Road safety audits & inspections

Please refer to this document as follows: **Ziakopoulos, A., Botteghi, G., Theofilatos, A., Papadimitriou, E (2017), Road safety audits & inspections, European Road Safety Decision Support System, developed by the H2020 project SafetyCube. Retrieved from www.roadsafety-dss.eu on DD MM YYYY**

Please note: The studies included in this synopsis 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.

Summary

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1.1 COLOUR CODE: LIGHT GREEN

On the basis of both study and effect numbers, it can be seen that road safety audits and inspections measures can have a positive effect on road safety. In a minority of cases their impact is inconclusive (or has isolated negative effects), but results still indicate an overall crash mitigation. The studies have good levels of quality.

1.2 KEYWORDS

Road safety audits; road safety inspections; network deficiencies

1.3 ABSTRACT

Road safety audits and inspections are conducted commonly by experts to highlight problems and deficiencies in a road or network for further consideration and examination by road management authorities. They are tools that enable secondary measures to be determined and applied. Five high quality studies were coded, and a meta-analysis based on the results of two of them was conducted. Results indicate a significant crash reduction of 60% after implementing the audit tool, hinting at considerable bonuses that stand to be gained from more widespread use of road safety audits. On a basis of both study and effect numbers, it is evident that road safety audits and inspections can create positive impacts on road safety by reducing crash and injury numbers. In a minority of cases their impact is inconclusive or has isolated negative effects. The results seem generally transferable with caution.

1.4 BACKGROUND

1.4.1 Definition of road safety audits and inspections

Road safety audits and inspections are defined as "the formal safety performance examination of an existing or future road or intersection by an independent, multidisciplinary team. It qualitatively estimates and reports on potential road safety issues and identifies opportunities for improvements in safety for all road users" (FHWA, 2017).

Road safety inspections report on the particularities of a road in use, and are undertaken by third-party surveyors. A common description is that they comprise all the processes of examining an existing road section, as undertaken by a third-party multidisciplinary team of experts. The examination can be qualitative and quantitative, and the resulting reports highlight potential road safety problems and margins for improvements in safety, for all road users.

Similarly, road safety inspections are examinations undertaken by expert teams aiming to provide insights into the particularities of the road segments and the outlying road environment. These particularities and noteworthy elements could induce outside effects on road users that affect their behaviour, and impact overall road safety.

1.4.2 How do road safety audits and inspections affect road safety?

As road safety, highway engineering and science in general progresses, many elements that improve road environments are introduced. Similarly, many outside elements can affect and interfere with the movement of vehicles. Some of these may be previously unseen elements such as new video advertising screen boards.

Road safety audits ensure that the existing road environment meets all required standards for safe use by all road users. Correspondingly, road safety inspections ensure that all nearby relevant elements are accounted for, and that their effect on the actions of the road management authorities is anticipated. Hence, it can be expected that the implementation of both kinds of measures will highlight road safety problems and increase road safety levels. This is primarily achieved via the implementation of secondary road measures, determined as a result of the road safety audits and inspections. Examples of these are traffic sign/signal installation and reconfiguration, road marking improvements, shoulder widening, pavement maintenance and various other measures.

1.4.3 How is the effect of road safety audits and inspections on road safety studied?

Road safety audits and inspections are rarely examined in the international literature, primarily because they are preliminary stages for the implementation of secondary measures. Typically, road safety level changes are treated as originating from the secondary measures and are attributed to them. However, there are cases where the effect of utilizing road safety audits and inspections is examined as a primary measure.

When a study takes the latter approach, a common practice is to identify a road section or network as a study area. In such cases, before-after measure application approaches are implemented to capture the effect of road safety audits and inspections in influencing road safety levels. Benefits are estimated using crash numbers or crash rates, which offer direct insights into road safety levels.

1.4.4 Overview of results

The effects of road safety audits and inspections on road safety tend to be positive overall. Most of the examined studies show uniform reductions in crash numbers, while the last two studies show crash reduction in most examined cases, but with some minor crash increases in isolated cases. Typically, these increases are in damage crashes rather than injury crashes, and hence they are effects of crash mitigation. Furthermore, all reported secondary measures appeared to have a beneficial effect. The meta-analysis conducted indicates a 60% reduction in the numbers of crashes, after conducting road safety audits in a road segment, and this is statistically significant.

