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PERFORMANCE OF SAFETY CAMERAS IN LONDON: FINAL REPORT

Version: 1

by R Gorell and B Sexton (TRL Limited)

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Executive summary

Safety cameras are a familiar sight throughout the country and have been used in London for just over a decade. The performance of safety cameras has been under intense media coverage, especially in the light of self-financing (cost recovery) initiatives.

Within London, safety cameras (both speed and red-light cameras) are the responsibility of the London Safety Camera Partnership. Most cameras have been inherited by the partnership from other organisations including the Highways Agency and London Boroughs. The London Safety Camera Partnership has asked TRL to undertake research to provide a robust analysis of the safety performance of the speed cameras under their authority, focusing on those which would have met the current primary criterion for installation adopted by the Department for Transport (i.e. having four or more collisions, each involving at least one person who was killed or seriously injured, in 3 years, over a distance of 1 km). Red-light cameras were not included in the analysis.

The principal methodology adopted for this research was a “before” and “after” study comparing collision numbers at safety camera sites with those at suitably matched control sites. Each safety camera site was paired with a control site with a similar collision history covering the 3 years before the installation of the safety camera. Each control site was also similar to its paired camera site in terms of traffic flow, length and geographical location. The study design enabled the effects of cameras to be isolated from regression-to-mean and trend effects. A secondary methodology, known as Empirical Bayes, was also used. This provided generally similar results to the main analysis, but also enabled estimates of the effects of cameras on individual types of accident to be made.

For the 77 safety camera sites which would have met the current primary criterion for installation (and where suitable control sites could be identified), it is estimated that the presence of safety cameras has reduced the number of collisions involving fatal or serious injury by a statistically significant 21%. Cameras are estimated to have reduced the total number of collisions involving fatal, serious or slight injury by a statistically significant 12%.
1 Introduction

Safety cameras are a familiar sight throughout the country, and have been used in London for just over a decade. The performance of safety cameras has been under intense media coverage, especially in the light of self-financing (cost recovery) initiatives.

Within London, safety cameras (both speed and red-light cameras) are the responsibility of the London Safety Camera Partnership (LSCP). Most cameras have been inherited by the partnership from other organisations including the Highways Agency and London Boroughs. The LSCP has asked TRL to undertake research to provide a robust analysis of the safety performance of the speed cameras under their authority, focusing on those which would have met the current primary government criterion for installation. Red-light cameras were not included in the analysis.

1.1 Installation criterion and selection of sites for analysis

At present, a fixed safety camera can only be installed if there have been four or more KSI collisions (i.e. each involving someone who was Killed or Seriously Injured) in three years, over a distance of 1 km. This primary criterion has been set by the Department for Transport. It applies nationally and helps to ensure that there is consistency in the installation of safety cameras and that their installation is directly related to the personal injury collision record at the site.

Many of the camera sites which are under the responsibility of the LSCP have been inherited from other organisations such as London Boroughs. Unfortunately, LSCP does not have information about the criteria adopted at these sites. Some of these “inherited” sites would not have been installed if they had been required to meet the current installation criterion. (Only the camera sites that have been installed following the creation of the LSCP can be guaranteed to have satisfied this criterion.)

The analysis presented in this report focuses on camera sites having 4 or more KSI collisions per km in the 3-year period before camera installation.

2 Methodology

An outline of the methodology adopted for this study is presented in this section. A more detailed discussion of some aspects of the statistical approach is presented in Appendix A.

The effectiveness of safety cameras can be judged by comparing the number of collisions during a "before" period with the number of collisions during an "after" period. However, this approach does not take into account possible trend and regression-to-mean (selection bias) effects, described below.

Despite increases in traffic flows, the frequency of many types of personal injury collision has been reducing in recent years due to the introduction of safety measures such as Local Safety Schemes, improved road standards and better car design. Thus reductions in the number of collisions would be expected to have occurred on London roads, whether or not speed cameras had been introduced. If this trend in collision frequency over the time between the "before" and "after" periods is not taken into account, the performance of the safety cameras may be over-estimated.

