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An Update on Red Light Camera Research: The Need for Federal Standards in the Interest of Public Safety

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ABSTRACT

Since publishing our critique of red light camera (RLC) studies in 2008, we have gained increased insights on the controversy over RLCs. Herein we provide additional information on RLCs, and use a question-and-answer format to address frequently asked questions. This update includes the rationale given for ignoring fatalities at RLC sites, the convergence in findings from the National Highway Traffic Safety Administration's compendium of best RLC studies, common violations of research methods in RLC evaluations, the RLC cost-to-benefit implications for motorists, an explanation for the increase in rear-end crashes at RLC sites, and why RLCs may be ineffective in reducing red light running crashes. We conclude with a proposed solution: restoring and improving federal standards through the Manual on Uniform Traffic Control Devices to assure proper intersection engineering prior to consideration of RLCs (even though RLCs are not recognized as an established safety device).

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Background

In 2008, we published our first critique of red light camera (RLC) studies (Langland-Orban, Pracht, & Large, 2008). The function of RLCs is to photograph vehicles that enter an intersection on a red light, which results in a citation that carries a fine. The public health concern with RLCs is the increase in crashes and injuries being reported in some studies.

Our critique reviewed five major RLC studies. Four were identified in the National Highway Traffic Safety Administration's (NHTSA) *Automated Enforcement: A Compendium of Worldwide Evaluations of Results* (Decina, Thomas, Srinivasan, & Staplin, 2007), as among the best in meeting NHTSA's data and research design standards among 75 RLC studies reviewed. The fifth was published in the *American Journal of Public Health* (Retting & Kyrychenko, 2002) and was the only publication identified in a medical library search for peer-reviewed publications on RLCs. The five studies had contradictory findings with differences due primarily to the varying adherence to research methodological rigor. The studies that best adhered to scientific research methods found RLCs were associated with increases in crashes and injuries.

The basic standards used for assessing validity when reviewing these studies were derived from Campbell and Stanley (1963) and the Office of the House Majority Leader's report on red light cameras (2001), which included the following points:

- Selection bias should not be evident in the choice of RLC or comparison sites used in the evaluation;
- Outcomes from the RLC sites should be separately analyzed and not merged with untreated or dissimilar sites;
- Angle, rear-end, and total crashes (and injury crashes) should be included as outcome measures;
- Variables that need to be controlled for must be included in the statistical analysis, such as traffic volume, yellow light timings, and a time trend as red light running crashes and injuries are declining over time absent the use of cameras;
- At least one year of data should be evaluated in both before and during camera time periods; and
- Findings from the statistical analysis should be fully disclosed, including confidence intervals and statistical significance.

After publishing our criticisms of the Retting and Kyrychenko study, Mr. Retting subsequently challenged our criticisms (Smyth, 2008). We responded by replicating his published analysis, which affirmed Retting and Kyrychenko (2002) had incorrectly reported their findings, as well as used flawed research methods. Our replication, which explains the errors, is published in an e-letter with the original article in the *American Journal of Public Health* on-line (Large, Orban, & Pracht, 2008).

Since publishing our critique we have provided approximately 80 interviews to news reporters throughout the U.S., Canada, and England. Our findings were broadly circulated in the news media; however, to date, only two elected officials have contacted us about our conclusions. This lack of interest among elected officials was profiled in a news article about sources of information used in RLC decision making, which illustrated the tactics used by industry proponents to foster confusion about RLC effectiveness (Van Sickler, 2010).

One journal reporter, who requested anonymity, revealed that the media can be a source of misinformation on RLCs. She disclosed that special interests that profit from cameras have threatened to reduce or withdraw their advertising revenues if the news is not reported that RLCs provide a safety benefit. The reporter explained that with such threats, journalistic ethics permit an editor to report the advertiser's perspective if also disclosing the contrary assessment that RLCs pose a safety threat, leaving readers to form their own conclusion. However, she explained that not all editors abide by this principle, which is compounded by the many controversies surrounding RLCs. For example, a Florida newspaper reported that their local poll found support for RLCs. The second half of the article mentioned some of the concerns about RLCs, which included using them to generate revenue, failing to save lives, failing to significantly reduce crashes, and increasing rear-end crashes (Thalji, 2010). However, the most important controversy was not mentioned: RLCs have been associated with an increase in injury crashes. While the reported controversies are true, the public health concern with RLCs is the *increase* in injury crashes, and possibly fatal crashes, as explained in the following sections.