1.5 TRANSFERABILITY

Coded studies are based on data from Canada, Greece, New Zealand, Norway and the United Kingdom. While this is a good sample of developed countries, there is scope for representation of other areas of the globe, and a respective gap of knowledge, especially concerning less motorized regions. Most studies conducted a uniform examination of all

crash types and road users. Two meta-analyses separated studies by injury severity. In conclusion, there appears to be scope for a greater variety of approaches.

1.6 NOTES ON ANALYSIS METHODS

While the methods for capturing the impact of high risk site treatment are similar (before-after measure application approaches), the outputs are interpreted in differing ways. Sometimes, raw crash numbers or descriptive statistics are provided, whilst other studies use significance testing to determine the level of statistical significance of each parameter. There is scope for investigating different road user categories and/or other geographical regions. The aforementioned factors make the findings for road safety audits and inspections transferable with caution.

Scientific overview

2.1 ANALYSIS OF STUDY DESIGNS AND METHODS

After appropriate use of search tools and databases, five (5) high quality studies were selected and coded for the measures of road safety audits and inspections. Notably, all studies investigated crash reduction in one form or another: Belcher et al. (2008), England et al. (2013) and Vardaki et al. (2014) investigated changes of crash numbers while Elvik et al. (2008) and Lougheed and Hildebrand, (2016) explored crash comparison with projected models or estimates that would occur in the absence of tools to address road network deficiencies.

The number of crashes and injured users provides a very direct method for investigating effects on road safety. Whilst this is direct and comprehensible it is also fairly simplistic, and often ignores network particularities best captured via crash rates (e.g. taking into account vehicle-kilometers).

To examine the relationship between the effects of road safety audits and inspections, the studies utilised either significance testing (e.g. Chi-square/χ^2 tests or standard error provision) or conducted basic descriptive statistical analysis as a minimum.

It should be noted that studies relevant to this topic are particularly scarce in the literature, particularly concerning road safety inspections. There is a significant knowledge gap in this area. It is also noteworthy that many of the studies consider road safety improvements as the consequence of implementing specific measures (i.e. as a result of road safety audits and inspections), not the beneficial impact of the screening processes themselves. The screening processes are often mentioned as an introductory process.

Whilst the interpretation of this interrelation depends primarily on the view of the researcher, there is value in summarizing the direct numerical impacts of road safety audits and inspections for the benefit of road safety researchers and stakeholders.

2.2 LITERATURE OVERVIEW

All studies reported a reduction in crash numbers after implementing road safety audits or inspections at a macroscopic level. For the results from Belcher et al. (2008), Elvik et al. (2008), England et al. (2013) and for some results from Lougheed and Hildebrand, (2016) no statistical significance testing was conducted or presented, and thus the findings are interpreted with caution.

In several cases, road safety audits and inspections proved to be highly beneficial in reducing crashes and crash rate. Isolated cases of crash increases were observed, but the respective studies (England et al., 2013 and Lougheed and Hildebrand, 2016) averaged their results to obtain the overall effect, and the resulting outcome was positive for road safety.

The results presented in Lougheed and Hildebrand (2016) show a reduction in more severe crashes, indicating that increases in damage-only crash numbers can be related to crash mitigation. Hence it can be observed that crash consequences are mitigated via the

implementation of road safety audits and inspections, and thus the overall road safety level is increased.

The overall positive results are intuitive considering the nature of the measure. Expert auditors and inspectors are expected to pinpoint safety issues already existing in the network, and to highlight potential problems before they arise, or issues not necessarily reducing safety levels but with potential ties to them (e.g. creation of sudden traffic pools).

