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Speed cameras, section control, and kangaroo jumps–a meta-analysis

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ABSTRACT

A meta-analysis was conducted of the effects of speed cameras and section control (point-to-point speed cameras) on crashes. 63 effect estimates from 15 speed camera studies and five effect estimates from four section control studies were included in the analysis. Speed cameras were found to reduce total crash numbers by about 20%. The effect declines with increasing distance from the camera location. Fatal crashes were found to be reduced by 51%, this result may however be affected by regression to the mean (RTM). Section control was found to have a greater crash reducing effect than speed cameras (−30% for total crash numbers and −56% for KSI crashes). There is no indication that these results (except the one for the effect of speed cameras on fatal crashes) are affected by regression to the mean, publication bias or outlier bias. The results indicate that kangaroo driving (braking and accelerating) occurs, but no adverse effects on speed or crashes were found. Crash migration, i.e., an increase of crash numbers on other roads due to rerouting of traffic, may occur in some cases at speed cameras, but the results do not indicate that such effects are common. Both speed cameras and section control were found to achieve considerable speed reductions and the crash effects that were found in meta-analysis are of a similar size or greater than one might expect based on the effects on speed.

1. Introduction

Fixed speed cameras and section control (point-to-point speed cameras) aim at reducing speed and thereby crashes. Excessive speed is a contributing factor to a large proportion of crashes, especially serious crashes, and speed reductions have consistently been found to be accompanied by considerable crash reductions. Example according to the power model that has been developed by Elvik (2009) (see also Cameron and Elvik, 2010) a decrease of average speed by 10% reduces the number of fatal crashes on average by 35% and the number of injury crashes by 16%. Fixed speed cameras take pictures of vehicles exceeding the speed limit (usually with a certain tolerance) and the vehicle owner (or driver) can then be sanctioned. Fixed speed cameras were first used in a large scale in 1998 in Victoria, Australia (Belin et al., 2010). Section control is an extension of fixed speed cameras. Speed is not measured at a single point but on a longer section of road. Based on pictures taken at two speed camera locations that may be installed at a distance of several kilometres from each other, the average speed is calculated and if the average speed exceeds the speed limit (or some limit above the speed limit) the vehicle owner (or driver) can be sanctioned.

Speed camera and section control programs differ in different countries in several ways. For example speed cameras may be in operation continuously or only at certain more or less predictable times (e.g., in Norway older speed cameras were equipped with mechanical cameras that were rotated between camera locations, Ragnøy, 2011), there are varying thresholds for sanctioning car owners/drivers, and there are differences in whether drivers or car owners are sanctioned. In general however, fixed speed camera and section control programs are quite similar in different countries and both speed cameras and section control are usually visible and signposted.

Concerns about speed cameras and section control refer mainly to privacy issues and the safety effects vs. revenue raising effects (Tay, 2010; Wilson et al., 2012). In contrast to hidden speed cameras however, fixed speed cameras are visible and signposted and the aim is to prevent speeding rather than to catch offenders. There are also concerns about crash migration, i.e.,, that crash reductions at camera sites may be compensated, or more than compensated, by increasing crash numbers at other locations. Crash migration might occur when drivers slow down at camera locations but drive faster before and/or after the camera than they would have done otherwise (kangaroo driving), or when traffic volumes move from roads with speed cameras to parallel roads

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without speed cameras (Andersson and Larsson, 2005; Wilson et al., 2012). On the other hand, there may be spillover effects when speed and crashes are reduced not only at the camera sites but also at other locations (Retting et al., 2008). Kangaroo effects at some distance from the speed cameras and a diversion of traffic away from roads with speed cameras would lead to an overestimation of the crash effects, especially if roads with increased volumes or increased speed are used as a comparison in before–after studies. Spillover effects on the other hand may lead to an underestimation of the crash effects if roads with reduced speed and without speed cameras are used as a comparison group in before–after studies. Another effect that may lead to an overestimation of the effects of speed cameras on crashes is regression to the mean (RTM). RTM occurs when safety measures are implemented at locations with exceptionally high crash numbers in the before period. At such locations crash numbers can be expected to decrease in the after period, even without any (effective) safety measures because crash numbers are always likely to be closer to the mean than farther away from the mean (Elvik, 1997a; Hauer, 1997).

