Sight Distance Treatments

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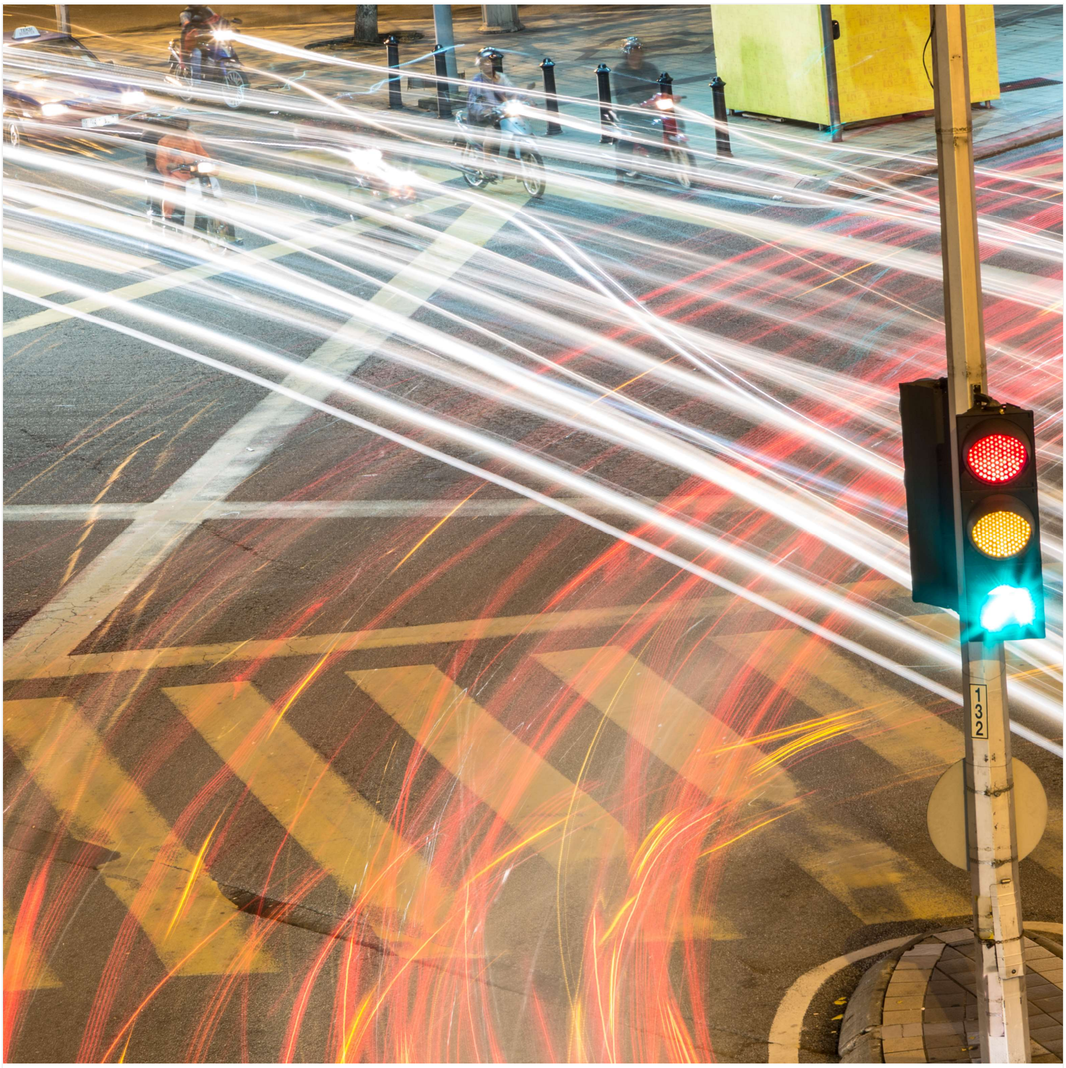

Please note: The studies included in this synopses were selected from those identified by a systematic literature search of specific databases (see supporting document). The main criterion for inclusion of studies in this synopsis and the DSS was that each study provides *a quantitative effect estimate*, 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

Soteropoulos, A., Stadlbauer, S., March 2017

1.1 COLOUR CODE: GREEN

Sight distance treatments at junctions seem to reduce crash occurrence. In addition, mostly positive effects on driver behaviour (e.g., decrease in drivers' speed) can be seen, although one effect was significantly negative.