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

Number	Author(s); Year; Country;	Sampling frame for audits/inspections studies	Method for audits/inspections impact investigation	Outcome indicator	Main Result
1	Belcher, M., Proctor, S., & Cook, P.; 2008; United Kingdom	Safety performance of 20 minor improvement schemes in Surrey, UK	Crash comparison	Crash numbers [Absolute difference]	The safety performance of 20 minor improvement schemes that had been audited and modified accordingly was checked against 20 similar schemes that had not been audited. The audited schemes had, on average, about one casualty per year fewer than the non-audited schemes.
2	Elvik, R., Høye, A., Vaa, T., & Sørensen, M.; 2008; Norway	Summary of effects that can be expected if specific measures are introduced as part of road safety inspections from previous research.	Crash comparison	Expected injury crash comparison [Percentage difference]	Road safety inspections resulted in reduction estimates for several types of crashes, thus improving road safety.
3	England, J., Hannah, J., & Wilkie, S.; 2013; New Zealand	Two NZ district councils served as case studies to assess the crash reduction of Road Infrastructure Safety Assessment.	Crash comparison	Crash numbers [Absolute difference]	The crash reductions mostly seem considerable, but not all of them are uniform (Fatal crashes were unchanged in Dunedin City, and collision with utility poles was increased across all injuries).
4	Lougheed, P., & Hildebrand, E.; 2016; Canada	This is a comparison of observed and predicted collision frequencies from three large-scale Public-Private-Partnership (P-3) rural freeway projects with similar fundamental characteristics.	Crash comparison	Expected Crash comparison [Percentage difference]	The total number of collisions is reduced significantly by 15%, while for injurious and fatal accidents this reduction reaches 36%.
5	Vardaki, S., Papadimitriou, F., & Kopelias, P.; 2014; Greece	A RSA of the Attica Freeway was conducted in mid-2009 aiming at identifying features of the roadway operating environment which might be potentially dangerous.	Crash comparison	Crash numbers [Percentage difference]	Specific site treatments that were conducted as a result of the road safety audit implementation were found to effectively reduce the number of road accidents.

Table 1: Description of coded studies

2.3 LIMITATIONS

A few limitations can be found in the current literature for the effects of road safety audits and inspections on road safety. Firstly, there are very few studies: this appears to be an under-researched topic. This shortcoming may indicate that there is a lack of interest in implementing the measures, or in devising new methods to monitor their benefits, despite the clearly significant results presented in this synopsis. Road safety inspections are particularly underrepresented: only one study presenting numerical effects could be located.

Secondly, all included studies originate from developed and highly motorized countries, known to possess and apply high road design standards. Hence, this sample is not particularly representative of the worldwide impact of road safety audit and inspection measures, and as such any results and conclusions drawn from this synopsis are transferrable with caution.

2.4 RESULTS FOR ROAD SAFETY AUDITS AND INSPECTIONS

2.4.1 Introduction

The effects of road safety audits and inspections identified can be summarized as follows:

- 1 study with a significant decrease in road crashes
- 3 studies with an unverified decrease in road crashes
- 1 study with unverified and significant decreases in road crashes overall, and some isolated unverified and significant increases in road crashes

The quantitative results of the coded studies are presented in Table 2, together with their general effects on road safety. This is included in the supporting document.

After collectively reviewing the results, the following points were observed:

a) There is an adequate number of studies
b) Those studies have used similar methods for analysis
c) There are similar indicators (though at times expressed differently)
d) The sampling frames seemed to be compatible

2.5 DESCRIPTION OF ANALYSIS CARRIED OUT

2.5.1 Meta-analysis

After considering the previous points, it was decided that a meta-analysis was possible, to determine an overall estimate of the effect of road safety audits and inspections on road safety levels. More specifically, the overall estimate of the raw proportion of crashes after conducting road safety audits (x_i) compared to the proportion of crashes before conducting road safety audits (n_i) was investigated. To do so, the respective numbers of crashes had to be defined for each study. Since England et al. provided data for two separate sites, they were treated as two separate inputs. The variance v_i of weights ($v_i = 1/x_i+1/n_i$) was then calculated for each study following Elvik (1999), and the statistical weight assigned to each parameter was $w_i = 1/v_i$.

2.5.2 Overall estimate on the absolute proportion of crashes

The results showed a statistically significant effect at a 95% level (p-value < 0.0001). The overall estimate for the crash reduction following road safety audits was found to be 0.0400, as shown in Figure 1, and additional parameters in Table 3. This means that the crash level after the audits was about 40% of that before, i.e. a reduction of 60%. This illustrates the potential gains from more widespread use of road safety audits.

