Red light camera interventions for reducing traffic violations and crashes: a systematic review

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Background

The Problem, Condition or Issue

Road traffic crashes are a major and increasing cause of injury and death around the world, with about 1.25 million people dying annually and between 20 and 50 million more suffering non-fatal injuries, including permanent disabilities. Road traffic injury and death rates are highest in African nations. Overall, low and middle-income nations are most at risk; over 90 percent of deaths due to road traffic crashes occur in these countries, although they only have about 54 percent of the world's vehicles (World Health Organization, 2017). According to the National Highway Traffic Safety Commission (2015), there were almost 5.7 million vehicular crashes in the U.S. in 2013. Of these, approximately 1.6 million (28 percent) involved some form of injury and 30,057 (0.5 percent) resulted in one or more fatalities; the remainder involved only property damage. These crashes resulted in 32,719 traffic fatalities (a fatality rate of 10.35 per 100,000 population). Only about 50 percent of traffic crash fatalities were drivers; the remainder were primarily vehicle passengers (approximately 18 percent), motorcyclists (approximately 14 percent) and nonoccupants (approximately 17 percent; these included both pedestrians and bicyclists). The annual economic cost of reported and unreported traffic crashes has been estimated at $242 billion.

Traffic data from the United States show that in the first decade of the 21st century (2000-2009), almost 9,000 people were killed as a result of red-light crashes (Federal Highway Administration, 2014a). During 2013, 697 people were killed and approximately 127,000 were injured in traffic crashes involving red light running. Only about half of the fatalities were the drivers who ran the red lights; the other half included pedestrians, bicyclists, and the occupants of vehicles struck by red-light runners (Insurance Institute for Highway Safety, 2015).

Intersections are locations on roads that have the potential to create conflict for drivers and pedestrians. These conflicts increase the risk of crashes; a considerable proportion of crashes occur at intersections, although they make up only a small proportion of the roadway system in the United States (Choi, 2010). One way to reduce this conflict is through the use of a traffic control device such as a traffic signal. Traffic signals are designed to identify which vehicles and/or pedestrians approaching an intersection have the right of way to pass through the intersection at any given time, as a way of ensuring orderly movement of traffic, reducing delays for waiting vehicles, and reducing the frequency of vehicular crashes (Federal Highway Administration, 2004a). The Federal Highway Administration's *Manual on Uniform Traffic Control Devices* (2012) specifically identifies situations where traffic conditions require the installation of traffic signals; generally these relate to situations where conflicting traffic movements that create crash potential could exist (Bochner & Walden, 2010).

A driver runs a red light when he or she enters an intersection after the traffic light has turned red. While most drivers do obey traffic signals, the possibility for violations does exist, either due to driver distraction, aggressive driving behaviors, or a deliberate decision to ignore the signal. Traffic light violations appear to be fairly common. A recent national telephone survey found that while the vast majority of drivers (94 percent) consider red light running to be unacceptable, over 35 percent admitted to having driven through a red traffic light in the past month and over 22 percent had done this more than once, although very few (2 percent) reported running red lights regularly or fairly often (AAA Foundation for Traffic Safety Culture, 2015).

A telephone survey conducted for national "Stop Red Light Running Week" identified some general characteristics of the typical red light runner. Red light runners tend to be younger drivers; to have no children or to have children under the age of 20; to be travelling alone; to be unemployed or working at a job that requires less education; to be driving more than two miles from home; to be in a rush to get to work or school (during weekday morning hours); and to have received a ticket for red light running. Although frustration is considered to be a key component of aggressive driving in general, the typical red light runner is not necessarily frustrated. The vast majority of drivers reported that if they were frustrated, they were more likely to engage in other types of aggressive driving behavior, such as weaving in and out of traffic, tailgating, speeding, or gesturing angrily, rather than running red lights. This does suggest that red light running may not actually be a form of aggressive driving or may not be a function of those factors that tend to explain other types of aggressive driving (Porter and Berry, 1999). Instead, it appears that drivers consider red light running to frequently be an intentional act that has few legal consequences (Federal Highway Administration, 2004b)

