

Speed cameras to reduce speeding and road traffic injuries: protocol for a systematic review

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BACKGROUND

Exceeding the speed limit is one of the most common criminal offenses committed in the UK and can engender tremendous social harm. Speed limits on roads regulate traffic speeds by establishing an upper limit on speed and reduce dispersion of vehicle speeds.

Consequences of speeding can be severe with both direct and indirect effects on health and wellbeing. There is a direct relationship between speeding vehicles and increased crash risk. Reaction and braking distances are longer at higher speeds which can increase the likelihood of road traffic crashes. Further, vehicles travelling at different speeds (both above and below average speeds) can create more interaction between vehicles which can increase the number of crashes. In the event of a collision, the severity of the injuries sustained is directly related to the speed of the vehicles. Faster vehicle speeds create more kinetic energy, which is absorbed by car occupants or other road users during a crash. In 2012 exceeding the speed limit was a contributory factor in 5% of casualties and 12% of fatalities in Great Britain (Department for Transport 2012). Indirectly, fear of speeding vehicles can discourage people from walking and cycling, or discourage parents from allowing their children to play outdoors, or travel on their own, with evidence that levels of active transport and children's independent mobility have experienced a decline in recent decades.

Despite the very real consequences of exceeding the speed limit, researchers have argued that speeding has been socially constructed as not a 'real' crime (Corbett 2000). British Social Attitudes survey found that 90% of people agreed that motorists should drive within the speed limit (NatCen Social Research 2013). However, according to an RAC survey, over 40% of motorists admit to breaking the speed limits on 20 mph and 30 mph roads in urban areas and on 50 mph and 60 mph roads in rural areas. Sixty-seven percent of motorists admitted to breaking the speed limit of 70 mph on motorways (RAC 2015).

Efforts to reduce speeding behaviour have traditionally focused on the 3Es: Education, Engineering and Enforcement. Educational interventions such as Safe Community Programmes aim to heighten driver awareness of speeding-related safety issues. Engineering interventions, such as speed humps or chicanes, change the road environment to physically slow traffic speeds. Enforcement measures focus on ensuring that the public

adhere to the posted speed limits through the automated or manual monitoring of traffic speeds.

This review concentrates on the implementation of automatic traffic speed enforcement using detection devices such as cameras to enforce speed limits. Speed cameras have the potential to reduce speed-related crime by increasing offenders' perceptions of the risk of being caught and facing consequences if they exceed the speed limit. Successful prosecution of offenders by speed cameras might also impact on recidivism rates.

The use of speed cameras is often publically divisive: Delaney and colleagues (2005) describe five recurring controversies:

- 1- Speed cameras raise revenue for local governments so there are concerns that in some instances they are implemented for financial reasons.
- 2- Concerns about fairness, a failure to notify offenders on the spot, and a lack of opportunity to explain circumstances.
- 3- Speeding is not always perceived as a safety problem (as 1 above).
- 4- Concerns about accuracy of cameras to detect speed within enforcement tolerances.
- 5- Concerns that photographic traffic law enforcement is 'spying' on law-abiding citizens (invasion of privacy) and that camera data may be used for other purposes.

Despite these concerns, many countries worldwide have expanded the use of speed cameras over time, based on research evidence that speed cameras reduce both traffic speeds and road traffic crashes. A detailed review of the research evidence on speed cameras is therefore timely.

A systematic review for the Cochrane Collaboration assessed the effectiveness of speed cameras for prevention of road traffic injuries and deaths in 2010 (Wilson et al, 2010). The review found that after implementation of speed cameras, the relative reduction in average speed ranged from 1-15% in the 35 studies included in the review; the reduction of proportion of speeding vehicles ranged from 14-65%; and the reduction in road traffic

crashes ranged from 8-49%. The authors were unable to conduct a meta-analysis of results due to considerable heterogeneity between and within included studies.

Aims

We aim to update and expand the Cochrane systematic review, to provide a comprehensive account of the range of automatic speed enforcement strategies employed worldwide.

We will update the Cochrane review to include studies published after 2010, and we will expand the review by collecting data on crime-related outcomes (such as other traffic law violations) and to include information for the EMMIE framework (Johnson et al. 2015) on mechanisms, moderators, implementation and economic costs of speed camera interventions. For each study we will describe the setting (e.g., nature of roads), theoretical basis for the intervention, characteristics (i.e., mobile or fixed; manned or unmanned; covert or overt), and outcomes. This descriptive piece will provide a global overview of the number and type of automatic speed enforcement strategies delivered for the period 1990 to 2015.

