

**Review of “The Impact of Red Light
Cameras (Photo-Red Enforcement) on
Crashes in Virginia” by Nicholas J. Garber,
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Summary

A large body of peer-reviewed research generally has found that camera enforcement reduces red light violations and injury crashes (e.g., Aeron-Thomas and Hess, 2005). Results of a new study (Garber et al., 2007) commissioned by the Virginia Transportation Research Council (VTRC) and completed in June 2007 appear to contradict these earlier findings, but there are significant methodological issues with the VTRC study that call into question the validity of its conclusions. The study was comprehensive, covering six Virginia communities that experimented with red light camera enforcement and including 7 years of crash data. However, the methods of analysis and quality of the data, particularly the data on traffic volumes at camera and noncamera intersections, do not support the authors' contention that they validly evaluated the effect of camera enforcement. The fact that multiple statistical methods were used to assess the effect of red light cameras is irrelevant, because only one method was theoretically capable of isolating the effect of camera enforcement site by site, the Empirical Bayes procedure, and the application of that method was not sound. This review discusses why the Empirical Bayes approach is the only method that could answer the question about camera enforcement, given the study's data, and how the VTRC application of that method likely was flawed. The review points out the weaknesses in the authors' conclusion that they had documented statistically significant benefits in some jurisdictions and significant disbenefits in others. The appropriate conclusion after reviewing the VTRC study is that it did not validly assess whether camera enforcement did or did not reduce crashes; hence, it cannot provide guidance to communities considering the use of red light cameras.

Description of Study

The VTRC study was a large, ambitious effort that attempted to sort out the potentially different crash effects of red light camera enforcement in six northern Virginia communities — Alexandria, Arlington County, Fairfax City, Fairfax County, Falls Church, and Vienna. These communities installed red light cameras at various times between 1997 and 2004. Seven years of crash data (1998-2004) were used in the analyses.

The study examined crash experience at 30 intersections where cameras were installed and at 48 comparison intersections without cameras in the six study communities. Analyses excluded five intersections where red light cameras were installed prior to January 1998 because of the absence of "before" data. Crash data were obtained from the Virginia Department of Transportation. The data set of about 3,500 crashes included all crashes occurring within 150 feet of the study intersections and resulting in injuries or property damage of at least \$1,000.

Four different analytic techniques were used, but results varied depending on the type of crash, jurisdiction, and analytic technique. Analyses ranged from simple before-after comparisons to an Empirical Bayes (EB) approach, widely regarded as the most robust before-after study method for this type of countermeasure evaluation.

Problems with non-EB Methods of Analysis

Three of the four analytic techniques applied by the VTRC researchers were insufficient for isolating the effects of camera enforcement on crashes. The simplest of the methods, the paired t-test, does not control for confounding factors (e.g., roadway geometry) that could affect the number of crashes. Analysis of variance is a more sophisticated approach, but it requires the faulty assumption that crash risk is normally distributed. The third level of analysis, generalized linear modeling, was touted by the authors as overcoming the limitations of the first two levels. However, this approach also is inadequate for assessing crash effects of camera enforcement because it fails to correct for bias in the selection of treatment sites (i.e., regression to the mean). Furthermore, correlated, mis-specified, or omitted variables in the models can lead to illogical conclusions; that several of the calibrated models suggest illogically that crashes decreased with increasing traffic volume is compelling evidence of this difficulty.

Empirical Bayes Method

The EB method overcomes the limitations of simpler methods by accounting for regression to the mean, changes in traffic volume, and trends in crashes due to factors such as weather, crash reporting practices, and driving habits (Persaud and Lyon, 2007). The EB method compares actual crash patterns at treated sites — in this case, intersections with cameras — with the crash patterns that would be expected absent treatment, using crash patterns at appropriate comparison sites to estimate expected crash patterns at treated sites. Robust crash prediction models require comparison sites with characteristics (e.g., traffic volume, geometry) similar to those of treatment sites, appropriate data, and correctly specified model parameters.

The VTRC study reported that red light cameras were associated with (1) an increase in rear-end crashes (about 42 percent for the EB approach); (2) a decrease in red light running crashes, defined as those in which a driver was charged with a red light violation (about 8 percent for the EB approach); and (3) an increase in total crashes (about 29 percent for the EB approach). Results varied widely by intersection and community. Based on the EB models, results from one community suggest cameras were associated with increases in all six crash types studied (rear-end, angle, red light running, injury red light running, total injury, and total), whereas two other communities experienced decreases in most of these crash types. The authors concluded from this mix of results that the safety effects of red light cameras vary. They suggest communities should be careful where they install cameras and offer some advice on how to choose locations for camera enforcement.

The question for the thoughtful reader, however, is whether the hodgepodge of VTRC findings represents truly different effects of red light cameras at different intersections and in different jurisdictions, as the VTRC authors conclude, or does it represent the failure of their methods, and

inadequacy of their data, to accurately assess crash effects of camera enforcement. That is, the hodgepodge of results could simply reflect inadequate data and inadequate statistical methods that come out in different ways for different intersections and jurisdictions because of uncontrolled random fluctuations and the poor quality of some of their data. The latter is clearly the case, as detailed in the following paragraphs.