1.2 KEYWORDS

junction; intersection; sight distance; improvement; sight conditions, field of view

1.3 ABSTRACT

From the studies on the effect of sight distance treatments on road safety in the literature (including one meta-analysis), it appears that in general sight distance improvements reduce crash occurrence. Moreover, studies show that measures for improving sight conditions (e.g. visual warning systems) can have positive effects on road user behaviour, e.g. a decrease in driving speed, whereas similar effects are possible with intended sight obstructions. Different kinds of warning signs were tested: (1) vehicle-activated warning signs and (2) standard static signs. Modifying effects regarding drivers' age were not found. As most of the studies were carried out in the United States, the transferability might be problematic. However, a European meta-analysis was included.

1.4 BACKGROUND

1.4.1 What are sight distance treatments?

Sight distance treatments at junctions refer to the improvement of sight conditions, especially regarding the junction sight triangles – imaginary lines formed by a driver's sight line to an approaching vehicle (Schurr & Sitorius 2010). Sight condition improvements at junctions include the elimination of fixed objects in medians or at junction corners, changing the horizontal or vertical curvature of the roadway (construction measures) or cutting overgrown brush or other vegetation (Poch & Mannering 1996). Moreover, traffic mirrors and additional warning signs/systems that actively detect vehicles on all approaches and active visual warning signs for the conflicting movements (e.g. Advanced LED Warning Systems) are installed (Weidemann et al. 2011). At junctions with turn lanes where the turning driver's view of oncoming opposing through-traffic is likely to be limited by the presence of another turning vehicle in the opposing turn lane, sight conditions are also often improved by offsetting opposing turn lanes (Hutton et al. 2015).

Sight Distance Treatments

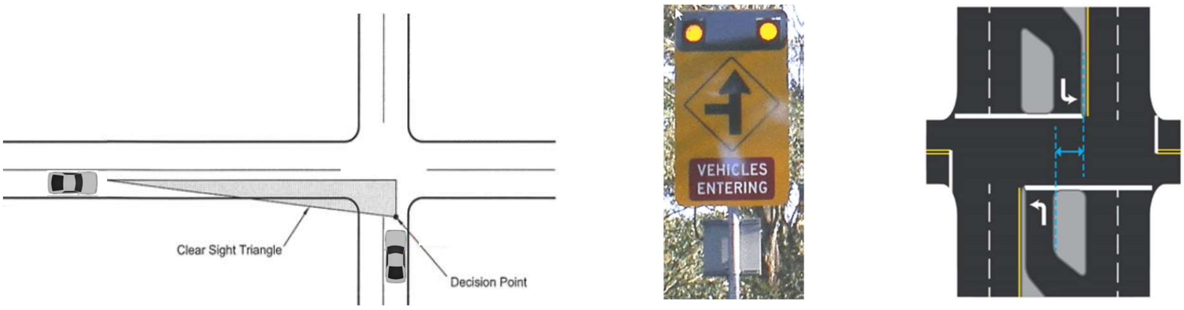

Figure 1. Example of junction sight triangle – left (Schurr & Sitorius 2010), active visual warning system with visual warning signs for entering vehicles – middle (Bradshaw et al. 2013), and offset of opposing left turning lanes – right (Hutton et al. 2015)

1.4.2 How do sight distance treatments affect road safety?

Sight distance affects the time it takes a driver to brake and stop the vehicle (Elvik et al. 2009). Improving sight conditions at intersections increases the time available for a driver to identify a vehicle, make a decision and react (Belluz et al. 2006). Rectifying sight distance obstructions could improve safety at intersections, at least concerning older drivers with slower reaction times (Schurr & Sitorius 2010). However, road users adapt their behaviour to the sight conditions at intersections and are particularly careful when visibility is poor (Elvik et al. 2009).

1.4.3 Which safety outcomes are affected by sight distance treatments?

In the international literature, the effect of sight distance treatments on road safety has been twice measured by accident frequency (number of crashes occurred). Many studies focused on other outcomes, such as the average speed, driving behaviour, field of view, lateral acceleration or roll-throughs.

