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Costing lives or saving lives: a detailed evaluation of the impact of speed cameras.

Linda Mountain and William Hirst, University of Liverpool and Mike Maher, Napier University

Introduction

The real problem with speeding is that it is socially acceptable. Most drivers speed but are rarely involved in crashes. Police tolerance to marginal speed limit infringements is assumed, the likelihood of detection is perceived as low and fixed penalties are not considered particularly severe. High performance vehicles with speed capabilities well in excess of maximum national speed limits are not illegal but rather are considered a symbol of personal success. The result is that speeding is not perceived as dangerous, criminal or immoral but rather is considered the norm. Attempts to enforce speed limits tend to be unpopular, being viewed more as an infringement of personal liberty than as a curb on anti-social and potentially lethal behaviour.

The evidence for the safety benefits of reduced speed is, however, strong. Certainly the basic laws of physics suggest that lower speeds will reduce both accident frequency and severity: lower speeds reduce both stopping distances and the energy dissipated in a crash. Available evidence does indeed confirm that both accident frequency and severity fall with reduced speeds (see, for example, McCarthy (2001), Stuster et al. (1998) and Taylor et al. (2000)). What is less clear is how best to ensure that drivers maintain safe speeds. While a wide range of approaches has been tried, speed enforcement cameras have undoubtedly attracted most public attention, frequently making headline news as, for example, happened recently following the publication of an evaluation of the UK national safety camera programme (Gains et al. 2004)

Certainly for those responsible for road safety, speed enforcement cameras are seen as a way of increasing the perceived risk of prosecution for speeding and hence raising drivers awareness of the dangers, and the unacceptability, of excessive speed. However, although the rapid proliferation of cameras in recent years has undoubtedly increased the perceived risk of prosecution it has not fundamentally changed attitudes to the consequences of excessive speed. Critics have suggested that the primary objective of cameras is to raise money rather than to improve road safety and there have been claims that they may actually cost lives. While most of the criticisms of speed cameras are spurious (PACTS 2003, Mylius 2004), arising from a social climate that continues to consider the speed and the personal liberty afforded by cars desirable, the use of speed cameras continues to be controversial.

In the UK the Road Traffic Act 1991 first authorised the use of automatic speed devices for the detection of offences but it was following the introduction of the cost recovery system for cameras (introduced on a pilot basis in eight counties in 2000 and extended nationally in 2001) that the most rapid increase in deployment occurred. There are now some 5000 locations in the UK where speeds are enforced by fixed or mobile cameras. In 2001, in attempt to refute claims that cameras were simply money-raising devices, the government controversially announced that speed cameras should be made more easily visible to motorists by, amongst other things, requiring camera housings to be yellow (DfT 2001). This was, however, criticised by many experts as a signal to drivers that it was only necessary to observe the speed limit at the cameras. The recently published evaluation of the effects of cameras in the UK reports that, at sites where safety cameras are in use, the number of people killed and seriously injured has fallen by 40%, with a 33% reduction in injury accidents (Gains et al. 2004). However, while the balance of evidence is certainly that cameras do reduce accidents, the evidence for the likely size of their effect is still by no means incontrovertible.

The fundamental problem with the evaluation of any road safety scheme is that before-and-after observations of changes in accident frequencies will include, not only changes due to the impact of the safety scheme, but also changes which would have occurred in any case: changes arising due to general trends in accidents and regression-to-mean (RTM) effects (see, for example, Hirst et al. 2004a). If these are ignored the effect of treatment will normally be over-estimated since, for most schemes, the effect of both trend and RTM effects will be a reduction in accidents in a subsequent time period even without the scheme. In the case of trend, for example, there has been a general downward trend in total personal injury accidents (PIAs) and in fatal and serious accidents (FSAs) for many years in the UK (Figure 1). Downward RTM effects arise when sites are selected on the basis of high accident frequencies. The selection criteria for the location of cameras normally include a poor accident history and, indeed the current guidelines for new sites in the UK include specific accident thresholds: 8 PIAs per km and at least 4 FSAs per km in the last three years. A further difficulty arises in that methods to correct for RTM effects normally rely on the use of accident prediction models to predict expected accident frequencies given the type of site and volume of traffic. The general downward trend in accident risk means that such models will tend to become outdated. Over time such models will increasingly overestimate expected accidents so that estimated treatment effects may still be exaggerated unless an appropriate correction is applied (Hirst et al. 2004b).