A previous review of the effectiveness of speed cameras (both fixed and mobile) was conducted by Pilkington and Kinra (2005). The review concluded that evidence for the effectiveness of speed cameras was relatively poor. A more recent review (Wilson et al., 2012) reported results for several types of speed cameras (including mobile and hidden speed cameras), but did not summarize effects for fixed speed cameras only or for section control only. The present study summarizes by means of meta-analysis results from empirical studies of the effects on crashes of fixed speed cameras and section control. Additionally, the results are compared with results from studies of the effects of speed cameras and section control on speed. The aim of the study is to summarize existing evidence of the effectiveness of speed cameras and section control in order to estimate the average size of the effect on crashes, the length of road on which a reduction of crashes can be expected, whether there are kangaroo effects (braking and accelerating) and to what degree crash effects can be accounted for by speed reductions, traffic diversion and RTM. More specifically, the following assumptions about the effects of speed cameras and section control are investigated:

1. Speed cameras and section control reduce crashes.
2. Speed cameras and section control have greater effects on more serious crashes.
3. Studies that have controlled for RTM have found smaller effects than other studies.
4. The effects of speed cameras decrease with increasing distance from the camera location, but without being reversed (crash numbers do not increase).
5. The effects of speed cameras on crashes can be accounted for by speed reductions (or other changes of driver behavior), and not by a diversion of traffic away from speed cameras.

The first four assumptions are investigated by means of meta-analysis of crash studies. The fifth assumption is investigated by comparing results from meta-analysis with crash effects that would be expected based on results from studies of the effects on speed and the power model of the relationship between speed and crashes.

2. Log-odds method of meta-analysis

Estimated effects of speed cameras and section control on crashes from different published studies are summarized using the log-odds method of meta-analysis (Christensen, 2003; Elvik, 2005; Fleiss, 1981). From each study at least one effect estimate is calculated. Effect estimates are calculated as odds ratios, i.e., as the ratio of the odds of a crash on a road with speed camera/section control against the odds of a crash on a comparable road without speed camera/section control. The estimated percentage change of the number crashes is equal to the odds ratio minus one, times one hundred; i.e., an odds ratio of e.g., 0.85 corresponds to a percentage change in crash number of $(0.85–1) \times 100 = -15$ percent. Effect estimates are calculated for different degrees of crash severity and for locations at different distances from the speed cameras, as far as information is available.

Summary effects are calculated as weighted means of the natural logarithms of the effect estimates (odds ratios), and then rescaled from the logarithmic scale. Statistical weights are, as far as possible, calculated as random effects (RE) weights. They are a

Table 1
Studies included in the meta-analysis.

Study	Sites	Specific distances from camera[a]	No. of effect estimates	Statistical weight[b]	Control for RTM
Speed camera studies					
ARRB, 2005 (Australia)	28 sites	Yes	9	560.3	No
DePauw et al., 2014 (Belgium)	65 sites	Yes	14	2,374.1	No
DfT, 1997 (UK)	21 cameras on 85 km	No	4	2,365.3	No
Elvik, 1997a,b (Norway)	64 sites	No	1	632.0	Yes
Hess, 2004 (UK)	49 sites	Yes	7	311.0	Yes
Larsson and Brüde, 2010 (Sweden)	51 sites	No	2	107.1	Yes
Li et al., 2013 (UK)	771 sites	Yes	1	458.4	Yes
Mountain et al., 2004 (UK)	62 sites	Yes	11	1,995.7	Yes
Newstead and Cameron, 2013 (Australia)	NA	No	1	15.6	No
Novoa et al., 2010 (Spain)	29 sites	Yes	4	509.5	No
Oei and Polak, 1992 (Netherlands)	4 sites	No	1	50.1	Yes
Pérez et al., 2007 (Spain)	22 sites	No	4	384.2	No
Shin et al., 2009 (USA)	NA	No	1	21.4	Yes
Skubic et al., 2013 (USA)	ca. 13 cameras on 32 km	No	1	129.8	No
Tay, 2000 (New Zealand)	NA	No	2	268.8	Yes
Section control studies					
Brassøe et al., 2011 (UK)	10 sites		1	130.1	Yes
Broughton et al., 2012 (Scotland)	52 km		1	14.7	No
Montella et al., 2012 (Italy)	30% of Italian motorways		2	475.8	Yes
Stefan and Winkelbauer, 2005 (Austria)	2.3 km		1	2.9	No

[a] Whether or not crash effects are reported for several specific distances from the speed cameras are reported (e.g., effects for crashes within 0.5 or 1 km of the speed camera).
[b] Sum of statistical weights in FE models of meta-analysis of all effects that are included in the meta-analysis.