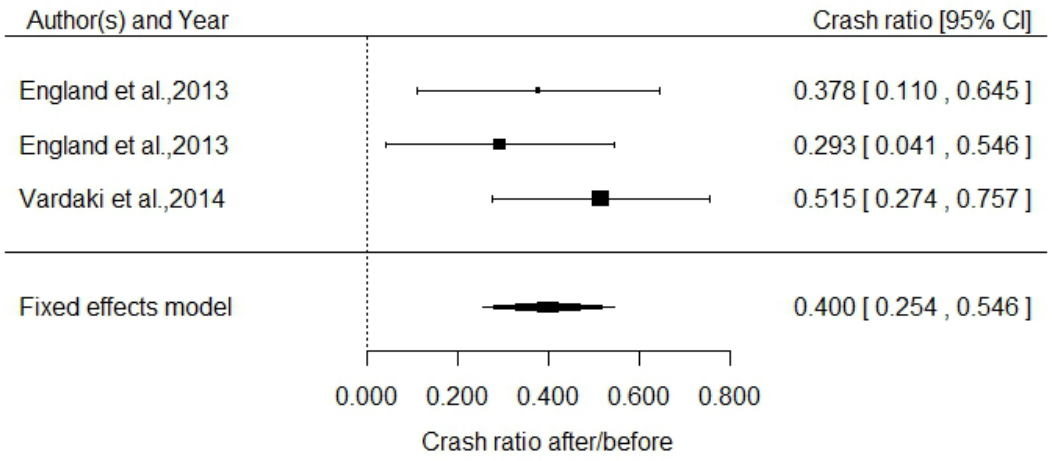

Figure 1: Forest plot for absolute proportion of crash reduction due to road safety audits.

Variable	Estimate	Std. Error	p-value	95% CI
Proportion of crash reduction due to road safety audits	0.400	0.0745	<0.0001	(0.2538, 0.5459)

Table 3: Fixed effects meta-analysis for crash reduction due to road safety audits

2.5.3 Heterogeneity

The Q test is significant ($Q_{[df=2]}$=1.5943, p-value = 0.4506) suggesting there is no considerable heterogeneity among the true effects. Therefore, the fixed effects meta-analysis that was carried out is preferred and there is no need to perform random effects meta-analysis.

2.5.4 Publication Bias

A funnel plot was produced in order to detect potential publication bias. The visual examination of the funnel plot shows that it is symmetrical, suggesting that there is no strong evidence for publication bias. A further method for testing for publication bias is to check whether the observed outcomes are related to their corresponding standard errors. The results showed that almost no publication bias exists (t = -0.6961, df = 1, p-value = 0.6129). The funnel plot appears on Figure 2 which follows.

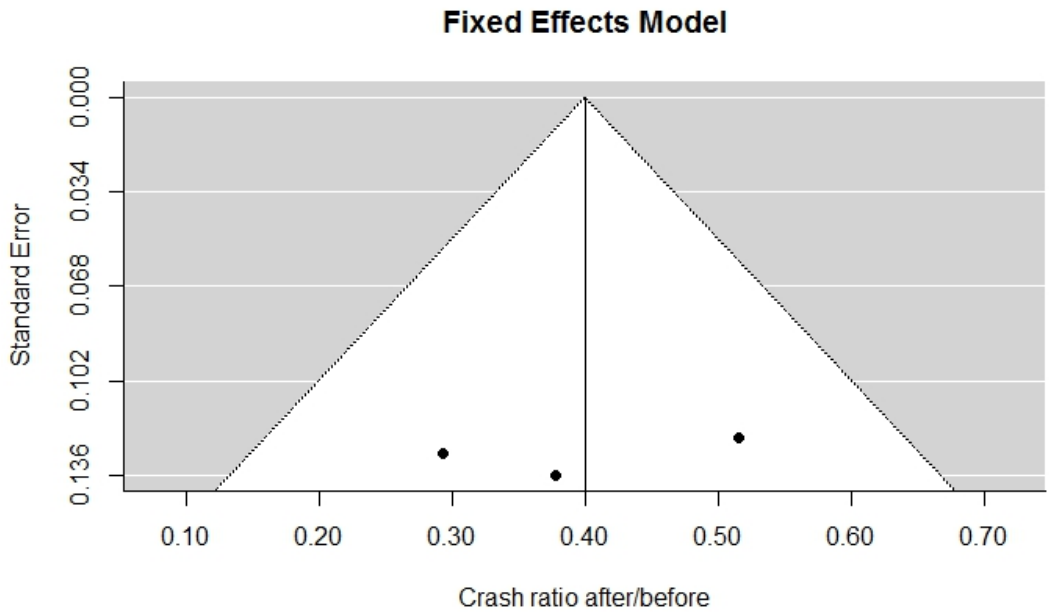

Figure 2: Forest plot for estimates of crash reduction due to road safety audits

2.5.5 Overall estimate for road safety

On the basis of both study and effect numbers, it can be argued that road safety audits and inspections measures have a positive effect on road safety. In a minority of cases the impact of road audits and inspections is inconclusive, with some isolated negative effects, but overall the effect is one of crash mitigation. These particular studies have good levels of quality, and their results consistently show that these measures reduce road safety risk.