With cameras there is also a real possibility that an “accident migration” effect may arise, with increases in accidents either on nearby roads or on the same road as the camera, upstream or downstream of it. The mechanisms by which such effects could arise are of two types. First, drivers may attempt to find an alternative route so as to avoid the route with the camera and as a consequence some of the beneficial effects of the camera may be eroded by increases in accidents on diversionary routes. If changes in route choice occur then it is also important to be aware that any accident reduction observed in the section where speed limits are enforced by the camera will include both the effects of a decrease in accident risk (due to reduced speeds or other changes in driver behaviour) and the effects of reduced traffic flow: ignoring any reduction in flow will lead to over-estimates of the benefits of reduced speeds. The second possible mechanism through which a migration effect may be induced is through drivers braking abruptly on their approach to the camera so as to avoid detection or rapidly accelerating after passing it so as to avoid an increase in travel time. This behaviour could potentially result in an increase in accidents upstream or downstream of the camera. The possibility of either form of accident migration suggests that the effects of changes in flow and changes in speed should be separately assessed and that accident frequencies in a range of distance bands from the camera should be considered.

No previous study has attempted to fully deal with all of these issues. The first published study of the safety effects of speed enforcement cameras to take account of both RTM and trend effects (Elvik 1997) is based on data for 64 cameras in Norway: a statistically significant reduction of 20% in the number of personal injury accidents (PIAs) was found. Although the possibility of an accident migration effect was noted there were insufficient data available to establish whether such an effect occurred. More recently a study based on data for 42 speed cameras in one UK county (Cambridgeshire) found, after allowing for trend and regression-to-mean effects, that the average effect of cameras was a 31% reduction in PIAs (Hess & Polak 2003). A subsequent study based on 49 cameras in Cambridgeshire studied accidents within various distance bands: the reduction in PIAs in the immediate vicinity of the camera (250m radius) was estimated to be 46% while over a 2km radius there was an estimated reduction of 21% (Hess 2003). While these results suggest that cameras can actually reduce accidents over a wide area, in the absence of flow data it was not possible to assess the extent to which changes in route choice could have been responsible for this reduction and whether any compensating increases may have occurred on diversionary routes.

The 2-year evaluation of the UK national safety programme, reported the effects of some 600 speed and red-light cameras in 8 regions of the UK (Gains et al. 2003). This study reported a 6% reduction in PIAs and a 35% reduction in people killed or seriously injured (KSI) compared to long-term trends. In this study, although trend effects were allowed for, the authors noted that insufficient data were available to check fully for RTM effects. No flow data were available but area wide comparisons were used to check for migration effects: it was concluded that there was “no gross accident migration effect”. More recently the 3-year evaluation has been published (Gains et al. 2004). Based on data for 24 regions, this study reports overall reductions of 33% in PIAs and 40% reductions in KSIs relative to long-term trends but no corrections for RTM or migration were applied.

Available studies of speed cameras are then open to the criticism that not all of the reported accident reductions can necessarily be directly attributed to the effects of the cameras on vehicle speeds and that there may be compensating increases in accidents elsewhere on the road network. The aim of this study was to separately assess the effect of speed cameras on accidents arising due to their impact on both speed and flow, at various distances from the camera, free of both RTM and trend effects. The objective was to establish: the magnitude of the accident reduction due to any speed reduction at the camera; whether the effect on speeds upstream and downstream of the camera results in an increase or decrease accidents; whether cameras result in a sufficient diversion of traffic to other routes to induce a significant impact on accidents.

Data

The data for this study relate to 62 fixed speed enforcement cameras at various locations throughout the UK. All of the cameras were on roads with 30mph speed limits where speeding problems are severe: in 2003 some 58% of cars and 54% of motorcycles were estimated to have exceeded the 30mph limit on UK roads (DfT 2004)).