Because we are continually being queried on our research, we provide highlights of our findings in a question-and-answer format. Our purpose is to communicate facts about RLCs by providing new information and to answer questions frequently asked by the news media.

What was learned about fatalities at RLC intersections?

In our original critique (Langland-Orban et al., 2008), we faulted the research methods used in the Federal Highway Administration's (FHWA) analysis titled *Safety Evaluation of Red-Light Cameras* (Council, Persaud, Eccles, Lyon, and Griffith, 2005). One FHWA official subsequently contacted us to point out that we overlooked an important finding: *fatal crashes* at RLC sites had increased, yet were ignored in the related economic analysis.

Council et al. (2005, p. 68) report the percent of fatal angle crashes increased in the after-camera period, as 0.5 percent of angle injury crashes were fatal before camera use and 0.8 percent were fatal after camera use. Using this information and their results from the seven jurisdictions, it was possible for us to calculate that the number of fatal angle crashes for the 370 RLC site years was expected to be 4.5 based on before camera data. However, the actual number of fatal angle crashes was 5.0 in the after-camera period, which is more than 10% higher than expected. Further, for every 100 definite injuries from angle crashes in the before-camera period, 1.28 was fatal, which increased to 1.71 in the after-camera period, a 33.6% increase. Therefore, increased, and not decreased, fatalities were associated with the use of RLCs in this study.

Additionally, the cost of fatal crashes was omitted from the Council et al. economic analysis. The rationale cited by the authors was that "*small numbers of fatalities* should not be allowed to affect decisions on roadway-based treatments such as RLCs" (pp. 48-49). They suggest that fatalities at RLC sites can be ignored because they most likely result from a person's age (e.g., elderly) or failure to use a safety belt, or relate to the type of vehicle driven. Council et al. (2005) further explained they excluded the cost of fatal crashes in their economic analysis because the cost of a single fatal crash "could significantly bias the results" due to the limited number of fatal and serious crashes in their study. In other words, the authors spotlight the statistical difficulties of including the cost of fatalities, while ignoring the practical implications of such events. Consequently, their estimated annual crash cost savings of $38,845 per RLC site is overestimated since the cost of fatal crashes was excluded.

Using their data, the actual estimated cost of an angle injury crash was $82,816 before RLCs and $100,176 after RLCs were implemented, as shown in Table 1. Instead of using these actual costs, the FHWA study used $64,468 for all angle injury crashes. It appears they averaged the cost of angle injury crashes for the before and after RLC time periods (excluding fatal crash costs), even though the cost of an angle injury crash was higher after RLCs were used.

As the Council et al. study (2005) is often cited by RLC proponents, the findings should be reconsidered in terms of actual crash counts, in addition to the percent changes reported. They report that RLCs were associated with a 25% reduction in angle crashes and a 15% increase in rear-end crashes. However, because rear-end crashes are more frequent than angle crashes, the *total* number of crashes (angle plus rear-end) was unchanged following RLC use. Further, the estimated reduction in injury crashes was

Table 1. Estimated Angle Injury Crash Cost by Council et al. (excluding fatal crashes) and the Actual Average

Code	Injury Severity	Estimated Cost of Angle Crash	Before Camera % of Total	Before Camera Weighted Cost	After Camera % of Total	After Camera Weighted Cost
K	Fatal	$0	0.50%	$0.00	0.80%	$0
A	Incapacitating Injury	$120,810	7.70%	$9,302	8.50%	$10,269
B	Non-severe injury	$103,468	30.80%	$31,868	37.40%	$38,697
C	Possible injury	$34,690	61.10%	$21,196	53.30%	$18,490
Average (excluding cost of fatalities)			100%	**$62,366**	100%	**$67,456**
K	Fatal	$4,090,042	0.50%	$20,450	0.80%	$32,720
Actual Average (including cost of fatalities)				**$82,816**		**$100,176**

