The impacts of a reduced speed enforcement tolerance threshold on road safety outcomes

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Abstract

Internationally, speeding behaviour remains a crucial concern for road safety agencies and researchers. In 2013, 1,193 people in Australia and 254 in New Zealand died as a result of crashes. Speed is estimated to have been a factor in over a third of these deaths. New Zealand sought to reduce these preventable deaths by introducing a speed enforcement campaign that focussed on lowering the speed enforcement threshold from 10km/h to 4km/h over a 2-month period. The campaign was implemented to reduce the incidence of speeding behaviour in an effort to reduce the number and the severity of crashes during the historically high-risk summer holiday period. Speed survey data collected by semi-overt mobile speed cameras was used to analyse the effects of the intervention on speeding. A quasi-experimental study design incorporating generalised linear models was used to evaluate the effects of the intervention on speeding and crashes. The results showed significant reductions in speeding by 10km/h or less (36%), and for speeding in excess of 10km/h (45%). Analysis of crash data revealed possible decreases of fatal (22%), serious (8%), and minor crashes (16%), but these reductions were not statistically significant. Although the campaign had a significant and substantial effect on reducing speeding behaviour, the duration of intervention period was likely not sufficient to reflect the full effects of this reduction on road trauma. While this initiative shows considerable promise as a road safety intervention, research over an extended period is recommended to more fully test the effects on reducing crash risk.

Introduction

Speed and road safety

The relation between speed and traffic crashes, injuries and deaths has been well established in road safety research literature, and is likely the single most salient factor impacting road safety today (Aarts & van Schagen, 2006; Elvik, 2005, 2012; European Transport Safety Council, 2011). Research has demonstrated that the risk of fatal crashes increases dramatically with the magnitude of speed and prevalence of speeding (Aarts & van Schagen, 2006; Cameron & Elvik, 2010; Elvik, 2013; Kloeden, McLean, & Glonek, 2002; Nilsson, 2004). It is a common misconception that low-level speeding does not pose a problem for road safety, and that Police enforcement should focus on high-end offenders (Job, Sakashita, Mooren, & Grzebieta, 2013). However, research has revealed that the increased risk posed by speeding behaviour in terms of serious injury or death resulting from crashes exists both at the higher end and lower end of the excess speed distribution (Cameron, 2013; Doecke, Kloeden, & McLean, 2011; Gavin et al., 2011).

Speed enforcement and tolerance thresholds

Police enforcement of the speed limits is one of many countermeasures to speeding, and remains a critical component of raising and maintaining compliance with the speed limits (Elvik, 2012; Global Road Safety Partnership, 2008; National Highway Traffic Safety Administration, 2008). Enforcement deters intentional speeding violations through the actual and perceived threat of detection, apprehension and punishment upon exceeding the speed limit (Wegman & Goldenbeld, 2006). Speed enforcement has also been shown to have a substantial positive impact on New Zealand road safety (Keall, Povey, & Frith, 2001; Povey, Frith, & Keall, 2003).

Speed enforcement is often conducted with a tolerance margin in place (Zaidel, 2002) within which drivers are not apprehended for excess speed (Fildes & Lee, 1993). The tolerance level applied to speed enforcement has previously also been described as a *de facto* speed limit (Cameron & Delaney, 2006). Researchers have argued that the tolerance threshold applied to speed enforcement should be set at the minimum level practicable, taking into account the accuracy of speed measurement devices, and small action slips on behalf of drivers (Soole, Lennon, & Watson, 2008). It can be reasonably suggested that greater compliance with the speed limits can be obtained by operating with a lower enforcement threshold, than by operating with a higher one; effectively lowering the *de facto* speed limit. Findings by Andersson (1989) and Luoma, Rajamäki and Malmivo (2012) indicate that this is indeed the case.

Method

Review of the campaign components

An enforcement campaign that focussed on the application of a reduced speed enforcement threshold was implemented across New Zealand over a two-month period. This initiative ("Safer Summer") was undertaken by New Zealand Police (NZP) and road safety sector partners, and involved a nation-wide speed enforcement campaign during the months of December 2013 and January 2014. The intervention consisted of three components: a reduced speed enforcement threshold, public awareness and advertising, and increased speed enforcement intensity.

