Evaluation of Red Light Camera Enforcement in Fairfax, Va., USA

MORE THAN ONE MILLION CRASHES OCCUR ANNUALLY AT TRAFFIC SIGNALS IN THE UNITED STATES, AND RED LIGHT CAMERAS INCREASINGLY ARE BEING USED TO SUPPLEMENT POLICE-ENFORCEMENT EFFORTS BY AUTOMATICALLY PHOTOGRAPHING VEHICLES WHOSE DRIVERS RUN RED LIGHTS. THIS FEATURE EVALUATES NINE INTERSECTIONS STUDIED.

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TRAFFIC SIGNALS, THROUGH USE of time separation, are designed to reduce motor-vehicle crashes at intersections involving conflicting traffic movements. High voluntary compliance with signals is essential for safe and efficient traffic movement. However, many drivers do not comply with traffic-signal indications.[1] More than one million motor-vehicle crashes occur annually at traffic signals in the United States.[2–6] Between 1992 and 1996, the number of fatal crashes at traffic signals increased 19 percent, from 1,888 to 2,242.[2,6]

A major cause of such crashes is drivers disregarding traffic signals. A review of 4,526 police-reported crashes in four U.S. cities found that running red lights and other traffic-control devices such as stop signs is the most frequent type of collision in urban areas.[7] It is estimated that nationwide about 260,000 red light running crashes occur annually, of which approximately 750 result in fatalities.[8] Motorists are more likely to be injured in crashes involving red light running than in other types of urban crashes. Retting et al. also found that occupant injuries occurred in 45 percent of the red light running crashes, compared with 30 percent for other crash types.[7] This indicates that reductions in red light running crashes would be especially beneficial in reducing urban crash losses.

Efforts to promote traffic-law compliance are constrained by limited police-enforcement resources, which have been declining in relation to the number of vehicles on the road.[9] Enforcing traffic-signal compliance in urban areas is difficult not only because of limited manpower but also because of factors associated with traditional enforcement methods, which in many cases require police to follow a violating vehicle through a red light to stop it. This action, plus pursuit in areas of high vehicle density, can endanger motorists, pedestrians and police officers. Therefore, conventional traffic enforcement in some communities is being supplemented with advanced technology.

Red light cameras increasingly are being used to help communities enforce traffic laws by automatically photographing vehicles whose drivers run red lights. A red light camera system is connected to the traffic-signal system and to sensors buried in the pavement at the crosswalk or stop line. The camera system continuously monitors the traffic signal, and the camera is triggered when any vehicle passes over the sensors faster than a preset minimum speed and at a specified elapsed time after the signal has turned red. A second photograph is taken that shows the violator in the intersection. The camera records the date, time of day, time elapsed since the beginning of the red signal and the speed of the vehicle. The use of a flash produces clear images under a wide range of light and weather conditions. Upon review of the photographic evidence and depending on state law requirements, a ticket is issued by mail to either the vehicle owner or driver at the time of the offense.

Red light camera technology has been in widespread use in many foreign countries since the 1970s.[10,11] The first sustained U.S. red light camera enforcement program was implemented in New York City, N.Y., USA, in 1992. About two dozen municipal enforcement programs were active by 1998.

Some early U.S. red light camera enforcement programs reported a decline in the number of tickets issued over time, suggesting program effectiveness in reducing red light violation rates. For example, San Francisco, Calif., USA, officials reported that after red light cameras were introduced, the number of violations recorded/10,000 vehicles at these intersections declined from 11.1 to 6.4 between

November 1996 and April 1997 (personal communication, San Francisco Department of Parking and Traffic, August 1997). However, these results are limited because of the absence of violation data for the period prior to camera enforcement and the lack of experimental study designs. Effects on intersections without red light cameras also are unknown.

In a recent evaluation of camera enforcement in Oxnard, Calif., Retting et al. reported a 42 percent decline in red light violations four months after the program was introduced.[12] Increases in driver compliance with red lights were not limited to the camera-equipped intersections but spilled over to non-equipped intersections as well.

The present study evaluates the influence of a red light camera enforcement program on violation rates and samples public opinion about camera use as a supplement to police efforts in the community.

METHODS

The study was conducted in the city of Fairfax, Va., USA, which has an estimated population of 21,000 and a land area of 6.5 square miles. A statewide red light camera law took effect in July 1995, permitting selected municipal governments to establish local camera enforcement programs. Rear photography is used to capture an image of the rear license plate of a vehicle detected entering an intersection on a red signal. The driver is not photographed. The registered vehicle owner is subject to a $50 fine, but unlike a violation resulting from conventional police enforcement, there is no driver's license sanction for a camera citation.

