Institute of Transport Economics
Norwegian Centre for Transport Research

Summary:

Evaluation of the crash effects of speed cameras

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Author: Alena Høye
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Crash effects of speed cameras that were installed in Norway in the years 2000 to 2010 were evaluated in a before-after empirical Bayes (EB) study. On road sections of medium length (100 m upstream to 1 km downstream of the speed cameras) a statistically significant reduction of the number of injury crashes by 22% and a non-significant reduction of the number of killed or severely injured (KSI) by 24% was found. On short (100 m upstream to 100 m downstream of the speed cameras) and long (100 m upstream to 3 km downstream of the speed cameras) road sections no statistically significant effects were found. For speed cameras that were installed in 2004 or later more favorable effects were found. The number of injury crashes was reduced by 9% on long and by 32% on medium road sections, and the number of KSI was reduced by 39% on long and by 49% on medium road sections. The results for KSI on the short sections are highly uncertain. The length of the before and after periods is three years before and after installation for each speed camera. The more favorable effects of speed cameras that were installed in more recent years are probably due to changed criteria for the installation of speed cameras and increased compliance with the criteria. The decreasing effect with increasing distance from the speed cameras is probably due to the decreasing effect on speed.

The effects of speed cameras on the numbers of injury crashes and KSI have been investigated in an EB evaluation, which is a before-after study with control for changes of crash risk over time, changes of volumes and road characteristics, and regression to the mean (RTM). Figure S.1 summarizes the results for road sections of different lengths. Results are shown for all speed camera and additionally for speed cameras with early (2000-2003) and late (2004-2010) years of installation.

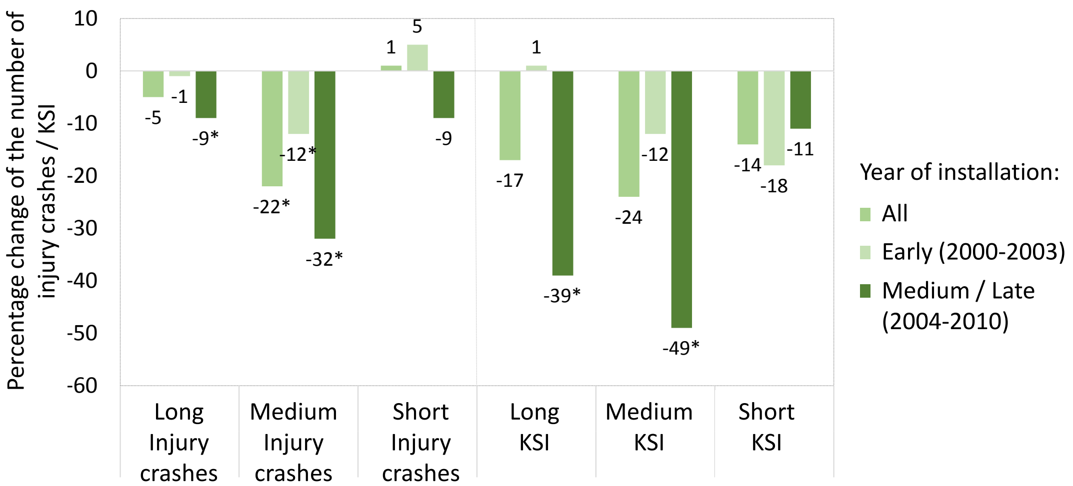

*Figure S.1: Effects of speed cameras on injury crashes and KSI, based on the EB-evaluation. Statistically significant results are highlighted with *.*

Figure S.1 shows only results from the EB-evaluation with control for RTM (results for KSI on the short road sections are calculated with a simplified formula). Speed cameras were for the most part installed at crash-prone locations. Therefore, larger and probably overestimated crash reductions were found without control for RTM.

The evaluation is based on 223 speed cameras that were installed in Norway in the years 2000 to 2010, and on crash data from three years before and three years after the installation of each speed camera. The evaluation was conducted for road sections of different length (overlapping sections were combined in order to avoid double counting of crashes):

- Long: From 100 m upstream to 3 km downstream of the camera sites
- Medium: From 100 m upstream to 1 km downstream of the camera sites
- Short: From 100 m upstream to 100 m downstream of the camera sites

The main results of the evaluation can be summarized as follows:

Speed cameras have the most favorable effects on the most serious crashes. Crash reductions are consistently larger for KSI than for injury crashes which is probably due to the larger effect of speed on more serious crashes.