Various local authorities and police forces supplied the required data. This comprised details of all accidents occurring at the camera schemes during the 3 years prior to implementation and for up to 3 years after implementation (an average after period of 2.3 years) together with various measures of before and after speeds. At least one measurement of traffic flow was also obtained during the periods both before and after the start of camera enforcement. The sample size was limited by the availability of sufficiently detailed data on accidents, speeds and flows. Supplementary information (to permit the use of predictive models to correct for RTM effects) included road class, the number of junctions, and the method of junction control.

There is currently no standard accident monitoring length for speed enforcement cameras in the UK and an appropriate monitoring length has been largely a matter of judgement. Ideally the aim would be to include the full length of road where accident frequencies are affected by the presence of the camera, while excluding sections beyond the area of influence of the camera: a monitoring length which is too short will fail to establish the full effect of the scheme in terms of the number of accidents saved; a monitoring length which is too long will suffer from the masking effect of accidents which are unaffected by the presence of the camera (resulting in an under-estimate of the percentage accident reduction). While 500m either side of the camera is most common in the UK, other lengths are also used including, for example, 100m upstream and 400m downstream of the camera and between the first major junctions upstream and downstream. In this study, with a view to assessing the true area of influence of the camera (including any evidence for any migration effect arising due to sudden braking or rapid acceleration) accident data were requested for a section of 2km centred on the camera. These data were not available for every site and the data used thus includes all available recorded accidents up to 1km either side of the camera, a total of almost 2000 accidents.

Analysis

The approach to the accident analysis is described in detail elsewhere (Hirst et al 2004a and 2004b) and will only be briefly summarised here. To control for RTM effects, the expected accidents in the before period were estimated using an Empirical Bayes (EB) approach. In this the underlying mean accident frequency is estimated as a weighted average of two sources of information: the observed accidents in the period before treatment, X_B, and a predictive model estimate of expected accidents given the nature of the site and the level of traffic flow (see, for example, Hauer 1997). In this study the predictive models derived by Mountain et al. (1997) were used. The parameters of this model depend on the road class, speed limit and carriageway type. For example, for a 30mph, single carriageway, A-road the model for annual PIAs is:

$$\hat{\mu} = 0.9 q_B^{0.6} L \exp(0.08 n / L)$$

where $\hat{\mu}$ is the predicted annual PIAs, q_B is the annual flow in the before period (in million vehicles per year), L is the section length (km) and n is the number of minor intersections.

The estimate of *total* before accidents in a before period of t_B years is then

$$\hat{\mu}_B = t_B . \hat{\mu}$$

As the predictive model was derived from data for the 12-year period 1980 to 1991 a correction was applied to allow for the fact that the model will be outdated due to trends in accident risk between the modelled period and the period of observation at the cameras (Hirst et al 2004b). The corrected estimated is given by

$$\hat{\mu}_{\mathrm{B\ CORRECTED}} = \gamma^t \hat{\mu}_{\mathrm{B}}$$

where γ is the average factor by which risk changes from year to year (estimated to be 0.98) and t is the elapsed time between the middle of the modelling and study periods. Thus, for example, for a camera that became operational in January 2001 (with a before period from January 1998 to December 2000) t = 13.5 and thus γ^t = 0.76.

Normally predictive accident models assume that the random errors are from the negative binomial (NB) family. If K is the shape parameter for the NB distribution (K=1.9 for above model), the EB estimate of total accidents in the before period, $\hat{M}_B$, is calculated as

$$\hat{M}_B = \alpha \hat{\mu}_{B\ \mathrm{CORRECTED}} + (1 - \alpha) X_B$$

where

$$\alpha = \left(1 + \frac{\hat{\mu}_{B\ CORRECTED}}{K}\right)^{-1}$$

To allow for the trend in accidents between the before and after periods, the expected accidents in the after period were estimated using a comparison group approach. The comparison group for this study comprised UK national accident totals during the relevant before and after period for each scheme. The estimate of after accidents allowing for trend, $\hat{M}_A$, is then

$$\hat{M}_A = \left(\frac{A_{A\_NAT}}{A_{B\_NAT}} \right) \cdot \hat{M}_B$$

where A_{B_NAT} = total national accidents in the before period, t_B years
A_{A_NAT} = total national accidents in the after period, t_A years

