Evaluation of Effectiveness of Red Light Camera Programme in Perth

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Abstract

A study was undertaken to evaluate effects of red light camera installations at 58 Perth metropolitan intersections. The cameras had been installed over the period between 1984 and 1998.

The effects of the presence of cameras were estimated in terms of cost of crashes and number of crashes, by comparing the number and cost of crashes "before" against the number and cost of crashes "after" the installation of red light cameras, over the same length of time. Periods of observation for the intersection sites varied depending on the date of installation and availability of crash data. The crash data by intersection were extracted from the database covering the period between 1980 and 1999. Observation periods ranged between 1 and 9.5 years, with the mean of 5 years. The estimates of camera effects were based on crash data collected over 292.7 camera-years of system installations/operations at the sample of intersection locations.

Two approaches were considered in estimating effects of cameras on crash occurrence at the intersections: (a) differences in cost and frequency of all crashes at the sample of intersections; and (b) differences in cost and frequency of crashes involving vehicles that might have run a red light on the approaching leg in the direction of the red light camera. These cost and crash frequency differences were adjusted using average annual change in cost and frequency of crashes at a control sample of 447 signalised intersections that had been in operation since 1985.
The results of the study indicated that installation of red light cameras together with camera signage has a significant effect on severity and occurrence of types of crashes. For all intersection crashes, it was shown that "after" period experienced over 50% reduction in fatal crashes, mostly accounted for by right turn against (71%) and other types of crashes (67%). The "after" period, when adjusted for differences at the control intersections, resulted in reduction of: right turn against (21%), right angle (30%) and other types of crashes (18%), while rear end crashes increased by 17% compared to the period "before". Reduction in the total number of crashes was negligible, 3%.

Analysis by road user movement suggested that largest reductions in the types and severity of crashes were associated with the vehicle movements in the camera direction. These movements accounted for 73% of the reduction in fatal crashes, mainly explained by right turn against (86%) and right angle crashes (50%). It was estimated that the 11% reduction in all right turn against crashes and the 18% reduction in all right angle crashes were explained by crashes involving vehicles travelling on one of the movements in the camera direction.

Road user movements other than those involving movements in the camera direction experienced similar reductions/increases in types of crashes. In addition, the study found a significantly positive correlation between average number of red light running infringements and total number of crashes, before and after installation of red light cameras, mainly accounted for by rear end and crashes other than right angle or right turn against crashes. These findings suggest that red light camera installation on an intersection, supported with signage, has a significant effect on occurrence of all types of crashes rather than only those that might have been associated with red light running.
It is estimated that the camera installation system at a location, on average, results in a reduction in the cost of crashes of $52,000 per year.

1. Introduction

In order to achieve a sustained reduction in number of serious and other types of crashes at intersections within Perth metropolitan area, Main Roads Western Australia (MRWA), in conjunction with Western Australian Police Services (WAPS), initiated in the early 1980s a red light camera installation programme. The programme commenced in 1984 by the first camera installation at the intersection with a prior history of a large number of right angle crashes. Since then, the number of red light camera installations has grown to the current level of 58, supported by 30 cameras. Seventeen of these sites are permanent. These red light camera sites contain a permanent traffic violation photo recorder capable of operating on a continual basis 24 hours a day 7 days a week. The remaining 13 cameras are rotated between the remaining 41 sites on a monthly basis. In general, all

legs of the intersection are signed with a red light camera at one approaching leg and warning signs placed at all approaches to the intersection.

Based on 1999 data, the average number of infringements issued to drivers for the 58 red light camera sites in Perth amounts to 794 infringements per site per year. The average yearly revenue per site amounts to $119,100.

The literature indicates that red light cameras play a role in deterring drivers from running red light at signalised intersections by increasing the perceived and actual threat of detection and prosecution. This study was undertaken in order to assess the driver deterrence from taking risks at the red light camera intersections, measured in terms of probability of involvement in crashes after installation compared to the one before the installation of red light cameras. The principal objective of the investigation into effectiveness of the programme was to arrive at estimates of changes in number and types of crashes, as well as associated costs, that could be accounted for by presence of a red light camera installation at a signalised intersection. In addition, the validity of the hypothesis that camera signage at approaches other than the camera approach has a similar relative effect on driver deterrence in taking risky traffic conflict manoeuvres at red light camera intersections was investigated.