There are a number of engineering countermeasures which focus on engineering design to reduce red light running. These generally involve changes to the intersection and/or the signal which (1) increase the visibility of traffic signals (e.g., through the use of overhead traffic signal displays rather than pole-mounted signals); (2) increase the likelihood that drivers will stop at red lights (e.g., by installing advance warning flashers to warn drivers when traffic signals are about to change to yellow); (3) reduce intentional violations (e.g., by careful timing of signal cycle lengths to ensure yellow intervals are long enough and that red cycles are not so long that drivers become frustrated and unwilling to wait for the next green interval); or (4) eliminate the need to stop (e.g., by removing traffic signals and replacing them with an alternative traffic control device, such as a stop sign or roundabout) (Federal Highway Administration, 2004c).

The traditional method of enforcing traffic signal violations generally requires the presence of an individual (usually a police officer) to monitor driver behavior and apprehend violators. This is extremely expensive, is a drain on scarce agency resources, and may create risk due to the possibility of high-speed pursuits. However, an increasingly popular alternative is automated enforcement through the use of red light cameras (RLCs). RLCs permit police to remotely enforce traffic signals without the need for an officer to be present at the scene of the violation. They operate continually without human intervention and do not result in potentially dangerous high-speed pursuits. Their mechanical nature also reduces the possibility of accusations of human bias, discrimination, or selective enforcement (Aeron-Thomas and Hess, 2005). As a result, the use of RLCs to increase compliance with traffic signals and facilitate the enforcement of relevant traffic laws is increasing (Bochner and Walden, 2010). RLCs are not a new technology; they have been used for almost 50 years. Israel first used RLCs for traffic enforcement as early as 1969, they were used in Europe by the early 1970s, and RLCs were adopted on a wide scale in Australia in the 1980s. In the United States, RLCs were first used in New York City in 1993 and their use has spread around the country.

RLCs are somewhat controversial and a number of states have passed laws prohibiting the use of RLCs to issue citations or are considering bills that would eliminate automated red light enforcement. Meanwhile, other states have enacted legislation permitting RLCs (see Teigen, Shinkle, and Essex, 2015 for a discussion of state legislation regarding RLCs).

One systematic review of the effect of RLCs on the incidence of red light violations as well as the incidence and severity of road crashes and casualties has been conducted, examining research published in or before 2002 (Aeron-Thomas & Hess, 2005). Although no randomized controlled studies into these issues were located, a number of controlled before-after studies were identified. The study concluded that RLCs were effective in reducing the total number of casualty crashes but that evidence regarding their effect on total collisions, on specific types of casualty collisions, or on total red light violations was not conclusive. The researchers also found that most existing studies did not adjust for issues such as spillover effects or regression to the mean.

The Intervention

This review will examine the effect of cameras designed to detect red-light violations and violators. This may include situations where cameras are installed at intersections as well as area-wide programs in which some but not all junctions have cameras in operation. Comparison conditions will include those intersections and/or areas that do not have RLCs installed.

An RLC is a fully automated photo detection system that includes three key elements: cameras, sensors or triggers, and a computer. The cameras may take still or video images, or both; modern systems generally use digital cameras but some older systems may use 35-mm cameras, which will require that the film be collected and developed. The cameras generally are located on all four corners of an intersection, so that vehicles coming from any direction may be photographed from multiple angles. (Federal Highway Administration, 2014b)

Triggers are designed to detect when a vehicle has passed a specific point in the road. Generally, these are induction loops buried under the pavement and connected to an electrical source and an electrical meter. When a car drives over the electrical wires, the electromagnetic field is affected and the meter detects the change. Most systems have two triggers in each lane and both must be activated sequentially within a set period of time. (Federal Highway Administration, 2014b)