The use of a comparison group ratio implicitly assumes that flows at the study site have changed in line with national trends. To take account of the effects of any flow changes due to camera installation, while avoiding double counting, it is necessary to have a representative measure of traffic flow at the scheme in the after period, q_A, together with flow data for the comparison group. If

Q_{B_NAT} = total national flow in the before period
Q_{A_NAT} = total national flow in the after period

then the expected flow in the after period if flows at the study site had changed in line with general trends, q'_A, can be estimated using

$$q'_A = \left(\frac{Q_{A\_NAT} / t_A}{Q_{B\_NAT} / t_B} \right) \cdot q_B$$

If the observed flow in after period, q_A, differs from q'_A then there have been local changes in flow at the site other than those attributable to trend. The estimate of expected after accidents allowing for local changes in flow, $\hat{M}'_A$, can then be estimated as

$$\hat{M}'_A = \hat{M}_A \cdot \left(\frac{q_A}{q'_A} \right)^{\beta}$$

It would be a matter of local knowledge to assess whether these changes were as a result of the camera or due to other causes. In this study there were no cameras where a change in flow due to other causes was anticipated: all local changes in flow were attributed to the impact of the camera. The change in accidents attributable to the impact of a camera on flow, S_F, was thus estimated as

$$\hat{S}_F = \frac{\hat{M}'_A / t_A - \hat{M}_A / t_A}{X_B / t_B}$$

and the change attributable to the effect of the camera on traffic speed (and possibly other aspects of driver behaviour), S_R , was

$$\hat{S}_R = \frac{X_A/t_A - \hat{M}'_A/t_A}{X_B/t_B}$$

The overall scheme effect, S , is then estimated as $\hat{S} = \hat{S}_R + \hat{S}_F$.

The non-scheme effects (i.e. the changes which would have occurred with or without speed enforcement cameras) are the changes due to national accident trends over the before and after periods, N_T , and RTM effects, N_R. These are estimated as

$$\hat{N}_T = \frac{\hat{M}_A/t_A - \hat{M}_B/t_B}{X_B/t_B}$$

$$\hat{N}_R = \frac{\hat{M}_B/t_B - X_B/t_B}{X_B/t_B}$$

The observed proportional change in observed accidents, B, which can be written

$$B = \frac{X_A/t_A - X_B/t_B}{X_B/t_B}$$

is thus made up of four elements, each of which was estimated separately

$$B = \hat{S}_R + \hat{S}_F + \hat{N}_T + \hat{N}_R$$

Impact on speeds

Table 1 summarises various measures of speed prior to camera enforcement and the changes in speed following implementation. The mean speed at the sites prior to the cameras was 33mph, with 64% of vehicles exceeding the speed limit. This is marginally higher than the UK national average for cars on 30 mph roads (a mean speed of 31mph with 59% exceeding the speed limit (DTp 2004)). Following the introduction of cameras, all measures of speed fell: mean speeds by an average of 4.4mph and 85th percentile speeds by 5.9mph. There was also a 35% reduction in the percentage exceeding the speed limit. These changes are not dissimilar from those observed in the recent national study (Gains et al. 2004) although a direct comparison cannot be made because the changes for fixed cameras on 30mph roads are not reported separately. For all types of cameras on 30mph roads the reported fall in mean speed was 2.4mph with a 33% reduction in vehicles exceeding the speed limit; for fixed cameras on urban roads (30 and 40mph limits) the corresponding falls were 5.3mph and 71%.

Impact on accidents

Table 2 summarises the total observed accidents, together with the observed and estimated percentage changes in these accidents for the 62 camera schemes. For all PIAs the data are presented both for 3 separate distance bands (up to 250m, 250-500m and 500-1000m from the camera) as well as for 3 cumulative distance bands (up to 500m, up to 1km and between major intersections). As there are a relatively small number of fatal and serious accidents (FSAs), only data for the 3 cumulative distance bands are given.

The "headline" data are given column 5. Here the observed average accident reduction over the normal monitoring length of 500m is a 26% fall in overall injury accidents with a 34% fall in fatal and serious accidents. For a more direct comparison with Gains et al. (2004) an adjustment for trend is required. This is given by the difference between columns 5 and 9 (B - $\hat{N}_T$). The headline figure after allowing for trend then becomes a 30% reduction in all PIAs with a 29% reduction in fatal and serious accidents.