The usual speed enforcement threshold applied by NZP is 10km/h over the limit for light motor vehicles, apart from school zones, which is 4km/h. It should be noted that NZP has long publicised the threshold applied to speed enforcement. Most jurisdictions, including all Australian states and territories, do not have a publicised or well-known speed enforcement threshold (Austroads, 2013). To generate awareness of the campaign, advertising and public relations media were run prior to and during the intervention. The publicity included: a launch event attended by the ministers of Police and transport, advertisements at Z Energy service stations, radio advertisements, roadside billboards, a TV commercial, internet advertisements and public engagement via social media. Police also increased speed enforcement operations with both highly visible and less overt approaches. Police officer patrols were intensified during this period and the 43 mobile speed cameras operated by NZP were also deployed for additional hours.

Evaluation design

A quasi-experimental evaluation design was used to analyse the influence of the intervention on speeding and motor vehicle crashes. Speed survey and crash data for the intervention period were compared to the same periods in the four preceding years. This would allow for any variation attributable to seasonality to be controlled for. It was intended that by introducing more than a single control period this would also provide a control for any year-on-year trends and variation. Subtracting the maximum decrease between consecutive controls from the minimum reduction for the experimental period will provide a degree of control for such potential trends. However, there remains a possibility of a non-linear underlying trend present in the crash and speed data that is difficult to quantify or control for with data available. The campaign period (December 2013 to January 2014) will be regarded as the intervention period, and the same months in the preceding 4 years will be regarded as controls.

Data

Speed data

Speed survey data was obtained from mobile speed cameras to measure any differences in speeds and speeding. The mobile cameras are deployed to a fixed number of allocated enforcement sites and capture the speed of every vehicle going past, which results in large volumes of speed survey data being recorded, with over 5 million vehicle speed readings per month. An aspect that is intrinsic to capturing speed survey data by means of speed cameras is the tendency for drivers to slow down in the vicinity of an overt camera and speeding up after it is passed (Elvik, 1997). The semi-overt mode of operation of mobile speed cameras is expected to have a minimal impact on manipulation behaviour (i.e. drivers slowing down if/when the camera van is identified). To ensure that any effects on driving speeds measured in the speed survey data is due to increased compliance across the road network, and not merely increased manipulation behaviour, a second source of data was also analysed.

This second source of data was collected by the New Zealand Transport Agency (NZTA) in association with Beca Group, which have gathered speed data from the implementation of a *Bliptrack* journey monitoring system. This system collects average speeds for individual vehicles over the distance monitored using Bluetooth and WiFi sensors. The site for data collection was a 12.7km stretch of state highway in north Waikato between Mercer and Bombay. The speed data collected from this site was used to compare the speed distributions of mobile speed camera survey data. The survey data from both sources was taken from 100km/h speed limit zones, which is where most severe crashes occur. In order to reduce the influence of impeded traffic on observed vehicle speeds, only vehicles with 4 seconds or more headway in front of them were included in the analyses.

Crash data

Crash and injury data are recorded in the NZTA crash analysis system (CAS). CAS contains the data of all attended crashes in New Zealand. This database records crashes by injury severity (non injury crash, minor injury crash, serious injury crash, or fatal injury crash). The data was formatted to consist of incident counts per day over the two-month periods used in the analysis. This method would allow for calculations to be performed on incident risk (e.g. fatal crash occurrence) for the treatment period compared with the four control periods.

Statistical analysis

Speeding

In order to test if the prevalence of speeding reduced at the lower end (0-10km/h excess), and above 10km/h excess, the speed data was formatted as two binary variables for both excess categories (0 = not exceeding, 1 = exceeding). The analysis of speed data was conducted by fitting binary logistic (logit) regressions using generalised linear models (GLM). This method of analysis allows for the calculation of the significance and magnitude of the difference in speeding for the experimental period with the control periods. Keall, Povey and Frith (2001) have previously successfully used this procedure to analyse differences in speeding between control and experimental conditions.

Crashes

In order to test if crashes reduced during the intervention period, GLMs were used to analyse the crash count data. D'Elia, Newstead and Cameron (2007) have previously successfully applied GLMs to crash count and crash severity data. Depending on the dispersion of count data, either a Poisson regression (for dispersion ≈ 1) or negative binomial regression (dispersion > 1) is more appropriate (Lord & Mannering, 2010). The criterion variable 'fatal crashes' met the dispersion assumptions of the Poisson distribution, while the remaining crash types were over-dispersed, and therefore analysed with negative multinomial regression techniques.