2.6 CONCLUSION

The meta-analysis carried out showed that road safety audits and inspections have a positive impact on road safety. There are some isolated cases where their effect appears to have a negative impact, but these are not significant when examining macroscopic effects of the measures.

Supporting document

3.1 SUPPORTING QUANTITATIVE TABLE

Table 2 is shown below, which includes all quantitative effects from the coded studies for the measures of road safety audits and inspections.

Number	Author(s); Year; Country	Measure Exposure	Outcome indicator	Quantitative Estimate	Effect on road safety
1	Belcher, M., Proctor, S., & Cook, P.; 2008; United Kingdom	Road Safety Audits	Crash comparison [Absolute difference]	Crashes: Abs. dif.[before-after] = 1	↑*
2	Elvik, R., Høye, A., Vaa, T., & Sørensen, M.; 2008; Norway	Road Safety Inspections	Expected injury crash comparison [Percentage difference]	Removing sight obstacles: Crash reduction [before-after]: [0% to 5%]	↑*
				Flattening side slopes: Crash reduction [before-after]: [5% to 25%]	↑*
				Providing clear recovery zones: Crash reduction [before-after]: [10% to 40%]	↑*
				Guardrail along embankments: Crash reduction [before-after]: [40% to 50%]	↑*
				Guardrail end treatment: Crash reduction [before-after]: [0% to 10%]	↑*
				Yielding light poles: Crash reduction [before-after]: [25% to 75%]	↑*
				Signing of hazardous curves: Crash reduction [before-after]: [0% to 35%]	↑*
				Correcting erroneous signs: Crash reduction [before-after]: [5% to 10%]	↑*
3	England, J., Hannah, J., & Wilkie, S.; 2013; New Zealand	Road Safety Audits	Crash comparison [Absolute difference]	Fatal crashes - Site 1 - Total crashes: Crashes: Abs. dif.[before-after] = 4 Crash Rates: Abs. dif.[before-after] = 0.50	↑*
				Severe crashes - Site 1 - Total crashes: Crashes: Abs. dif.[before-after] = 30 Crash Rates: Abs. dif.[before-after] = 3.60	↑*
				Minor crashes - Site 1 - Total crashes: Crashes: Abs. dif.[before-after] = 88 Crash Rates: Abs. dif.[before-after] = 9.70	↑*
				All injuries - Site 1 - Head on crashes: Crashes: Abs. dif.[before-after] = 15 Crash Rates: Abs. dif.[before-after] = 1.90	↑*
				All injuries - Site 1 - Lost control-segment: Crashes: Abs. dif.[before-after] = 12 Crash Rates: Abs. dif.[before-after] = 0.80	↑*
				All injuries - Site 1 - Lost control-bend: Crashes: Abs. dif.[before-after] = 69 Crash Rates: Abs. dif.[before-after] = 7.20	↑*
				All injuries - Site 1 - Intersections: Crashes: Abs. dif.[before-after] = 7 Crash Rates: Abs. dif.[before-after] = 0.50	↑*
				All injuries - Site 1 - Dark/twilight crashes: Crashes: Abs. dif.[before-after] = 40 Crash Rates: Abs. dif.[before-after] = 5.00	↑*
				Fatal crashes - Site 2 - Total crashes: Crashes: Abs. dif.[before-after] = 0 Crash Rates: Abs. dif.[before-after] = -0.90	↓*
				Severe crashes - Site 2 - Total crashes: Crashes: Abs. dif.[before-after] = 45 Crash Rates: Abs. dif.[before-after] = 4.90	↑*

