Speeding: general police enforcement, speeding

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Please note: The studies included in this synopses were selected from those identified by a systematic literature search of specific databases (see supporting document). The main criterion for inclusion of studies in this synopsis and the DSS was that each study provides a *quantitative effect estimate*, preferably on the number or severity of crashes or otherwise on road user behaviour that is known to be related to the occurrence or severity of a crash. Therefore, key studies providing qualitative information might not be included in this synopsis.

1 Summary

Botteghi, G., Theofilatos, A., Macaluso, G., May 2017

1.1 COLOUR CODE: GREEN

The effects of speed enforcement are mostly positive in reducing crash frequency, mean vehicle speed and the proportion of drivers exceeding the speed limit. Furthermore, the coded studies encompass several topics and have good levels of quality and consistency. For the reasons mentioned above, the overall impact of speed enforcement is characterized as effective.

1.2 KEY WORDS

Enforcement; speed; deterrence; road; accident; systematic review; traffic violations; efficiency; enforcement performance indicators.

1.3 ABSTRACT

Speed enforcement aims to prevent drivers exceeding the speed limit by penalizing those who do. Therefore, speed enforcement affects the level of road safety, causing a reduction in crash frequency, in mean vehicle speed and in the number of vehicles travelling over the posted speed limit. Seven high quality studies involving various speed enforcement measures were coded. On the basis of both studies and effect numbers, it can be argued that speed enforcement creates positive impacts on road safety. However, there were isolated cases that reported different results.

1.4 BACKGROUND

Definition of speed enforcement

Speed limit enforcement is the action taken by appropriately empowered authorities to check that drivers are complying with the speed limit in force. This not only affects the speed violators who get caught (specific deterrence), but also those who see or hear that others get caught (general deterrence). There are various tools and methods available for speed enforcement.

How does speed enforcement affect road safety?

Police enforcement is based on the principle that people try to avoid penalty. Most important is that people have the impression that there is a high chance that they will be penalized when violating a rule. The subjective chance of apprehension is primarily affected by the actual level of enforcement. In addition, it is affected by how much people see or hear about police enforcement. Therefore, the subjective chance of apprehension can be increased by applying both visible and hidden enforcement activities, by publicising specific enforcement activities (e.g. in national or regional media), and by feedback on the results of enforcement activities (e.g. in national or regional media).

Which safety outcomes are affected by speed enforcement?

The reviewed studies focus on various outcomes. In some studies, the main focus is estimating the reduction of the number of crashes due to the speed enforcement with different methods (e.g. before-after comparison, calculation of crash modification factors, etc.). In addition to this, other studies

investigate the effects of speed enforcement on speed reduction and on the number of vehicles travelling over the speed limit.

How is the effect of speed enforcement on road safety studied?

The international literature has examined a variety of different approaches and ways to study the effect of speed enforcement on road safety. Often this measure is examined alongside others (e.g. seat belt enforcement, etc.) and not by itself, and its examination is adjusted to the models selected to capture the entire situation for the given case.

1.5 OVERVIEW OF RESULTS

The effects of police enforcement on road safety tend to increase the level of road safety. Findings from the studies demonstrate that the presence of speed enforcement, or the increase in the amount of speed enforcement, leads to a reduction in crash frequency and speed, and to an increase in speed compliance. Usually the various study findings link police enforcement to decreased crash frequency.

In particular, one study shows that as the number of enforced sites and issued tickets increased, and the average check length decreased, a reduction of speed-related collisions was observed. With regard to mean vehicle speed, the majority of studies show a significant reduction, with a beneficial effect on road safety. Positive effects were also found on the share of vehicles exceeding the speed limit. Conversely, one study reports a non-significant effect of the increase of fixed penalties for speeding on the speed compliance.

Transferability

The coded studies are based on data from several countries including Norway, Netherlands, Canada and the United Kingdom. In addition, two meta-analyses were identified and coded consisting of results from different countries (Australia, United states, European Union countries, South Korea, Israel, etc.) were collected. Although this is a good sample for general trends in developed countries, there is a lack of studies representing less motorized countries. Moreover, the totality of studies examines all motor vehicles, without differentiating between different road users. All the above could make the results for police enforcement generally transferable, caution is required road user behaviour in different countries as well as their sensitivity to penalties may significantly differ.

1.6 NOTES ON ANALYSIS METHODS

The methodology applied for capturing the impact of police enforcement on road safety varies considerably between studies. This variation is mainly in terms of the mathematical models utilised, but also in the outcomes evaluated as dependent variables. More specifically, there is a variety of different methods such as repeated measures analysis, before and after analysis, linear models etc. There is also a certain margin for investigating different road user categories and/or other geographical regions.