It is generally considered that red light running is a more common cause of fatal and serious injury crashes at signalised intersections than other types of crashes not associated with the red light running. That is, red light running crashes tend to be more severe than other types of crashes. Croft (1980) found that red light running accounted for 19 percent of crashes and 23 percent of casualties at signalised intersections. Likewise, research conducted by the US Department of Transportation, Federal Highway Administration (2000) shows a higher percent of total injuries resulting from red light running crashes compared to all crashes at urban signalised intersections, 54 percent and 44 percent, respectively.

There is also a burdensome cost associated with red light running crashes. According to Hulscher (1984) the nett cost associated with 750 red light running casualty crashes in the Sydney area was estimated at $26 million per annum. Lawson (1992) calculated the average cost of red light running crashes at £18,730 each based on figures from 276 such crashes at 29 signalised intersections in Birmingham.

According to Hulscher (1984) there was a typical decrease in the incidence of red light running infringements after the installation of red light cameras at New South Wales signalised intersections. Similarly, an evaluation of the red light camera programme in Melbourne by South et al (1988) showed a statistically significant reduction in the number of right angle crashes (33%) at 46 camera sites compared to 46 control sites. However, the second study using a subset of 41red light camera sites by Andreassen (1995) found that there was no significant difference in number of crashes between all signalised intersections and the intersections with red light cameras installed. Contrary to this study, an investigation conducted by the Insurance Institute for Highway Safety looking at signalised intersections in Oxnard, California, illustrated that injury crashes reduced by 29 percent after the commitment to and installation of red light cameras (cited in Highway & Safety Report, Stamler, 2001, p.3). According to this study there is strong evidence that red light cameras influence driver behaviour overall. That is, there was a corresponding reduction of signalised intersection crashes throughout the city although red light cameras were installed at only 11 of the city's 125 signalised intersections.

According to the SA DOT (1989, 1991) a cost benefit comparison of the effect of red light cameras would take into account the set-up costs, income from revenue, operating costs, and crash savings. This study estimated that for 15 red light camera sites with 5 cameras the set-up costs would be $1.8 million, annual revenue of $272,000, and annual operating costs of $285,000. There was no significant change in reported crashes.

2. Methodology

Evaluation of the red light camera programme in the Perth metropolitan area was based on the "before/after" study design in order to assess effects of red light cameras on occurrence of crashes with respect to frequency, type and severity. The length of time period of exposure after installation of red light camera was compared against the same length of time before the installation.

2.1 Sample

The sample consisted of 58 intersections with active red light cameras installed between 1984 and 1988. Choice of intersection approaches at which red light cameras were installed was based on prior history of right angle

crashes. Observation periods across the sample ranged between 1 and 9.5 years, depending on the installation date and availability of crash data. The average observation period was 5 years. Over the sample of sites, 292.7 camera-years operation/presence of the system crash data were compared with the same number of years of crash data after installations of the cameras. The study opted for the minimum observation period to satisfy the "before/after" design in attempt to reduce or completely eliminate bias that could have been associated with variability between the sites related to crash history or traffic conflict exposures. Data utilised for the study were extracted from the MRWA/WAPS crash database covering the period between 1980 and 1999. The observation period for each intersection was determined as the maximum available length of time constrained by the database. In order to control for the differences in types and severity of crashes over the 15-year time period, average crash trends of the population of 447 signalised intersections that had been in operation without cameras since 1985 were used to adjust the differences that could have been associated with factors other than presence of red light camera. In estimating effects of red light cameras it was assumed that the probability of relative occurrence of various types of crashes and cost of these crashes is similar for both groups of intersections.

2.2 Limitations of Study

Due to complexity in compiling information, no adjustment has been done to control for the differences in expected number and characteristics of crashes that could have been associated with changes to intersection geometry, signalisation or traffic exposure. For the purpose of simplicity, it was assumed that these factors remained the same over the observation period for each of the intersections in the sample. In addition, due to changes in the Western Australian Legislation with regard to crash reporting requirements in November 1988, raising reporting level for property damage crashes (PDO) from $300 to $1000, the number of some types of crashes could have been affected in the "after" or "before" or both time periods for some intersections. However, these legislative changes to crash reporting would have no effect on number of casualty crashes reported during the study period or other crashes at the intersections on which red light cameras had been installed since 1994. For the period between 1989 and 1994, the change in reporting level could have had some effect on reduction in PDO crashes producing bias towards larger reduction in right angle, right turn against and other types of crashes, and smaller increase in rear end crashes, as indicated in the results section below. It was anticipated that the number of crashes that otherwise would have been reported would not significantly impact on the results of the study. In addition, since no control was done on traffic exposure, which, most likely, had an increasing trend over the study period, the findings presented in the following sections are expected to be biased towards lower rather than higher red light camera effects on occurrence of crashes.