1.4.4 How is the effect of sight distance treatments studied?

Two studies of the international literature examined the effect of sight distance treatments conducting a before-after design. These (quasi-)experimental methods are very suitable regarding crash occurrence. One study developed crash reduction factors associated with specific measures. Four designs used an experimental design focusing on driving behaviour, while a driving simulation was also used for investigating the effects of sight distance treatments.
The studies identified focused both on urban and rural intersections. Some of them limited their design to specific intersection types (e.g. T-arms or staggered intersections).
Most research has been done in the United States, but a study from Australia and New Zealand, as well as a meta-analysis from Norway were also found.

1.5 OVERVIEW RESULTS

There were 9 studies coded for sight distance treatments. Among those, one was a meta-analysis including studies focusing on the crash occurrence before and after the improvement of sight distance.

Sight Distance Treatments

1.5.1 Main results

As already mentioned above, there are different measures regarding sight distance treatments. Therefore, separate consideration is needed. For instance, there were studies focusing on the effects of left-turn lane offsets, whereas others looked at Advanced LEDs Warning Systems.

The meta-analysis reports significant positive effects for all crashes (-12%) and property damage only crashes (-16%) after sight distance improvements were implemented. The reduction of 3% in injury crashes, however, was non-significant.

The main findings of the remaining eight original studies are:

- A left-turn offset leads to a significant positive effect on the drivers' maximum yaw (radians/sec).
- A (intended) sight obstruction (screen treatment on minor road) leads to significant reduction of mean speed and has significantly positive effects on the identification of a target vehicle.
- In one study the installation of an ALWS (Advanced LEDs Warning System) showed a statistically significant positive effect on the average speed on the main road, whereas another study on ALWS presented the opposite.
- An ALWS leads to a significant reduction of mean speed driven on the main road during conflict situations.
- Furthermore, they also have significant positive influence on the average waiting time on the minor road.
- Blinking LEDs lead to significantly less roll-throughs on the minor road.

1.5.2 Transferability

Overall, since 8 studies as well as a meta-analysis were found, the topic has been studied to an adequate extent. Research mainly focused on crashes with motor vehicles. Even though there was one meta-analysis added, including studies from Europe, research was mainly carried out in the United States, Australia and New Zealand. The transferability may be questioned because of potential regional characteristics.

1.6 NOTES ON ANALYSIS METHODS

In general, the coded studies are of sufficient quality and methodologically sound. However, some of the studies used only small samples for investigation.

Overall, since 8 studies as well as a meta-analysis were found, the topic has been studied to an adequate extent. Research mainly focused on crashes with motor vehicles. Even though there was one meta-analysis added, including studies from Europe, research was mainly carried out in the United States, Australia and New Zealand. The transferability may be questioned because of potential regional characteristics.

2 Scientific overview

2.1 LITERATURE REVIEW

2.1.1 Analysis of study designs and methods

Overall eight high quality studies and one meta-analysis on sight distance treatments were selected and coded. Out of them two studies, as well as the meta-analysis, focused on accident frequency. Five studies investigated driving behaviour whereas one study focused on sight obstruction and the length of gaps when turning left. Studies on sight distance treatments mostly deployed (quasi-) experimental methods. Two studies (Bradshaw et al. 2013; Charlton 2003) as well as the meta-analysis (Høye 2008) used a before-after design. Four studies (Classen et al. 2009; Hutton et al. 2015; Shechtman et al. 2007; Weidemann et al. 2011) used an experimental design focusing on driving behaviour, while a driving simulation (Kwon & Ismail 2014) was also used in investigating sight distance treatments. One study (Agent et al. 1996) developed crash reduction factors associated with specific measures.

The studies identified focused both on urban and rural intersections. Some of them limited their design to specific intersection types (e.g. T-arms or staggered intersections).
Most research has been done in the United States, but a study from Australia and New Zealand, as well as a meta-analysis from Norway, including studies from Finland, Norway and the United States were also found.

Table 1 illustrates an overview of the main features of coded studies (sample, method, etc.).

