Red-Light Running and Sensible Countermeasures
Summary of Research Findings

RICHARD A. RETTING, ALLAN F. WILLIAMS, AND MICHAEL A. GREENE

Deliberate running of red lights is a common and serious violation that contributes substantially to the more than 1 million motor vehicle collisions that occur at traffic signals each year. Urban-based highway safety research has examined various aspects of the red-light running problem, including the contribution of red-light violations to motor vehicle crashes, the frequency of red-light running, characteristics of red-light runners, and the influence of signal timing on red-light running behavior. A brief summary of recent research efforts to examine the problem of red-light running is provided, and the use of countermeasures, including red-light cameras, to reduce the problem is discussed.

Each year in the United States, more than 1 million motor vehicle collisions occur at traffic signals, resulting in more than 500,000 injuries and several thousand fatalities; the number of fatal crashes occurring at traffic signals increased by 19 percent between 1992 and 1996 (*1–5*). Deliberate running of red lights is a common and serious violation that contributes substantially to this problem. Despite the enormous scope of red-light running, it has been the subject of relatively little research.

Research shows that running red lights and other traffic control devices such as Stop and Yield signs is the most frequent cause of collision in urban crashes (*6*). Researchers studied a sample of 4,526 police reports of motor vehicle crashes on public roads in four urban areas—Akron, Ohio; Arlington, Virginia; New Orleans, Louisiana; and Yonkers, New York—during 1990 and 1991. Of 13 crash types identified, running traffic controls accounted for 22 percent of all crashes and 27 percent of injury crashes. Among crashes involving running traffic controls, 24 percent involved running red lights. By itself, "ran signal" crashes accounted for about 5 percent of the crashes sampled.

The same study showed that motorists are more likely to be injured in crashes involving red-light running than in other types of crashes. Occupant injuries occurred in 45 percent of the red-light running crashes studied compared with 30 percent for other crash types. One reason for high injury rates in this type of crash is that these collisions often involve side impacts at relatively high speeds, which can result in passenger compartment intrusion. Injury severity increases with the severity of vehicle intrusion, and ejection is also a risk in side-impact crashes (*7*).

Some drivers inadvertently enter an intersection after onset of a red signal; others commit intentional acts of red-light running. Because drivers cannot predict the onset of a yellow signal, the likelihood that a driver will stop is related to speed and distance from the intersection when the signal changes. Previous research has examined a so-called dilemma zone, where some drivers are going too fast when the signal changes to yellow to either enter prior to the onset of red or stop without hard braking (*8*). Signals that provide insufficient yellow intervals cause some drivers to run red lights inadvertently. However, many drivers who run red lights are provided adequate opportunity to stop safely but choose instead to proceed through a red signal; these drivers are referred to in this paper as deliberate red-light runners.

RESEARCH ON RED-LIGHT RUNNING

Frequency of Red-Light Running

A study conducted over several months at two busy intersections in Arlington, Virginia (an urban area outside Washington, D.C.), indicates that motorists frequently run red lights. Red-light running was monitored using a microprocessor-based GATSO red-light camera at two sites between November 1994 and March 1995 (only one direction at each intersection was observed). The camera was positioned at each site for about half the time and was set to run continuously during that period. It recorded speed and lane position for vehicles entering the intersection on red that were traveling at least 24 km/h (15 mph) (a speed threshold was employed to limit false readings caused by vehicles turning right on red and emergency vehicles entering on red at low speed). Both locations had 4-sec yellow signal phases, which was deemed adequate.

