TIME AND DISTANCE HALO EFFECTS OF AN OVERTLY DEPLOYED MOBILE SPEED CAMERA

Philip Champness; Professor Mary Sheehan
Centre for Accident Research and Road Safety- Queensland (CARRSQ)
School of Psychology and Counselling
Queensland University of Technology (QUT)

Lisa Folkman, State Traffic Support Branch, Queensland Police Service (QPS)

Contact: Philip Champness, CARRSQ.
Phone: 61 7 38644684, Fax: 61 7 38644907, Email: p.champness@qut.edu.au

KEY WORDS

Speed Cameras, Time Halos, Distance Halos, Speed Enforcement.

ABSTRACT

This study investigated time and distance halo effects of mobile overt speed cameras. It was hypothesised that there would be a substantial reduction in vehicle speeds at an operational camera site and that this effect would gradually dissipate over distance from the camera vehicle. It was tentatively predicted that vehicles' speeds may remain below baseline levels for some time after removal of the speed camera. Electronic data loggers were used to accurately record each vehicle's speed as it crossed a set of induction loops buried in the road. Loops were spaced every 500 metres for 3.5 kilometres of a 100 kph high quality and high volume road section. Speeds were compared with baseline measures for each data collection point and across points. The first hypothesis was supported. There was a significant 6 kph reduction in mean and a 7 kph reduction in 85th percentile vehicle speeds, and the number of vehicles exceeding the speed limit fell from 53 % to 16 % immediately adjacent to the operational camera. However, these effects had completely disappeared by 1,500 metres downstream. Upstream halos were negligible. There was no time halo effect. In conclusion, this research found that mobile overt speed cameras are effective in reducing vehicle speeds. However, the reduction in speed is only for a relatively short distance and in a one-off trial only occurs while the camera is in operation.

INTRODUCTION

Most evaluation research of speed cameras has focused on their effect on vehicle crashes, while relatively few studies have evaluated the direct effect that cameras have on vehicle speeds. This is understandable given that reducing crashes is the ultimate goal of speed cameras. The research evaluating speed camera effects on crashes has been encouraging with most studies indicating cameras do produce a significant reduction in crashes (Pilkington & Kinra, 2005). However there are some issues that make it difficult to be confident in determining the effect of speed cameras on crash numbers and severity. Two of the main methodological problems with using crashes as the criterion are regression to the mean, and the fact that, statistically speaking, crashes are relatively rare, which makes it difficult to obtain reliable results (Hauer, 1997). By measuring vehicle speeds it is possible to gain a clearer picture of the more direct influence speed cameras have on driver behaviour. Thus this study uses changes in vehicle speeds as the criterion measure.

A number of European studies have measured vehicle speeds at fixed location speed camera sites and have found reductions in vehicle speeds at the sites evaluated (*National safety camera program: Three year evaluation report*, 2003). There has been limited research investigating the effects of mobile speed cameras on vehicle speeds, but both an ACT and a Queensland study evaluating changes in speeds at speed camera locations, soon after each of those states introduced their mobile speed camera programs, found significant speed reductions at camera sites compared to comparison sites (Edgar, 2001; Walsh & Wessling, 1998). However, a literature search revealed only three published studies that have measured vehicle speeds upstream and downstream from fixed location speed cameras (Chin, 1999; Keenan, 2002; Tae-Jun Ha, Jeong-Gyu Kang, & Je-Jin Park, 2003), and no published studies evaluating distance halos for mobile speed cameras were found. Like the studies that only evaluated speed changes in the immediate vicinity of speed camera sites, all three of these studies on fixed cameras found large reductions in vehicle speeds at speed camera sites. However, these studies revealed that motorists quickly regained speed once they had passed the camera site. For example, the British study found that mean and 85^{th} percentile vehicle speeds had returned to pre-camera levels by 500 metres downstream from fixed cameras (Keenan, 2002). While investigation of a Singaporean camera showed that it produced about a 20 % reduction in vehicle speeds at the camera site and increased speed limit compliance from around three percent to about 85 percent for cars and from about 40 percent to 99 percent for trucks, distance halos were very short, with estimates of effective speed limit compliance limited to about 100 meters in each direction from the camera for cars and about 300 metres for goods vehicles (Chin, 1999). Results from the Korean study are more encouraging with effective upstream distance halos of about one kilometre, which the authors attribute to the presence of a warning sign posted before each speed camera site. However, similar to the UK study downstream effect was less than 500 metres, with motorists travelling faster after exiting the speed camera sites than on approaching them (Tae-Jun Ha et al., 2003). For example, at one of the 60 kph speed limit Korean sites mean speeds were 75 kph 500 metres before the camera, 60 kph at the camera site and 80 kph 500 metres downstream from the camera site.