Columns 6 to 8 give the estimates of the safety effects of the cameras due to their impact on speeds and flow. For the 500m monitoring length, the overall average effect of cameras on accidents is a reduction of 25%, similar to the observed reduction. This is made up of a reduction of 20% attributable to the impact of the cameras on speed (and possibly other aspects of driver behaviour), with a 5% reduction attributable to a diversion of traffic to other routes (where there is a possibility of an increase in accidents). The effect on fatal and serious accidents is an overall average reduction of 11%: only one third of the observed reduction and, with a 95% confidence interval of –26% to +9%, this reduction is not statistically significant. The overall effect of the cameras on fatal and serious accidents includes a fall of 5% attributable to diversion of traffic to other routes, with a fall of only 6% attributable to the impact of the cameras on speed: again inspection of the confidence interval indicates that this is not significant.

A possible explanation of the somewhat disappointing effect on fatal and serious accidents as compared with other studies might be that the sites included in this study had comparatively few serious accidents prior to camera installation. Inspection of column 3 (Table 1) confirms that the schemes do not generally meet the current UK guidelines for new static camera sites. Over the 1km section centered on the camera, there were, on average, 15.9 observed PIAs/km in the 3 years before camera installation, of which 2.7 accidents/km (17%) were fatal or serious. Thus while the study sites had, on average, almost twice as many total accidents as are required by the current criteria, they would fail to meet the current criterion for FSAs. However, in spite of this, at 17%, the proportion of fatal and serious accidents at these sites is rather higher than the national average of 13% for 30mph roads (DfT 2003a) and the estimated RTM effect (an average reduction of 18% for a

500m monitoring length) suggests that these sites had considerably more fatal and serious accidents than expected given their site characteristics and traffic volume. Camera sites selected on the basis of an even higher frequency of FSAs may have site characteristics which give rise to higher expected frequencies (for example, higher traffic volumes) so that RTM effects will not necessarily be any larger than those observed in this study. Never-the-less it is clearly important to establish the size of the effect since, if not fully accounted for, RTM could explain much of any observed accident reduction.

The data for PIAs in the 3 separate distance bands suggests that the accident reduction tends to be largest and most consistent in the region up to 250m from the camera but on average accidents are reduced in all 3 regions. There is then no evidence of a migration effect upstream or downstream of the cameras due to sudden changes in speed on approaching or passing the camera. When the data are combined into the cumulative distance bands, the average reduction in PIAs attributable to speed effects (column 7) is of the order of 20% for all distance bands. Thus, in terms of the percentage accident reduction attributable to the cameras, there is little to choose between monitoring lengths of 1km either side of the camera and the more commonly used 500m either side of the camera or indeed "between major junctions".

The estimates of the impact of flow changes at the cameras (column 8) suggest that cameras do, on average, result in a significant diversion of traffic to other routes: there is an average accident reduction of around 5% attributable to the effects of the cameras on traffic flow which, although small, is statistically significant. This would suggest that, for camera sites where alternative routes are available, as a minimum flows before and after camera installation should be checked to assess the extent of any changes in route choice. Ideally, if changes in flow do occur, accidents on likely diversionary routes should be monitored to assess whether any compensating increases have occurred on them.

The estimates of the non-scheme effects (trend and RTM) are given in columns 9 and 10. RTM effects result in a significant reduction in both PIAs and FSAs in all distance bands. While the effect on PIAs is comparatively small, for FSAs the change attributable to RTM represents over half of the observed accident reduction. The estimates of trend effects are rather variable, and while there is an average fall in FSAs due to trend, there is an average increase in PIAs. This is a consequence of the range of implementation dates for the cameras included in this study. Figure 1 shows the national trends in accidents. While the underlying trend is downwards and FSAs decline fairly consistently year-on-year, total PIAs tend to fluctuate with several year-on-year increases. Thus for PIAs, depending on the implementation date, the effects of trend between the periods before and after implementation, can be up or down. For the range of implementation dates for these sites (generally the mid-1990s) the average trend effect was upwards.