Another element that needs to be adjusted for is the regression-to-mean effect which may arise from selection bias. Regression to the mean may occur when a safety measure is introduced as a result of a chance peak in collisions. Following such a peak, a reduction in collisions is to be expected, even in the absence of the safety measure. Once again, if this effect is not taken into account, it can lead to an over-estimate of the performance of the safety cameras.
Any methodology adopted must be able to isolate and quantify the real effects of the safety cameras separately from the effects of trend and selection bias. An appropriate way to achieve this is to carry out a “before” and “after” study comparing collision numbers at “camera” sites with those at suitably matched “control” sites, as this provides a means of correcting the raw “before” to “after” differences in collisions at camera sites for both selection bias and trend effects.

Before undertaking the analysis it was necessary to collect "before" and "after" data from the camera sites and identify and collect data from suitable control sites.

Background information on the safety camera sites and issues concerning the collection of data are presented in Section 2.1. The identification of suitable control sites for this study is discussed in Section 2.2. The collection of "before" and "after" data from the camera and control sites is described in Section 2.3. In Section 2.4 there is a brief description of the statistical approaches applied in the analysis in order to isolate the effect of the safety cameras on collision frequency, and Section 2.5 presents the results. The Appendix gives more information on the statistical method and presents some further results.

2.1 Safety camera sites and data collection

At this stage it is important to understand how the LSCP defines a camera site and how collision data are recorded. It is also important to state that this analysis is based on Personal Injury Collision data, as collected by the Police under the “Stats19” regime.

Each safety camera is installed on the Greater London road network. This network is defined by a series of links and nodes. In general the nodes are major junctions and the links are the roads between these major junctions. (Occasionally there are nodes at the boundaries between boroughs.) Collisions which occur within 50m of a node centre are associated in the database with that node.

Each camera is assigned to a link within the network. Collisions which occur within 400m on either side of the camera on the link in question are said to occur at a camera site. If the camera is located near a node, the site is truncated. For example, if the camera site is 200m from the centre of a node in one direction and 800m from the centre of a node in the other direction, the camera site will be limited by the presence of the node in one direction (and its 50m radius) and will also be limited to 400m in the opposite direction. In this case the camera site will be 550m long, and will not include the node at the end of the site. The extent of each camera site was set up by LSCP in advance of the present study.

This study focuses on the analysis of camera sites that would have satisfied the current primary criterion for installation. Using the collision data it is possible to establish which camera sites had at least 4 KSI collisions in the 36 months before installation. Once identified, an analysis can be carried out on these sites to see how camera sites satisfying the criterion have performed.

The study focuses on camera sites which had at least 4 KSI collisions. One of the statistical approaches adopted to take account of trend and regression-to-mean effects (as described in Section 2.4) benefits from the use of data from as many sites as possible. Therefore, data from all camera sites were collected and made available for use in this study.

It should be noted that the selection of camera sites which each had at least 4 KSI collisions in the 36 months before installation has two limitations/approximations. Firstly, the camera sites may be less than 1 km long, as described above, but the installation criterion is defined “per km”. This means that some sites that could have satisfied the criterion may have been missed. Secondly, there may in practice be a delay of a few months between a site being identified as meeting the criterion and the actual installation of a camera at the site. For example, if the collision record at a site was 4 KSI in the years 1998, 1999, 2000, the camera may have actually been installed in May 2001. This leads to a problem in identifying the appropriate before period as it is impossible to say with certainty how long the delay is between the site meeting a criterion and the installation of the camera. For this study, it has been assumed that the before period covers the 36 months immediately prior to the installation date. As a result, the before period may not exactly match the period used for determining whether or not the criterion had been met.
2.2 Identifying the control sites

After consultation with the LSCP, and as noted at the start of Section 2, it was concluded that for this study it would be most appropriate to identify a set of “control” sites against which the camera sites could be compared. Ideally these control sites would have the same “before” personal injury collision record as the camera sites, i.e. the same number of personal injury collisions in the three-year period prior to the camera installation. (The period of three years is used to limit the effect of random variation in the data.)