2 Scientific Overview

2.1 ANALYSIS OF STUDY DESIGNS AND METHODS

After appropriate use of various search tools and databases, three (3) high quality studies and three (3) meta-analyses (Elvik et al., 2011; Elvik et al., 2015; Erke et al., 2009) were selected and coded to evaluate the effectiveness of the speed enforcement on road safety. Three studies (Goldenbeld et al., 2005; Li et al., 2017; Erke et al., 2009) investigated the effects of speed enforcement on the number of accidents; Goldenbeld et al. (2005) also analysed the mean speed and the percentage of vehicles travelling over the posted speed limit. Furthermore, one other study (Walter et al., 2011) focused on the number of drivers exceeding the speed limit and Walter et al. (2011) also analysed the drivers' speed.

In terms of investigation methods used, there is a variety of different methods such as repeated measures analysis, before and after analysis, modelling studies (cross-sectional) etc. In order to examine the relationship between the various exposures and outcome indicators, the majority of the studies used multivariate statistical models or univariate parameter significance testing (e.g. generalized linear model with Poisson distribution, multiple linear regression model, F-test, etc.). Moreover, one study (Erke et al., 2009) combined data from multiple studies through a meta-analysis. A study (Walter et al., 2011) did not mention any statistical analysis, but comparisons before and after the speed enforcement were conducted.

Regarding the number of accidents, all the examined studies show a reduction of crash frequency. Additionally, Goldenbeld et al. (2005) shows a decrease in the number of injury accidents and serious traffic casualties, while Li et al. (2017) asserts that as the number of enforced sites and issued tickets increase, the number of speed-related collisions decreases and, as the average check length decreases, a greater reduction of speed related collisions is observed. The last study concerning the crash frequency is a meta-analysis conducted by Erke et al. (2009), which shows a significant reduction of crash frequency for all severities, due to different measures, such as implementation of speed enforcement, increase of the amount and change type of speed enforcement.

When examining speed enforcement, another popular outcome is the number of drivers exceeding the speed limit. The first study by Goldenbeld et al. (2005) shows a significant decrease in the percentage of offenders during the enforcement program. In the same way, Walter et al. (2011) reports a reduction in the proportion of speeding drivers and 'extreme' speeding drivers (15mph or more above the speed limit), due to the increase in the level of enforcement.

With regard to mean speed, Goldenbeld et al. (2005) reports a significant reduction during the enforcement program. Similarly, findings from Walter et al. (2011) show a decrease in 85^{th} percentile speed and mean speed, but without any statistical evidence.

An overview of the main features of the coded studies (sample, method, outcome and results) is illustrated on Table 1.

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Table 1 Description of coded studies.