Although it is common to consider accident reductions in percentage terms it is also of interest to consider the size of the absolute accident reduction achieved. The benefits in social and human costs as well in cost-benefit terms will be greater with a 50% reduction in accidents at a site with 20 accidents than a 100% reduction at a site with only 5 accidents. Current estimates suggest that the average value of preventing an injury accident on a 30mph road is approximately £45,000, with the figure rising to over £1million for a fatal accident (DfT, 2003b).

In Table 3 the scheme effects (corrected for trend and RTM) are given in terms of the annual accident reduction per kilometer. Although the average annual reduction is slightly smaller for the longer monitoring length, doubling the monitored length (by using 1km either side of the camera rather than 500m) does mean that the overall accident reduction is larger: with a 500m section the total accident saving attributable to speed changes over 3 years would be on average 3 accidents as compared with around 5.5 for a 1km section. Clearly the annual average reduction in fatal and serious accidents is very small but potentially important in both social and cost-benefit terms.

Discussion

Fixed speed cameras on 30mph roads were found to reduce mean speeds by an average of 4.4mph and the percentage exceeding the speed limit by 35%. The effects of the cameras on traffic speeds resulted in a reduction in accidents up to 1km upstream and downstream of the cameras. Over this distance, the average effect of the cameras was a fall in PIAs of some 25%, of which a fall of 20% was attributable to their impact on speed. In absolute terms this is an average reduction of 1 PIA/km/year. Although the safety benefits of fixed cameras decline with distance from the camera, monitoring over a length of 1km upstream and downstream of the camera has the advantage that all of the accident savings achieved are included. The reduction in both percentage terms and in terms of accidents per unit length are similar to those based on a monitoring length of 500m: there is no evidence of any masking effect due to the inclusion of sections where the cameras have had little or no influence. It is possible that the beneficial effects of fixed cameras extend beyond 1km in either direction but this could not be established from the data available for this study.

The impact of cameras on fatal and serious accidents was rather less certain. While reductions of the order of one third were observed, more than half of this was attributable to RTM effects, and the fall in fatal and serious accidents attributable to the cameras was not significantly different from zero. Given the relatively low frequency of fatal and serious accidents at these sites the results are perhaps not surprising. It does, however, highlight the danger of placing too much emphasis on observed numbers of fatal and serious accidents. If cameras are targeted at sites with large numbers of such accidents they may achieve a substantial reduction in observed accidents in a subsequent period simply because of RTM effects. Equally some recent press reports (for example, Clark 2004) have highlighted as the “worst” camera sites, locations where more fatal and serious accidents were observed in the after period than in the before period. This is not evidence that these cameras have failed or are "costing lives": such observations can arise simply as a result of a "reverse RTM effect" due to an unexpectedly small number of observed accidents for a particular site during the before period. It simply highlights the need to control for RTM effects and the need to bear in mind that, since data is not always readily available to fully control for RTM, the results of observational studies must be treated with caution. While the targeting of clearly visible cameras at serious accident "blackspots" may appease some motorists (making it difficult for them to argue that the camera is designed to raise revenue) such targeting should not be to the exclusion of sites which have large numbers of less serious speed related accidents that could also benefit from increased speed enforcement (and which could prevent a fatal accident before it happens).

There is no evidence that the effects of any sudden braking on the approach to a fixed camera or any rapid acceleration after passing it have any detrimental effect on safety. However, the impact of cameras on route choice does have a small but significant impact on accidents on the routes with cameras: the diversion of traffic away from routes with cameras results in a 5% fall in PIAs at the cameras. It is thus possible that there is an increase in accidents on the diversionary routes. This suggests that traffic flows at speed cameras should be routinely monitored along with speeds and accidents and, where changes in route choice are detected, consideration should be given to monitoring accidents on the alternative routes used.

Conclusions

The main obstacles to achieving the road safety benefits possible from further deployment of speed enforcement cameras seem to be public opposition and a consequent lack of political will. Speed enforcement cameras on 30mph roads have been shown to offer safety improvements over a distance of up to 1km upstream and downstream of the camera, with reductions in accidents over this distance averaging 20% or 1 PIA/km/year attributable to reductions in speed. To realise the full potential safety benefits of cameras what is needed is wider deployment and less emphasis on fatal and serious accidents in selecting locations for new cameras. This may require a shift in public attitudes to speeding and its consequences: an acceptance that speeding, like drinking-and-driving or smoking in public places, endangers the quality of life of both the individual and others and, as a consequence, is socially unacceptable.