Red light camera enforcement in Fairfax was preceded by a 30-day warning period, during which cameras were used to photograph violators, but no tickets were issued. Signs advising motorists of photo enforcement of traffic-signal laws were posted on major roadways at numerous locations entering the city. City officials attempted to generate publicity and awareness of the new program by issuing a press release and providing information to local media. Postcards announcing the camera program were mailed to all Fairfax City residents. Actual enforcement began on July 25, 1997.

Red light violation data were collected immediately prior to the warning period and then three months and one year after enforcement began. A total of nine intersections were included in the study: five camera sites were selected on the basis of histories of crashes involving red light running (the initial group of three intersections where red light cameras were installed during 1997 and two intersections where red light cameras were installed during 1998), two noncamera sites were located in Fairfax City to determine if changes in red light running observed at camera sites spilled over to other intersections (no camera installation was, or is, planned for these sites) and two control sites were located outside Fairfax City in nearby Arlington and Fairfax counties. The control sites were selected to control for factors that might affect red light violations (e.g., weather and seasonal variability in travel patterns), and little effect at these sites was expected. The noncamera and control sites allowed safe and unobtrusive deployment of video cameras and human observers. Speed limits at the study sites ranged from 25 to 45 miles per hour (mph).

Data for each site were recorded for a single intersection approach. Observers deployed video cameras unobtrusively to record traffic approaching and entering these intersections with a clear view of the signal indication and the stop line or crosswalk. Video cameras were positioned on tripods and hidden behind trees, shrubbery, or utility poles. Observations were limited to daytime hours (approximately 8 a.m. to 6 p.m.), Monday through Saturday. The time of day and total number of hours observed during the baseline period and during camera enforcement were matched as closely as possible. The total number of hours observed for the nine sites is summarized in Table 1.

A red light violation was defined as a vehicle entering an intersection after the signal light had been red for a minimum elapsed time of 0.4 seconds—a criterion established for issuing red light camera tickets in Fairfax—and the measured speed of the vehicle was at least 15 mph. Use of a minimum travel speed helped to eliminate potential false positives associated with right-turn-on-red movements and emergency vehicles. A trained observer applied these criteria to red light running events recorded at the noncamera and control sites, employing timecode from videotape to determine elapsed time. Scoring of red light running at all sites was limited to vehicles traveling straight through the intersection.

Table 1. Number of hours observed.

	Before	Three months after	One year after
Camera sites	113	117	117
Noncamera sites	48	48	50
Control sites	71	72	71

The duration of yellow traffic-signal timing has been found to influence red light running at urban intersections.[13] Therefore, yellow signal timings at the camera sites were checked against an Institute of Transportation Engineers (ITE) proposed recommended practice and found to be adequate.[14]

Vehicle exposure—the number of vehicles entering the intersection on the observed approach—was measured at camera sites using the same pavement sensors that detect red light violations (loop detectors installed for red light camera operation are independent of those used for traffic-signal control). Vehicle exposure was estimated at noncamera and control sites using videotape; vehicle counts were measured for 5 minutes of each 15-minute study period and extrapolated. At all sites, violation rates/10,000 vehicles were analyzed using loglinear models. Changes in violation rates after the enforcement program began were compared for the camera vs. noncamera sites and then for the camera and noncamera sites vs. control sites.

Finally, random sample telephone surveys of Fairfax residents about their awareness and opinions of red light camera enforcement were conducted approximately one month before and one year after the enforcement program began. A 10-question survey was administered to people of driving age (16 years old and older) using a random-digit-dial sampling method. The sample consisted of 300 responses for the baseline and subsequent surveys.

Table 2. Fairfax City red light camera: Baseline and after.