Each "camera" site was matched or paired with a suitable "control" site, and this process was based on the "before" total personal injury collision record at the camera site (not just the KSI record). This ensured that the maximum number of sites could be paired. As well as matching the number of collisions at the control and camera sites, it is also necessary to ensure that the links themselves have matching characteristics. For example, it is desirable that the camera site and its control site have similar vehicle flow levels and lengths and come from the same geographical area in London. By ensuring that camera and control sites are as similar as possible, we improve our ability to identify any excess collision reduction at the camera sites arising from the effects of the cameras themselves. Regression-to-mean effects are reduced by collecting collision data for a three-year period before camera installation. This reduces the scope for upward bias in the estimate of the “before” collision frequencies at the sites. Matching the control and camera sites on their “before” collision frequencies is also designed to reduce regression-to-mean effects since any selection bias that is present at the camera sites will tend to be replicated at the control sites - so that the subsequent regression-to-mean effect will also make itself felt at the control sites and the net regression-to-mean effect will thus be minimised when control and camera sites are compared in the analysis.

Once a control site has been identified for each camera site, it is necessary to extract “after” data for each camera site and its control site. Once again, these data cover a period of three years in order to limit the effects of random variation in the data. An appropriate statistical approach can then be used to analyse and compare the “before” and “after” data at the camera sites and control sites.

The LSCP has access to data on all the personal injury collisions that occur on the London Accident Analysis Unit network via two computer programs; “AccStats” and “Discoverer”. The control sites were identified using the following approach.

A Traffic Accident Data (TAD) report was generated using the “AccStats” software. This report lists the number of personal injury collisions that occurred in the three years before the installation of each camera site. For each camera site the date of its installation and the Borough of its installation were extracted and used to generate a second set of collision reports. This second report lists the numbers of personal injury collisions that have occurred on all the links within the Borough for the period three years before the installation of the camera site. The report was then scrutinised to identify links with the same, or a very similar, number of collisions to the camera site, over the three years before the safety camera was installed. These links were plotted with the camera site onto a map in order to establish the general characteristics of both the camera site and the control sites. These maps were then examined to determine which of the potential link sites best matched the camera site. For example, the matching will take account of the lengths of the links, likely flow levels and the geographical relationship of the potential control sites to the camera sites.

A number of rules were applied to identify the control sites. Wherever possible, the camera site and the control site were in the same Borough. If this was not possible, then a control site from a neighbouring Borough was identified. The camera sites are on roads which are either on the “Borough” road network or roads on the Transport for London Road Network (TLRN). Where there was a choice between possible control sites, preference was given to road links on the same road network as the camera site. In order to avoid potential difficulties with regard to the “sphere of influence” around the camera site, it was decided that a control site could not be immediately adjacent to a safety camera site link. Finally, it was checked that the chosen control site did not become a camera site within the three year “after” monitoring period.
It should be noted that there were a small number of safety camera sites where no suitable control site could be identified. Most of these were on the M4. (The M4 sites have been subject to a separate analysis undertaken for the Highways Agency “West London Speed Camera Demonstration Project”.) In total, suitable controls for 9 safety camera sites could not be identified (6 of which were sites with 4 or more KSI collisions). Therefore, these sites have been excluded from the analysis.

2.3 Extraction of “before” and “after” data

In order to extract the “before” and “after” data, details of the control sites were added to the database which contains details of the safety camera sites. (This effectively created a series of non-camera sites which could be accessed using the same software as the camera sites.)

Using the “Discoverer” software, two sets of spreadsheets were produced which detailed the number of fatal, serious and slight injury collisions that had occurred at the safety camera sites and control sites during each month. These spreadsheets covered the period January 1986 to April 2004. (This period covers three years before the installation of the first camera to the most recently available data.) A macro was produced to isolate the collisions that had occurred at each safety camera site and its paired control site during the 36 months before and 36 months after the installation of the safety camera.

The month of installation of the camera at each site was excluded from the analysis. For example, if the camera site was installed in April 1998, the before period covers the months April 1995 to March 1998 and the after period covers the months May 1998 to April 2001. This allows a “settling down” period following installation.

It was noted during the data extraction process that in the LSCP database systems there would sometimes be a camera site defined but the system would not yield the necessary collision data. The main reason for this, which has been confirmed with LSCP, is that a camera site had been defined (incorrectly) and then removed from part, but not all of the system. This problem affected 21 of the apparent safety camera sites (4 of which were sites with 4 or more KSI collisions).