Quantitative analyses will be conducted to assess intervention effectiveness. Specifically, where well-designed controlled evaluations of programmes have been conducted, we will include estimates of the effect of interventions on the defined primary (e.g., reduction in speeding vehicles) and secondary (e.g., road traffic crashes) outcomes, and where possible, identify the effectiveness of individual components of successful programmes. We will also seek to identify and explore the dominant mediators of speeding behaviour with a view to understanding the mechanisms of action of effective programmes. We will summarise costs of the programmes if economic data are available.

METHODS

Criteria for considering studies

We will use broad inclusion criteria for considering studies, in order to include programmes that have undergone controlled evaluation, as well as those that have been assessed descriptively or qualitatively.

Types of study

We will include both experimental and observational studies of automated traffic speed enforcement programmes. Experimental study designs will be used to provide evidence of effectiveness, and may include controlled-before-after (CBA) studies, controlled interrupted time series, and randomised controlled trials. Observational study designs will be included to provide details of mechanisms, moderators, implementation and economic costs, and may include cohort, cross-sectional, or case-control studies.

Types of population

Inclusion criteria:

- Roads subject to any type of automated or semi-automated speed enforcement intervention.

Exclusion criteria:

- Interventions using red light traffic signal cameras at signalized junctions.

Types of programme

This review covers all types of automated or semi-automated speed enforcement measures. This includes speed cameras (photo radar), laser and other radar devices, as well as ancillary equipment such as road embedded electromagnetic loops.

Outcome measures

Primary outcome measures

The primary outcome variables will be proportion of vehicles travelling over the posted speed limit, and the average speed of traffic.

Secondary outcome measures

The secondary outcome variables will be number of traffic crashes, fatalities from crashes, injuries from crashes, and numbers of traffic law violations.

Other data

We will also seek data on economic outcomes (including costs of providing the intervention and income generated by the intervention) and process outcomes (e.g. data on implementation).

Identification of eligible studies and data extraction

Our search methods will comprise four parts: first, we will search electronic bibliographic databases for published work (see below for electronic databases to be searched); secondly, we will search the grey literature for unpublished work; thirdly, we will search trials registers for ongoing and recently completed trials; finally, we will search reference lists of published studies, contact authors and specialist groups to enquire about unpublished studies (*see Appendix 1 for full search strategy for a selected database*). In order to reduce publication and retrieval bias we will not restrict our search by language, date or publication status. The sources to be searched have been chosen based on their coverage of the topic.

Electronic sources

We will search the following:

1. Ovid MEDLINE(R) 1946 to current;
2. Ovid MEDLINE(R) In-Process & Other Non-Indexed Citations;
3. Ovid MEDLINE(R) Daily and Ovid OLDMEDLINE(R) 1946 to current;
4. Ovid TRANSPORT (includes the Transport Research Information Services (TRIS), The International Road Research Documentation (IRRD) and The European Conference of Ministers of Transport (TRANSDOC) databases) 1968 to current;
5. National Police Library
6. Embase Classic+Embase (OvidSP) 1947 to current;
7. ISI WOS: SCI-EXPANDED (1970) & CPCI-S (1990) to current;
8. PubMed (current);

Other sources

We will search the following websites for reports and other grey literature:

1. The Scottish Government (<http://www.scotland.gov.uk/Topics/Justice/crimes>)
2. College of Policing catalogue (<http://www.college.police.uk/>)
3. UK Justice (<https://www.justice.gov.uk/>)

We will also perform an internet search, using the Google search engine, to search for grey literature and organisations related to prevention of speeding and road traffic crashes (including for instance: Australian College of Road Safety, Institution of Highways and Transport, The International Association of Traffic and Safety Science). The search strategy

(Appendix 1) will be adapted as necessary to search all other listed sources including the internet search.

Screening and review process

All studies identified through the search process will be exported firstly to the EndNote bibliographic database for de-duplication. Once duplicate records have been removed the records will be imported into EPPI-Reviewer 4 software for screening and coding. This will allow the team to manage coding tasks, assess inter-rater reliability, and share the results (within the consortium and externally). Two review authors will independently examine the titles, abstracts, and keywords of electronic records for eligibility according to the inclusion criteria above. Results of this initial screening will be cross-referenced between the two review authors, and full-texts obtained for all potentially relevant reports of studies. Full-texts of potentially eligible studies will go through a secondary screening by each reviewer using a screening form based on the inclusion criteria (*to be prepared*) for final inclusion in the review, with disagreements resolved by discussion with a third author. Reference lists of all eligible trials will be searched for further eligible studies.