While research indicates time halo effects can be produced by non-automated speed enforcement (Hauer, Ahlin, & Bowser, 1982); there appears to be no published research evaluating time halo effects of short term deployment of speed cameras, such as is the practice with Queensland's mobile speed camera system. As fixed cameras typically operate 24 hours per day, time halos are irrelevant for this type of speed enforcement technology. However, part of the philosophy of using mobile as opposed to fixed cameras is an attempt to gain a widespread general deterrence effect with limited resources. The general deterrent effect on speeding throughout the road network will be more effective if traffic speeds remain suppressed at speed camera sites for some time after cameras are redeployed elsewhere. Thus, creating a time halo effect is an important goal of mobile speed camera programs. Therefore, one of the objectives of this study is to evaluate time halo effects of a mobile overt speed camera.

Hypotheses:

1. There will be a significant reduction in vehicle speeds at the camera site compared to speeds at the same site during corresponding times when the camera is absent.
2. There will be a short upstream distance halo effect during the deployment time.
3. There will be a downstream distance halo effect during the deployment time, and this should be greater than the upstream effect.
4. It is tentatively predicted that there may be some time halo effects at the camera site and possible upstream or downstream time halo effects from the camera site after the speed camera is removed.

METHOD

Sample and equipment

A high quality section of multilane 100 kph highway was used for the experiment. Traffic volumes are approximately 50,000 per 24 hours at the experimental road section. All vehicle speeds were recorded at each of seven measurement sites. Measurement sites were 500 metres apart, with two sites upstream from the speed camera site, one immediately adjacent to the speed camera site, and four sites downstream from the speed camera site. The last measurement site (2000 metre downstream) was at the beginning of a change from 100 kph to 80 kph speed limit.

Excel Technology speed and vehicle classification data loggers were used for the experiment. These loggers were calibrated against a tested and approved police car speedometer, a GPS, and a LIDAR. The data logger at the camera site was also calibrated against the GATSO speed camera. All loggers record with an accuracy of plus or minus 2 %, and most readings were within 1% accuracy. Motorists were unaware that their speeds were recorded and individual vehicles were not identified.

Design

Distance halos were measured on two dimensions, within sites and between sites. Speeds were recorded at each measurement site during the speed camera deployment time. Speeds recorded during the deployment period were compared at each measurement site with measures collected at the same site for corresponding times the day before and day after deployment. Speeds were also compared between sites during the deployment period. Time halos were measured by comparing speeds for the two hour period immediately prior to the speed camera operation and the two hour period immediately after removal of the camera with speeds during the operational period at the speed camera site.

So as to avoid the potential confounding effects of any speed camera site learning, speed cameras were not operated in the vicinity of the experimental site for one year. It was recognised that peak and off-peak traffic volume times may effect vehicle speeds and thus be a potential confound. To avoid this problem one month of baseline data was collected prior to deployment of the speed camera. This data was analysed to select times of the day and days of the week in which traffic is free flowing and speeds and volumes are most likely to be reliable. It was found that traffic volumes and speeds are fairly consistent from Monday to Thursday from early morning until around 4 pm, after which peak volumes can interfere with motorist's choice of speed. Based on this analysis the speed camera was deployed on a Tuesday from 10 am until 1 pm. This allowed confidence in using data from the day before deployment (Monday) and day after deployment (Wednesday) during the same time period as the camera deployment time period to be used as comparison groups. The chosen deployment time allowed at least two hours of free flowing traffic immediately before and immediately after the deployment time to be available to test for time halo effects.

Measures

Time and distance halos were measured using mean speeds, 85^{th}, 90^{th} and 95^{th} percentile speeds, the variance, and the number of vehicles exceeding the speed limit of 100 kph and number of vehicles exceeding the infringement tolerance limit of 110 kph and the number of vehicles exceeding 120 kph.