23 fewer definite injury crashes over 370 RLC site years (i.e., 132 RLC sites over multiple years), which is equivalent to each RLC site having one less definite injury crash every 16 years. Regardless, fatal angle crashes increased following RLC use, as did the estimated cost of angle injury crashes. Despite the flaws in the assumptions and analysis, the FHWA study (Council et al., 2005) continues to be posted on the Federal Highway Administration web site as purported evidence of RLC effectiveness (Federal Highway Administration, 2010).

Of the seven studies identified by the NHTSA compendium as the best observational RLC research, is there any consensus in the findings?

There is convergence: none of the seven studies identified as the best in design and data in the NHTSA's compendium (Decina et al., 2007) statistically permit concluding RLCs provide a safety benefit. Further, three of the seven studies report increases in injury crashes. The methods and actual results from each of the seven observational studies must be reviewed to understand what each found, as the executive summaries are often misleading or incomplete. The studies' findings are summarized below.

- As discussed above, Council et al. (2005) found that RLCs were not associated with a meaningful reduction in crashes or injuries, particularly as fatal angle crashes increased following RLC use, as did the estimated cost of angle injury crashes.
- Burkey and Obeng (2004) reported a significant increase in crashes and "possible injury" crashes.
- Garber, Miller, Abel, Eslambolchi, and Korukonda (2007), using Empirical Bayes, reported RLCs were associated with a significant increase in crashes, including angle crashes and injury crashes, three fatalities, and no significant change in red light running crashes.
- Synectics Transportation Consultants (2003) reported a two percent increase in fatal and injury crashes at RLC sites, whereas comparison sites experienced a 12.7 percent decrease.
- Washington and Shin (2005) reported no change in total crashes at RLC sites in Phoenix, Arizona, and reported an 11% decrease in *total* crashes in Scottsdale, Arizona. However, the change in Scottsdale was not significant as the confidence interval overlaps with that of the comparison intersections (p. 90). Also, page 18 of their report reveals the comparison sites were distinctly dissimilar from the RLC sites. Comparison sites averaged 0.82 crashes annually, whereas RLC sites averaged 33.77 crashes. Thus, the selection of comparison sites in Scottsdale directly violates research standards required for internal validity pertaining to statistical regression and biases in differential selection of the comparison group (Campbell & Stanley, 1963, p. 5). Finally, the percent of fatal angle crashes in Scottsdale was higher at RLC sites than at "all intersections" (p. 95), and their economic analysis excluded the cost of fatal crashes since it was modeled after the Council et al. study (2005), meaning the crash cost savings were overestimated.

- The Butler (2001) study was not accessible to us; however, the NHTSA compendium reported it but did not find a significant safety benefit to cameras.
- Cunningham and Hummer (2004) merged outcomes from RLC approaches with non-RLC approaches, meaning their findings are not specific to RLC sites.

More recently, an analysis published in the *Journal of Trauma* (Wahl et al., 2010) reported an RLC program was ineffective in producing a safety benefit. The authors suggested alternative interventions should be pursued.

Some studies are reported to use "unscientific" research methods. What does this mean?

The NHTSA's compendium (Decina et al., 2007) criticized some RLC review studies for failing to control for other sources of variation in the outcome measure. The criticism stems from these studies failing to account for other factors that can increase or decrease crashes, such as changes in traffic volume or a long running time trend of declining injury crashes. A common error among inexperienced researchers is to make simple before and after comparisons. Decina et al. (2007) identified the following RLC review studies as violating this research tenet, meaning these reports should *not* be used in RLC decision making:

- Cochrane Collaboration (Aeron-Thomas & Hess, 2005);
- Transportation Research Board (McGee & Eccles, 2003);
- *Traffic Injury Prevention* (Retting, Ferguson, & Hakkert, 2003);
- *Road and Transport Research* (Hakkert & Gitelman, 2004); and
- Proceeding from Transportation Research Board conferences (Flannery & Maccubbin, 2002; Persaud, Council, Lyon, Eccles, & Griffith, 2005).