Results

Mean speeds and speed distributions

Table 1 contains descriptive data of the mobile speed camera survey data. Mean speeds do not appear to have decreased by a substantial amount. There was a .6 to a 2km/h difference in mean driving speed for the Safer Summer period compared with previous years. Similarly, the speed of the fastest 15% of vehicles (85th percentile speed) was only slightly lower by 1 to 2km/h compared with previous years. Although the observed change in mean speeds was relatively small, examining vehicle speeds visually presents a more detailed representation of where exactly the changes for the Safer Summer period appear to have occurred.

Table 1. December–January period descriptive statistics for speed

Period	***N***	**Mean (km/h)**	**Standard deviation**	**85th percentile (km/h)**
2009–2010	1,109,581	90.3	10.2	99
2010–2011	1,247,971	90.9	9.6	99
2011–2012	1,153,268	90.6	9.2	99
2012–2013	1,026,188	89.9	9.4	98
2013–2014	1,206,476	89.4	8.8	97

Figure 1 shows that Safer Summer, in comparison to the previous four years, follows the same shape of distribution, but with slightly higher kurtosis (as would be expected from the smaller standard deviation) and a more sharply declining slope as vehicle speeds approached the 100km/h speed limit. While other periods remain closely grouped together as the speed curves approach 100km/h, the solid line, representing the Safer Summer period, breaks off around the 100km/h mark, shifting to the left. It appears that the change in driving speeds for the Safer Summer period has principally occurred at the top-end of the distribution (+1.3 SD from the mean), and considering the large proportion of cases under the speed limit, this may explain why the mean did not shift as much as might be expected. Analyses on the proportions speeding will provide more insight into the observed change at the tail-end of the speed distribution.

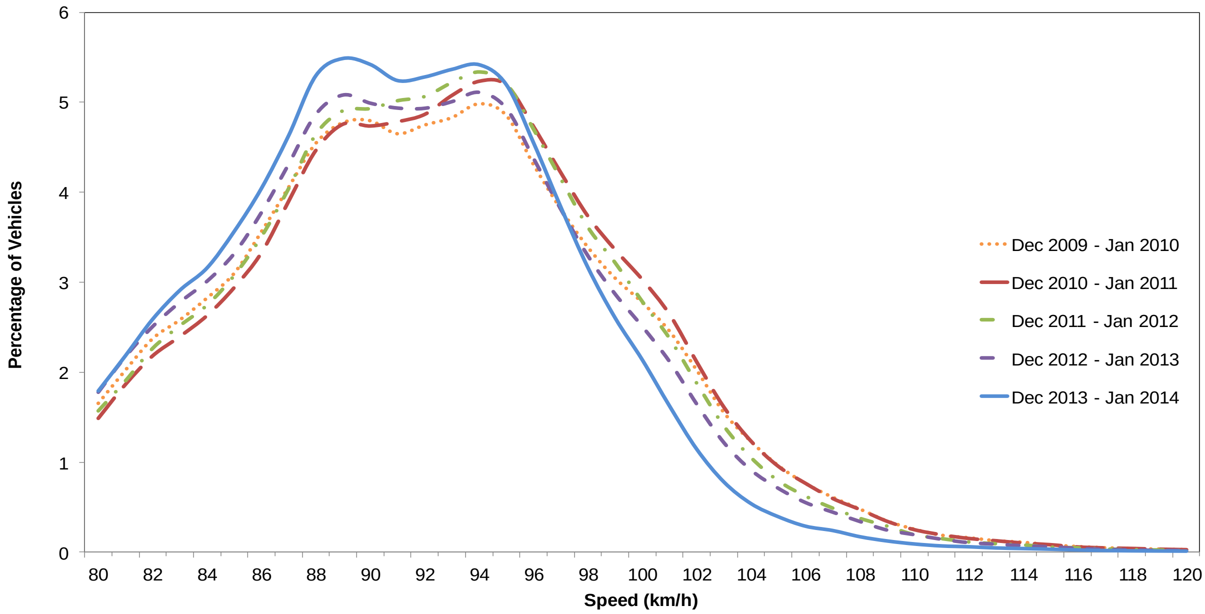

Figure 1. Speed curves for December – January periods

Speeding

Binary logistic regressions were performed to test if significantly fewer drivers were speeding during the intervention period compared to control periods. Table 2 shows the model coefficients, which indicate that vehicles speeding at 1-10km/h over the limit significantly decreased during the intervention period. The model for speeding at 11km/h+ over the limit also showed significant decreases in speeding during the intervention period.