Procedure

QPS deployed a GATSO wet film speed camera mounted in a highly visible Toyota Landcruiser Station Wagon for approximately 3 hours, from 09: 58: 40 to 13:02: 48 on Tuesday 14/09/04. The vehicle used in the experiment was a standard speed camera vehicle with markings on its side designating it as a speed camera unit. During the deployment period 7,659 vehicles drove through the experimental site. Speeding tickets were issued as per normal police operating procedures.

RESULTS

Table 1 demonstrates that during the speed camera deployment period meaningful reductions in vehicle speeds were achieved compared to vehicle speeds during the comparison times at the same site. Mean vehicle speeds were reduced by 5.95 kilometres per hour at the camera site during deployment compared to mean vehicle speeds during the corresponding time period the day before deployment. A t-test revealed that this was highly statistically significant, t = 56.88 (15960), p <.001, _^{2} = .17. A comparison of the deployment time with the corresponding period the day after deployment revealed a similar result; mean vehicle speeds were 6.09 kilometres per hour less during the deployment period, t = -57.74, (15957), p <.001, _^{2} = .17. Mean speeds were only 0.14 kilometres per hour different the day before deployment than the day after deployment for the corresponding time period, ns. The pattern of speed reduction was fairly consistent across all the measures utilised. There was a barely significant 0.8 % increase in the number of vehicles exceeding 110 kph, _^{2} (df1) = 4.137, p = .04, Ø = .02. Otherwise, there was no significant difference in speeds recorded between the two comparison periods; that is the corresponding time periods the day before and day after deployment of the camera. For example, the 85^{th}, 90^{th} and 95^{th} percentiles are the same the day before camera deployment and the day after its deployment. The 0.8 % increase in the number of vehicles exceeding 120 kph the day after camera deployment compared to the day before its deployment is non-significant, _^{2} (df1) = 3.22, p = .07, Ø = -.01. Differences in the number of vehicles exceeding 100 kph between the before and after time periods were even less significant, _^{2} (df1) = 1.53, p = .22, Ø = .01. These findings are consistent with baseline measures and indicate that the pattern of vehicle speeds is very stable for the road section when no speed enforcement is being deployed, suggesting that the experimental results are reliable.

Table 1
Vehicle speeds (KPH) adjacent to the active speed camera and at repeating times (the day before and the day after deployment).

Measures 9:58am to 1:02pm	Monday Day before	Tuesday Deployment time	Wednesday Day after
Mean	100.79	94.84	100.93
SD	6.91	6.25	7.0
Variance	47.77	39.09	49.08
85th percentile	107	100	107
90^{th} percentile	109	101	109
95^{th} percentile	112	102	112
N >100 kph	4385 (52.81%)	1189 (15.51%)	4463 (53.76%)
N >110 kph	554 (6.67%)	63 (.82%)	621 (7.48%)
N >120 kph	47 (.57%)	4 (.05%)	66 (.8%)

Table 2 and Table 3 display distance halo effects of the camera during deployment both upstream and downstream from the camera. Table 2 shows mean and 85^{th} percentile speeds. Table 3 displays the number of vehicles exceeding the posted speed limit and the number of vehicles exceeding the infringement tolerance limit of 110 kph for the deployment period and for the repeating time periods, i.e. the same times of the day before and the day after speed camera deployment.

Table 2
Mean and 85th percentile speeds upstream and downstream from the active speed camera at repeating time periods.

Measurement Sites	Day before		Deployment day		Day after	
	mean	85th	mean	85th	mean	85th
1 k upstream	97.14	104	96.43	103	96.99	104
.5 k upstream	99.87	106	99.24	106	99.89	106
Camera site	100.79	107	94.84	100	100.93	107
.5 k downstream	100.83	107	97.61	103	100.79	108
1 k downstream	99.70	105	98.20	103	100.03	107
1.5 k downstream	97.96	105	99.25	106	99.29	106
2 k downstream	85.09	97	88.93	98	89.85	99

Distance halo effects

Figure 1 shows the effect of an overt mobile speed camera on vehicle 85th percentile speeds. Figure 2 shows the percentage of vehicles exceeding the speed limit of 100 kph, and Figure 3 shows the percentage of vehicles exceeding the infringement tolerance level of 110 kph. In each of these Figures vehicle speeds for time periods that correspond to the deployment time period for the day before and day after deployment are included. Distance halos are clearly identifiable in these Figures. The magnitude of speed reduction is strongest immediately adjacent to the speed camera site. All measures have a very similar pattern; the camera has minimal impact on upstream speeds, but produces a large reduction in speeds at the camera site. A reduction in speeds is maintained for one kilometre downstream, but the magnitude of the reduction is already diminishing by 500 meters downstream from the camera site. The effect of the speed camera has completely dissipated by 1.5 kilometres downstream.