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Number	Author(s); Year; Country	Measure Exposure	Outcome indicator	Quantitative Estimate	Effect on road safety
				Minor crashes - Site 2 - Total crashes: Crashes: Abs. dif.[before-after] = 143 Crash Rates: Abs. dif.[before-after] = 16.80	↑*
				All injuries - Site 2 - Head on crashes: Crashes: Abs. dif.[before-after] = 14 Crash Rates: Abs. dif.[before-after] = 2.40	↑*
				All injuries - Site 2 - Lost control-segment: Crashes: Abs. dif.[before-after] = 28 Crash Rates: Abs. dif.[before-after] = 4.70	↑*
				All injuries - Site 2 - Lost control-bend: Crashes: Abs. dif.[before-after] = 73 Crash Rates: Abs. dif.[before-after] = 6.30	↑*
				All injuries - Site 2 - Intersections: Crashes: Abs. dif.[before-after] = 19 Crash Rates: Abs. dif.[before-after] = 3.40	↑*
				All injuries - Site 2 - Dark/twilight crashes: Crashes: Abs. dif.[before-after] = 44 Crash Rates: Abs. dif.[before-after] = 3.90	↑*
				All injuries - Site 2 - Object struck/bank edge: Crashes: Abs. dif.[before-after] = 18 Crash Rates: Abs. dif.[before-after] = 2.30	↑*
				All injuries - Site 2 - Object struck/utility pole: Crashes: Abs. dif.[before-after] = 5 Crash Rates: Abs. dif.[before-after] = -0.10	↑*
				All injuries - Site 2 - Object struck/trees: Crashes: Abs. dif.[before-after] = 17 Crash Rates: Abs. dif.[before-after] = 2.80	↑*
				All injuries - Site 2 - Object struck/ditch: Crashes: Abs. dif.[before-after] = 22 Crash Rates: Abs. dif.[before-after] = 3.50	↑*
4	Lougheed, P., & Hildebrand, E.; 2016; Canada	Road Safety Audits	Expected Crash comparison [Percentage difference]	Damage only - Single Vehicle - Project #1: Crashes: Percentage difference [predicted-observed] = -5.0%, S.e. = 0.04	↓*
				Damage only - Single Vehicle - Project #2: Crashes: Percentage difference [predicted-observed] = 2.0%, S.e. = 0.05	↑*
				Damage only - Single Vehicle - Project #3: Crashes: Percentage difference [predicted-observed] = 6.0%, S.e. = 0.06	↑*
				Damage only - Single Vehicle - W. Average: Crashes: Percentage difference [predicted-observed] = -2.0%, S.e. = 0.04	↓*
				Damage only - Multi Vehicle - Project #1: Crashes: Percentage difference [predicted-observed] = 23.0%, S.e. = 0.02	↑*
				Damage only - Multi Vehicle - Project #2: Crashes: Percentage difference [predicted-observed] = -36.0%, S.e. = 0.02	↓*
				Damage only - Multi Vehicle - Project #3: Crashes: Percentage difference [predicted-observed] = 1.0%, S.e. = 0.00	↑*
				Damage only - Multi Vehicle - W. Average: Crashes: Percentage difference [predicted-observed] = 15.0%, S.e. = 0.02	↑*
				Damage only - All accidents - Project #1: Crashes: Percentage difference [predicted-observed] = -1.0%, S.e. = 0.05	↓*
				Damage only - All accidents - Project #2: Crashes: Percentage difference [predicted-observed] = -2.0%, S.e. = 0.05	↓*
				Damage only - All accidents - Project #3: Crashes: Percentage difference [predicted-observed] = 61.0%, S.e. = 0.06	↑*

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Number	Author(s); Year; Country	Measure Exposure	Outcome indicator	Quantitative Estimate	Effect on road safety
				Damage only - All accidents - W. Average: Crashes: Percentage difference [predicted-observed] = 1.0%, S.e. = 0.05	↑*
				Injury - Single Vehicle - Project #1: Crashes: Percentage difference [predicted-observed] = 37.0%, S.e. = 0.02 CI [95%] = (-0.18, -0.06)	↑
				Injury - Single Vehicle - Project #2: Crashes: Percentage difference [predicted-observed] = 44.0%, S.e. = 0.03 CI [95%] = (-0.18, -0.06)	↑
				Injury - Single Vehicle - Project #3: Crashes: Percentage difference [predicted-observed] = 86.0%, S.e. = 0.03 CI [95%] = (-0.18, -0.06)	↑
				Injury - Single Vehicle - W. Average: Crashes: Percentage difference [predicted-observed] = 39.0%, S.e. = 0.02 CI [95%] = (-0.18, -0.06)	↑
				Injury - Multi Vehicle - Project #1: Crashes: Percentage difference [predicted-observed] = 10.0%, S.e. = 0.01 CI [95%] = (-0.18, -0.06)	↑
				Injury - Multi Vehicle - Project #2: Crashes: Percentage difference [predicted-observed] = 1.0%, S.e. = 0.01 CI [95%] = (-0.18, -0.06)	↑
				Injury - Multi Vehicle - Project #3: Crashes: Percentage difference [predicted-observed] = -12.0%, S.e. = 0.02 CI [95%] = (-0.18, -0.06)	↓
				Injury - Multi Vehicle - W. Average: Crashes: Percentage difference [predicted-observed] = 8.0%, S.e. = 0.01 CI [95%] = (-0.18, -0.06)	↑
				Injury - All accidents - Project #1: Crashes: Percentage difference [predicted-observed] = 33.0%, S.e. = 0.03 CI [95%] = (-0.18, -0.06)	↑
				Injury - All accidents - Project #2: Crashes: Percentage difference [predicted-observed] = 39.0%, S.e. = 0.03 CI [95%] = (-0.18, -0.06)	↑
				Injury - All accidents - Project #3: Crashes: Percentage difference [predicted-observed] = 82.0%, S.e. = 0.04 CI [95%] = (-0.18, -0.06)	↑
				Injury - All accidents - W. Average: Crashes: Percentage difference [predicted-observed] = 36.0%, S.e. = 0.03 CI [95%] = (-0.18, -0.06)	↑
				All injuries - Single Vehicle - Project #1: Crashes: Percentage difference [predicted-observed] = 13.0%, S.e. = 0.05 CI [95%] = (-0.22, -0.02)	↑
				All injuries - Single Vehicle - Project #2: Crashes: Percentage difference [predicted-observed] = 19.0%, S.e. = 0.06 CI [95%] = (-0.22, -0.02)	↑
				All injuries - Single Vehicle - Project #3: Crashes: Percentage difference [predicted-observed] = 71.0%, S.e. = 0.07 CI [95%] = (-0.22, -0.02)	↑