Table 1 Description of coded studies

Author, Year, Country	Sample, method/design and analysis		Reference group	Additional information on analysis
Agent et al., 1996; United States	Development of accident reduction factors using a survey of numerous US states and a review of literature	Accident reduction factors associated with specific safety improvements	-	only presentation of accident reduction factors
Bradshaw et al., 2013, Australia	Investigation of vehicle activated signs at high risk, rural and sign controlled T-intersections with sight restriction	Before-after analysis of mean speed and crash occurrence	-	Focus on six rural T-intersections
Charlton, 2003, New Zealand	Study of the effectiveness of sight restricting screen treatment on minor road at a staggered intersection	Before-after analysis of approach speeds and drivers' traffic detection rates	-	Focus on one rural staggered intersection
Classen et al., 2009, United States	Repeated measures experimental design including 8 intersections and 71 healthy drivers subjoined to young and old drivers	Experiment with repeated measures examining the driving performance	unimproved intersections in same road network	Focus on urban (residential) and signalised intersections
Høye 2008; Norway	Meta-analysis including 6 studies using a case control before-after design with fixed and random effects	Meta-analysis with random effects and fixed effects	-	Meta-analysis includes studies from Finland, Norway and the United States

Sight Distance Treatments

Author, Year, Country	Sample, method/design and analysis		Reference group	Additional information on analysis
Hutton et al., 2015; United States	Investigation of effectiveness of offset of left-turn lanes at intersections by the use of the naturalistic driving study data	Experimental approach on driver behaviour using a logistic regression analysis	-	Focus on different intersection types and different kinds of offsets
Kwon & Ismail, 2014, United States	Investigation of Effectiveness of an Advanced LED Warning System for a rural intersection	Experimental study focusing on driver behaviour	-	Focus on rural intersection with stop signs at minor road
Shechtman et al., 2007, United States	Evaluation of intersection design on driving performance on urban, suburban and residential street networks including 39 participants	Driving simulation recording kinematic measures	untreated intersections	Focus on urban and suburban road and kinematic measures
Weidemann et al., 2011, United States	Investigation of Effectiveness of an Advanced LED Warning System for a rural intersection	Experimental study focusing on driver behaviour	-	Focus on rural intersection with stop signs at minor road

2.1.2 Study results

In her meta-analysis Høye (2008) investigated the crash occurrence before and after sight distance improvements. For all crashes there was a statistically significant percent change of -12%. Also the estimate for property damage only crashes was significant (-16%). However, for limited to injury crashes only, the percent change of -3% was not significant. Moreover, Agent et al. (1996) indicate a reduction in crash occurrence resulting from construction/reconstruction at intersections, however no test for statistical significance and only the accident reduction factors (without methodical detail) are presented.

Hutton et al. (2015) investigated the effects of left-turn lane offsets at intersections. Regarding sight obstruction, opposing left-turning vehicles create a sight obstruction in 85% of the time at negative offset (which requires the turning vehicle to travel farther during the turning manoeuvre to clear the intersection). At zero offset the amount drops to 14% and at a positive offset to 10%. Furthermore, the critical gap does vary with left-turn lane offset. Overall, the critical gap got longer, the wider the negative offset was. However, at two-way stop-controlled intersections there were not any big differences presented. At signalised intersections some pairs of offset categories are statistically significantly different to others: −16 ft or less (7.5 s) from 1 ft to 3 ft (5.0 s) and from 4 ft to 6 ft (4.7 s); −10 ft to −6 ft (6.5 s) from 1 ft to 3 ft (5.0 s); -5 ft to−1 ft (7.0 s) from 1 ft to 3 ft (5.0 s) and from 4 ft to 6 ft (4.7 s) and 0 ft (6.2 s) from 1 ft to 3 ft (5.0 s).
Shechtman et al. (2007) also investigated the effects of a left-turn lane offset. They focused on the maximum yaw (radians/sec) and the maximum lateral acceleration (g). Left-turn lane offset leads to a significantly smaller maximum yaw. Hence, both older and younger drivers seem to have better lateral control of the vehicle. Furthermore, there were no differences between young and old drivers in any of the kinematic or behavioural measures for this manoeuvre.
Classen et al. (2009) looked at the effect of a left-turn offset on the driving performance. Even though results were not statistically significant and an age effect was detected, benefits for both older and younger drivers were presented.

Charlton (2003) investigated the effects of (intended) sight obstruction due to a screen treatment on the minor road. Motorists approaching the intersection on the minor road had a significantly lower speed of 23.7% because their field of view was obstructed so that they had to lower speed to safely enter the junction. Furthermore, the investigators placed a target vehicle in the intersection area.

Sight Distance Treatments

After the screen treatment was implemented almost 90% more (statistically significant) of the motorists could correctly report the presence and location of the target vehicle.