3. Results

Two approaches were considered in estimating effects of red light cameras on crash occurrence at the population of signalised intersections:
(b) differences in number and cost of crashes involving vehicles that might have run red light by entering intersection from the approaching leg in the direction of red light camera, and
(b) differences in number and cost of all crashes at the intersections.
In each case, the number, and subsequently cost, of crashes were adjusted using average annual change in types of crashes at a control sample of 447 non-camera signalised intersections that had been in operation since 1985. The cost of crashes were determined using 1996 crash and injury unit costs estimated by Bureau of Transport Economics (2000), updated by MRWA using ABS estimates for average weekly earning and applied to types of crashes occurred within Western Australian built-up areas. For the purpose of crash data analysis on vehicle movements involved in crashes the sample of intersections were realigned to the standard compass bearing, north indicating the position of the red light camera.
The analysis of crash data with respect to possible effects involving vehicle movements from the camera leg and all vehicle movements at the intersections is presented in the sections below.

3.1 Vehicles Movements in the Direction of Red light Camera

Since initial placement of cameras at intersection approaches was based on frequency and severity of right angle crashes probably associated with vehicles running a red light from a particular approach, it was assumed that most likely effect of camera existence would be associated with vehicles approaching or entering intersections from these legs. However, due to lack of driver knowledge of camera operation, together with existence of warning signs, it was hypothesised that the presence of a red light camera would have a significant effect on

driver behaviours in taking risks in running a red light when making any of the three movements from all intersection approaches.

Change in Crash Pattern

Over the intersection sample period of 585 years there were 12,627 reported crashes, of which 5,744 involved vehicles travelling in the direction of red light camera. The "after" period recorded 2,807 crashes compared with the "before" period with 2,937 crashes, the difference of 130 crashes. The data suggest that red light cameras had a significant effect (Poisson distribution, $p < 0.01$) on reduction in number of fatal crashes, a reduction of 8 crashes, from 11 crashes before to 3 crashes after installation of the cameras. Similarly, some reduction in minor injury and PDO crashes was observed during the "after" period compared to the "before" period (see Figure 1).

Figure 1. Severity of crashes before and after installation of red light cameras when one of the vehicles was travelling in the direction of camera

The analysis suggested statistically significant changes in types of crashes ($X^2 = 68.65$, d.f. = 3, $p < 0.001$), mainly accounted for by a decrease in right angle and right turn against, and increase in rear end crashes (see Figure 2, below). The reduction in number of right angle and right turn against crashes resulted in a marginal reduction in minor injury (6.9%), accounted for by other crashes (35.1%), right turn against (25.6%) and right angle (16.4%); and a reduction in fatal crashes (72.7%), accounted for by right turn against (85.7%) and right angle crashes (50%). All types of crashes were reduced by 4.4%. When adjustment was done by the percentage change in average number of types of crashes at the control intersections (right turn against, -3.2; right angle, -3.8; other types, -1,2; and rear end, 0.2), it was estimated that the "after" period experienced reductions in right turn against, right angle and other types of crashes in order of 16.7%, 29.4%, and 14.3%, respectively, while rear end crashes increased by 18%. The estimated reduction in all crashes was 3.3%.

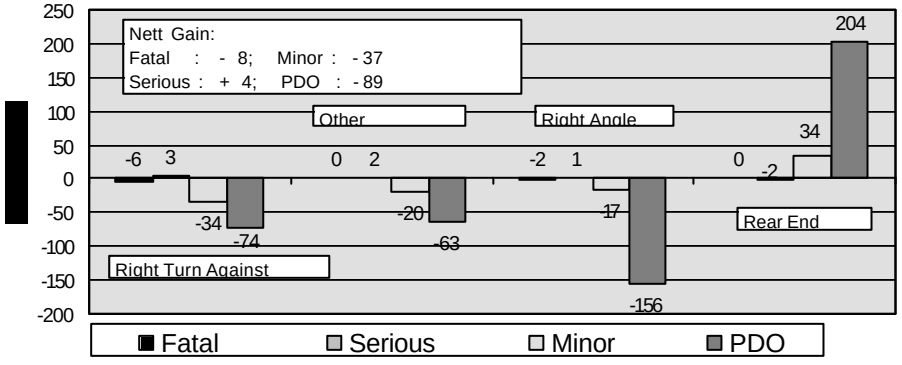

Figure 2. Differences in the severity of crashes" after" vs " before" by type of crash when one of the vehicles was travelling in the direction of camera

Cost of Crashes

The two time periods, before and after installation of red light cameras were compared in terms of cost of crashes. Estimates of cost of crashes by severity were applied to the difference in number of crashes using MRWA crash costs estimates as follows: fatal $1,810,874; serious $306,472; minor injury $15,961; and PDO

$10,202. Most of the crash cost reduction was accounted for by reduction in fatal crashes, and largely associated with right turn against and right angle crashes (see Table 1).