It should also be noted that camera sites with less than 3 years of after data have been excluded from the analysis presented here. That is, sites that were installed after April 2001 are not included in the analysis.

As a result, 77 safety camera sites with 4 or more KSI collisions in the 3 years prior to installation, and 194 other camera sites, have been paired with suitable control sites. The analyses focus on the effect of safety cameras on collision numbers at the 77 sites with 4 or more KSI collisions in 3 years.

2.4 Analysis

As noted earlier, it is not sufficient to simply compare the "before" and "after" collisions at the camera sites. This is because such a comparison does not separate the effects of the cameras from trend or site selection bias (regression to mean) effects. This problem is not new - the regression to mean (RTM) problem is one that is inherently associated with evaluation of treatment effects in any situation where a treatment (intervention) has been introduced at sites selected because they have high collision frequencies. By definition, camera sites selected because of high numbers of KSI collisions will be a biassed sample of all potential camera sites, and so it is likely that there will be RTM effects.

There are several possible ways of dealing with RTM and trend effects. One (Hauer, 1997 chapter 9) is to compare the collision frequencies at the camera sites before and after installation, with those at control sites that are matched with the camera sites in terms of collision frequencies. The matching means that the RTM effect at the control sites will be of similar size to that at the camera sites. The before-after difference at the control sites will consist of this RTM effect, together with an underlying time-trend if one exists. The before-after difference at the camera sites will consist of the effect of the cameras, an RTM effect, and the underlying time trend. Comparing the camera and control sites will thus enable the effect of the cameras to be isolated.
A second approach is via the "Empirical Bayes" (EB) method (Hirst et al, 2004; Mountain et al 2004; Hauer 1997, chapter 11). Here, the underlying "before" collision rate at camera sites is estimated from two sources of data, one being the accident frequencies for the population of sites from which camera sites are selected, and the other being the actual "before" frequencies of accidents at the camera sites. The effect of this analysis is to remove the source of any potential RTM effect from the "before" collision frequencies at the camera sites. The difference between this corrected value and the observed "after" collision frequencies at the camera sites is then made up of the effect of the cameras, together with any time trend in collisions between the “before” and “after” periods. If this time trend can be estimated from “before” and “after” collision frequencies at control sites (which may also need to be adjusted for RTM), then the effect of cameras alone can be isolated.

In the present study, the first approach was the main one taken. This was fully appropriate for estimating the effects of cameras on total collisions since the camera and control sites were matched in terms of total (i.e. all severities) collision frequency. For estimating the effects of cameras on KSI collisions, the situation was more complicated since the camera and control sites had not been matched for this class of collisions. The approach taken here was to select from the overall pool of 271 control sites a subset of 68 that had experienced at least 4 KSI collisions in the three year period, and use these as the control sites for the KSI collision estimates.

As a secondary analysis, the EB approach was used. However the problem here was that no information was available on the collision frequencies at the population of potential camera sites, and insufficient information about these sites was available to allow these collision frequencies to be estimated using known collision model relationships between site characteristics and collisions. Information was, however, available on KSI collision frequencies at the full set of 271 camera and 271 control sites. Since many of these camera sites were not originally chosen on the basis of their KSI record, this set of data provides an indication of the underlying collision frequencies at the population of potential camera sites. The EB approach used in this way should provide a good indication of the effects of cameras on the assumption that the bias introduced by the initial selection of sites is relatively weak. Although this assumption cannot be tested in this study there was broad agreement between the results of the two approaches. This gives reassurance that in situations where only the EB approach can be used (i.e. the analysis of individual types of collision reported in the Appendix), it will have given reasonably robust results.

### 2.5 Results

Table 1 summarises the results of applying to KSI collisions the first of the above approaches. At sites where there had been four or more KSI collisions in the previous three years, cameras were estimated to reduce KSI collisions by 20.6%, an effect that was statistically significant at the 5% (p=0.05 level). The table shows the approximate 95% confidence interval for this estimate. The second (EB) approach produced a very similar result, the 95% confidence interval being -5% to -32%.