Choosing crash frequency as outcome variable and investigating the effects of vehicle activated signs (signs that start to blink if vehicles are entering/approaching) compared to standard static signs, Bradshaw et al. (2013) present positive effects. The authors also investigated the effects of large static signs compared to standard static signs and further compared activated signs to large static signs. They collected data of six sites. Overall, results show that vehicle activated signs have positive effects on road safety (minor injury, severe injury and fatal crashes). Also large static signs seem to be safer than the standard signs. However, no details regarding significance were presented for the overall estimates. Bradshaw et al. (2013) also compared the mean speeds driven under the different conditions. Again, for the overall estimates no details regarding significance were presented. Nevertheless, vehicle activated signs compared to other signs and large static signs compared to standard signs lead to a reduction of mean speeds.

Kwon & Ismail (2014) investigated the effects of an alert system designed to mitigate an increase in roll-throughs by redesigning the minor approach sign system. In the new design, two STOP signs on the minor road were turned into LED blinker STOP signs. The LED blinking was activated by a vehicle at the corresponding "STOP Ahead" sign and deactivated when the vehicle reached the STOP sign. After the installation of the ALWS (Advanced LED Warning System) the average speed on the main road significantly dropped by 1.54 kph. During conflict situation (blinking LEDs) the average speed on the minor road significantly dropped by 6.26 kph. At the same time the average waiting time on the minor road significantly increased by 1.31 seconds. When it comes to roll-throughs on the minor road, the installation of the ALWS leads to a non-significant positive effect (-13.88%). During conflict situations, the amount of roll-throughs was reduced by 12%, however, again in a non-significant way.
Weidemann et al. (2001) also looked at the effect of an ALWS-installation as a low-cost countermeasure for rural through-stop intersection crashes. After the installation, the average speed on the main road significantly increased by 1.6 kph. During a conflict situation (blinking LEDs) the average speed on the main road decreased by 7.2 kph. The average waiting time on the minor road increased by 5.4 seconds during conflict situations. The installation of ALWS had a non-significant negative effect on roll-throughs. However, during conflict situations the amount of roll-throughs significantly decreased by 24%.

2.1.3 Description of analysis carried out

Vote-count analysis

Considering the number of studies with the relevant estimates it was decided that a vote-count analysis can be conducted. Table 2 gives an overview of the results of the analysis. Results show that sight distance treatments in general have significant positive effects on accident frequency. Also many non-significant estimates were counted.
Furthermore, estimates of vehicle activated traffic signs were mostly significantly positive.
When it comes to vehicle speeds, however, the installation of vehicle activated traffic signs might lead to a significant increase in some cases.

Sight Distance Treatments

Table 2 Results of the vote-count analysis

	Total number of effects tested	Result (number of effects)*				Result (% of effects)	
		↗	-	↘		↗	↘
Accident Frequency	**14**	**-**	**13**	**1**		**0%**	**100%**
Sight distance improvement	2	-	1	1		0%	100%
Vehicle activated traffic sign	12	-	12	-		0%	0%
Vehicle speed	9	1	3	5		17%	83%
Vehicle activated traffic sign	7	1	3	3		25%	75%
Sight obstruction	2	-	-	2		0%	100%

*Significant effects on road safety are coded as: positive (↘), negative (↗) or non-significant (–)

As presented above, it can be summarised that sight distance treatments have an overall positive effect on road safety. The only inconclusive result concerns the mean speed driven when vehicle activated traffic signs were installed. As there was only one negative effect presented for an indirect variable on road safety (speed), for sight distance treatments, a green colour code was assigned. This seems appropriate as the increased speed was possibly provided by a sense of security after the installation of a vehicle activated traffic sign.

2.2 CONCLUSION

Studies on the effects of sight distance treatments on road safety identified in the international literature focused mainly on driving performance. In two studies accident frequency was also used as an outcome variable. Further, one of the chosen studies investigated the effects of sight obstruction and the gap length when making a left-turn.

Since there were many different measures investigated in the international literature a general conclusion about the effects cannot be drawn. For sight distance improvements in general (results presented in meta-analysis) it can be summarised that significant positive effects for all crashes and property damage only crashes can be achieved. Furthermore, left-turn offsets have positive effects on driving behaviour at intersections, whereas intended sight obstruction also has positive effects on speed and drivers' attention.
In addition, an ALWS (Advanced LEDs Warning System) can help to reduce drivers' speed and positively influence the average waiting time and number of roll-throughs.