Vehicle speeds for corresponding times the day before deployment and the day after deployment are very similar. Baseline measures collected prior to the experimental trial show this pattern to be reliable. The large reduction in speed on all three days at the 2000 metre downstream site was due to the speed limit changing from 100 kph to 80 kph. It is interesting to note that as vehicles enter the 80 kph speed limit zone they continue to travel well above the posted speed limit; even after having passed a speed camera only two kilometres prior to this point.

Figure 1

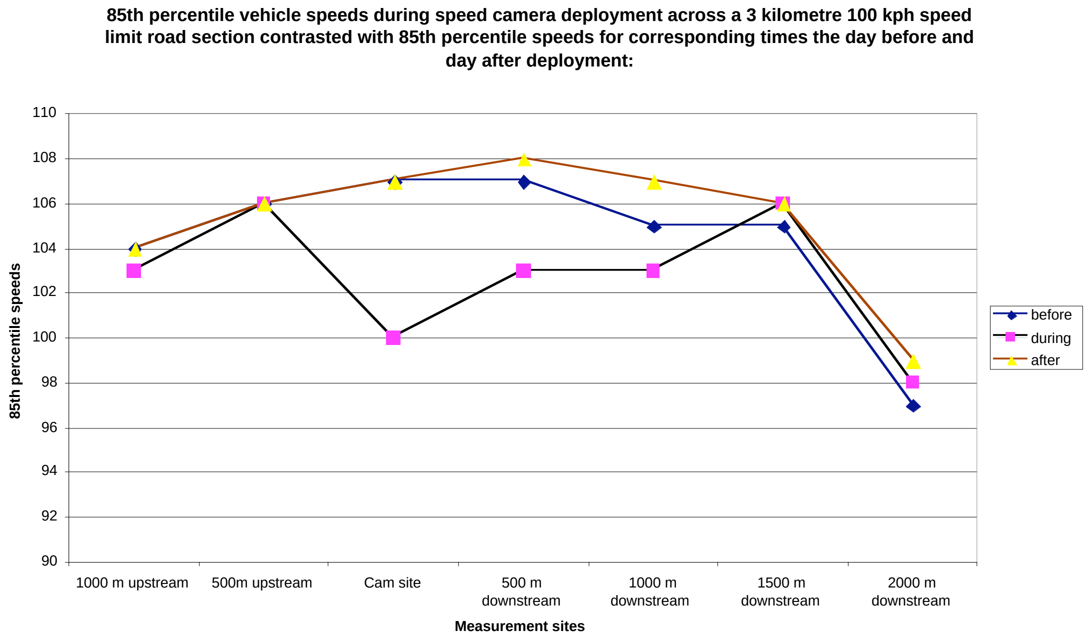


Table 3

Percentage of vehicles exceeding the 100 kph and 110 kph speeds upstream and downstream from the active speed camera at repeating time periods.

Measurement Sites	Percentage of Vehicles & Repeating Time					
	Day before		Day of Deployment		Day after	
	>100 K	>110 K	>100 K	>110 K	>100 K	>110 K
1 k upstream	33.61	3.06	29.06	3.07	33.11	3.08
.5 k upstream	47.05	5.81	41.93	4.4	46.83	5.83
Camera site	52.81	6.67	15.51	0.82	53.76	7.48
.5 k downstream	51.98	7.46	30.78	2.28	52.5	7.76
1 k downstream	44.94	5.45	35.39	3.28	46.71	6.49
1.5 k downstream	34.3	3.16	43.27	4.88	42.59	4.94
2 k downstream	7.93	0.84	9.77	0.85	12.11	1.2