A total of 8,121 red-light runners were obtained over a period of 2,694 hr, for an average of 3.0 red-light runners per hour. This total includes vehicles that entered any time after onset of a red signal. The two sites differed widely. At Site 1, a divided six-lane, high-speed [72-km/h (45-mph)] principal arterial, 6,171 violations were observed during 1,176 hr (5.2 per hour). At Site 2, a four-lane, 48-km/h (30-mph) roadway, 1,950 violations were captured during 1,518 hr of camera deployment (1.3 per hour). Site 1 had more than twice the traffic volume as Site 2 (approximately 30,000 vehicles per day at Site 1 versus 14,000 at Site 2). Site 1 generates higher traffic volumes during the morning peak period, whereas Site 2 generates higher afternoon peak traffic volumes. Table 1 provides a summary of violations recorded at the two experimental sites. Results are presented for total violations and those that occurred 1 sec or more after onset of a red signal (severe cases). Precipitation was monitored during data collection, and it was found that the influence of rainfall on red-light running was insignificant.

Characteristics of Red-Light Runners

To develop a profile of deliberate red-light runners, driver behavior was studied at an intersection in Arlington, Virginia (*9*). The study

R. A. Retting and A. F. Williams, Insurance Institute for Highway Safety, 1005 North Glebe Road, Arlington, VA 22201. M. A. Greene, User Technology Associates, 4301 North Fairfax Drive, Arlington, VA 22201.

TABLE 1 Red-Light Running at Two Virginia Sites

Hour	Site 1				Site 2			
	Average No. Red Light Runners (Total)		Average No. Red Light Runners (1 Sec +)		Average No. Red Light Runners (Total)		Average No. Red Light Runners (1 Sec +)	
	Weekday	Weekend	Weekday	Weekend	Weekday	Weekend	Weekday	Weekend
0*	1.1	3.5	0.4	1.0	0.3	0.6	0.1	0.2
1	0.3	2.2	0.1	0.6	0.2	0.3	0.1	0.1
2	0.2	1.1	0.1	0.5	0.2	0.3	0.1	0.1
3	0.1	0.9	0	0.2	0.1	0.2	0	0.1
4	0.4	0.5	0	0.1	0.2	0.1	0.1	0.1
5	3.2	1.2	0.8	0.1	0.2	0.2	0.2	0.1
6	5.8	2.4	1.0	0.5	1.0	0.3	0.1	0
7	8.7	2.3	1.2	0.5	2.1	0.6	0.5	0.2
8	11.5	3.8	2.0	0.7	4.0	0.9	0.9	0.2
9	10.6	4.1	1.7	0.9	1.4	1.3	0.3	0.4
10	8.8	5.0	1.9	0.7	1.0	1.4	0.2	0.3
11	9.3	6.9	2.2	2.2	1.3	1.7	0.3	0.4
12	8.8	9.1	2.2	4.4	1.8	1.8	0.4	0.4
13	8.7	8.5	2.0	1.8	1.1	1.9	0.3	0.3
14	9.7	9.1	2.4	2.7	1.5	2.0	0.5	0.4
15	7.5	8.6	2.0	2.6	1.7	2.1	0.4	0.4
16	5.6	7.0	1.3	1.6	3.2	1.9	0.6	0.3
17	6.4	6.3	1.2	2.0	3.7	1.4	0.7	0.2
18	7.2	4.9	1.4	1.3	2.8	0.9	0.6	0.1
19	5.2	4.5	1.0	0.7	1.5	0.8	0.4	0.2
20	4.5	3.4	0.9	0.7	0.8	0.7	0.2	0.2
21	4.1	3.7	0.9	0.3	0.8	1.0	0.2	0.2
22	4.8	4.2	0.9	0.7	0.6	0.6	0.2	0.1
23	3.0	3.8	0.9	0.8	0.3	0.5	0.1	0.1
Hourly Average	5.6	4.5	1.2	1.2	1.3	1.0	0.3	0.2
Daily Average	134.4	106.9	28.1	27.6	31.9	25.0	7.9	5.1

* Midnight

compared demographics and driving records of red-light runners (drivers who entered the intersection 1/2 sec or more after commencement of the red phase) with motorists who had an opportunity to run a red light but did not. Data were collected using the combination of a red-light camera and trained observers. A total of 1,373 observations—462 violators and 911 compliers—were recorded during 234 hr of on-site data collection. As a group, deliberate red-light runners were younger, were less likely to use safety belts, had poorer driving records, and drove smaller and older vehicles than drivers who stopped for red lights. Deliberate red-light runners were more than three times as likely to have multiple speeding convictions on their driver records (Table 2). No gender differences were found between violators and drivers who did not run red lights. Among Virginia drivers, violators and compliers had the same proportion (13 percent) with at least one prior crash reported on the Department of Motor Vehicles driver abstracts; reliable crash data were not available from other jurisdictions.