The cameras and meter are linked to the computer, which is located in a terminal block near the intersection. When a vehicle sets off the trigger, the computer determines whether or not the traffic light is red. If the light is green or yellow, the trigger is ignored. If the traffic light is red when a vehicle sets off the trigger, the computer signals the cameras to take one or more photographs to document the traffic violation. The light must be red when the system is triggered; if the vehicle is already in the intersection when the traffic light changes from yellow to red, the cameras will not be activated. Additionally, the cameras will only be activated if the vehicle is moving over the triggers at a predetermined speed; if the vehicle has stopped on an induction loop or activates only the first of the two triggers, the computer will not signal the cameras. (Federal Highway Administration, 2014b)

Most systems take at least two photographs. One photograph shows the vehicle entering the intersection while the second shows the same vehicle passing through the intersection. At least one photograph will include a rear view of the vehicle, to capture the rear license plate. Most systems also superimpose the date and time of the violation, the location of the intersection, the speed at which the vehicle was travelling and the amount of time that elapsed between the light turning red and the vehicle entering the intersection. (Federal Highway Administration, 2014b).

In many jurisdictions, laws governing the use of RLCs require the placement of signs near intersections with cameras, warning drivers that intersections are photo-enforced. The Federal Highway Administration (2005) recommends that advanced warning signs be used on all approaches to photo-enforced intersections, even if not required by law.

Why it is Important to do the Review

The only existing previous systematic review of the effect of RLCs on road traffic crashes (Aeron-Thomas and Hess, 2005) is about 10 years old. It includes studies published in 2002 or earlier and is based on a very small sample of eligible studies. While the search process examined a large number of traffic-related websites, only a small number of electronic databases were searched. Additionally, RLC technology has continued to improve and the use of RLCs has expanded and become more widely accepted, which may have an effect on the impact of RLCs on driver behavior traffic patterns.

This review will update the earlier systematic review of RLCs to include more recent research and will summarize the most recent scientific evidence on the effectiveness of RLCs on traffic patterns. It has the potential to impact police and government policies and procedures and to increase traffic safety. If RLCs are shown to be effective in reducing red light violations, traffic crashes, and traffic fatalities, the empirical support provided by this review may encourage efforts to advocate for the more widespread use of RCLs in communities around the U.S. and internationally. This review may also provide some insight into which type of RCL (e.g., still camera vs. video) is most effective in reducing traffic violations, crashes, and fatalities.

Objectives

The main objective of this research is to assess the impact of RLCs on the incidence of red-light violations and the incidence and severity of traffic crashes, injuries, and fatalities. An additional objective is to identify any substantive or methodological variables that may moderate effect sizes. The goal of this research is to systematically review and synthesize all the existing empirical research on the effect of RLCs on traffic patterns. RLCs are utilized and have been studied around the world (Aeron-Thomas and Hess, 2005) and research from as many nations as possible will be included. The researchers intend to measure effect sizes in each study and examine which components of RLC automated traffic enforcement programs are most effective in which circumstances.

Additionally, this study will examine any studies that incorporate cost-effectiveness information or cost-benefit analyses. The purpose of this is to provide evidence-based information to inform criminal justice professionals and policy-makers when determining whether the adoption of RLCs is reasonable.

Methodology

Criteria for including and excluding studies

Types of study designs

Studies to be included will be those that involve one of the following research designs:

1. Experimental design/randomized controlled trials (RCT): This category includes true experiments that use random assignment to assign intersections to the treatment and control groups.

2. Quasi-experimental/quasi-randomized design: This category includes studies that allocate the treatment and control conditions using quasi-random processes, rather than truly randomizing treatment allocation.

3. Controlled before/after (CBA) design: This includes studies in which data is collected both before and after the treatment was initiated.

4. Controlled interrupted time series: This category includes studies in which data are collected at multiple separate time points before and after the treatment was initiated.

For all research designs, a non-intervention control condition will not exclude normal routine traffic enforcement by criminal justice system personnel. Therefore, police officers may still issue citations for traffic violations at intersections at which RLCs are not present but that were included in the study. However, studies in which additional methods of traffic enforcement (e.g., crackdowns) were used at control intersections will be excluded.

Studies using RCT and quasi-RCT designs must collect data for a minimum of one year (12 months) after the implementation of the treatment (installation of RLCs). Studies using a CBA design must collect data for at least one year before and one year after the implementation of the treatment.