Figure 2

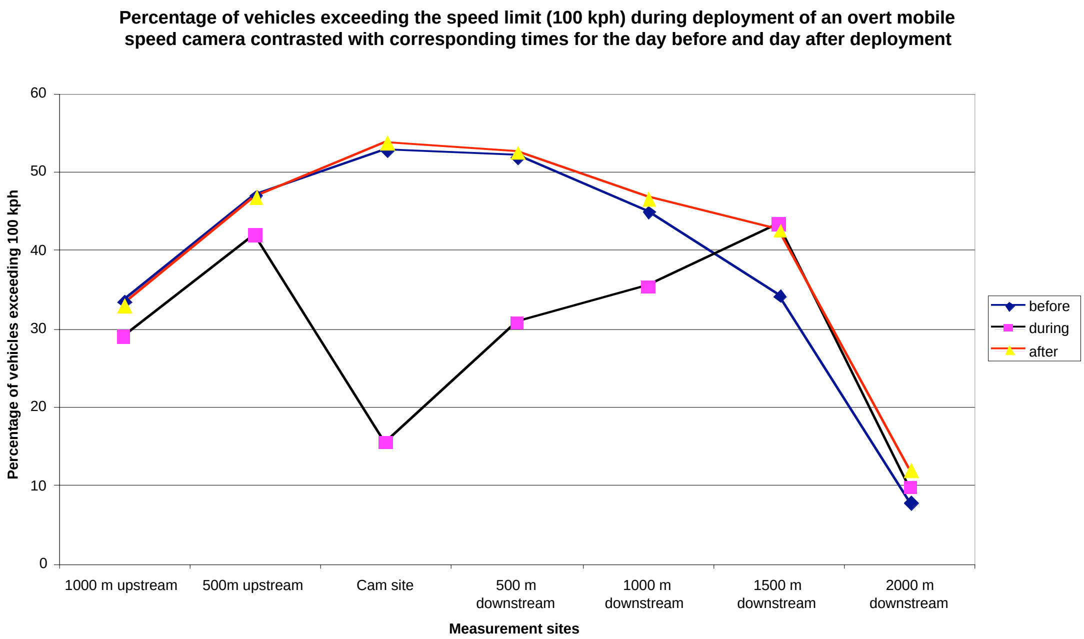
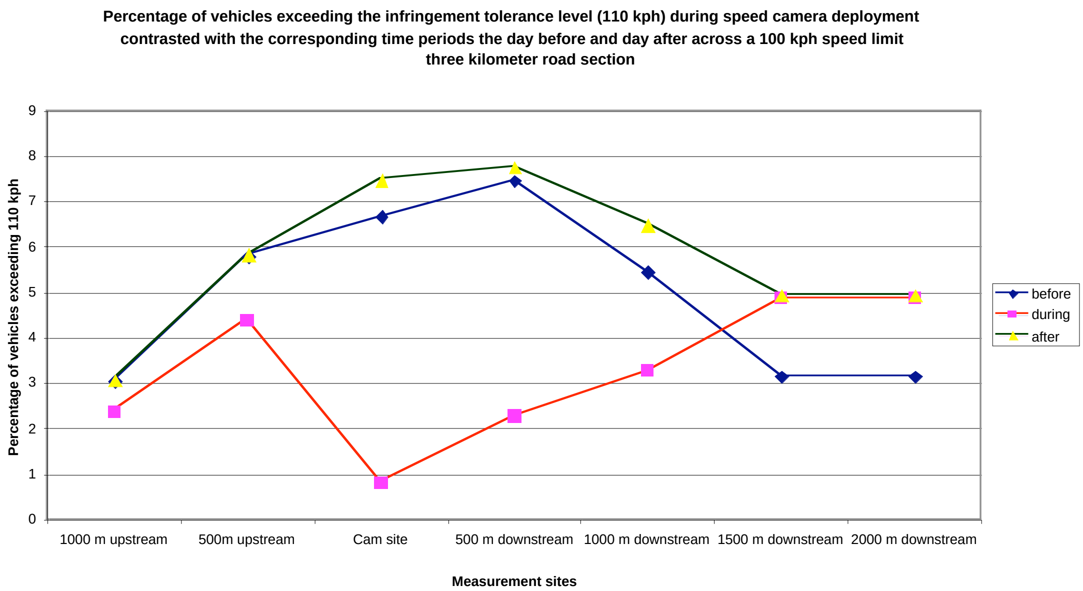