Problems with Application of the EB method

Although the VTRC study employed a valid statistical method, the EB method, to estimate crash effects associated with camera enforcement, a review of the study and available data used indicate the EB method may have been misapplied. The process used to predict the expected number of crashes at camera-enforced intersections in the after period likely underestimated the expected number of red light running and right-angle crashes (crash types targeted by red light cameras) absent enforcement. This occurred because the selection of comparison sites and the use of these sites to calibrate the crash prediction models were inappropriate.

Baseline data from camera and noncamera sites should not have been combined

Combining baseline (i.e., pre-camera enforcement) crash data for camera and comparison sites is acceptable if there are insufficient data from comparison sites to develop a reliable crash prediction model, but only if the baseline number of crashes at comparison and camera sites are comparable. In their study, the VTRC researchers combined baseline crash data but did not demonstrate that the baseline numbers of crashes at the camera and comparison sites were comparable. For example, in all six communities, the mean number of angle crashes during the pre-camera enforcement period was substantially higher at camera sites than at comparison sites. Whether this difference was due to real differences in crash experience or to the regression-to-the-mean phenomenon, combining these two data sets to estimate the crash prediction models biased the crash effect estimates and thus was inappropriate. Comparison and treatment data were combined for other crash types as well, but changes in angle crashes are of particular concern because this is the type of crash generally caused by red light runners, and because cameras often are installed at intersections with high rates of angle crashes.

Comparison sites should not have included noncamera intersections in communities with camera-enforced intersections

Comparison sites included signalized intersections without cameras in the communities where red light cameras were installed. This is a problem because the goal of photo enforcement is to reduce violations and crashes on a citywide basis. Prior research conducted in one of the study communities — Fairfax, Virginia — reported large reductions in red light running at noncamera intersections, reductions

comparable with those observed at camera-enforced sites (Retting et al., 1999). If publicity accompanying the implementation of red light cameras brings about changes in driving behavior that reduces crashes at noncamera intersections used as comparison sites, the crash prediction models would underestimate crash reductions at camera-enforced sites. Crash reductions for the community as a whole also would be underestimated if crash reductions at noncamera sites, due to camera enforcement at other sites, are not considered.

In addition to concerns about comparison sites, there were other concerns about the crash prediction models and quality of the data.

Crash prediction models were not robust

The VTRC study used a highly unusual crash prediction model to estimate the effects of intersection characteristics (e.g., traffic volume, speed limit, number of lanes) in the application of the EB methodology. The more conventional, and widely accepted, model correctly implies that as long as an intersection has traffic, it will have crashes, and that crashes are an increasing function of traffic volume. In contrast, the VTRC model implied illogically that zero crashes would occur if any of the variables other than traffic volume had a value of zero, regardless of the traffic volume level. One term in the model that easily could equal zero is the difference between the actual duration of yellow signal timing at a given intersection and the recommended duration based on guidelines published by the Institute of Transportation Engineers (1985). If these two values were equal, the model would predict zero crashes. This clearly would not be the case in the real world. Other important problems with the models included the use of a large number of potentially correlated independent variables and small sample sizes of crashes for several crash prediction models. All of these problems likely produced unstable and unreliable parameter estimates for many of the models, such that estimates of expected crashes without camera enforcement, a key ingredient of the EB methodology, likely were incorrect.

Traffic volume data were missing for minor roads

Lack of traffic volume data for minor roads/side streets in some of the analyses was a concern, especially because red light cameras typically are implemented at intersections for which traffic volume data for minor roads are a key factor affecting the frequency of crashes.

Large fluctuations in traffic volumes were reported at some intersections

Large anomalies in traffic volumes at some intersections raised concerns about the accuracy of these data. At one camera site, estimated traffic volume nearly doubled from 34,000 vehicles per day in 2001 and 2002 to 65,000 in 2003. At another camera site, estimated traffic volume more than tripled from 18,000 vehicles per day in 1998 and 1999 to 64,000 in 2000 and 2001. At other camera and

comparison sites, traffic volumes showed unusual declines and large yearly fluctuations. Traffic volume data have a substantial impact on crash predictions in the EB methodology, so the quality of these data is an important issue.

There was a potential reporting bias associated with the definition of red light running crashes

Another concern was the study's estimated effects on crashes involving drivers charged with running a red light. If crash-involved drivers who ran red lights were more likely to be charged with disobeying a traffic signal after red light cameras were in place, there would be a bias toward reporting more crashes involving drivers charged with running a red light in the after period. This could be one reason the VTRC researchers found that at about 30 percent of the camera sites, red light running crash rates were higher after cameras were installed. Such a bias could result in inaccurate estimates of the effects of camera enforcement on red light running crashes. Other researchers have avoided this problem by ignoring whether drivers were charged with red light running (e.g., Council et al., 2005).

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