Nature	Severity				Total ($M)	Annual Average Crash Cost Difference ($1000)/ Red Light Camera Location	
	Fatal ($M)	Serious Injury ($M)	Minor Injury ($M)	PDO ($M)		Unadjusted	Adjusted
Right Turn Against	-10.865	0.919	-0.543	-0.755	-11.243	-38.409	-37.705
Other	0.000	0.613	-0.319	-0.643	-0.349	-1.192	0.077
Right Angle	-3.622	0.306	-0.271	-1.592	-5.178	-17.689	-16.289
Rear End	0.000	-0.613	0.543	2.081	2.011	6.870	6.564
Total	-14.487	1.226	-0.591	-0.908	-14.760	-50.421	-47.189

Table 1. Differences in cost of crashes after and before installation of red light camera when one of the vehicles was travelling in the camera direction

Over the observation period of 292.7 years, the estimated cost of crashes at the red light camera intersections fell by 14.7 million dollars, translated to reduction of $50,421 per camera-year operation per site. When adjustment was done by the percentage change in average annual crash type cost estimated for the control sample of signalised intersections (right turn against, -0.5; right angle, -0.9; other types, -2.0; and rear end, 0.4 thousand dollars), then camera-year crash cost saving per intersection is estimated at $47,189.

3.2 All Crashes at Red Light Camera Intersections

Generally, all approaches to red light camera intersections were signed with red light camera warning signs. It was anticipated that these signs would have substantial impact on driver behaviours when attempting to make intended manoeuvres through the intersection irrespective of whether the location of the camera was at the approach or not. The study hypothesis that most drivers are unaware of camera location and that driver knowledge of its operation is limited. If this hypothesis is true than one would expect that the signs on approaching non-camera legs would have similar effects on perceptual and cognitive processes drivers use as those acquired at the times when entering or approaching the intersection from the red light camera leg. It was expected that these effects would have similar relative outcomes on crash occurrence, not taking into consideration absolute effects measured in terms of number of crashes associated with initial placement of camera on selected approaches to the intersections. The results associated with the hypothesis are presented in the sections below.

Differences in Types of Crashes

Analysis of the data indicated that there were 6,444 reported crashes before and 6,183 after installation of red light cameras at the intersections in the study sample. Red light camera installation seemed to be associated with significant reduction in fatal crashes (under Poisson distribution, $p < 0.05$), from 15 crashes during "before" compared against 7 crashes during the "after" period. Similarly, some reductions in the number of crashes were observed among minor injury and PDO crashes, 55 and 199, respectively (see Figure 3, below).

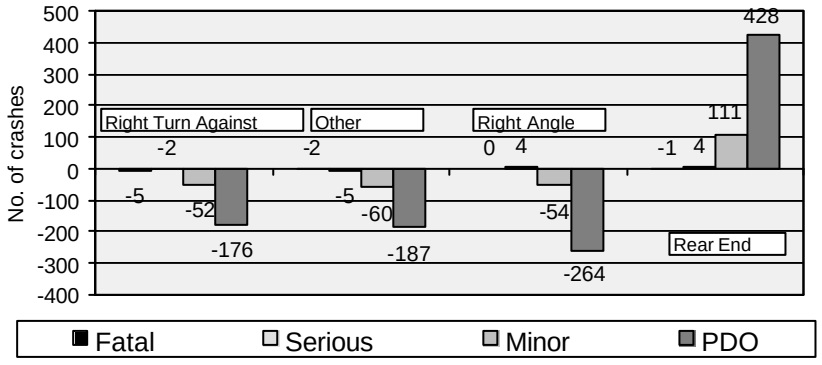

Figure 3. Differences in type and severity of all crashes at intersections before vs after installation of red light cameras

No statistically significant changes in crash severity pattern was found between the two periods. However, comparison of changes in the number of crashes showed a significant reduction in fatal crashes ($p < 0.05$), resulting from the initiatives in enforcement or traffic safety improvements at the sample of intersections. There seems to be a statistically significant association between the period and type of crashes ($X^2 = 157.40$, d.f. = 3, $p < 0.001$). Large reductions were recorded in right turn against (23%), right angle crashes (33%), and other types (19%), while rear end crashes increased by 17%. When adjustment was done for the changes in types of crashes at the control intersections, the expected reductions slightly decreased, as follows: right turn against to 21%, right angle to 30% and other types to 18%.