To illustrate the importance of including meaningful variables in a study, Table 2 provides the variables integrated into each of the five analyses that we critiqued in 2008. The studies that integrated relevant independent variables in the analysis found RLCs were associated with increases in crashes and injuries. This reveals the complexity of conducting public health research because an outcome can be incorrectly attributed to an intervention if variables necessary to explain the outcome are excluded.

Another type of research flaw in some RLC studies is the use of a process measure, such as violations or traffic citations, instead of an actual safety outcome, e.g., crashes or injuries. Unlike crashes, citations are "endogenous," meaning officials responsible for issuing citations directly control the number issued. For example, Retting, Williams, Farmer, and Feldman (1999) studied violations, not crashes. In contrast, Wahl et al. (2010) analyzed violations and crashes and found violations decreased following RLC use, but crashes did not, meaning RLCs were ineffective in reducing crashes. Also, Lum and Wong (2003) studied stopping propensity at yellow lights, without analyzing the association between stopping propensity and crashes. It is not possible to make conclusions about safety associated with RLCs if the impact on crashes and injuries is not evaluated.

Is there an economic incentive in using RLCs?

RLC vendors and government entities clearly can receive an economic benefit from cameras, in addition to automobile insurance companies that use RLC tickets as a basis for increasing a driver's insurance rate. However, RLCs are merely an expense for motorists. Even if using the FHWA study (Council et al, 2005), which estimated annual crash cost savings per RLC site as $38,845 (excluding the cost of fatal crashes), it affirms RLCs are economically disadvantageous to motorists. The estimated savings must be considered relative to the cost to motorists to achieve the savings. For example, in Temple Terrace, Florida, RLCs were installed in two directions at two intersections, for a total of four RLC sites. If believing the estimated annual savings of $38,845 per site, the annual estimated crash cost savings to Temple Terrace drivers and/or their insurance companies would be $155,380 ($38,845 per site, multiplied by four sites). In the first year, 21,000 RLC tickets were issued in Temple Terrace, primarily to drivers making right turns (Shopes, 2009; Cohn, 2009). At $125 per citation, the cost assessed to ticketed drivers was $2.6 million, which greatly exceeds the estimated crash cost savings of $155,380. This difference is an extremely adverse cost-to-benefit relationship for affected motorists, particularly as crashes were reported to increase at Temple Terrace RLC sites. The use of RLCs has a double negative effect for motorists, as they are put more at risk for both a fine and a crash.

Citations can become a taxation method. A study by the Federal Reserve Bank of St. Louis evaluated ticketing in North Carolina over a 14-year period, and found the issuance of tickets increased in the year following a decline in municipality revenues. The authors concluded tickets are not just used for public safety, but also to generate revenue (Garrett & Wagner, 2006). As a taxation method, RLCs are highly inefficient due to the large percentage of revenues that accrues to private out-of-state vendors, which diminishes funds available within a community for investments and/or consumer purchases, thereby reducing the volume of money flowing through local businesses.

Due to the adverse cost-to-benefit relationship for motorists, citizens in some communities have placed referendums on local ballots, allowing voters to decide on banning RLCs in their community. For example, in November 2010, voters in Houston, Texas, voted to ban RLCs, which had produced more than $44 million in fines from 2006 to 2010 (Pinkerton & Olson, 2010).

If RLCs are associated with large increases in rear-end crashes, does this imply that drivers are following too closely?