**Table 1: Percentage change in KSI collisions (4 or more KSI safety camera sites)**

<table>
<thead>
<tr>
<th>Estimated effect of safety cameras on KSI collisions</th>
<th>Statistical significance level</th>
<th>Approximate 95% confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>-20.6%</td>
<td>p&lt;0.05</td>
<td>-3.8% to -37.4%</td>
</tr>
</tbody>
</table>
The results of the analysis for all personal injury collisions are shown in Table 2. They indicate that there was a 12.4% reduction in all injury collisions attributed to the introduction of cameras where there had been 4 or more KSI collisions in the previous 3 years.

Table 2: Percentage change in all personal injury collisions (4 or more KSI safety camera sites)

<table>
<thead>
<tr>
<th>Estimated effect of safety cameras on all injury collisions</th>
<th>Statistical significance level</th>
<th>Approximate 95% confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>-12.4%</td>
<td>p&lt;0.01</td>
<td>-4.2% to -20.6%</td>
</tr>
</tbody>
</table>

### 3 Conclusions

The results presented in this report provide a good understanding of the performance of safety cameras in London, and indicate substantial, statistically significant reductions in collisions following their introduction. At sites where there had been 4 or more KSI collisions in the previous 3 years there was an estimated 21% reduction in KSI collisions and a 12% reduction in all injury collisions attributable to the introduction of the cameras.

### Acknowledgements

The work described in this report was carried out in the Safety Group of TRL Limited. The authors are grateful to Chris Baughan and Marie Taylor who carried out the technical review of this report.

The authors wish to acknowledge the following LSCP staff for their assistance in extracting collision data used in this study: Sandra Cowland, Martin Brophy, John Devenport, and Vlad Kovach.

### References


West London Speed Camera Demonstration Project:
Appendix A. Analysis of safety camera data

A.1 The Empirical Bayes approach

As described in the main text, one of the analysis approaches used in the study is known as Empirical Bayes (EB). EB uses a methodology to estimate the expected number of collisions conditional (based) on the actual (sample) number observed. This approach can be used to estimate the number of expected “before” collisions at the camera and control sites and thus provides a way of taking account of the RTM effect. The underlying parameters were estimated in the present study using all the available “before” data (that is, data from all sites, whether or not the camera or control site had had 4 or more KSI collisions in the previous 3 years). The underlying mean collision value (µ) took the same value for all the camera and control sites regardless of whether they had had 4 or more KSI collisions in 3 years. The data were also used to derive the proportion (α) to use in the empirical Bayes equation. This was needed when deriving the conditional expected collision values per site; see the approach in Hauer (1997, chapter 11). The conditional EB estimate for collisions in the before period (Mk) for sites with K observed collisions was then estimated from the following:

\[ Mk = \alpha \mu + (1-\alpha) K \]

The EB estimate for all camera site “before” collisions used the EB expected collision values summed over those camera sites with 4 or more KSI collisions, and similarly for the control sites.

If detailed flow data, link length data and intersection data had been available then µ could have been modelled and may have varied according to the resulting collision model. In fact, a limited amount of “before” and “after” vehicle flow data was obtained from the subset of safety cameras that were installed in 2003. (These were the only sites where some form of “before” and “after” flow data were available.) These sites were not included in the main analysis as they have less than 3 years of “after” data. The sample was small, but indicated that vehicle flows did not substantially change after the camera installation at these sites. This suggests that a model that allows for flow changes is not required in the analysis. The approach used here is therefore considered to be an appropriate application of EB given the constraints. However, as pointed out in Section 2.4 it does rely on the assumption that the bias associated with selecting the whole set of 271 camera sites was relatively unimportant, such that these sites and their matched controls give a reasonable estimate of the underlying accident rate at potential camera sites. This assumption cannot be tested, which is why the EB approach was used only as a secondary analysis in the study. However, there was broad agreement between the results of the EB approach and the simple comparison of matched camera and control sites. This gives reassurance that in situations where only the EB approach can be used (ie the analysis of individual types of collision reported below in this Appendix), it will have given reasonably robust results.