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Oxfordshire, Poole, Rotherham, Sheffield, South Tyneside, Strathclyde, Suffolk, Swansea, Thames Valley, Wakefield, and Worcestershire.

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Figure 1: National trends in accidents 1980-2002

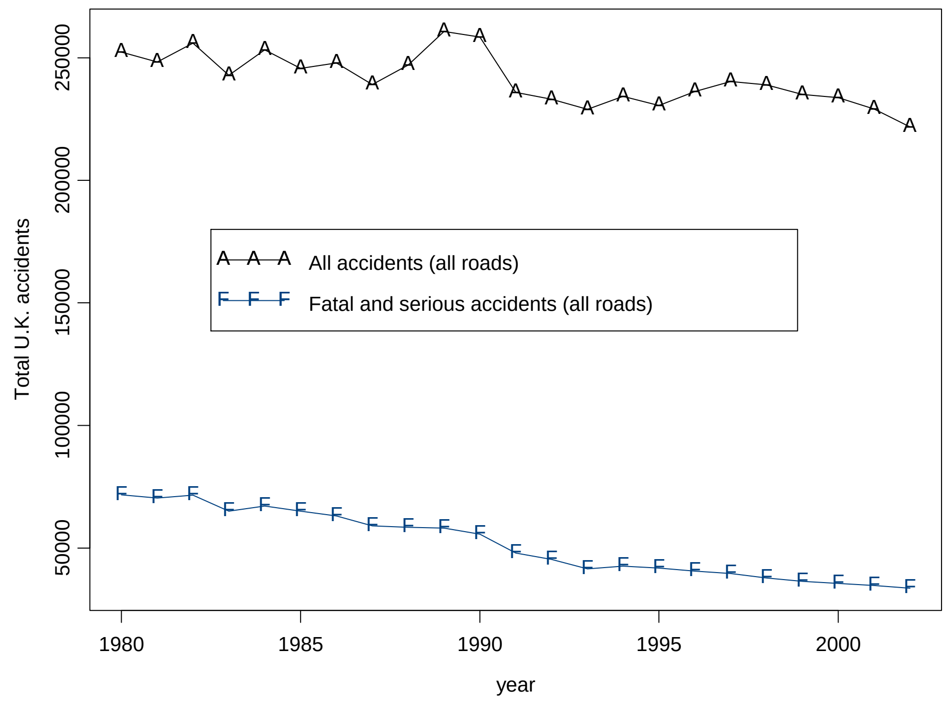

Table 1: Summary of observed speeds

Speed measurement	**Number of sites***	**Mean before scheme** *(s.e) {95% C.I.}*	**Mean change** *(s.e.) {95% C.I.}*
Mean (mph)	57	32.8 *(0.56) {31.7, 34.0}*	-4.4 *(0.37){-5.2, -3.7}*
85th percentile (mph)	61	38.9 *(0.55) {37.8, 39.9}*	-5.9 *(0.45) {-6.8, -5.0}*
Standard deviation (mph)	50	6.3 *(0.18) {5.9, 6.6}*	-1.2 *(0.22) {-1.6, -0.7}*
% exceeding speed limit	61	64.3 *(2.48) {59.4, 69.3}*	-35.2 *(2.57) {-40.3, -30}*
Mean speed of speeders (mph)	45	36.9 *(0.42) {36.0, 37.7}*	-1.4 *(0.26) {-1.9, -0.8}*

* Not all sites have data for all measures of speed

Table 2: Impact of cameras on accidents.