Table 2. Model estimation and odds ratios vs. Dec 2013 – Jan 2014 for speeding

Parameter	Coefficient estimate (β)	Odds ratio (Exp. β)	95% confidence interval	Wald χ^2	*p*
1-10km/h excess speed				28,720.52	<.001
Dec 2009 – Jan 2010	.74	2.10	2.07, 2.12	21,313.60	<.001
Dec 2010 – Jan 2011	.77	2.15	2.13, 2.18	24,106.43	<.001
Dec 2011 – Jan 2012	.61	1.83	1.82, 1.85	13,971.05	<.001
Dec 2012 – Jan 2013	.47	1.60	1.58, 1.62	7,653.82	<.001
>10km/h excess speed				3,136.75	<.001
Dec 2009 – Jan 2010	.96	2.61	2.52, 2.70	2,675.22	<.001
Dec 2010 – Jan 2011	.89	2.44	2.35, 2.53	2,344.92	<.001
Dec 2011 – Jan 2012	.67	1.95	1.88, 2.03	1,207.16	<.001
Dec 2012 – Jan 2013	.59	1.80	1.73, 1.87	859.34	<.001

Note. *N* = 5,743,484

The odds ratios given in Table 2 can be seen as the risk or prevalence of speeding in each of the control periods compared with the intervention period (which is set at 1). Odds ratios below 1 denote lower risk, while ratios above 1 indicate higher risk. For example the odds ratio for speeding in excess of 10km/h in Dec 2012 – Jan 2013 is 1.8 times (80%) higher. The confidence interval shows the 95% reliability range of the odds ratio parameter estimate. Table 3 shows the total crash counts for each time period, along with the odds ratios expressed as percentage decreases. The odds ratio nearest the intervention of 1.6 for speeding by 1-10km/h over the limit translates to a statistically significant reduction of 35.7%. When accounting for the maximum year-on-year variation between control periods of 13.6%, this leaves a 22.1% conservative estimated net reduction outside of any expected variation. The odds ratio nearest the intervention of 1.8 obtained for speeding in excess of 10km/h translates to a statistically significant reduction of 45.2%. When accounting for the maximum year-on-year variance between control periods of 20.2%, this leaves a 25% conservative estimated net reduction outside of any expected variation.

Table 3. Change in speeding for intervention period vs. controls

Time period (Dec–Jan)	**1-10km/h excess speed**		**>10km/h excess speed**	
	Speeding (%)	**Percentage Decrease**	**Speeding (%)**	**Percentage Decrease**
2009–2010	10.7	49.5*	0.9	61.8*
2010–2011	11.0	50.9*	0.8	59.5*
2011–2012	9.5	43.2*	0.7	49.3*
2012–2013	8.4	35.7*	0.6	45.2*
2013–2014	5.4		0.3	

Note. *N* = 5,743,484; *Significant at 99.9% probability level.

Comparison of mobile speed camera and Bliptrack speed survey data

Using the Bliptrack system speed data to validate the camera survey analyses, it was revealed that the excess speed readings produced by the *Bliptrack* system are lower than might be expected on a 100km/h road for all of the measurement periods (Figure 2). The data recorded involves the average speed over the entire (12.7km) stretch of road, and is not a cross section of speed readings at any particular point in time (as is the case with speed camera data).