The trend applied to the EB adjusted “before” collisions at camera sites was determined from the control site collision data. It was estimated as the ratio of the control site “after” collisions to the control site “before” collisions, adjusted for RTM. The estimate was based on only those control sites which matched the camera sites in terms of the level of collision, for example, those having 4 or more KSI collisions in the “before” period.
A.2 Further results

Data supplied by the London Safety Camera Partnership consisted of collision data for 3 years before a camera was installed and for 3 years after it had been installed. Every camera site was matched to a control site that had a very similar number of all personal injury collisions for the 3 year “before” period; the control site was also on a similar road and in the same Borough. Three years of “before” and “after” collision data were also supplied for control sites.

The main text presents estimated effects of speed cameras on KSI collisions and all injury collisions for cameras that had been installed at sites experiencing at least 4 KSI collisions in the preceding three years. These sites were the main focus of the study since they meet the current primary installation criterion for speed cameras. Analyses were also carried out to estimate the effect of speed cameras on all injury collisions at all sites on the LSPC network. The results of this analysis are shown in Table A1, which also repeats the results obtained for the 4 or more KSI sites. It was not possible to carry out a robust analysis of the effect of all the LSPC cameras on KSI collisions, as the matching of camera and control sites for the set of 271 camera sites was on the basis of all injury collisions, and there was insufficient information on the underlying population accident rates to allow the EB approach to be used.

Across all sites, cameras were estimated to reduce all injury collisions by 11.6%. This effect was statistically significant.

**Table A1. Effects of speed cameras on KSI and all injury collisions**

<table>
<thead>
<tr>
<th>Type of camera site</th>
<th>Type of collision</th>
<th>Estimated effect of safety cameras</th>
<th>Statistical significance level</th>
<th>Approximate 95% confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 or more KSI</td>
<td>KSI</td>
<td>-20.6%</td>
<td>p&lt;0.05</td>
<td>-3.8% to -37.4%</td>
</tr>
<tr>
<td>4 or more KSI</td>
<td>All injury</td>
<td>-12.4%</td>
<td>p&lt;0.01</td>
<td>-4.2% to -20.6%</td>
</tr>
<tr>
<td>All</td>
<td>All injury</td>
<td>-11.6%</td>
<td>p&lt;0.01</td>
<td>-5.8% to -17.4%</td>
</tr>
</tbody>
</table>

Further analyses were undertaken to investigate the reductions in individual types of personal injury collisions resulting from the introduction of safety cameras. These analyses were based on the sites with 4 or more KSI (“before”) collisions. Here, the simple comparison of matched camera and control sites became less appropriate, because the matching had not been in terms of individual types of collision.

Table A2 therefore presents the results of EB analyses. There are uncertainties with this application of the EB approach, associated with the assumptions discussed in Section 2.4. However, the good agreement between the EB results and those of the simple analysis in situations where both could be applied does give reassurance that the estimates presented in Table A2 are reasonably valid.
Table A2. Percentage change in specific types of personal injury collision attributable to speed cameras

<table>
<thead>
<tr>
<th>Collision type, involving….</th>
<th>Size of safety camera effect</th>
<th>Statistical significance level</th>
<th>Approximate 95% confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Powered 2-wheeler</td>
<td>-20.5%</td>
<td>p&lt;0.01</td>
<td>-8.7% to -32.3%</td>
</tr>
<tr>
<td>Cyclist</td>
<td>-28.8%</td>
<td>p&lt;0.01</td>
<td>-10.4% to -47.2%</td>
</tr>
<tr>
<td>Pedestrian</td>
<td>-11.8%</td>
<td>ns</td>
<td>+1.4% to -25.0%</td>
</tr>
<tr>
<td>Child</td>
<td>-16.6%</td>
<td>ns</td>
<td>+0.8% to -34.0%</td>
</tr>
<tr>
<td>Darkness</td>
<td>-12.6%</td>
<td>p&lt;0.05</td>
<td>-1.6% to -23.6%</td>
</tr>
<tr>
<td>Wet</td>
<td>-16.5%</td>
<td>p&lt;0.05</td>
<td>-4.3% to -28.7%</td>
</tr>
</tbody>
</table>