Subsequent research on a subset of these same drivers compared criminal records, obtained through the Virginia State Police, of the deliberate red-light runners with those of motorists who had an opportunity to run a red light but did not. There was some indication that violators were more likely than compliers to have a criminal record, but the result was not statistically significant. Among 506 drivers—136 violators and 370 compliers—8.1 percent of violators had criminal records compared with only 4.9 percent of compliers.

COUNTERMEASURES FOR REDUCING RED-LIGHT RUNNING

A number of countermeasures are available to address the red-light running problem. These include *engineering measures*, which provide durable and physical solutions, and *enforcement techniques*, which attempt to deter unsafe driver behavior.

Removal of Unwarranted Traffic Signals

Traffic signals maintained at locations with very low traffic volumes may contribute to red-light running and intersection crashes. Studies of low-volume intersections that were converted from signal control to stop sign control report reductions in crashes and injuries (*10*). Recent crash analyses of signal removals at 199 low-volume intersections in Philadelphia reported an overall crash reduction of 24 percent (*11*).

TABLE 2 Driver Characteristics of Violators and Compliers, Virginia 60-Month Driver Records

	Percent of Drivers			Mean			
	Age < 30	2+ Speed Convictions	3+ Total Convictions	Age	Speed Convictions	Total Convictions	Point Balance
Violators	29[a]	22[b]	22[c]	35	0.96	1.83	−0.88
Compliers	14[a]	7[b]	12[c]	42	0.40	0.93	+1.18

[a] Age $\chi^2 = 21.493$, P-value < 0.001
[b] Speed convictions $\chi^2 = 22.062$, P-value < 0.001
[c] Total convictions $\chi^2 = 10.289$, P-value = 0.016

Signal Timing and Red-Light Running

One factor shown to influence the risk of red-light violations and potential intersection conflicts is the length of the clearance or change interval. Stein reported that inadequate signal change intervals were associated with elevated crash rates. In a follow-up study, researchers examined the influence of the duration of the change interval on driver behavior at several intersections where yellow and/or all-red signal timings were modified (*12,13*). Revised signal timings were computed for each site utilizing a method proposed by ITE that incorporates site-specific criteria including traffic speeds and intersection geometry (*14*). Outcome measures for the study included the proportion of signal cycles with vehicles entering on a red light and the proportion of vehicles exiting the intersection after onset of a conflicting green signal. Increases in the length of the yellow signal toward values associated with the ITE-proposed recommended practice significantly decreased the chance of red-light running. Results indicate that clearance intervals set closer to values proposed by ITE can reduce red-light violations and potential right-angle conflicts, and that such safety benefits can be sustained.

Enforcement

Resources to enforce traffic laws, including signal violations, are inadequate and have diminished in relation to the number of vehicles on the road (*15*). Traditional enforcement, when employed, requires an officer to observe a red-light violation and then chase, stop, and cite the violator. This process can endanger motorists, pedestrians, and officers because in many cases, the officer would have to run the red light after the violator. Such safety consequences plus the sheer volume of violations mean police cannot sufficiently enforce against red-light running.