Figure 3



Time halo effects

Table 4 compares vehicle speeds during the speed camera deployment time period with the two hour time period immediately prior to deployment and the two hour time period immediately after deployment. The various measures reported show a large statistically significant reduction in vehicle speeds during the deployment time compared to the before and after time periods. For example, the mean speed is reduced by 6.71 kph during the deployment period (M = 94.84) compared to the mean speed during the period of two hours before deployment (M= 100.55). This is a highly significant difference and accounts for about 15 % of the variance in recorded speeds, t = .49 (13107), p <.001, _^{2} = .15. Table 4 also shows any time halo effects by comparing the two hours prior to the camera deployment with the two hours following the camera deployment period. For example, mean vehicle speeds were significantly lower for the time period two hours immediately after the speed camera deployment period (M= 100.02) than they were for the two hours immediately prior to the camera deployment (M=100.55), t = 4.15 (11935), p <.001, _^{2} = .001. However, in practice this difference in speeds is trivial, as demonstrated by the very low effect size. The statistical significance obtained is primarily due to the large sample size, rather than the effect of the speed camera. The same pattern holds for the other measures contrasting the before and after deployment periods, the before and during deployment periods and during the deployment and after periods. Due to space constraints statistics relating to the other measures reported in Table 4 are not provided, but the pattern of results is similar to the reported mean speed examples.

Table 4
Speed distribution at the camera site 2 hours immediately before the speed camera deployment and 2 hours immediately following its removal

Measures	2 hours before	Cam Deployment	2 hours after
Mean	100.55	94.84	100.02
SD	7.02	6.25	6.92
Variance	49.31	39.09	47.90
85th percentile	107.04	100	106.57
90^{th} percentile	109	101	108.28
95^{th} percentile	112.07	102	111.37
N >100 kph	2773 (50.88%)	1188 (15.51%)	3058 (47.14%)
N >110 kph	374 (6.86%)	63 (.82%)	384 (5.92%)
N >120 kph	28 (.51%)	4 (.05%)	30 (.46%)

DISCUSSION

All the measures utilized in this study produced a similar pattern of results. Upstream vehicle speeds were not significantly reduced by the speed camera deployment, but a substantial reduction in vehicle speeds was achieved at the speed camera site. It appears motorists begin to accelerate almost immediately after passing the speed camera, as vehicles' speeds have already increased by three kph by the time they reach the 500 metre site. Thus, the effect has been halved by this point. From this 500 metre downstream point, vehicle speeds continue to increase slowly, so that by the time motorists are 1.5 kilometres downstream from the active speed camera they are travelling at baseline speeds. That they are travelling at the speed at which they would normally travel, at that location, at that time of the day and that day of the week when there is no camera in operation.

Distance halos for overt vs fixed cameras

Relatively few studies have evaluated the effects of speed cameras on vehicle speeds. Those studies that have done so have mainly evaluated fixed cameras. For example, Keenan (2002) in the UK and Tae Hue 2003 in South Korea collected downstream measures to evaluate fixed cameras. A comparison of these results suggests that downstream distance halos are slightly longer for overt mobile cameras than for overt fixed cameras. The reason for this cannot be determined from the data, but it may be that motorists are more confident about the exact location of fixed cameras, so they only reduce speed for the minimum distance required to avoid a penalty, whereas mobile cameras create more uncertainty, so have a greater deterrence effect. Another possible explanation is that Australians may be more cautious drivers than those in the UK and South Korea, and thus take longer to increase their speed. Whatever the reason the differences in distance halos between these studies is relatively small. All of these studies indicate speed cameras have a relatively short effect on drivers' speed choice.

