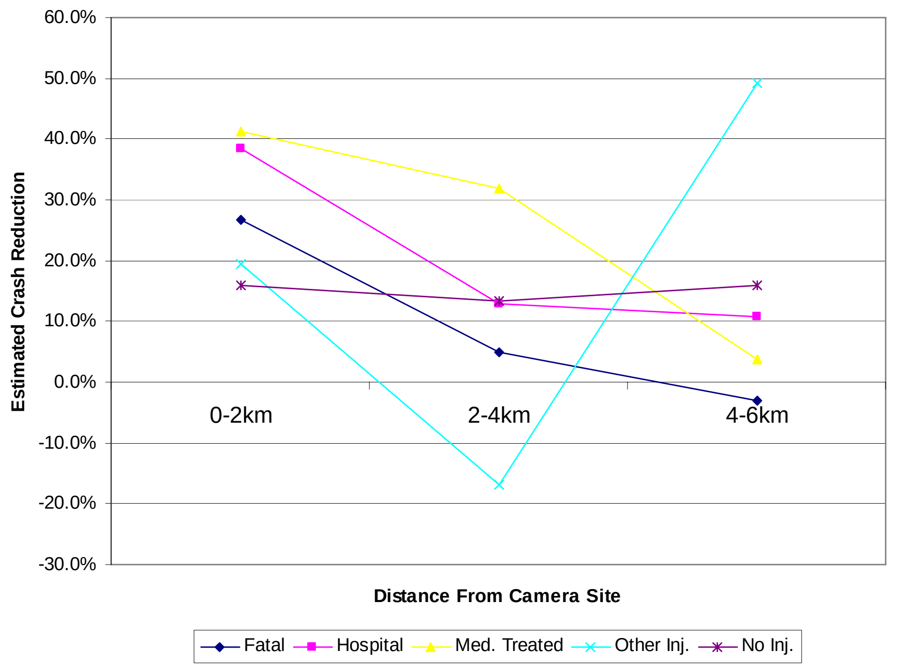
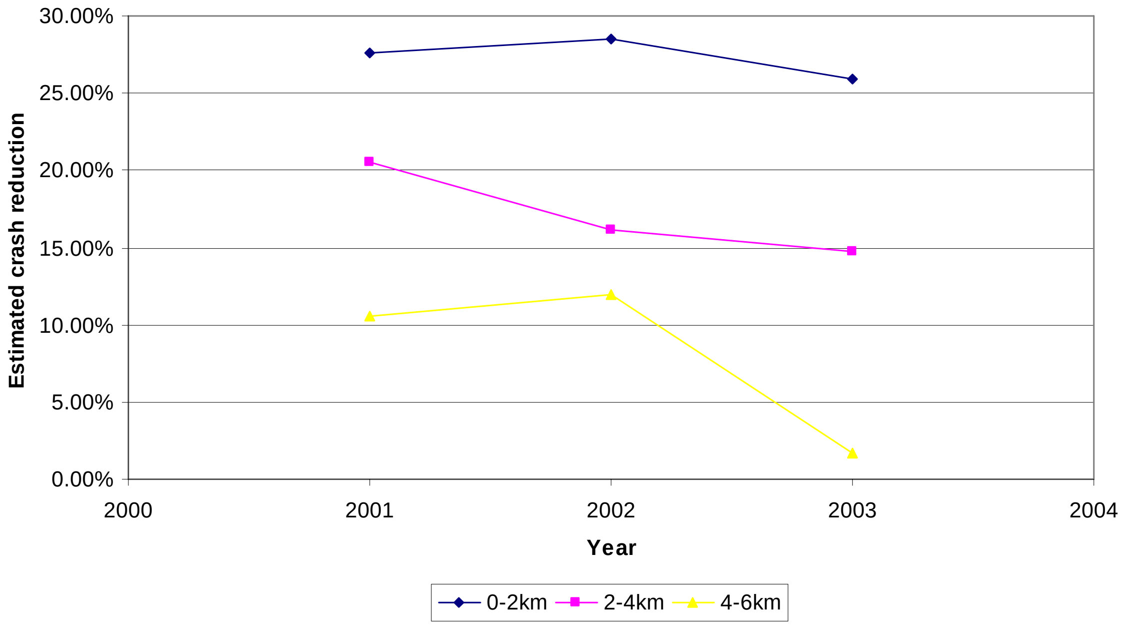


***Figure 3**: Percentage crash reduction in total crashes of all severities by year and distance from speed camera zone*



Absolute Crash Savings

Estimates of the absolute magnitude of crash savings attributable to the speed camera program during 2001 to 2003, rather than just the percentage reductions shown in Table 1, are shown in Table 2. These have been derived by using the estimated annual percentage reductions in Table 1 along with the average annual pre-program crash frequency by crash severity level and annulus of influence. It should be noted that 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 in the treatment group accounting for 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 or the treatment effects are assumed to have influenced the treatment 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 speed camera program.