Exclusion criteria

Qualitative or descriptive studies that do not include formal comparisons of treatment and control groups will be excluded from this research. This will include, for example studies that examine an RLC intervention program in a neighborhood quantitatively but do not include comparisons between those intersections that had an RLC presence and a control group of intersections where cameras were not installed.

Language of publication will not necessarily be a criterion for exclusion. Although limited resources do not permit a search for studies that are not in English, studies with English abstracts or keywords that are identified during the literature search will be included whenever possible. Additionally, studies will not be excluded based on geographic location; research conducted outside the United States will be included when identified. Finally, unpublished as well as published reports of research will be included when identified.

Types of participants

This review will focus on the effect of RLCs on traffic patterns. Participants will include all signalized intersections in which RLCs have been installed, and any signalized intersections without RLCs that are used as control groups.

Types of interventions

The intervention must involve the use of RLCs. An RLC is considered to be a still and/or video camera (either digital or film) that is used to detect red-light violators and identify them so that they may be charged with their violations.

Research may examine individual junctions or intersections with traffic signals at which cameras are employed or examine a larger area in which cameras are installed at some of the signaled intersections in the community.

Types of outcome measures

For a study to be included in this review, it must use at least one of the following outcome measures:

- Red-light violations, based on the number of vehicles and/or drivers that pass through a junction after entering on a red light (vehicles that enter a junction on a yellow light but do not clear the intersection before the light changes to red are not included).

- Road traffic crashes, based on both number and severity, and including information on injuries and fatalities/casualties as well as damage-only crashes.

Additional outcomes that may be examined include:

- Effect size variations based on substantive or methodological variations (e.g., the deterrent effect of public awareness and publicity campaigns, warning signage, and other variations in RLC implementation)

- Cost-benefit analysis

Sample Eligible Studies

Pulugurtha and Otturu (2014) conducted a controlled before-after study examining the impact of red-light cameras on road crashes in Charlotte, North Carolina, analyzing data for intersections where cameras were installed and later terminated. The researchers used a before installation period of 1.5 to 3.5 years, an after-installation period of about 5 to 7 years, and an after-termination period of 3 years. Data were not included for a period of six months after camera installation to minimize possible adjustment and novelty effects of the new cameras. A total of 32 signalized intersections with red-light cameras and 48 control sites were used in the study. The researchers examined total crashes as well as rear-end crashes, sideswipe, left-turn, angle, and right-turn crashes. Data were examined using descriptive analyses, paired t-tests, and the Empirical Bayes method.

Ko, Geedipally, and Walden (2013) conducted a controlled before-after study of the effect of red-light cameras on casualty crashes in Texas, using 254 signalized intersections with cameras in 32 jurisdictions around the state. The study used before and after periods of one to three years. In addition, data were collected for 66 reference/control intersections, which were selected so that they were at least two miles away from the nearest treatment intersection, to minimize spillover effects. The researchers examined the effects of red-light cameras on total red light running crashes, rear-end red light running crashes, and right-angle red light running crashes.

Search strategies

Multiple strategies will be employed to search for research that meets the eligibility criteria. The search strategies will be adapted as necessary to search all listed sources, as well as a search of the internet.

1. Online electronic bibliographic databases will be searched for published works (see Appendix A for details of electronic databases).
2. The websites of international institutes and research agencies focusing on transportation issues will be searched (see Appendix B for details of websites).
3. The reference lists of review articles and prior research into RLC effectiveness will be examined.

4. A keyword search using Google and Google Scholar will be conducted to search the grey literature; the first 100 hits of each search will be examined.

Keywords for search process

The following list of keywords will be used to search the various databases and websites, although they may be adapted as necessary to meet the requirements of the various search engines or to conform to international terminology variations and spelling conventions (e.g., UK vs. US spelling). The terms are intentionally general in nature and avoid potentially limiting words (e.g., experiment, randomization) to ensure that searches cast the broadest possible net and that relevant background material will also be identified. If necessary, terms may be truncated in order to find variations of individual words (e.g., camera vs. cameras). Additional terms may be included as needed.