Accident type	Distance from camera*	No.of sites**	Total observed accidents [accs/km/year in before period]	Observed change in accidents % change *(s.e.){95%CI}*	Accident change attributable to scheme effects % change *(s.e.){95%CI}*			Accident change attributable to non-scheme effects % change *(s.e.){95%CI}*	
					Overall scheme effect	Change in speed	Change in flow	Trend in accidents	RTM
				B	$\hat{S}$	$\hat{S}_R$	$\hat{S}_F$	$\hat{N}_T$	$\hat{N}_R$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
All PIAs	Up to 250M	62	757 [5.6]	-34% *(7) {-47, -19}*	-25% *(6) {-36, -13}*	-20% *(6) {-31, -7}*	-5% *(3) {-10, 0}*	0% *(3) {-6, 6}*	-9% *(2) {-12, -6}*
	250 to 500M	55	548 [4.7]	-15% *(9) {-30, 4}*	-15% *(8) {-28, 2}*	-10% *(8) {–24, 5}*	-5% *(1) {-8, -2}*	+8% *(3) {2, 14}*	*-8%* *(3) {-13, -1}*
	500M to 1KM	40	616 [4.2]	-13% *(10) {-32, 7}*	-12% *(9) {-28, 6}*	-9% *(9) {-27, 10}*	-4% *(1) {-6, -1}*	+3% *(4) {-3, 9}*	-4% *(2) {-7, -1}*
	Up to 500M	62	1305 [5.3]	-26% *(6) {-36, -13}*	-25% *(5) {-35, -14}*	-19% *(6) {-30, -8}*	-5% *(2) {-10, -1}*	+4% *(3) {-1, 9}*	-5% *(1) {-7, -3}*
	Up to 1KM	62	1921 [4.9]	-18% *(6) {-30, -6}*	-24% *(5) {-33, -13}*	-19% *(6) {-28, -6}*	-5% *(2) {-8, -2}*	+8% *(3) {+3, +14}*	-4% *(1) {-5, -2}*
	Between majors	62	1809 [4.9]	-18% *(6) {-30, -6}*	-22% *(5) {-33, -12}*	-17% *(6) {-28, -5}*	-5% *(2) {-8,-2}*	+8% *(2) {+4, +13}*	-4% *(1) {-5, -2}*
Fatal & serious accidents	Up to 500M	62	211 [0.89]	-34% *(10) {-51, -11}*	-11% *(9) {-26,9}*	-6% *(9) {-21, 12}*	-5% *(2) {-8, -2}*	-5% *(2) {-10, -1}*	-18% *(5) {-25, -9}*
	Up to 1KM	62	317 [0.85]	-28% *(10) {-44, -8}*	-13% *(8) {-28, 5}*	-9% *(8) {-28, 9}*	-4% *(1) {-7, -2}*	-1% *(2) {-5, 4}*	-15% *(4) {-21, -6}*
	Between majors	62	297 [0.84]	-27% *(10) {-44, -6}*	-11% *(8) {-26, 6}*	-7% *(9) {-23, 11}*	-4% *(1) {-7, -2}*	-1% *(2) {-5, 3}*	-15% *(4) {-22, -7}*

*Location of accidents relative to camera (both upstream and downstream)
**Not all sites have accident data for

(s.e.) = standard error of the estimate, {95%CI} = 95% confidence interval of the estimate

Table 3: Summarised estimates of absolute accident changes

Accident type	**Distance from camera***	**Observed change in accidents** **accs/km/yr** ***(s.e.){95%CI}***	**Accident change attributable to scheme effects:** **accs/km/yr** ***(s.e.){95%CI}***	
			Change in speed	**Change in flow**
(1)	(2)	(3)	(4)	(5)
All PIAs	Up to 500M	-1.36 *(0.35) {-2.08, -0.68}*	-1.02 *(0.31) {-1.58, -0.36}*	-0.28 *(0.12) {-0.51, -0.02}*
	Up to 1KM	-0.91 *(0.30) {-1.47, -0.29}*	-0.91 *(0.29) {-1.44, -0.31}*	-0.25 *(0.09) {-0.44, -0.07}*
Fatal and serious accidents	Up to 500M	-0.31 *(0.10) {-0.51, -0.11}*	-0.11 *(0.09) {-0.26, 0.07}*	-0.02 *(0.01) {-0.05, 0}*
	Up to 1KM	-0.24 *(0.10) {-0.44, -0.05}*	-0.13 *(0.07) {-0.27, 0.01}*	-0.02 *(0.01) {-0.04, 0}*

*Location of accidents relative to camera (both upstream and downstream)
(s.e.) = standard error of the estimate, {95%CI} = 95% confidence interval of the estimate