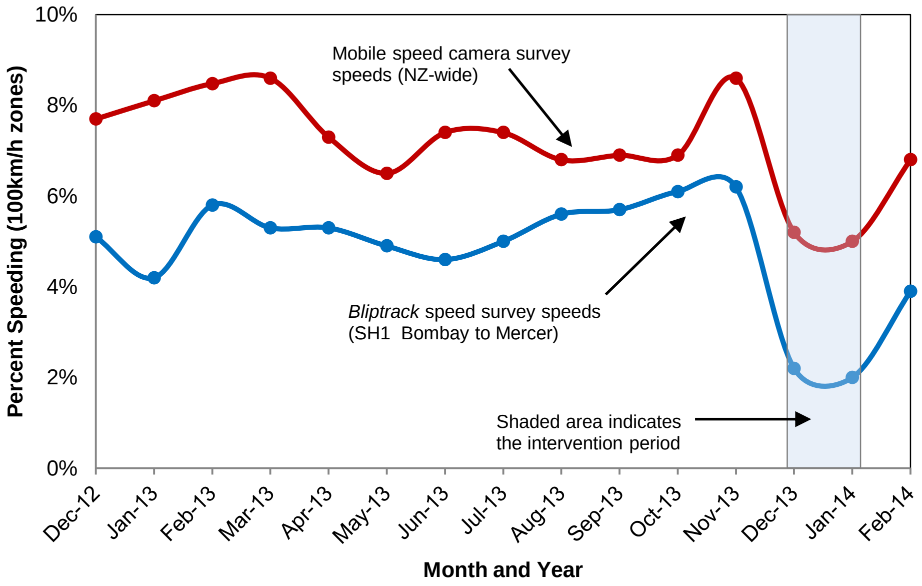

Figure 2. Percentage of speeding vehicles observed in two independent speed surveys

The percentage of speeding vehicles for speed camera captured survey data and *Bliptrack* data varied by approximately +/- 1% per month during the 1-year period leading up to the intervention period. The proportions of speeding vehicles in both datasets appear fairly stable until November 2013, and then drop considerably in the subsequent December 2013 and January 2014 months. This decrease was not observed for the same months in the previous year, and also does not persist in

February, when the enforcement threshold reverted to 10km/h. The decrease in speeding observed in the speed camera survey data was also present in the data captured by the *Bliptrack* system. This indicates that the effects on speeding are not a result of increased manipulation behaviour at camera sites, and is evidence that intervention was associated with overall increased compliance.

Crashes

As mentioned earlier, Poisson or negative binomial regressions were performed to test if the risk of crashes significantly decreased during the intervention period compared with the control periods. Table 4 presents the results of these analyses. The interpretation of these results is similar to the results of the analyses for speeding. A significant reduction in the risk of fatal crashes was obtained for the intervention compared to the December 2009 – January 2010 control period; however, the lack of statistical precision in the estimates for crash effects has resulted in non-significant results for the models tested. The best estimates for odds ratios show that minor injury, serious injury and fatal crashes decreased by a non-significant margin.

Table 4. Model estimation and odds ratios versus December 2013 and January 2014 for crashes and injuries

Parameter	**Coefficient estimate (β)**	**Odds ratio (Exp. β)**	**95% confidence interval**	**Wald χ^2**	***p***
Fatal crashes				6.41	.170
Dec 2009 – Jan 2010	.50	1.64	1.10, 2.44	5.95	.015
Dec 2010 – Jan 2011	.36	1.44	.95, 2.16	3.00	.083
Dec 2011 – Jan 2012	.36	1.44	.95, 2.16	3.00	.083
Dec 2012 – Jan 2013	.25	1.28	.84, 1.95	1.35	.245
Serious injury crashes				.63	.959
Dec 2009 – Jan 2010	.10	1.10	.75, 1.62	.24	.621
Dec 2010 – Jan 2011	.15	1.17	.79, 1.72	.61	.436
Dec 2011 – Jan 2012	.07	1.07	.73, 1.58	.12	.730
Dec 2012 – Jan 2013	.09	1.09	.67, 1.60	.18	.668
Minor injury crashes				3.54	.472
Dec 2009 – Jan 2010	.31	1.37	.95, 1.96	2.87	.090
Dec 2010 – Jan 2011	.26	1.30	.91, 1.87	2.06	.152
Dec 2011 – Jan 2012	.25	1.29	.90, 1.85	1.90	.168
Dec 2012 – Jan 2013	.17	1.19	.83, 1.71	.89	.344

Table 5 shows the total crash counts for each time period, along with the odds ratios expressed as percentage decreases. Two-hundred-and-one fewer minor injury crashes, 21 serious injury crashes, and 11 fatal crashes occurred during the intervention period compared to the closest control period. Although some of percentage reductions in crashes observed for the intervention period compared to the control periods appear to be considerable (particularly for fatal crashes), these decreases were not statistically significant. The confidence limits for all crash types are wide and overlap for at least one of the control periods. This indicates a high degree of variation and uncertainty in the model, and the results obtained may be attributable to the small sample size.