- Red and light and camera*
- Red-light and camera*
- Speed and camera*
- Traffic and camera*
- Red and light and violation*

Obtaining identified research studies

After searches have identified relevant research, it will be necessary to obtain full-text versions of all material. The following sources will be used, generally in the order listed below:

1. When possible, full-text versions will be obtained from electronic journals or documents available through the Florida International University (FIU) or Florida Atlantic University (FAU) library databases or from www.ResearchGate.net.
2. If an electronic version is not available, a print version will be obtained from either FIU or FAU libraries, if possible.
3. If none of the above sources produce a copy of the research in either electronic or print format, a copy will be requested from another university through the FIU Interlibrary Loan Office.
4. If none of these methods are successful, attempts will be made to contact the author(s) of the research study or the funding agency to request a copy of the research report.

Screening and review process

All identified studies will be listed in a spreadsheet to check for duplications. Once duplicate records are removed, each study will be screened to determine if it meets the basic inclusion criteria:

1. The study deals with the use of RLCs to enforce traffic light violations or reduce/prevent traffic crashes.

2. The study includes a comparison/control group.

3. The effectiveness of RCLs was measured by comparing intersections/communities where RCLs were installed (experimental/treatment group) with intersections/communities without RCLs (control group).

4. The study reports post-RCL-installation measures of at least one of the following:
    a. Incidence of red light violations
    b. Incidence of road traffic crashes
    c. Severity of road traffic crashes

5. Extraneous variables were controlled by at least one of the following methods:
    a. Randomization
    b. Matching
    c. Pre-test measures of violations and crashes

For a study to be eligible for inclusion, all of the above criteria must be met. The publication status of the study (unpublished vs. published) will not affect the study's inclusion.

At least two review authors will independently examine each study for eligibility based on the above criteria. Any disagreements will be resolved by discussion with a third review author.

Description of methods used in primary research

The earlier review (Aeron-Thomas and Hess, 2005) found no studies using an experimental design with RCT or a quasi-experimental design. A small number of studies were found that employed a controlled before-after design and met the inclusion criteria specified by Aeron-Thomas and Hess.

Studies included in this review will use methodologies that employ a treatment vs. control group research design and have post-treatment measures. Studies can be experimental, quasi-experimental, or use a controlled before-after design. Outcomes generally will come from official data on traffic violations, crashes, and fatalities. The studies may vary in the method of assignment to treatment or control group; while random assignment to assign RCLs to intersections or geographic areas is most desirable, quasi-random assignment may be more likely.

Studies may adjust for regression to the mean (RTM), either through the use of randomized trials or statistically, and/or the issue of spillover effects (displacement and/or diffusion of benefits). However, it is also likely that some studies will fail to adjust for one or both of these issues.

Criteria for determination of independent findings

It is possible for studies to report multiple outcomes, or for researchers to publish several articles using data from the same sample. For proper statistical analyses, it is important to ensure that all studies come from independent samples. Therefore, all articles that meet the criteria for inclusion will be examined to identify situations where multiple articles analyzed data from the same sample. If the same outcome is reported in multiple studies, the effect sizes will be combined. This will also be done if a single study reports the same outcome multiple times with different types of data from the same sample.

At the same time, however, studies may examine multiple outcome measures (e.g., the same study may look at the effect of RLCs on traffic violations and on traffic crashes). In these cases, the results will be analyzed separately.

Details of study coding categories

All eligible studies will be coded on a variety of criteria, including study characteristics (methodological type, dates of data collection, etc.), sample characteristics (e.g., size, location); study methods and procedures (selection process, characteristics of treatment and control areas, associated publicity campaigns, etc.), descriptions of the independent and dependent variables (e.g., construct and operationalization), effect size data (if any), adjustment for bias (e.g., regression to the mean, spillover/diffusion), and study conclusions.

Every eligible study was coded by two review authors, using a standardized data coding set (see Appendix C). Any disagreements were identified and resolved by discussion with a third review author.