Conducting a vote-count analysis, the overall positive effect of sight distance treatments on road safety can be emphasized. Even if there was one inconclusive but significant estimate presented, a green colour code can be assigned to the measure, as this concerns an indirect variable on road safety and is limited to only one.

3 Supporting document

3.1 METHODOLOGY

3.1.1 Literature Search strategy

The literature search was conducted in November and December 2016. It was carried out in four databases with similar search strategies. The following databases were browsed through during the literature search: 'Scopus', 'Science Direct', 'TRID' and 'Taylor and Francis Online'. Detailed search terms, as well as their linkage with logical operators and combined queries are shown in the following tables. The study scope did not exclude countries or source types like "Journal" or "Project". In some of the searches remaining studies were limited to subject areas (e.g. "Engineering"). Out of the overall 606 potentially eligible studies, after screening the abstracts of these 606 studies, from 25 the full-text were obtained and 5 were coded and included in the synopsis. Other already known or during the literature search occasionally (e.g. via Google) found studies as well as studies found in the literature search for other topics and including effects for address limited sight distance were added as additional studies (4). The reference lists of the studies were only partly checked.

Table 3 Literature search strategy, database: Scopus

search no.	search terms / operators / combined queries	hits
#1	(TITLE-ABS-KEY ("sight distance" OR "measure" OR "safety") AND TITLE-ABS-KEY ("intersection" OR "junction" OR "traffic")) AND PUBYEAR > 1989	**66,444**
#2	(TITLE-ABS-KEY ("sight distance" AND "limited" or "restricted" OR "measure" OR "safety") AND TITLE-ABS-KEY ("intersection" OR "junction" OR "traffic")) AND PUBYEAR > 1989	**169**

Table 4 Literature search strategy, database: ScienceDirect

search no.	search terms / operators / combined queries	hits
#1	pub-date > 1989 and ("sight distance" OR "field of view" AND "intersection" OR "junction").	**15,542**
#2	pub-date > 1989 and ("sight distance" AND "intersection" OR "junction") and ("limited" AND "measure" or "treatment")	**368**
#3	pub-date > 1989 and ("sight distance" AND "intersection" OR "junction") and ("limited" AND "measure" or "treatment" AND "safety")[All Sources(Engineering)]	**213**

Table 5 Literature search strategy, database: TRID

search no.	search terms / operators / combined queries	hits
#1	"sight distance" OR "field of view" AND "intersection" OR "junction"	**3,656**
#2	"sight distance" OR "field of view" AND "intersection" OR "junction"	**392**
#3	"sight distance" AND "limited" AND "intersection" OR "junction" AND "measure" AND "safety"	**127**

Table 6 Literature search strategy, database: Taylor & Francis Online

search no.	search terms / operators / combined queries	hits
#1	Search Everything ("sight distance" OR "field of view") AND Abstract ("sight distance" OR "field of view")	**97**

Sight Distance Treatments

Table 7 Results Literature Search

Database	**Hits**
Scopus (remaining papers after several limitations/exclusions)	169
Science Direct	213
TRID	127
Taylor & Francis Online	97
Total number of studies to screen title/ abstract	**606**

The final 9 studies included in the synopsis indicate that the topic has been investigated to an adequate extent. The prioritising criteria for coding were the following, however all studies codable and suitable for the topic were coded.

- Prioritising Step A (e.g. meta-analysis first)
- Prioritising Step B (most recent studies)
- Prioritising Step C (Journals over conferences and reports)
- Prioritising Step D (Prestigious journals over other journals and conference papers)

One meta-analysis was found.

3.1.2 Exploratory analysis of results

Table 8 presents information on the main outcomes of coded studies on sight distance treatments.

Table 8 Main outcomes of coded studies on sight distance treatments

Author, Year, Country	**Exposure variable**	**Outcome variable / Outcome type**	**Effects**		**Main outcome description**
Agent et al., 1996; United States	Sight distance improvements (due to construction/reconstruction)	Crash count / All	–	percent accident reduction=30%	Non-significant reduction of crash occurrence due to sight distance improvements at intersections
Bradshaw et al., 2013, Australia	Vehicle activated sign - active	Change in mean speed	–	Absolute difference=-2.78 km/h	Non-significant positive effect of active vehicle activated signs compared to standard static signs
	Vehicle activated sign - passive	Change in mean speed	–	Absolute difference=-1.1 km/h	Non-significant positive effect of passive vehicle activated signs compared to standard static signs
	Vehicle activated sign - active	Change in mean speed	–	Absolute difference=-1.7 km/h	Non-significant positive effect of active vehicle activated signs compared to passive vehicle activated signs
	Vehicle activated sign - active	Crash count / Fatal	–	Percent accident reduction=10.17%	Non-significant positive effect of active vehicle activated signs compared to standard static signs
	Vehicle activated sign - passive	Crash count / Fatal	–	Percent accident reduction=4%	Non-significant positive effect of passive vehicle activated signs compared to standard static signs