Number	Author(s); Year; Country;	Sampling frame for law and enforcement investigation	Method for law and enforcement investigation	Outcome indicator	Main Result
1	Elvik, R.; 2011; various	An accident modification function for speed enforcement was developed, relating the size of the effect on accidents to the level of enforcement introduced. 13 studies of the effects of speed enforcement were retrieved. 2 cross-sectional studies were omitted, while 11 before-after studies containing 63 data points (then reduced to 15) remained. Only the best models were coded.	Meta-analysis (Inverse function fitted to non-weighted data points & logarithmic function fitted to weighted data points)	Number of accidents [crash modification function]	A positive relationship between the amount of enforcement (the size of the dose) and the effect on accidents was expected. When studies were pooled and data points aggregated, to reduce the contribution of random variation in estimates of effect, a dose–response pattern emerged.
2	Elvik, R.; 2015; various	A meta-regression for speed enforcement and speed cameras was developed, relating the size of the effect on accidents to the level of enforcement introduced.	Meta-regression (Logarithmic function fitted).	Number of accidents [crash modification function]	A positive relationship between the amount of enforcement (the size of the dose) and the effect on accidents was expected.
3	Erke A., Goldenbeld C., Vaa T.; 2009; Netherlands	The report investigates the effectiveness of speed enforcement based on the results of 47 studies. The studies are categorized according to many moderator variables: visibility, signposting, randomization, accompanying publicity, change of type or amount of enforcement, increase of the amount of enforcement, country, accident severity, study methodology, study design.	Fixed and random effects step-by-step Meta-analysis (log-odds method) & Trim and fill analysis	Number of accidents [percent accident reduction]	The overall result is a significant reduction of the number of accidents and there is no indication of publication bias according to the result from the trim and fill analysis.
4	Goldenbeld C., Van Schengen, I.; 2005; Netherlands	The study estimated the effects of 5 years (1998-2002) of a regional speed enforcement program on single carriageway rural roads in the Dutch province of Friesland. 12 road sections (length 60 km) and 28 rural road sections (length 116 km) were considered to evaluate the effects on speed and road accidents respectively.	Repeated measures analysis & before/after comparison [F-test]	Mean speed [R-squared]; Percentage of offenders [R-squared]; Injury accidents [odds ratio]; Serious traffic casualties [odds ratio]	Both the mean speed and the percentage of speed limit violators decreased during the targeted enforcement program. The number of road accidents and casualties decreased more at the enforced than at the comparison roads. Based on the available data, the best possible estimate of the traffic safety effect of the enforcement program is a 21% reduction of both serious casualties and injury accidents.
5	Li R., El-Bassoon K., Kim A., Targum S.; 2017; Canada	In this study, the number of enforced sites, average check length, and number of issued tickets were selected as three important enforcement performance indicators, and their impacts on safety were investigated. In total, 96 monthly observations were used in the model estimation.	Generalized linear model (Poisson distribution)	Monthly Number of Speed-Related Collisions [slope]	The results show that as the number of enforced sites and issued tickets increased, the number of speed-related collisions decreased. Also, as the average check length decreased, a greater reduction of speed related collisions was observed.
6	Walter L., Broughton J., Knowles, J.; 2011; United Kingdom	Operation Radar was a four-week campaign mounted by the Metropolitan Police in which the level of police enforcement of traffic laws was increased along a six-mile route in London (A23). The study. The operation was carried out five days per week between 6th and 30th May2008, except for the Bank (public) holidays.	Comparisons between before and after and between before and during the operation	Speed of drivers [absolute difference]; drivers exceeding the speed limit [percent change];	Analysis of the speed data showed that 85th percentile and mean speeds reduced systematically during the operation at sites where static speed enforcement was targeted. The proportion of speeding drivers and 'extreme' speeding drivers (15mph or more above the speed limit) reduced substantially during the operation.

Limitations

There are a couple of limitations in the current literature examining the effects of speed enforcement on road safety. The first is that the totality of studies comes from developed countries, and consequently there is a lack of information concerning the impact of speed enforcement in less motorized countries, such as South America or Africa. The impact of speed enforcement in these environments should be captured from similar studies for a more collective approach.

Secondly, Walter et al. (2011) uses speed as a measure of effectiveness, which is a secondary parameter and does not directly provide a clear image regarding the number of crashes.

2.2 RESULTS FOR SPEED ENFORCEMENT

Introduction

The effects of speed enforcement on road safety can be summarized as follows:

- 3 studies with a significant reduction in the number of accidents;
- 1 study with a non-significant effect on speed compliance;
- 1 study with a significant positive effect on the number of vehicles travelling over the posted speed limit;
- 1 study with a reduction in the number of drivers exceeding the speed limit, but no statistical analyses were performed;
- 1 study with a significant reduction in mean speed;
- 1 study with a reduction in speed, but without any statistical analyses.

The complete detailed results from the coded studies appear in Table 2, which is presented in the supporting document. After the results were reviewed together, in possible consideration of a meta-analysis, the following points were observed:

a) There is an adequate number of studies. However,
b) Those studies have used different models for analysis.
c) There are different indicators, and even when they coincide they are not measured in the same way.
d) The sampling frames were different.

Description of analysis carried out

Review-type analysis

After considering the previous points, it was decided that a meta-analysis could not be carried out in order to find the overall impact of speed enforcement on road safety. Despite the suitable number of studies, the sampling frames, outcome variables and statistical analyses are all too different for the meta-analyses to be unified. Most importantly, two meta-analyses are included in the coded studies, and since the results have different weights, the only analysis that can be performed is a qualitative one.

Taking the above into consideration, it was decided that both the meta-analysis and the vote count analysis are inappropriate, and thus the review type analysis was selected.

The positive effects of crash reduction appear to occur in several locations, for different severities (fatal, injury, all severities) and also on urban, suburban and rural study sites. Positive effects were also found for the mean speed on rural roads, both for riders and for drivers.

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Regarding speed compliance, one study reports a non-significant effect of speed enforcement on road safety. However, the majority of the studies show a significant positive effect for different road types and users.