Analysis

Descriptive analysis

All studies meeting the inclusion criteria will be described in detail. Information will include:

1. Study design - including design and quality; risk of bias; data collection methods, types of statistical analyses
2. Participants - intervention and controls; setting of study; nature of roads used
3. Program components - type of camera; camera signage practices; publicity campaigns
4. Study outcomes - red light running and crashes

Assessment of risk of bias in included studies

For each included study, two review authors will assess the study quality. Disagreements will be resolved by discussion with a third review author. Study quality analysis will be based the following study dimensions:

1. Selection and matching of intervention and control areas
   a. Similarity of study and control sites
   b. No changes in control sites during the study period
   c. Control sites not adjacent to intervention sites
   d. Control group did not receive the intervention
2. Blinding of data collection and analysis
   a. Outcome data obtained from routine reporting systems
   b. Analyses conducted blind to intervention and control groups

3. Pre- and post-intervention data collection periods
    a. Length of before period is at least 1 year
    b. Length of after period is at least one year
4. Reporting of results
    a. Main findings clearly described
    b. Uncertainty due to random variability (confidence intervals) reported
    c. Appropriate statistical tests are used to assess the main outcomes (p-values)
5. Control of confounders
    a. Potential confounders are described
    b. The distributions of confounders in intervention and control sites are assessed and similar
    c. The effect of confounders on the results is discussed
6. Control of other potential sources of bias
    a. The study controlled for potential bias due to regression to the mean
    b. The study reported or controlled for spillover effects
    c. Other sources of bias were addressed

Moderators

Moderators are "variables that may explain outcomes across different studies" (Johnson, Tilley, & Bowers 2015, p.462). Primary moderators of interest include the country in which the study was conducted and study quality. Studies will be stratified to examine the effects of these moderators. Other possible moderators include time of day and day of week of RLC effects, speed limit variations, the presence of warning signs, and signal timing. These will be examined if there is sufficient data.

Statistical procedures and conventions

A standardized summary measure for each outcome will be devised, based on relative effects, rather than effect differences. Post-treatment outcome is divided by pre-treatment outcome to show proportional change. Summary measures for all studies will be calculated when possible. Rate ratios will be estimated by dividing the pre- and post-treatment outcome counts by the corresponding ratio in the control area.

For example, the estimated rate ratio for total collisions would be:

$$\frac{\text{collisions after/collisions before in treatment area}}{\text{collisions after/collisions before in control area}}$$

Assuming that post-intervention traffic volume remains the same in the control and treatment areas, this rate ratio estimates the change in the collision rate in treatment compared to control areas. For studies where outcomes are expressed as counts or rates, we will estimate the intervention effect using rate ratios with a 95% confidence interval (CI).

Heterogeneity among the effect estimates will be assessed using a chi-squared test at a 5% significance level and quantified using the I^2 statistic, the percentage of between-study variability that is due to true differences between studies (heterogeneity) rather than due to sampling error. While the I^2 index also has similar problems with power when the number of studies is small, it does permit the researcher to determine the magnitude of heterogeneity as well as its existence. Therefore, the I^2 index will also be computed as a way of measuring the extent of true heterogeneity. I^2 value greater than 50% will be considered to reflect substantial heterogeneity. Sensitivity analyses will be conducted to investigate possible sources of heterogeneity due to study quality (e.g., adequate vs. inadequate periods of outcome data collection). Details of each intervention will be presented in a table of study characteristics.

Four effect sizes – the standardized mean difference (d), correlation coefficient (r), the odds-ratio (OR), and the risk ratio (RR) will be computed using the web-based effect-size calculator available on the Campbell Collaboration website. In addition, the pooled mean effect size estimate (d+) will be calculated using direct weights, which are defined as the inverse of the variance of d for each study (Borenstein, Hedges, Higgens, & Rothstein, 2009). We will compute an approximate confidence interval for d+ using chi-square.

For the meta analysis, when at least three studies report the same outcome, the results will be pooled. We will pool the log of the rate ratio and its standard error, which will be calculated assuming a Poisson distribution for the number of collisions in each area and time period. When there are not enough studies for a meta-analysis, we will provide a narrative description of the results of the individual studies.