Red-light cameras can help communities enforce traffic laws by automatically photographing the license plates of vehicles whose drivers run red lights. A red-light camera system is connected to the traffic signal and to sensors buried in the pavement at the crosswalk or stop line. The system continuously monitors the traffic signal, and the camera itself is triggered by any vehicle passing over the sensors above a preset minimum speed and a specified time after the signal has turned red. A second photograph is taken that typically shows the red-light violator in the intersection. The camera records the date, time of day, time elapsed since the beginning of the red signal, and speed of the vehicle; use of a flash produces clear images of vehicles under all light and weather conditions. Tickets typically are sent by mail to owners of violating vehicles based on review of photographic evidence.

Red-light camera technology has been in widespread use in many foreign countries since the 1970s (*16,17*). Red-light camera enforcement in conjunction with public awareness can modify driving behavior and has been shown to reduce red-light violations and intersection crashes. Victoria, Australia, began using cameras at traffic signal intersections in 1983 and posted signs alerting motorists of the cameras' presence. A subsequent report by the Road Traffic Authority found a 32 percent decrease in right-angle collisions and a 10 percent reduction in injuries after the cameras were installed (*18*). An evaluation of red-light camera enforcement in Oxnard, California, found that within 4 months of camera implementation, red-light violation rates decreased 42 percent. Increases in driver compliance were not limited to camera-equipped sites but spilled over to nonequipped intersections as well (*19*).

Ownership of Vehicles Driven Through Red Lights

Laws governing use of red-light cameras for enforcement may provide for the issuance of civil penalties (similar to a parking ticket) against the registered vehicle owner, without regard to who is driving at the time of the offense. Because some have expressed concern about this legal issue, research was undertaken to examine the relationship between drivers running red lights and the ownership of these drivers' vehicles. A sample consisting of all red-light running tickets issued by Arlington police officers during a 20-day period in February 1995 was drawn retrospectively. These tickets were issued using conventional means, without a camera, and the officers were not aware of the research. Using DMV records, registered owners (as of April 1995) of 300 vehicles driven in violation were determined and compared with the names of the corresponding drivers. Results of this comparison are presented in Table 3. Similar results (not presented here) were found for a sample of drivers charged with speeding. On the basis of these results, it is likely that drivers who run red lights either are the vehicle owners or reside in the same households as the owners. Therefore, sanctions against the vehicle owner for red-light running could be expected to deter many potential violations.

Public Support for Red-Light Camera Use

Although the "big brother" issue has been raised by some opponents of photographic enforcement technology, a 1995 public opinion survey sponsored by the Insurance Institute for Highway Safety revealed wide acceptance and support for red-light camera use. In a nationwide representative random telephone survey, 66 percent of 1,006 people surveyed said they favor the use of red-light cameras.

TABLE 3 Relationship Between Owners and Operators of Vehicles Ticketed for Red-Light Running

	Percent
Registered Owner and Operator Match	72
Address Only Match	9
Leased Vehicle	5
Commercial Vehicle	3
Government Vehicle	1
No Match	10
Total	100

compared with 28 percent who opposed. In the evaluation of red-light camera enforcement in Oxnard, California, nearly 80 percent of Oxnard residents supported using red-light cameras as a supplement to police efforts to enforce traffic signal laws (*19*). Similar public opinion surveys in European countries revealed that the majority of drivers support or accept such systems (*20*).

SUMMARY AND CONCLUSION

Red-light running has become a frequent violation; it may appear trivial to violators, but the safety consequences are real. Red-light violations can be reduced through engineering measures such as signal modifications, which address the physical aspects of the problem, and enforcement measures, which deter unsafe driver behavior. Limited enforcement resources and logistical difficulties of conducting conventional red-light enforcement preclude adequate police attention to this problem. Monitoring of red-light running reveals a consistent pattern of violations that is unlikely to decline without appropriate countermeasures. Red-light camera technology may provide an opportunity for such intervention. Red-light camera enforcement in conjunction with public awareness can modify driving behavior and has been shown to reduce red-light violations and intersection crashes. Poor driving records associated with deliberate red-light runners suggest that drivers in this high-risk group perceive only a small chance of getting caught and are therefore not deterred. As communities throughout the United States begin implementing red-light camera enforcement programs, well-designed research studies are needed to determine their effectiveness and to develop recommended practices.