Overall estimate for road safety

On the basis of the coded studies, it can be asserted that the implementation of speed enforcement, or an increase in the amount of it, has an overall positive effect on road safety. However, there are cases when its impact is inconclusive, but these are in the minority and occur due to unexpected circumstances. The fact that the results are mostly consistent and show a decrease in the number of accidents, in mean speed and in the number of drivers exceeding the speed limit, leads to the assignment of the green colour code for speed enforcement. The variation between indicators, models, framing and general details between studies made the circumstances for conducting a meta-analysis inappropriate.

Conclusion

The review-type analysis carried out show that speed enforcement is usually associated with a reduction in crash frequency and mean speed. In addition, the presence or increase of speed enforcement encourages drivers to keep the speed limits.

3 Supporting document

3.1 IDENTIFYING RELEVANT STUDIES

Literature search strategy

The search strategy aimed at identifying recent studies regarding the implementation of Laws and Enforcement for speeding. The main database that was consulted was Scopus. In general, only recent (after 1990) journal studies were considered, but high quality conference papers (e.g. in world-class conferences such as TRB) and reports were also considered. Moreover, all reference lists were checked especially from recent high ranked journal papers, in order to ensure that no relevant studies were left out. After an abstract and title screening, out of 1013 potentially eligible studies, 389 were found to be mostly relevant to the topic and were then full-text screened. However, after a full-text screening and according to our prioritization criteria (please see below) 5 quality studies (2 of which were a meta-analysis) out of the final 15 were coded and included in the synopsis.

Limitations/ Exclusions:

- Search field: TITLE-ABS-KEY
- Published: 1990 to current
- Document Type: "Review" and "Article"
- Language: "English"
- Source Type: "Journal"
- Only Transport Journals were considered
- Subject Area: "Engineering and Psychology"

Database: Scopus **Date:** 28th March 2017

search no.	search terms / operators / combined queries	Hits
#1	(„law" OR "enforcement")	522,120
#2	(„speed" OR „speeding")	4,412
#3	#1 AND #2	1,013

Results of Literature research

Database	Hits
Scopus	1013
Total number of studies to screen title	1013

3.2 SCREENING

The abstracts of relevant studies from the initial literature search results were examined to narrow the scope and to detect studies that would be more appropriate at a first stage. Those abstracts give hints as to whether the full text warrants close examination for coding and inclusion in the project.

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Total number of studies to screen title	1013
Number of articles remaining after screening of the title = Total number of studies to screen abstract	458
Remaining studies after abstract screening	389
Total number of studies to screen full text	389

3.3 ELIGIBILITY

Total number of studies to screen full-text	389
Full-text could be obtained	389
Reference list examined	Yes
Eligible papers prioritized	7

3.4 PRIORITIZING CODING

- Prioritizing Step A (existing meta-analyses)
- Prioritizing Step B (most recent studies)
- Prioritizing Step C (Journals over conferences and reports)
- Prioritizing Step D (Prestigious journals over other journals and conference papers)
- Prioritizing Step E (Studies from Europe)

3.5 SUPPORTING QUANTITATIVE TABLE

Below follows Table 2, which includes all quantitative effects from the coded studies for the measures of speed enforcement.

Table 1: Quantitative results of coded studies for speed enforcement impacts on road safety.

Number	Author(s); Year; Country;	Outcome indicator	Exposure	Quantitative Estimate			Effect on road safety
1	Elvik, R.; 2011; various	Number of accidents [crash modification function]	Relative Level of enforcement	weighted data points		CMF: N=-0.248, p=0.00, a=0.05	↓
				non-weighted data points		CMF: N=0.352, p=0.001, a=0.05	↓
				Ten times current level		Per.Ch.: N= -11.4%	↓*
2	Elvik, R.; 2015; various	Number of accidents [crash modification function]	Relative Level of enforcement	All accidents-all studies		Coefficient of meta-regression (b1)=-0.0581 (*Dependent variable was in logarithmic scale), st.error= 0.0104*	↓
				All accidents-conventional		Coefficient of meta-regression (b1)=-0.0711 (*Dependent variable was in logarithmic scale), st.error= 0.206*	↓
3	Erke A., Goldenbeld C., Vaa T.; 2009; Netherlands	Number of accidents [percent accident reduction]	Implementation of speed enforcement	All severities	Stationary manual	Per.Acc.Red.: N=-11%, CI [95%] = [-22;1]	↓
					Patrolling	Per.Acc.Red.: N=-6%, CI [95%] = [-16;4]	↓
					Radar laser	Per.Acc.Red.: N=0%, CI [95%] = [-3;4]	-
					Composite other	Per.Acc.Red.: N=-18%, CI [95%] = [-33;1]	↓
				Injury	Stationary manual	Per.Acc.Red.: N=-12%, CI [95%] = [-26;5]	↓