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Number	Author(s); Year; Country	Measure Exposure	Outcome indicator	Quantitative Estimate	Effect on road safety
				All injuries - Single Vehicle - W. Average: Crashes: Percentage difference [predicted-observed] = 15.0%, S.e. = 0.05 CI [95%] = (-0.22, -0.02)	↑
				All injuries - Multi Vehicle - Project #1: Crashes: Percentage difference [predicted-observed] = 18.0%, S.e. = 0.02 CI [95%] = (-0.22, -0.02)	↑
				All injuries - Multi Vehicle - Project #2: Crashes: Percentage difference [predicted-observed] = -18.0%, S.e. = 0.02 CI [95%] = (-0.22, -0.02)	↓
				All injuries - Multi Vehicle - Project #3: Crashes: Percentage difference [predicted-observed] = 50.0%, S.e. = 0.02 CI [95%] = (-0.22, -0.02)	↑
				All injuries - Multi Vehicle - W. Average: Crashes: Percentage difference [predicted-observed] = 12.0%, S.e. = 0.02 CI [95%] = (-0.22, -0.02)	↑
				All injuries - All accidents - Project #1: Crashes: Percentage difference [predicted-observed] = 13.0%, S.e. = 0.05 CI [95%] = (-0.22, -0.02)	↑
				All injuries - All accidents - Project #2: Crashes: Percentage difference [predicted-observed] = 16.0%, S.e. = 0.06 CI [95%] = (-0.22, -0.02)	↑
				All injuries - All accidents - Project #3: Crashes: Percentage difference [predicted-observed] = 70.0%, S.e. = 0.08 CI [95%] = (-0.22, -0.02)	↑
				All injuries - All accidents - W. Average: Crashes: Percentage difference [predicted-observed] = 15.0%, S.e. = 0.05 CI [95%] = (-0.22, -0.02)	↑
5	Vardaki, S., Papadimitriou, F., & Kopelias, P.; 2014; Greece	Road Safety Audits	Crash comparison [Absolute difference]	Treated Sites - Accidents [before-after] = 94 Control Sites - Accidents [before-after] = 134 Chi^2 test: (χ2=42, df=1, p<0.01)	↑
				Total Sites - Accidents [before-after] = 196 Chi^2 test: (χ2=42, df=1, p<0.01)	↑
↑	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		

Table 2: Quantitative results of coded studies and impacts on road safety.

3.2 METHODOLOGY

Literature search strategy

In this chapter the literature search undertaken is presented separately for the two measures of road safety audits and inspections, as examined in this synopsis. The measures were handled separately until the writing of this synopsis, when it was decided that their merging would provide more comprehensive and coherent insights into their effects. The results are summarized in the relevant tables. Several databases were examined in an attempt to locate all relevant scientific publications. As with the standards specified for the SafetyCube project, journal or conference papers published after 1990 were prioritized over reports.