Analysis of crashes involving vehicle movements other than those in red light camera directions suggests that camera warning signs have similar effects to the effects arising from a red light camera at the approaches to the intersection. Although absolute effects in terms of number of crashes associated with vehicle movements from non-camera approaches with the warning signs were by default significantly less, as it was identified as such before installation of red light cameras at the intersections, compared to the camera direction vehicle movements, the relative effects were similar with respect to severity and nature of crashes. Non-camera direction movements resulted in similar statistically significant changes in proportion of the types of crashes ($X^2 = 91.11$, d.f. = 3, $p < 0.001$), resulting in reductions/ increases in the types. Reductions in proportion of crashes were recorded for right turn against (28%), right angle (34%) and other types (21%) of crashes, while there was an increase of 16% in rear end crashes. An adjustment for the changes at control intersections resulted in small but not significant decrease in the observed percentage reductions in types of crashes.

Before And After Comparison of Cost of All Crashes

Analysis of costs of the change in number of types of crashes based on crash severity suggests that overall there was a reduction in cost of crashes, explained by reduction in Right Turn Against, Other types and Right Angle crashes, and an increase in cost of Rear End crashes (see Table 2).

Nature	Severity				Total ($M)	Annual Average Crash Cost Difference ($1000)/ Red Light Camera Location	
	Fatal ($M)	Serious Injury ($M)	Minor Injury ($M)	PDO ($M)		Unadjusted	Adjusted
Right Turn Against	-9.054	-0.613	-0.830	-1.796	-12.293	-41.994	-40.971
Other	-3.622	-1.532	-0.958	-1.908	-8.020	-27.396	-23.527
Right Angle	0.000	1.226	-0.862	-2.693	-2.329	-7.957	-5.927
Rear End	-1.811	1.226	1.772	4.366	5.553	18.970	18.238
Total	-14.487	0.306	-0.878	-2.030	-17.089	-58.377	-52.187

Table 2. Differences in cost of all crashes between the periods "after" and "before" installation of red light cameras

Annual average crash cost per red light camera intersection was estimated at $58,377. When the reduction cost is adjusted for the average annual change in types of crashes determined for the period 1985 to 1999, the reduction of cost of crashes is estimated at $52,197, mainly accounted for by crashes involving vehicles travelling in the direction of red light camera (90.4%), indicating that initial selection of camera locations was appropriate in producing largest effects on crash cost reduction at the intersections.

4. Conclusions and Recommendations

Comparison of numbers of crashes before and after installation of red light cameras indicated a substantial reduction in number of fatal and other less severe crashes, largely associated with right turn against, right angle and crashes other than rear end crashes. The observed increase in rear end crashes outweighs the benefits resulting from the reduction in other types of crashes. The reduction in right turn against and right angle fatal crashes, of over 50%, accounted for most of the economic benefits associated with red light cameras.

In addition, the study findings pointed to the significance of installation of warning camera signs at all approaches to the red light camera intersections. Reduction in types of crashes involving vehicles approaching an

intersection from non-camera legs was found to be similar to those entering the intersection from the camera approach.

The study indicated that average crash cost reduction per camera-year-operation would be in the range of $50, 000, which is equivalent to the cost of initial capital investment in the system. Annual community benefits arising from the existing red light camera programme is estimated at $3,000,000. The benefits might be considered as marginal, however, exposure to red light camera systems in the Perth metropolitan area most likely influence driver behaviours at other locations of similar traffic interactions, resulting in crash savings not investigated in this study.

In conclusion, the results of this before/after crash analysis study suggest that the installation of red light cameras at signalised intersections with prior history of crashes similar to these in the sample plays a significant role in traffic safety, in that red light cameras have substantial effects on driver decisions when passing through the intersections.

It is recommended that the results of this study be utilised as a basis for further expansion of the red light camera programme in the Perth metropolitan area, as well as in other urban environments when there is a warrant for such types of traffic safety enforcement means. In addition, it is suggested that the red light camera programme should be an integral part of road safety and enforcement strategies in order to reduce community cost associated with road trauma.

Finally, due to a large number of red light runners recorded at the camera intersections, it is recommended that a study be undertaken to better understand factors, causes and driver behavioural characteristics that lead to risk taking at similar locations. The results of such a study would assist in the formulation of appropriate strategies on community awareness on the existence and functions of red light cameras as well as general traffic safety at signalised and non-signalised intersections.

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