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Number	Author(s); Year; Country;	Outcome indicator	Exposure	Quantitative Estimate			Effect on road safety
					Patrolling	Per.Acc.Red.: N=-6%, CI [95%] = [-20;10]	↓
					Radar laser	Per.Acc.Red.: N=2%, CI [95%] = [-3;8]	-
					Composite other	Per.Acc.Red.: N=-18%, CI [95%] = [-30; -4]	↓
				Fatal	Stationary manual	Per.Acc.Red.: N=-27%, CI [95%] = [-44; -2]	↓
					Patrolling	Per.Acc.Red.: N=-12%, CI [95%] = [-35;18]	↓
					Radar laser	Per.Acc.Red.: N=-21%, CI [95%] = [-42;7]	↓
					Composite other	Per.Acc.Red.: N=-16%, CI [95%] = [-36;11]	↓
			Increase of the amount of enforcement	All severities	overall	Per.Acc.Red.: N=-14%, CI [95%] = [-20;-6]	↓
					increase<200%	Per.Acc.Red.: N=-3%, CI [95%] = [-9;4]	↓
					increase>200%	Per.Acc.Red.: N=-11%, CI [95%] = [-21; -1]	↓
				Injury	overall	Per.Acc.Red.: N=-14%, CI [95%] = [-20; -8]	↓
					increase<200%	Per.Acc.Red.: N=-4%, CI [95%] = [-11;3]	↓
					increase>200%	Per.Acc.Red.: N=-7%, CI [95%] = [-20;9]	↓
				Fatal	overall	Per.Acc.Red.: N=-23%, CI [95%] = [-34; -10]	↓
					increase<200%	Per.Acc.Red.: N=-12%, CI [95%] = [-27;8]	↓
			Change of type of enforcement	All severities		Per.Acc.Red.: N=-21%, CI [95%] = [-29; -13]	↓
				Injury		Per.Acc.Red.: N=-16%, CI [95%] = [-30;1]	↓
				Fatal		Per.Acc.Red.: N=-35%, CI [95%] = [-38; -32]	↓
			All measures	All severities		Per.Acc.Red.: N=-18%, CI [95%] = [-23; -13]	↓
4	Goldenbeld C., Van Schagen, I.; 2005; Netherlands	Mean speed [R-squared]	Speed enforcement*T	R-squared: MS=0.09, F (5,125) = 2.4, p=0.038, a=0.05			↓
		Percentage of offenders [R-squared]		R-squared: PO=0.07, F (5,125) = 1.9, p=0.096, a=0.10			↓
		Injury accidents [odds ratio]	Speed enforcement	Odds ratio: IA=-0.79, CI [95%] = [0.66;0.95]			↓
		Serious traffic casualties [odds ratio]		Odds ratio: C=-0.79, CI [95%] = [0.63;0.99]			↓
5	Li R., El-Basyouny K., Kim A., Gargoum S.; 2017; Canada	Monthly Number of Speed-Related Collisions [slope]	Increase of Number of Enforced Sites	Slope: N=-0.032, SE= 0.0059, a=0.01			↓
			Increase of Average Check Length	Slope: N=0.0507, SE= 0.0166, a=0.01			↑
			Increase of Number of Issued Tickets	Slope: N=-0.0946, SE= 0.0083, a=0.01			↓
6	Walter L.,	Speed of	Increase of the	before-	A23 targeted	Abs. Diff.: S=-1.9 mph	↓*

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Number	Author(s); Year; Country;	Outcome indicator	Exposure	Quantitative Estimate			Effect on road safety
	Broughton J., Knowles, J.; 2011; United Kingdom	drivers [absolute difference]	level of enforcement	after	other A23 sites	Abs. Diff.: S=-1.0 mph	↓*
				before-during	other A23 sites	Abs. Diff.: S=-0.6 mph	↓*
		drivers exceeding the speed limit [percent change]		before-during	A23 targeted	Per. Ch.: D=-9%	↓*
					close off-route sites	Per. Ch.: D=-4%	↓*
					other A23 sites	Per. Ch.: D=-7%	↓*

↓	denotes positive road safety effects	-	denotes unclear or marginal road safety effects
↑	denotes negative road safety effects	*	denotes that no statistical analysis was conducted for the significance of the effects

3.5 REFERENCES

List of coded studies

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