3.2.1 Identifying relevant studies for road safety audits

Measure: road safety audits implementation

Database: Scopus **Date:** 20th of December 2016

search no.	search terms / operators / combined queries	hits
#1	"road" AND "safety"	
#2	AND "audit*"	159
#3	AND ("effect" OR "measure")	66
	All years	66

Database: TRID (trid.trb.org) **Date:** 20th of December 2016

search no.	search terms / operators / combined queries	hits
#1	Road safety audit measure effect	1
	All years	2

Database: Science Direct **Date:** 20th of December 2016

search no.	search terms / operators / combined queries	hits
#1	"road" AND "safety" AND "audit*"	822
#2	AND ("effect" OR "measure" OR "tool*" OR "network deficiencies")	291

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"

Results of Literature Search

Database	Hits
Scopus (remaining papers after several limitations/exclusions)	66
TRID	2
Science Direct	291
Total number of studies to screen title/ abstract	359

Road safety audits & inspections

Screening

Total number of studies to screen title/ abstract	359
-De-duplication	0
-exclusion criteria A (not related to the topic/not relevant risk factor)	336
-exclusion criteria B (part of meta-analysis)	0
Remaining studies	23
Not clear (full-text is needed)	23
Studies to obtain full-texts	23

Eligibility

Total number of studies to screen full-text	23
Full-text could be obtained	10
Reference list examined Y/N	Yes (+0 papers)
Eligible papers prioritized	4

Prioritizing coding

- Prioritizing Step A (accidents over other performance indicators)
- Prioritizing Step B (Journals over conferences and reports)
- Prioritizing Step C (journal quality)
- Prioritizing Step D (more recent studies)

No meta-analyses were found.

List of coded studies for road safety audits

1. England, J., Hannah, J., & Wilkie, S. (2013, August). RISA: a case study of the crash reduction potential of RISA on local rural roads in New Zealand. In Australasian Road Safety Research Policing Education Conference, 2013, Brisbane, Queensland, Australia.

2. Proctor, S., Belcher, M., & Cook, P. (2001). Practical road safety auditing. Thomas Telford.

3. Lougheed, P., & Hildebrand, E. (2016). Road Safety Audits and major P-3 freeway projects: estimating the reduction in collision frequencies. Canadian Journal of Civil Engineering, 43(11), 977-985.

4. Vardaki, S., Papadimitriou, F., & Kopelias, P. (2014). Road safety audit on a major freeway: implementing safety improvements. European Transport Research Review, 6(4), 387-395.

Additional References:

FHWA Road Safety Audit web page, retrieved 20/06/2017, https://safety.fhwa.dot.gov/rsa/

3.2.2 Identifying relevant studies for road safety inspections

Measure: road safety inspections implementation

Database: Scopus **Date:** 20th of December 2016

search no.	search terms / operators / combined queries	hits
#1	"road" AND "safety"	
#2	AND "inspection*"	377
#3	AND ("effect" OR "measure")	99
	All years	103

Database: TRID (trid.trb.org) **Date:** 20th of December 2016

search no.	search terms / operators / combined queries	Hits
#1	Road safety audit measure effect	12
	All years	22

Database: Science Direct **Date:** 20th of December 2016

search no.	search terms / operators / combined queries	Hits
#1	"road" AND "safety" AND " inspection*"	568
#2	AND ("effect" OR "measure" OR "tool*" OR "network deficiencies")	128

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"

Results Literature Search

Database	Hits
Scopus (remaining papers after several limitations/exclusions)	103
TRID	22
Science Direct	128
Total number of studies to screen title/ abstract	253

3.12 Screening

Total number of studies to screen title/ abstract	253
-De-duplication	0
-exclusion criteria A (not related to the topic/not relevant risk factor)	246
-exclusion criteria B (part of meta-analysis)	0
Remaining studies	8

Not clear (full-text is needed)	8
Studies to obtain full-texts	8

Eligibility

Total number of studies to screen full-text	8
Full-text could be obtained	6
Reference list examined Y/N	Yes (+0 papers)
Eligible papers prioritized	1

Prioritizing coding

- Prioritizing Step A (accidents over other performance indicators)
- Prioritizing Step B (Journals over conferences and reports)
- Prioritizing Step C (journal quality)
- Prioritizing Step D (more recent studies)

No meta-analyses were found.

List of coded studies for road safety inspections

1. Elvik, R., Høye, A., Vaa, T., & Sørensen, M. (Eds.). (2008). The handbook of road safety measures. Emerald Group Publishing Limited.

3.15.1 Specific data for inspections cited and cross-referenced from:

Elvik, R. (2006). Road safety inspections: safety effects and best practice guidelines. Transportøkonomisk institutt.