Site category/ intersection	Number of violations			Number of vehicles			Violations/ 10,000 vehicles			Percent change: Violations/ 10,000	
	Before	Three months after	One year after	Before	Three months after	One year after	Before	Three months after	One year after	Three months after	One year after
Camera											
Fairfax Circle	99	120	78	19,119	20,439	20,685	51.8	58.7	37.7	+13	– 27
Main/University	44	45	21	18,181	20,454	20,646	24.2	22.0	10.2	– 9	– 58
123/Eaton	78	60	37	23,613	23,769	20,874	33.0	25.2	17.7	– 24	– 46
123/North*	94	99	38	16,761	19,365	17,040	56.1	51.1	22.3	– 9	– 60
Lee Hwy./123*	21	31	18	14,850	20,886	14,946	14.1	14.8	12.0	+5	– 15
Total	334	355	192	92,524	104,913	94,191	36.3	33.8	20.4	– 7	– 44
Noncamera											
Main/Burke Station	122	106	82	24,966	25,158	25,740	48.9	42.1	31.9	– 14	– 35
Lee Hwy./Eaton	66	52	53	24,825	23,169	28,209	26.6	22.4	18.8	– 16	– 29
Total	188	158	135	49,791	48,327	53,949	37.8	32.7	25.0	– 14	– 34
Control											
Fairfax County	22	23	25	38,343	39,543	36,891	5.7	5.8	6.8	+2	+19
Arlington County	29	29	28	28,895	28,392	29,550	10.0	10.2	9.5	+2	– 5
Total	51	52	53	67,238	67,935	66,441	7.6	7.7	8.0	+1	+5

*Red light cameras were not present at these two sites during the three-months-after period.

RESULTS

Table 2 provides a summary of red light violations and vehicle exposure observed at the nine study sites during the baseline period and during camera enforcement. One year after enforcement began, violation rates were lower at all camera and noncamera sites. Overall reductions in violations/10,000 vehicles at the five camera sites were 7 percent three months after enforcement began and 44 percent after one year. Overall reductions at the two noncamera sites were 14 percent three months after enforcement began and 34 percent after one year. The overall violation rate at the control sites essentially was unchanged at 7.6 during the baseline period, 7.7 after three months of enforcement and 8.0 after one year.

There was no statistically significant difference between the reduction in violation rates at the camera and noncamera sites either three months ($p = 0.9261$, Table 3a) or one year ($p = 0.4821$, Table 3b) after enforcement began. Overall, the violation rate/10,000 vehicles across the camera and noncamera sites was reduced approximately 9 percent (from 36.8 to 33.5) three months after enforcement began and 40 percent (from 36.8 to 22.1) after one year.

There was no statistically significant difference between the reduction in violation rates at the camera and noncamera sites compared with the control sites three months after enforcement began ($p = 0.3410$, Table 4a). There was, however, a statistically significant difference between the reduction in violation rates at the camera and noncamera sites compared with the control sites one year after enforcement began ($p = 0.0340$, Table 4b).

Table 3a. Analysis of variance table—camera sites vs. noncamera sites, baseline vs. three months after.

Effect	Degrees of freedom	Mean square	*F*-statistic	*p*-value
Site	6	0.500	46.7	0.0003
Three months after vs. before	1	0.026	2.4	0.1816
Camera sites after vs. other	1	0.000	0.0	0.9261
Error	5	0.011		

Table 3b. Analysis of variance table—camera sites vs. noncamera sites, baseline vs. one year after.

Effect	Degrees of freedom	Mean square	*F*-statistic	*p*-value
Site	6	0.435	9.7	0.0124
One year after vs. before	1	0.959	21.3	0.0057
Camera sites after vs. other	1	0.026	0.6	0.4821
Error	5	0.045		

Results of the public-opinion surveys are summarized in Tables 5 through 7. One month before enforcement, 17 percent of respondents were aware of Fairfax's plan to use red light cameras; one year after enforcement began, 89 percent knew cameras were in use. Respondents who knew cameras were in use were asked whether they favored or opposed them as

a supplement to police efforts to enforce against red light running. Respondents who did not know cameras were in use were asked if they would favor or oppose them. Respondents who knew cameras were in use were somewhat more favorable about the program than those who did not know. Overall, 84 percent favored camera use one year after enforcement began, compared with 75 percent one month before cameras were installed (Table 7). Support for camera use was lower among males than females (78 percent vs. 88 percent, respectively, one year after enforcement began, $p = 0.019$).

DISCUSSION

This study found a large and highly significant reduction in red light violations one year after implementation of the red light camera enforcement program in Fairfax. Most Fairfax residents knew about the cameras, and the violation rate across the camera and noncamera sites was reduced approximately 40 percent one year after enforcement began. This finding is not surprising given similar large declines reported after installation of camera systems in Oxnard[12] and in other countries, including England, Scotland and Singapore.[15–17] However, effects of camera programs in other cities may differ depending on factors such as the number of cameras deployed and the extent of publicity about them.