Table 5. Crash counts by period

Time period (Dec–Jan)	Minor injury crashes		Serious injury crashes		Fatal crashes	
	N	**Decrease (%)**	***N***	**Decrease (%)**	***N***	**Decrease (%)**
2009–2010	1,441	26.8	312	9.6	64	39.1*
2010–2011	1,374	23.2	330	14.6	56	30.4
2011–2012	1,360	22.4	303	6.9	56	30.4
2012–2013	1,256	16.0	308	8.4	50	22.0
2013–2014	1,055		282		39	

Note. *Statistically significant at the 95% probability level.

Discussion

The aims of the *Safer Summer* campaign were to reduce the prevalence of low-level speed violations and higher-end speeding in order to reduce the risk of crashes. The intervention consisted of three distinct components: a reduction in the speed enforcement threshold, increased speed enforcement intensity and a publicity campaign. Considering that more than one variable was changed during the treatment period, this creates a difficulty in attributing the effects to antecedents, as these could have resulted from any one aspect or a combination. A reduced speed enforcement threshold has previously been shown to have independent effects on driving speeds (Andersson, 1989; Luoma et al., 2012). The increased intensity of speed enforcement (Elvik, 2011; Povey et al., 2003) and public awareness created through the publicity campaign (Tay, 2005) are seen as having enhanced this effect.

The treatment period was associated with a lower mean speed, however, this difference was fairly small and appeared insensitive to changes in the top-end in the distribution. Examining the speed distributions provided additional context, and showed that slower drivers sped up and drivers at the higher-end slowed down. Speed data was further analysed by comparing the proportion of speeding vehicles as a percentage of all free-flow vehicles. This provided an estimate of the decrease in the prevalence of speeding. The results of these analyses showed that substantial and statistically significant decreases in speeding rates were present during the intervention period. Speeding within the usual 0-10km/h speed enforcement tolerance decreased by 36%, which was a 22% net reduction when controlling for the maximum variance between control periods. Speeding above 10km/h excess speed decreased by 45%, which was a 25% net reduction when controlling for the maximum variance between control periods. A comparison with a supplementary source of speed survey data confirmed the decreases in speeding were likely present across the road network, and not limited to camera sites.

The decreases in speeding associated with the campaign were expected to have had a significant and substantial impact on reducing the risk of serious crashes and resulting injuries and deaths. Although the best estimates showed reduced crash risk during the treatment period, statistical analyses could not confirm the significance of the reductions in fatal crashes (22%), serious injury crashes (8%), and minor injury crashes (16%). Decreases in speeds and speeding have previously been shown to strongly relate to crash severity, and to a lesser extent crash occurrence (Cameron, 2013; Doecke et al., 2011; Elvik, 2012; Gavin et al., 2010). While this relationship could not be reproduced in the present study, these findings provide indirect evidence of reduced risk being associated with the intervention. If speeding can be kept down over prolonged periods of time (which was associated with the intervention), the risk of fatal and serious injury crashes is expected to reduce by a significant margin. It is, therefore, likely that if the duration of the campaign were increased, the lower crash and casualty counts that were present during the campaign period would reach a critical point where statistically significant decreases in crashes and casualties are realised.

Conclusions

The present study has evaluated a speed enforcement campaign that focussed on the application of a reduced enforcement threshold, and has estimated the effects on speeding and crashes. Luoma et al. (2012) have previously found that a lower speed enforcement threshold causes drivers to slow down, and decreases speeding rates. However, the authors did not examine the impact on crash risk and occurrence. While the present study did include a statistical analysis of crash rates, the inability to detect significant effects for crashes and injuries is likely a result of insufficient data, prompting a need for further research. It is recommended to trial the implementation of a reduced speed enforcement threshold over a longer period (4 to 6 months or longer) in order to more accurately estimate any associated reductions in crash risk and injury severity. Removing the enforcement intensification component is also recommended for the duration of the experiment in order to separate the effects of the lowering of the enforcement threshold from increased Police presence.

The campaign was associated with the safest summer on New Zealand roads in recent history, however, it is unclear from the analyses precisely how much of the reductions in crashes can be attributed to the intervention. It can also not be determined how many additional crashes and casualties would have occurred in its absence. It can, however, be concluded that the well publicised, prolonged reduction in the speed enforcement threshold, combined with a strong enforcement effort, demonstrated high efficacy in changing road user behaviour. This was evident from the instantaneous decrease in speeding upon the commencement of the campaign, and immediate increase in speeding after the intervention ended (Figure 2). Previous research has strongly established the relationship between the risk of serious crashes and speed, and provides ample indication that over a greater intervention period, significant reductions in crashes and injuries would be realised.

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