Data extraction

Two review authors will independently code relevant data in EPPI Reviewer using a standardised data coding set (*see Appendix 2 for draft data items*). Corresponding authors of studies will be contacted directly if the required data are not reported in the published manuscript.

ANALYSIS

Descriptive analysis

We will describe all studies that meet the inclusion criteria, including:

1. Study design

- Study design and quality (risk of bias)
- Data collection methods, modes, and techniques; validity of tools
- Statistical and other analyses

2. Participants (intervention and control if relevant)

- Study setting (country, urban/rural location)

- Nature of roads (Road type: motorway, major, minor, and speed limit)

3. Components of programme

- Mobile or fixed cameras
- Manned or unmanned cameras
- Covert or overt cameras
- Single point or average speed
- Theoretical basis used in the design of the intervention components

4. Outcomes

- Primary outcomes (e.g. Percentage of vehicles travelling above the speed limit, average speeds)
- Secondary outcomes (e.g. road traffic crashes, deaths and injuries, numbers of traffic law violations).

Assessment of risk of bias in included studies

Two review authors will independently assess the quality of the included studies and any discrepancies were resolved by deferment to a third review author. Study quality will be based on:

- 1) Matching of intervention and control areas (e.g. the comparability of the areas; whether control areas are adjacent to the intervention area)
- 2) Blinding of data collection and analyses
- 3) Lengths of data collection time period pre- and post-intervention
- 4) Selective reporting of results by study authors
- 5) Control of confounders (e.g. was there an assessment of the distribution of confounders between intervention and control groups?)
- 6) Any other potential sources of bias.

The review authors will rate the risk of bias as high risk, low risk, or unclear or unknown risk.

Statistical analysis

Measures of treatment effect

To facilitate comparisons of studies we will devise a standardised and well-defined summary measure for each outcome. Summary measures will be based on relative effects, rather than difference in effect, where the outcome after intervention is divided by that before the intervention as an expression of the proportional change in outcome. We will calculate summary measures for all studies where possible (i.e. where required information is reported or adequate data is available for calculation).

We anticipate that the majority of studies will be CBAs reporting outcomes in intervention areas before and after the intervention, and for comparable time periods in a control area. We will estimate a rate ratio by dividing the count of the outcome post- and pre-intervention in the intervention area by the corresponding ratio in the control area.

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

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

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

Data synthesis

We will pool the results in a random-effects meta-analysis if three or more studies report the same outcome. We will pool the logarithm of the rate ratio its standard error (calculated assuming a Poisson distribution for the number of collisions in each area and time period). If there are too few studies for a meta-analysis the results of individual studies will be presented in a narrative review. Heterogeneity among the effect estimates will be assessed using a chi-squared test at a 5% significance level and 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. We will consider an I^2 value greater than 50% to reflect substantial heterogeneity. We will conduct sensitivity analyses in order to investigate possible sources of heterogeneity due to study quality (e.g., adequate vs. inadequate allocation concealment; low vs. high attrition). Details of each intervention will be presented

in a table of study characteristics. We will use statistical software (Stata version 14) to conduct the meta-analysis.

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- RAC (2015) RAC Report on Motoring 2014: Britain on the road.
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Appendix 1 – OVID Transport Database search strategy