Changes in driver compliance with red lights in Fairfax were not limited to camera-equipped intersections and occurred at nonequipped intersections, based on the experience at the two noncamera sites. The presence of cameras may promote a general readiness to stop for red lights. One factor that may promote generalization to noncamera sites in Fairfax is the relatively large number of intersections equipped with cameras. This spillover effect is important because the practice in many communities has been to deploy only a few cameras.

Reductions in red light violations were very limited during the three-months-after period and took longer to achieve in Fairfax than in Oxnard, where violations were reduced by 42 percent within four months of camera enforcement. One factor may be a higher monetary fine and driver's license sanctions for camera citations in Oxnard. Another factor may be that Fairfax is a small city, and the majority of citations were issued to non-Fairfax residents who may have taken longer to learn of the enforcement program. Communities such as Fairfax that attract large numbers of drivers from surrounding jurisdictions should publicize their programs using conspicuous road signs, billboards, media announcements and other means.

Table 4a. Analysis of variance table—camera and noncamera sites vs. control sites, baseline vs. three months after.

Effect	Degrees of freedom	Mean square	*F*-statistic	*p*-value
Site	8	1.198	156.3	0.0001
Three months after vs. before	1	0.018	2.4	0.1692
Camera and noncamera sites after vs. other	1	0.008	1.0	0.3410
Error	7	0.008		

Table 4b. Analysis of variance table—camera and noncamera sites vs. control sites, baseline vs. one year after.

Effect	Degrees of freedom	Mean square	*F*-statistic	*p*-value
Site	8	0.894	23.8	0.0002
One year after vs. before	1	0.702	18.7	0.0035
Camera and noncamera sites after vs. other	1	0.260	6.9	0.0340
Error	7	0.038		

Table 5. Among respondents who knew about red light camera use: "Do you favor or oppose the use of cameras to enforce against red light running in Fairfax, as a supplement to police efforts?" (Percent)

	One month before ($N = 51$)	One year after ($N = 267$)
Favor	86	86
Strongly favor	59	59
Somewhat favor	28	27
Oppose	12	12
Somewhat oppose	6	3
Strongly oppose	6	9
Don't know	2	2

Table 6. Among respondents who did not know about red light camera use: "Would you favor or oppose the use of cameras to enforce against red light running in Fairfax, as a supplement to police efforts?" (Percent)

	One month before ($N = 249$)	One year after ($N = 33$)
Favor	73	73
Strongly favor	46	33
Somewhat favor	27	39
Oppose	23	21
Somewhat oppose	9	9
Strongly oppose	14	12
Don't know	3	3

Table 7. Among total respondents: "Do you/would you favor or oppose the use of cameras to enforce against red light running in Fairfax, as a supplement to police efforts?" (Percent)

	One month before ($N = 300$)	One year after ($N = 300$)
Favor	75	84
Strongly favor	48	56
Somewhat favor	27	28
Oppose	21	13
Somewhat oppose	8	3
Strongly oppose	13	9
Don't know	3	2

It is important to determine the long-term effects of red light camera enforcement on violation rates and motor-vehicle crashes. The effects of enforcement on crash rates in Fairfax have yet to be determined, but South et al. reported a 32 percent decrease in right-angle collisions at camera-equipped intersections in Victoria, Australia.[18] Based on these findings and red light running crash data from Birmingham, United Kingdom (U.K.), Lawson concluded that the costs of installing and maintaining red light cameras at intersections where red light running crashes occur will pay for themselves in terms of crash reductions within short periods of time.[19]

Support for camera use as a supplement to police efforts to reduce red light running increased from 75 percent before enforcement to 84 percent one year after enforcement began. Similar support was found among Oxnard residents after cameras had been in place for several months.[12] In a separate national public opinion survey, 61 percent of respondents said they favor camera use; the highest support was found in large cities, where 83 percent of respondents favor such devices.[20] Public opinion surveys in European countries, where automated traffic enforcement has been in use for many years, revealed the majority of drivers support or accept red light camera use.[21]

A relatively small but constant number of residents (10 to 15 percent) strongly oppose such cameras, largely because of privacy concerns. However, driving is a regulated activity on public roads, and neither the law nor public opinion suggests that drivers should not be observed on the road or have their violations documented. Red light cameras can be designed to photograph only a vehicle's rear license plate and not vehicle occupants, as is the case in Virginia.

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