Rear-end crashes can occur even when trailing drivers are abiding by speed limits and following distance guides, which is explained using Florida's rear-end presumption law and the mathematics underlying rear-end crashes. Since 1958, Florida case law holds a rebuttable presumption that the trailing driver in a rear-end collision is the sole cause of an accident (*McNulty v. Cusack*, 1958). One established rebuttal to this presumption is abrupt and arbitrary braking in accelerating traffic. The Florida Supreme Court ruled: "*Abrupt and arbitrary braking in bumper-to-bumper, accelerating traffic is an irresponsible and dangerous act that invites a collision...It is a sudden stop by the preceding driver at a time and place where it could not reasonably be expected by the following driver that creates the factual issue*" (*Eppler v. Tarmac America, Inc.*, 2000).

This ruling acknowledges the hazards of abrupt stops. Unfortunately, RLCs encourage abrupt stops, which are not always anticipated by trailing drivers. Abrupt braking is dangerous because drivers attempt to stop as quickly as possible, yet drivers need different distances to stop due to differences in driver reaction times and in distances needed by different types of vehicles to stop.

Stopping has three basic steps: (1) the driver's perception time to changing road conditions that require braking followed by the reaction time to initiate braking, (2) the vehicle response time to engage the brakes, and (3) the distance needed to stop once the brakes engage, which is determined by speed, road conditions, vehicle type, and tire quality. The total time for driver perception and reaction can range from about one to two seconds, which means a trailing driver closes the distance to the forward vehicle in the process of braking, before their brakes engage. Vehicles are separated by two seconds of driving time if using the "Two Second Rule," which is the following distance guide recommended in the Official Florida Driver's Handbook (Department of Highway Safety and Motor Vehicles, 2010). However, since the range for driver reaction times to braking includes two seconds, the trailing driver's brakes can engage at or beyond the same place on the road where the forward vehicle's brakes engaged, and a rear-end crash is likely to occur if the trailing vehicle requires a longer stopping distance. The forward driver's ability to quickly stop affects the distance available to trailing drivers, making abrupt stops hazardous.

Why would RLCs not reduce red light running crashes?

Of the seven studies identified as best in the NHTSA compendium, only Garber et al. (2007) specifically analyzed crashes caused by red light running, as the others used the broader category of all angle crashes, regardless of the cause. Using EB analysis, Garber et al. found no significant change in red light running crashes at RLC sites. A possible explanation is that the majority of red light running crashes result from *unintentional*, rather than *intentional*, red light running. For example, when intentional red light running occurs immediately after the signal changing to red, cross traffic has not been released and the likelihood of a crash is low. In contrast, unintentional red light running is hazardous because cross traffic can be in the intersection when the infraction occurs. The failure of RLCs to reduce red light running crashes is consistent with crashes occurring from unintentional red light running. Further, the Garber et al. (2007) study reveals that angle crashes are not a good proxy for red light running crashes since they found red light running crashes did not significantly change at RLC sites, whereas angle crashes significantly increased.

Understanding root causes of red light running crashes (e.g., intentional versus unintentional infractions, driving under the influence, or traffic signal or intersection defects) is necessary to advance remedies that are specific to the problem. In contrast, RLC advocates presume red light running crashes occur from willful red light running.

Does a mutually agreeable resolution exist among RLC proponents and opponents?

When the Centers for Disease Control and Prevention (CDC) identified motor vehicle safety as one of the top 10 public health accomplishments of the 20th Century, it was, in part, attributed to the federal government being given the authority in 1966 to advance safety by establishing standards for roads and intersections (CDC, 1999). The Federal Highway

Table 2. Variables Included in RLC Evaluations Critiqued in 2008

	Found RLCs Associated with Increased Crashes/Injuries			Reported a Safety Benefit to RLCs	
	Burkey & Obeng	Garber et al.*	Synectics*	Council et al.	Retting & Kyrychenko
Average daily traffic volume	X	X	X	One volume used for all time periods	
Amber (yellow) signal time	X	X	Set per regulations		
Speed limit on major road	X	X			
Left turn lanes on road	X	X			
Through lanes on number of lanes	X	X			
Time	X (month)	X (year)			
Percent of trucks on major road		X			
All-red clearance interval	X				
Right turn lane	X				
Sidewalk at intersection	X				
Solid median at intersection	X				
Pedestrian signal at intersection	X				
No left or right turn on red signs	X				
Snow	X				
Precipitation	X				

*Garber et al. and Synectics Transportation Consultants accounted for intersection geometry in selecting comparison intersections, therefore their statistical analysis did not need to incorporate these (control) variables.