Sight Distance Treatments

Author, Year, Country	Exposure variable	Outcome variable / Outcome type	Effects		Main outcome description
	Vehicle activated sign - active	Crash count / Fatal	–	Percent accident reduction=6.67%	Non-significant positive effect of active vehicle activated signs compared to passive vehicle activated signs
	Vehicle activated sign - active	Crash count / Severe injury	–	Percent accident reduction=6.83%	Non-significant positive effect of active vehicle activated signs compared to standard static signs
	Vehicle activated sign - passive	Crash count / Severe injury	–	Percent accident reduction=2.67%	Non-significant positive effect of passive vehicle activated signs compared to standard static signs
	Vehicle activated sign - active	Crash count / Severe injury	–	Percent accident reduction=4%	Non-significant positive effect of active vehicle activated signs compared to passive vehicle activated signs
	Vehicle activated sign - active	Crash count / Minor injury	–	Percent accident reduction=3.17%	Non-significant positive effect of active vehicle activated signs compared to standard static signs
	Vehicle activated sign - passive	Crash count / Minor injury	–	Percent accident reduction=1.17%	Non-significant positive effect of passive vehicle activated signs compared to standard static signs
	Vehicle activated sign - active	Crash count / Minor injury	–	Percent accident reduction=1.67%	Non-significant positive effect of active vehicle activated signs compared to passive vehicle activated signs
	Vehicle activated sign - active	Crash count / Casualty	–	Percent accident reduction=4.33%	Non-significant positive effect of active vehicle activated signs compared to standard static signs
	Vehicle activated sign - passive	Crash count / Casualty	–	Percent accident reduction=1.67%	Non-significant positive effect of passive vehicle activated signs compared to standard static signs
	Vehicle activated sign - active	Crash count / Casualty	–	Percent accident reduction=2.67%	Non-significant positive effect of active vehicle activated signs compared to passive vehicle activated signs
Charlton, 2003, New Zealand	Sight obstruction (screen treatment on minor road)	Reduction of mean speed	↘	Relative difference=-23.7%, p<0,01	Significant positive effect of sight obstruction on reduction of mean speeds
	Sight obstruction (screen treatment on minor road)	Correct report of presence and location of target vehicle	↘	Relative difference=89.9%, p<0.01	Significant positive effect of sight obstruction on correct report of presence and location of target vehicle
Classen et al., 2009; United States	Left-turn offset	Driving performance	–	-	Benefits for both older and younger drivers although there was an age effect detected
Høye 2008; Norway	Improvement of sight distance	Crash count / All (unspecified)	↘	Percent change in accidents=-12%	Significant reduction of crash occurrence due to the improvement of sight distance at junctions