ACKNOWLEDGMENT

This work was supported by the Insurance Institute for Highway Safety.

REFERENCES

1. *Traffic Safety Facts 1992*. Report HS-808-022. U.S. Department of Transportation, 1993.
2. *Traffic Safety Facts 1993*. Report HS-808-169. U.S. Department of Transportation, 1994.
3. *Traffic Safety Facts 1994*. Report HS-808-292. U.S. Department of Transportation, 1995.
4. *Traffic Safety Facts 1995*. Report HS-808-471. U.S. Department of Transportation, 1996.
5. *Traffic Safety Facts 1996*. Report HS-808-649. U.S. Department of Transportation, 1997.
6. Retting, R. A., A. F. Williams, D. F. Preusser, and H. B. Weinstein. Classifying Urban Crashes for Countermeasure Development. *Accident Analysis and Prevention*, Vol. 27, No. 3, 1995, pp. 283–294.
7. Warner, C. Y., M. B. James, and C. E. Strother. *A Perspective on Side Impact Occupant Crash Protection*. Technical Paper Series 900373. Society of Automotive Engineers, 1990.
8. Gazis, D., R. Herman, and A. Maradasin. The Problem of the Amber Signal Light for Traffic Flow. *Traffic Engineering Journal*, 1960.
9. Retting, R. A., and A. F. Williams. Characteristics of Red Light Runners: Results of a Field Investigation. *Journal of Safety Research*, Vol. 27, No. 1, 1996, pp. 9–15.
10. Kay, J. L., L. G. Neudorff, and F. A. Wagner. *Criteria for Removing Traffic Signals*. Report DOT-FH-11-9524. U.S. Department of Transportation, 1980.
11. Persaud, B., E. J. Hauer, R. A. Retting, R. Vallurupalli, and K. Mucsi. *Crash Reductions Related to Traffic Signal Removal*. Insurance Institute for Highway Safety, Arlington, Va., 1996.
12. Stein, H. S. Traffic Signal Change Intervals: Policies, Practices, and Safety. *Transportation Quarterly*, Vol. 40, No. 3, 1986, pp. 433–445.
13. Retting, R. A., and M. A. Greene. Influence of Signal Timing on Red-Light Running and Potential Vehicle Conflicts at Urban Intersections. In *Transportation Research Record 1595*, TRB, National Research Council, Washington, D.C., 1997, pp. 1–7.
14. *Determining Vehicle Change Intervals: A Proposed Recommended Practice*. ITE, 1985.
15. Freedman, M., and N. Paek. *Enforcement Resources Relative to Need: Changes During 1978–89*. Insurance Institute for Highway Safety, Arlington, Va., 1992.
16. Makinen, T., and O. Hway-liem. *Automatic Enforcement of Speed and Red Light Violations*. SWOV Institute, Leidschendam, The Netherlands, 1992.
17. Blackburn, R. R., and D. T. Gilbert. *NCHRP Synthesis of Highway Practice 219: Photographic Enforcement of Traffic Laws*. TRB, National Research Council, Washington, D.C., 1995.
18. South, D., W. Harrison, I. Portans, and M. King. *Evaluation of the Red Light Camera Program and the Owner Onus Legislation*. Victoria Road Traffic Authority, Hawthorn, Victoria, Australia, 1988.
19. Retting, R. A., A. F. Williams, C. M. Farmer, and A. F. Feldman. *Evaluation of Red Light Camera Enforcement in Oxnard, California*. *Accident Analysis and Prevention*, in press.
20. Muskaug, R. Drivers' Acceptance of Automatic Traffic Surveillance. *Traffic Engineering and Control*, Vol. 34, No. 5, 1993, pp. 243–246.

Publication of this paper sponsored by Committee on Traffic Law Enforcement.