1988 to June 2015

- 1 (police* or speed* or vehicle* or motor vehicle* or automobile).mp. [mp=abstract, title, heading word, accession number] (141888)
- 2 (enforce* or detect* or radar* or camera* or laser* or limit*).mp. [mp=abstract, title, heading word, accession number] (73435)
- 3 ((police* or speed* or vehicle* or motor vehicle* or automobile) adj3 (enforce* or detect* or radar* or camera* or laser* or limit*)).mp. [mp=abstract, title, heading word, accession number] (10158)
- 4 (accident* or colli* or fatal* or injur* or crash* or speed*).mp. [mp=abstract, title, heading word, accession number] (99376)
- 5 (reduc* or prevent* or safe* or deter* or aver* or avoid* or control* or prohib* or stop* or cut* or curtail* or decreas* or limit* or minim* or moderat*).mp. [mp=abstract, title, heading word, accession number] (290107)
- 6 ((accident* or colli* or fatal* or injur* or crash* or speed*) adj3 (reduc* or prevent* or safe* or deter* or aver* or avoid* or control* or prohib* or stop* or cut* or curtail* or decreas* or limit* or minim* or moderat*)).mp. [mp=abstract, title, heading word, accession number] (29906)
- 7 3 and 6 (6353)
- 8 before-after.mp. [mp=abstract, title, heading word, accession number] (364)
- 9 before-and-after.mp. [mp=abstract, title, heading word, accession number] (4158)
- 10 before-and-after-studies.mp. [mp=abstract, title, heading word, accession number] (1182)
- 11 before-and-after-study.mp. [mp=abstract, title, heading word, accession number] (989)
- 12 8 or 9 or 10 or 11 (4158)
- 13 controlled-trial.mp. [mp=abstract, title, heading word, accession number] (40)
- 14 controlled-trials.mp. [mp=abstract, title, heading word, accession number] (48)
- 15 13 or 14 (79)
- 16 placebo-controlled.mp. [mp=abstract, title, heading word, accession number] (32)
- 17 placebo-effect.mp. [mp=abstract, title, heading word, accession number] (0)
- 18 placebo-kontrollierten.mp. [mp=abstract, title, heading word, accession number] (3)
- 19 placebo-konzepts.mp. [mp=abstract, title, heading word, accession number] (1)
- 20 placebo-washout.mp. [mp=abstract, title, heading word, accession number] (1)
- 21 placebogruppe.mp. [mp=abstract, title, heading word, accession number] (1)
- 22 placebokontrollierten.mp. [mp=abstract, title, heading word, accession number] (3)
- 23 16 or 17 or 18 or 19 or 20 or 21 or 22 (41)
- 24 double-blind.mp. [mp=abstract, title, heading word, accession number] (64)
- 25 single-blind.mp. [mp=abstract, title, heading word, accession number] (18)
- 26 24 or 25 (81)
- 27 randomisation.mp. [mp=abstract, title, heading word, accession number] (8)
- 28 randomization-.mp. [mp=abstract, title, heading word, accession number] (48)
- 29 randomize.mp. [mp=abstract, title, heading word, accession number] (2)
- 30 randomized.mp. [mp=abstract, title, heading word, accession number] (228)
- 31 randomizing.mp. [mp=abstract, title, heading word, accession number] (5)
- 32 randomly.mp. [mp=abstract, title, heading word, accession number] (1399)
- 33 27 or 28 or 29 or 30 or 31 or 32 (1644)
- 34 comparative.mp. [mp=abstract, title, heading word, accession number] (4736)
- 35 comparative-analysis.mp. [mp=abstract, title, heading word, accession number] (1054)

- 36 34 or 35 (4736)
- 37 impact-studies.mp. [mp=abstract, title, heading word, accession number] (1083)
- 38 impact-study.mp. [mp=abstract, title, heading word, accession number] (2195)
- 39 impact-study-environment.mp. [mp=abstract, title, heading word, accession number] (770)
- 40 impact studies.mp. [mp=abstract, title, heading word, accession number] (1083)
- 41 37 or 38 or 39 or 40 (3188)
- 42 field-studies.mp. [mp=abstract, title, heading word, accession number] (2620)
- 43 12 or 15 or 23 or 26 or 33 or 36 or 41 or 42 (15981)
- 44 7 and 43 (602)

Appendix 2 – Data items to be extracted

Study design

- Meta-analysis
- RCT
- Controlled interrupted time series
- Controlled before and after
- Before/after not controlled
- Cross sectional
- Case study
- Qualitative
- Commentary

Study length

- Dates of before period
- Dates of after period

Data collection details

- Data sources
- Creation of variables

Characteristics of intervention sites

Characteristics of control sites

Study setting and nature of roads

- Country
- Urban/rural
- Road type (motorway, major road, etc)

Study aims

Intervention type:

- Mobile
- Fixed
- Manned
- Unmanned
- Covert
- Overt
- Average Speed
- Single point

Intervention components

- Number of cameras
- Size of area covered

Implementation (what is needed to implement speed cameras)

Mechanism

- Theory or mechanism of change

Measures of exposure to speed cameras

Outcome measures:

- Percentage of speeding drivers above the speed limit
- Average speed in areas with and without cameras
- Duration of speed reduction
- Road user deaths
- Road user injuries
- Road traffic crashes
- Total numbers of crimes

Statistical Methods

Description and treatment of bias and confounding

- Matching of intervention and control areas (e.g. the comparability of the areas; whether control areas are adjacent to the intervention area)
- Blinding of data collection and analyses
- Lengths of data collection time period pre- and post-intervention
- Control of confounders (e.g. was there an assessment of the distribution of confounders between intervention and control groups?)
- Adjustment for time trends
- Any other potential sources of bias (regression to the mean, adjustments for seasonality)
- Selective reporting of results by study authors

Results - – identify where to find quantitative results

- Difference between groups (include CI)
- Interpretation

Cost information