Most research evaluating the effects of speed cameras on vehicle speeds has relied on relatively small samples of spot vehicle speeds, typically 100 to 200 sample vehicles per site, to estimate the effects of speed cameras. For example, Keenan (2002)(Tae-Jun Ha et al., 2003) collected 200 sample speeds at each site and Edgar (2001) checked 100 vehicle speeds at each site. Therefore, a major strength of this study is that it measured speeds for the whole population of vehicles (7,659) passing the camera site during camera deployment and the whole population of vehicles passing the camera site in the non deployment comparison times. This eliminates sampling bias that is likely to occur when using LIDAR or a similar technology to collect sample vehicle speeds downstream from a camera site or at a comparison site. Another advantage of this study is that it used baseline measures, rather than a comparison site, thus eliminating sampling bias that may occur from the use of a comparison site on a different road section that may have a different speed distribution. Thirdly, this study measured vehicle speeds at seven points over a section of road upstream and downstream from an active camera, as opposed to just one or two points, thus it provides a more complete picture of the effects of a speed camera.

Due to the high cost of installing speed measuring equipment, the scope of this study was limited to one speed camera site. Results may not generalise to dissimilar road conditions. However, given that the study was carried out on a section of high quality multilane 100 kph road with a high traffic volume (approximately 50,000 per 24 hours), it seems reasonable to assume that such a large sample should be a reliable reflection of the general driving population's behaviour. This view is somewhat supported by results found by Newstead and Cameron (2003) on the effects on crashes of the Queensland speed camera program. They found that the main impact of speed cameras on crash reductions was within a two kilometre radius of camera sites. This finding is consistent with the results of this study which suggests the influence of speed cameras is limited to about 1.5 kilometres.

Conclusion

Overtly deployed mobile speed cameras do produce meaningful reductions in vehicle speeds, but only for a relatively short distance downstream (1.5 kilometre) from the camera site. No meaningful reduction could be identified 500 metres upstream from the camera site. The main practical road safety implication of these findings is that to maximise the impact of speed cameras on reducing speeding, and hopefully speed-related crashes, speed camera deployment will be most effective if it is within a maximum range of one kilometre from locations that have a history of high speed-related crash risk.

ACKNOWLEDGEMENTS

- Chief Superintendent Kerry Dunn, State Traffic Support Branch, Queensland Police Service (QPS)
- Superintendent Dr Grant Pitman, Queensland Police Service
- Sergeant Neville Davidson, Traffic Camera Office, Queensland Police Service
- Peter Kolesnik Senior Research Officer QPS
- Alan Krosch, Executive Director (Traffic and Road Use Management), Queensland Department Main Roads
- Troy McKenzie, Systems Advisor (RUI), Queensland Department of Main Roads
- Paul Cranitch Advisor (Traffic Data Acquisition) DMR
- Gary Mahon, Director (Strategic Policy), Queensland Transport (QT)
- Leanne Kirby Research and Development Officer QT
- Motor Accident Insurance Commission (MAIC)

REFERENCES:

Chin, H.C. (1999). Investigation into the effectiveness of the speed camera. *Proceedings of the Institution of Civil Engineers, Transport, 135*(2), 93-101.

Edgar, A. W. (2001). *Evaluation of the effectiveness of speed cameras in the ACT* (No. RC90251). Melbourne: ARRB Transport Research.

Hauer, E. (1997). *Observational before-after studies in road safety: Estimating the effect of highway and traffic engineering measures on road safety*. Oxford, England: Pergamon.

Hauer, E., Ahlin, F. J., & Bowser, J. S. (1982). Speed enforcement and speed choice. *Accident Analysis and Prevention, 14*(4), 267-278.

Keenan, D. (2002). Speed cameras - the true effect on behaviour. *Traffic Engineering and Control, 43*, 154-161.

National safety camera program: Three year evaluation report. (2003). London: Department of Transport.

Newstead, S., & Cameron, M. (2003). *Evaluation of the crash effects of the Queensland speed camera program* (No. Final). Melbourne: Monash University Accident Research Centre.

Pilkington, P., & Kinra, S. (2005). Effectiveness of speed cameras in preventing road traffic collisions and related causalities: Systematic review. *British Medical Journal, 330*(7487), 331-331.

Tae-Jun Ha, Jeong-Gyu Kang, & Je-Jin Park. (2003). The effects of automated speed enforcement systems on traffic-flow characteristics and accidents in Korea. *Institute of Transport Engineers. ITE Journal, 73*(2), 28-31.

Walsh, D., & Wessling, G. (1998). *Speed cameras: Queensland last off the blocks but is it leading the race?* Paper presented at the 3rd National conference on injury prevention and control.