To assess which program components are the most effective under various circumstances, effect sizes and correlations between study features will be examined. Meta-analytic regressions will be used to investigate factors such as the independent influences of program components, methodological quality, and design features.

Treatment of qualitative research

We do not plan to include qualitative research.

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APPENDIX A

ELECTRONIC SOURCES

- Academic OneFile
- Academic Search Complete
- CINAHL (Cumulative Index to Nursing and Allied Health Literature)
- Cochrane Central Register of Controlled Trials (CENTRAL)
- Cochrane Database of Systematic Reviews
- Criminal Justice Abstracts
- Criminal Justice Periodical Index
- Dissertation Abstracts
- EBSCOHost
- EconLit
- EMBASE
- EThOS (UK E-Theses Online Service)
- Expanded Academic ASAP
- Health and Safety Science Abstracts
- Hein Online
- Heritage
- Interuniversity Consortium for Political and Social Research (ICPSR)
- JSTOR
- LexisNexis: Academic
- MEDLINE
- National Criminal Justice Reference Service (NCJRS)
- National Police Library
- OmniFile Full Text Mega (Wilson)
- Ovid MEDLINE(R)
- Ovid TRANSPORT
- ProQuest
- PsycINFO
- PubMed
- Sociological Abstracts
- Spire Project (Theses and Dissertations), UK
- Transport Research and Innovation Portal (TRIP)
- TRID - an integrated database combining records from the Transportation Research Board's Transportation Research Information Services (TRIS) Database and the Organization for Economic Cooperation and Development's Joint Transport Research Centre's International Transport Research Documentation ITRD) database
- Web of Science (ISI – includes Social Sciences Citation Index, Science Citation Index, and Art & Humanities Citation Index)

APPENDIX B

LIST OF SPECIALIZED WEBSITES

- AA Foundation for Traffic Safety, USA - www.aaafoundation.org
- American Transportation Research Institute - http://atri-online.org/
- Australasian College of Road Safety, Australia - http://acrs.org.au/
- Australia and New Zealand Society of Evidence Based Policing - http://www.anzsebp.com/
- Australian Transport Safety Bureau (ATSB) - https://www.atsb.gov.au
- Belgian Road Safety Institute - http://www.ibsr.be/en
- Center for Accident Research and Road Safety (CARRS-Q), Australia - https://research.qut.edu.au/carrsq
- Center for Evidence-Based Crime Policy, USA - http://cebcp.org/evidence-based-policing/
- Center for Problem-Oriented Policing, USA - http://www.popcenter.org/
- Centers for Disease Control and Prevention (CDC), USA – http://www.cdc.gov/
- Chalmers University of Technology, Area of Advance Transport, Sweden - http://www.chalmers.se/en/areas-of-advance/Transport/Pages/default.aspx
- CROW, Netherlands – http://www.crow.nl/english-summary
- Department of Transport Planning and Engineering, National Technical University of Athens, Greece - http://www.civil.ntua.gr/departments/transport/
- European Road Safety Observatory (ERSO) - http://ec.europa.eu/transport/wcm/road_safety/erso/index-2.html
- European Transport Safety Council - http://etsc.euhttp://etsc.eu/
- Federal Highway Administration (FHWA), USA - http://www.fhwa.dot.gov/
- Federal Highway Research Institute (BASt), Germany - www.bast.de/EN/Home/
- Finnish Transport Agency - http://portal.liikennevirasto.fi/sivu/www/e
- French Institute of Science and Technology for Transport, Development, and Networks (IFSTTAR) - http://www.ifsttar.fr/en/welcome/
- Institute for Road Safety Research (SWOV), Netherlands – http://www.swov.nl/index_uk.htm
- Institute for Transport Sciences (KTI), Hungary - http://www.kti.hu/index.php/home
- Institute of Transport Economics (TOI), Norway - https://www.toi.no/?lang=en_GB
- Institute of Transportation Engineers (ITE), USA – http://www.ite.org/
- Institute of Transport Studies (Monash), Australia - http://www.eng.monash.edu.au/civil/research/centres/its/
- International Transport Forum - http://www.internationaltransportforum.org/
- Justice Research and Statistics Association, USA - http://www.jrsa.org
- Laboratoire d'Economie des Transports (LET), France - http://www.let.fr/?lang=en
- National Highway Traffic Safety Administration (NHTSA), USA - http://www.nhtsa.gov/
- Police Executive Research Forum, USA - http://www.policeforum.org/
- Police Foundation, USA - http://www.policefoundation.org/
- Rand Corporation, USA - http://www.rand.org/
- Scottish Institute for Policing Research - http://www.sipr.ac.uk/
- Society of Evidence Based Policing, UK - http://www.sebp.police.uk/
- Swedish National Road and Transport Research Institute (VTI) - http://www.vti.se/en/
- Swiss Council for Injury Prevention (BFU) - http://www.bfu.ch/en
- Technion – Israel Institute of Technology - http://www.technion.ac.il/en/
- Trafikverket/The Swedish Transport Administration - http://www.trafikverket.se/en/startpage/
- Transport Canada (TC) - www.tc.gc.ca/eng/