Speed cameras have larger effects on medium sections (1.1 km) than on long sections (3.1 km). All speed cameras combined, a statistically significant reduction of the number of injury crashes by 22% was found on the medium sections while no statistically significant effect was found on the long sections. The effects on KSI are also larger on the medium sections than on the long sections, but none of them are statistically significant. For those speed cameras that were installed in 2004 or later, statistically significant reductions of both injury crashes and KSI were found on the medium road sections, and smaller (but still statistically significant) reductions of injury crashes and KSI were found on the long road sections. Decreasing effects with increasing distance from the speed cameras is consistent with the decreasing effect on speed that was found in other studies.

The results are not easily interpreted for the short road sections. Only small and non-significant effects were found on the short road sections. The results for KSI on these sections are calculated with a simplified formula because the more correct (unbiased) formula yields illogic results (with the unbiased formula far larger reductions of KSI are found in the EB-evaluation with control for RTM than without control for RTM, although a large effect of RTM is present). Thus, the results for KSI on the short road sections are possibly biased. Additionally, the results for KSI on the short road sections are based on only few KSI in the after period and they are highly sensitive for the injury outcome of one of these crashes. Omitting this crash improves the effect of speed cameras on short road sections dramatically to statistically significant reductions by 38% for all speed cameras and by 55% for speed cameras installed in 2004 or later.

Moreover, the effects of RTM may be overestimated on the short road sections, and the effects on both injury crashes and KSI may therefore be larger than indicated by the results of the EB-evaluation. They are, however, still likely to be less favorable than on the medium road sections.

If one assumes that the small or lacking effect of speed cameras on the short sections is real, a possible explanation is that the crash reducing effect of reduced speed is partly or wholly offset by an increase of the number of rear end collisions.

Speed cameras that were installed in 2004 or later have larger effects than earlier speed cameras. Both for injury crashes and for KSI statistically significant reductions were found on the medium and long road sections, the effects being larger for KSI than for injury crashes and larger for the medium than for the long road sections. On the short road sections, the results also indicate more favorable effects than for the early speed cameras, but none of the results are statistically significant. Improved effects of later speed cameras may be due to the change of the criteria for installing speed cameras, especially the new criterion for high speed, and to the improved compliance with the criteria. The installation of digital cameras in all camera housings (instead of analogue cameras that were rotated between the camera housings) may have contributed as well, although such an effect is more uncertain because many drivers may not have been aware of the change.

Crash reductions are large compared to the results from other studies (expect on the short road sections). This refers to speed cameras that were installed in 2004 or later, both compared to speed reductions that were found in other studies and compared to the results from other crash evaluations of speed cameras. Only on the short road sections smaller (but highly uncertain) crash effects were found than one would expect based on the results from other studies of the effects of speed cameras on speed or crashes. Results from other studies cannot confirm the possible explanation of an increase of rear end collisions at speed cameras.

Compared to the results of an evaluation of section control (Høye, 2014C) speed cameras have somewhat larger effects on injury crashes on the medium road sections (-22% for all speed cameras, -32% for speed cameras from 2004 or later, between -12 and -22% for section control), while the results for KSI are similar (about -50% for both speed cameras from 2004 or later and for section control). On the long sections, speed cameras have smaller effects than section control. On the short sections the effects are smaller as well but highly uncertain.

How reliable are the results? Several tests were made for assessing who several methodological aspects of the study may have affected the results:

- ***Regression to the mean:*** Observed crash numbers in the before period are consistently higher than those predicted by a crash prediction model (Høye, 2014B). Crash numbers would therefore most likely have decreased in the after period, even without any effective safety measure because of RTM. RTM is controlled for by using the EB method. However, effects of RTM may be overestimated for the short road sections.
- ***Speed limit changes and other changes of road characteristics:*** Such changes are controlled for statistically. These calculations are somewhat imprecise because they are based on general relationships between speed limits and other road characteristics and crashes. The effects of such changes on the overall results are however only small and the results would not change noticeably if the calculations had been based on other assumptions.

- *Outlier bias:* One of the short road sections had one crash with two KSI in the after period (of a total of seven KSI in the after period). This crash has a disproportionate influence on the overall result and far larger crash reductions would have been found without this crash, or if only one person had been killed or severely injured in this crash. Otherwise, none of the road sections has a large effect on the overall result, such that the overall result changes noticeably if the section is omitted from the analysis or if the observed number of crashes or KSI is set equal to the predicted number.