Table 2: *Estimated total crash savings attributable to the Queensland speed camera program by year after program implementation.*

		Year			
Crash Severity	**Distance From Camera Zone**	**2001**	**2002**	**2003***	**2003** Annualised**
Fatal	0-1.99 km	95	61	102	136
	2-3.99 km	14	2	19	25
	4-5.99 km	-14	-16	-9	-12
Hospital Admission	0-1.99 km	2155	2146	1577	2102
	2-3.99 km	114	53	51	68
	4-5.99 km	29	15	-11	-14
Fatal and Hospital Admission	0-1.99 km	2002	1883	1353	1804
	2-3.99 km	114	37	64	85
	4-5.99 km	6	-5	23	-31
Medically Treated	0-1.99 km	3135	3418	2452	3269
	2-3.99 km	168	156	95	127
	4-5.99 km	-6	4	-13	-18
Fatal to Medically Treated	0-1.99 km	5331	5564	4369	5826
	2-3.99 km	297	215	176	234
	4-5.99 km	3	-5	-36	-48
Other Injury	0-1.99 km	199	701	227	303
	2-3.99 km	-26	-24	-51	-69
	4-5.99 km	22	45	40	54
No Injury	0-1.99 km	1487	1337	1106	1475
	2-3.99 km	81	89	93	124
	4-5.99 km	32	32	20	27
All Severity Levels	0-1.99 km	6944	7335	5513	7351
	2-3.99 km	354	285	214	285
	4-5.99 km	56	63	7	10

NB: Negative crash saving estimates indicate an estimated crash deficit
**: First 9 months of 2003 only*
*** Annualised 2003 crash savings are crash savings estimated for the entire of 2003 based on the crash savings to September 2003 multiplied by 12/9*

Table 2 shows the crash savings for 2003 based on only nine months of crash data. In order to give indicative whole year results for 2003, assuming consistent program effectiveness across the year, the 2003 estimates have been scaled up by a factor of 12/9. These estimates are referred to as 2003 annualised crash savings in Table 2. It should also be noted that the estimates of crashes saved for all severity levels, for fatal to medically treated crashes aggregated and for fatal and hospitalisation crashes aggregated were not obtained by summing 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 speed camera program has continued to result in significant estimated crash savings throughout the period 2001 to 2003. Reflecting the percentage crash savings shown in Table 1, Table 2 shows substantial savings in absolute crash numbers being estimated in the 2001-2003 period. In the period 2001 to 2003, savings in crashes of all severities were estimated to be in the order of between 7,000 and 7,300. Similarly, estimated savings in medically treated to fatal crashes from 2001 and 2003 were between 5,300 and 5,800 whilst savings in hospitalisation and fatal crashes combined were above 1,800 in each year.

As in Newstead and Cameron (2003), 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 83% of the Queensland crash population falling within this distance from a speed camera zone (Figure 1). As in the original study, 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 speed camera program over the period from program introduction to September 2003 have been estimated. 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 1996 basis A$, the crash cost estimates from the BTE were $1,652,994 for a fatal crash, $407,990 for a crash resulting in hospital admission, $13,776 for a minor or other injury crash and $5,808 for a non-injury crash.

To be consistent with the original study of Newstead and Cameron (2003), the crash costs given by the BTE have been 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 ratio estimate. This means in Table 3, for example, that 2001 crash costs are given in 2001 dollars, whilst 2003 crash costs are given in 2003 dollars. The resulting estimates of crash cost savings associated with the Queensland speed camera program for each year after program implementation from 2001 to 2003 are given in Table 3. It should be noted that crash savings from year to year are not directly comparable in Table 3 because of currency inflation differences between each year.

As in Table 2, crash costs savings for 2003 have been given for January to September 2003, the period of the evaluation data, as well as estimated annualised figures for the whole of 2003. As before, the annualised figures represent an estimate of the crash cost savings that would have accrued over the whole of 2003 based on the estimate for the first 9 months of the year and are more directly comparable with the earlier program years.

Table 3: *Estimated total crash cost savings attributable to the Queensland speed camera program by year after program implementation.*

	Year			
Crash Severity	**2001**	**2002**	**2003***	**2003** Annualised**
Fatal	$175.7M	$88.0M	$219.2M	$292.4M
Hospital	$1,047.4M	$1,037.6M	$778.0M	$1,037.4M
Medical	$50.7M	$56.6M	$41.2M	$54.9M
Other	$3.0M	$11.4M	$3.5M	$4.7M
No Injury	$10.4M	$9.7M	$8.4M	$11.1M
Total	$1,287.2M	$1,203.3M	$1,050.3M	$1,400.4M

**Crash cost savings for 2003 are for the 9 months from January to September only*

*** Annualised 2003 crash cost savings are crash cost savings estimated for the entire of 2003 based on the crash cost savings to September 2003 multiplied by 12/9*

It is clear from the estimates in Table 3 that the Queensland speed camera program has continued to result in substantial savings to the community through reduced crash costs throughout the period 2001 to 2003. In fact, the estimated total social cost benefits of the program over each these years has been higher than any of the earlier program years (see Newstead and Cameron, 2003), culminating in the greatest estimated savings in 2003 of $1.4b.

7. CONCLUSIONS

Analysis in this study has been able to estimate the crash effects of the Queensland speed camera program over the period January 2001 to the end of September 2003. It updates the initial evaluation of the speed camera program reported in Newstead and Cameron (2003) that estimated crash effects of the program only to mid-2001.

Results of analysis showed the Queensland speed camera program resulted in sustained large crash reductions over the period from 2001 to 2003. No statistically significant trend to reduced crash savings were estimated over this period. Point estimates of program performance suggest some of the greatest crash reductions since program commencement occurred during the 2001-2003 period. Crash effects within 2km of a defined speed camera zone give the best indication of program performance with this area covering 83% of reported crashes in Queensland based on speed camera zones used up until February 2004. Analysis in this study estimated a reduction in fatal and hospitalisation crashes in this area of between 32% and 37% during 2001-2003 with a corresponding reduction in all reported crashes, including non-injury crashes, of between 26% and 29%. These translate to annual savings of over 1,800 fatal and hospitalisation crashes and 7,000 to 7,300 crashes of all severities. Total savings in costs to society corresponding to these estimated crash savings were in the order of $1.2 to $1.4 billion in each year from 2001 to 2003.

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