- Transport Research Board (TRB), USA - http://www.trb.org
- Transport Research Center (CDV), Czech Republic - http://www.cdv.cz/en/
- Transport Research Laboratory (TRL), UK - http://trl.co.uk/
- Transport Safety Research Centre (TSRC), UK - http://www.lboro.ac.uk/departments/lds/research/groups/tsrc/
- United Nations Official Documents System - http://documents.un.org/
- Vera Institute of Justice, USA - http://www.vera.org/
- VTT Technical Research Centre of Finland, LTD (VTT) - http://www.vttresearch.com/
- World Health Organization (WHO) – http://www.who.int/en/

APPENDIX C

DRAFT DATA CODING SET

1. Study design
   a. Meta-analysis
   b. RCT
   c. Controlled interrupted time series
   d. Controlled before and after
   e. Before/after not controlled
   f. Cross sectional
   g. Case study
   h. Qualitative
   i. Commentary
2. Study length
   a. Dates of before period
   b. Dates of after period
3. Data collection details
   a. Data sources
   b. Creation of variables
4. Site characteristics
   a. Characteristics of treatment sites
   b. Characteristics of control sites
5. Study setting/nature of roads
   a. Location of study (country)
   b. Urban/rural
   c. Road type (highway, major road, etc.)
6. Goals of study
7. Intervention
   a. Type of intervention
   b. Number of cameras
   c. Size of area covered
8. Outcome measures
   a. Number/percentage of drivers running red light
   b. Road traffic crashes, including total crashes as well as different types of crashes (rear-end, right-angle, etc.)
   c. Fatalities
   d. Injuries
9. Statistical methods - description and treatment of bias and confounding factors
   a. Matching of treatment and control areas, including similarity and location (are control areas adjacent to treatment areas)
   b. Lengths of pre-and post-treatment data collection periods
   c. Assessment and control of confounders
   d. Adjustment for time trends
   e. Other potential sources of bias (regression to the mean, seasonality, etc.)
   f. Selective reporting of results by study authors

10. Results when quantitative results provided in full text
    a. Differences between groups, including confidence intervals
    b. Interpretation
11. Cost information

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Sources of support

External: We do not anticipate the need for external funding to conduct this research.
Internal: We plan to apply for a Faculty Development Award from Florida International University.

Declarations of interest

There are no potential conflicts of interest

Preliminary timeframe

Approximate date for submission of the systematic review: 31 December 2017

Plans for updating the review

This review will be updated on a five-year basis. This will require identifying and coding any new studies and rerunning the analyses.

AUTHOR DECLARATION

Authors' responsibilities

By completing this form, you accept responsibility for preparing, maintaining and updating the review in accordance with Campbell Collaboration policy. The Campbell Collaboration will provide as much support as possible to assist with the preparation of the review.

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Form completed by: Ellen G. Cohn and Suman Kakar	**Date: October 24, 2016**