Administration's Manual on Uniform Traffic Control Devices (2009) establishes standards to achieve uniformity in traffic control throughout the nation. Federal standards are needed regarding RLC programs to assure intersection safety, even though RLCs were not found to be an evidence-based safety intervention in studies identified as the best RLC research (Decina et al., 2007). Such standards would *not* preclude states from enacting laws that prohibit the use of RLCs, as some states have already done: Maine, Mississippi, Montana, Nevada, New Hampshire, West Virginia, and Wisconsin (Copeland, 2010), or establishing more stringent standards regarding yellow light timings, as occurred in Georgia.

Instead of establishing standards for RLCs, the FHWA and NHTSA (2003) issued "guidelines" that recommend an engineering analysis and improvements prior to considering RLCs, but did not mandate such. Consequently, RLCs can be used at intersections with engineering defects, which, if corrected, would all but eliminate red light running. It is a false dichotomy to assume the existence of only two alternatives, to either do nothing or use RLCs, as the evidence-based remedy is to make engineering improvements, particularly lengthening yellow light timings.

As reported in the Office of the House Majority Leader's report (2001), federal standards for traffic signal timings were relaxed in 2000, allowing for shorter yellow light timings while permitting the use of enforcement (tickets) *and* making the all-red clearance interval optional. These changes were contrary to accepted safety standards, but necessary to allow RLC programs to be profitable, as well as to create the appearance of an epidemic of red light running for the public. The former standards must be restored and strengthened if the goal is to maximize public safety.

RLC proponents have said they agree with correctly engineered intersections. If true, they should also agree with restoring the former standards and requiring an engineering analysis, with any indicated improvements, prior to consideration of RLCs. Further, full disclosure of the number of "red light running" crashes at an intersection, as a consideration for implementation of RLCs, should be required to prohibit the obfuscation that occurs by reporting angle crashes or total crashes, as the majority are typically unrelated to red light running.

At present, the Federal Highway Administration's (FHWA) web site, titled "Red Light Cameras/Automated Enforcement" (2010), creates confusion about RLC effectiveness. The FHWA web site states RLCs reduce the "number of red light running crashes," and provides a link to the Insurance Institute for Highway Safety's web site, which is an association funded by automobile insurance companies. Oddly, the FHWA web site does not reference the two studies identified as among the best RLC studies in the NHTSA compendium (Decina, 2007), which adhered to scientific research methods. Both concluded RLCs were associated with increases in crashes and injuries. They were conducted in Virginia (Garber et al., 2007) and North Carolina (Burkey & Obeng, 2004). In 2008, by email, we suggested the FHWA include these studies on their web site. An email response was received from the FHWA's Office of Safety Design (D. Warren, personal communication, June 13, 2008), which stated the following intentions:

We intend to add links to technical reports on this topic that were prepared using federal funds including the Virginia and North Carolina reports you mentioned as well as a recent worldwide critical evaluation of results published by NHTSA.

Although this response was sent more than two years ago, the FHWA web site has not been modified to include the two credible studies.

A parallel problem has emerged with the use of speed cameras, suggesting a need for improved federal standards to assure speed limits are correctly set. The FHWA official who contacted us also informed us that, similar to RLCs, roadway engineering can be manipulated to increase speed camera tickets by setting speed limits that are less than what safety requires. The FHWA official explained this increases the percentage of people who are defined as speeders, thereby increasing the number of speed camera tickets issued as drivers choose speeds perceived as safe, not always attending to changes in posted speed limits.

It is important for the public at large and federal, state, and local officials to understand that motor vehicle safety is advanced through evidence-based methods. Attempts to generate revenue through traffic citations are directly contrary to public safety since infractions are increased by improper roadway engineering, creating hazards and expense for the public.

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