Sight Distance Treatments

Author, Year, Country	Exposure variable	Outcome variable / Outcome type	Effects		Main outcome description
	Improvement of sight distance	Crash count / Injury accidents	–	Percent change in accidents=-3%	Non-significant reduction of injury crash occurrence due to the improvement of sight distance at junctions
	Improvement of sight distance	Crash count / Property damage only accidents	↘	Percent change in accidents=-16%	Significant reduction of property damage only crash occurrence due to the improvement of sight distance at junctions
Hutton et al., 2015; United States	Negative offset	View blocked to opposing vehicle present	–	Relative proportion=85.6%	85.6% of opposing drivers create sight obstruction for turning vehicle
	Zero offset	View blocked to opposing vehicle present	–	Relative proportion=13.8%	13.8% of opposing drivers create sight obstruction for turning vehicle
	Positive offset	View blocked to opposing vehicle present	–	Relative proportion=9.6%	9.6% of opposing drivers create sight obstruction for turning vehicle
	-16 ft or less	Critical gap length / (s)Signalised intersection	–	Absolute proportion=7.5	7.5 seconds of gap length
	-15 to -11 ft	Critical gap length (s) / Signalised intersection	–	Absolute proportion=6.1	6.1 seconds of gap length
	-10 to -6 ft	Critical gap length (s) / Signalised intersection	–	Absolute proportion=6.5	6.5 seconds of gap length
	-5 to -1 ft	Critical gap length (s) / Signalised intersection	–	Absolute proportion=7	7 seconds of gap length
	0 ft	Critical gap length (s) / Signalised Intersection	–	Absolute proportion=6.2	6.2 seconds of gap length
	1 to 3 ft	Critical gap length (s) / Signalised intersection	–	Absolute proportion=5	5 seconds of gap length
	4 to 6 ft	Critical gap length (s) / Signalised intersection	–	Absolute proportion=4.7	4.7 seconds of gap length
	-16 ft or less	Critical gap length (s) / Two-way stop-controlled intersection	–	Absolute proportion=4.8	4.8 seconds of gap length
	-15 to -11 ft	Critical gap length (s) / Two-way stop-controlled intersection	–	Absolute proportion=5.2	5.2 seconds of gap length

Sight Distance Treatments

Author, Year, Country	Exposure variable	Outcome variable / Outcome type	Effects		Main outcome description
	-10 to -6 ft	Critical gap length (s) / Two-way stop-controlled intersection /	–	Absolute proportion=5.2	5.2 seconds of gap length
	0 ft	Critical gap length (s) / Two-way stop-controlled intersection	–	Absolute proportion=5.3	5.3 seconds of gap length
Kwon T.M. & Ismail H., 2014; United States	Installation of ALWS	Average speed / Main road	↘	Absolute difference=-1.54 km/h, p<0,0001	Significant positive effect of installation of ALWS on average speed on main road
	Conflict situation (LED blinking)	Average speed / Main road	↘	Absolute difference=-6.26 km/h, p~0	Significant positive effect of blinking LEDS on average speed on main road
	Conflict situation (LED blinking)	Average waiting time / Minor road	↘	Absolute difference=1.31 seconds, p~0	Significant positive effect of blinking LEDS on average waiting time on minor road
	Installation of ALWS	Roll-Throughs / Minor road	–	Percent change=-13.88%	Non-significant positive effect of installation of ALWS on roll-throughs on minor road
	Conflict situation (LED blinking)	Roll-Throughs / Minor road	–	Percent change=-12%	Non-significant positive effect of blinking LEDs on roll-throughs on minor road (no roll-throughs observed)
Shechtman et al., 2007, United States	Left-turn offset	Maximum yaw (radians/sec)	↘	F test=47.27, p<0.01	Significant positive effect of left-turn offset on maximum yaw
	Left-turn offset	Maximum lateral acceleration (g)	–	F test=2.51, p=0.12	Non-significant positive effect of left-turn offset on maximum lateral acceleration
Weidemann et al., 2011, United States	Installation of ALWS	Average speed / Main road	↗	Absolute difference=1.6 km/h	Significant negative effect of installation of ALWS on average speed on main road
	Conflict situation (LED blinking)	Average speed / Main road	↘	Absolute difference=-7.2 km/h	Significant positive effect of blinking LEDS on average speed on main road
	Conflict situation (LED blinking)	Average waiting time / Minor road	↘	Absolute difference=5.4 seconds	Significant positive effect of blinking LEDS on average waiting time on minor road
	Installation of ALWS	Roll-Throughs / Minor road	–	Percent change=11%	Non-significant negative effect of installation of ALWS on roll-throughs on minor road
	Conflict situation (LED blinking)	Roll-Throughs / Minor road	↘	Percent change=-24%	Significant positive effect of blinking LEDs on roll-throughs on minor road (no roll-throughs observed)

*Significant effects on road safety are coded as: positive (↘), negative (↗) or non-significant (–)

3.2 FULL LIST OF STUDIES

3.2.1 Meta-analyses

Høye A. (2008). Redesigning junctions in: The Handbook of Road Safety Measures, Norwegian (online) version.

Following studies were concluded in the Meta-analysis:

Brüde, U. & Larsson, J. (1985). Korsningsåtgärder vidtagna inom vägförvaltningarnas trafik-säkerhetsarbete. Regressions- och åtgärdseffekter. VTI-rapport 292. Linköping, Statens väg- och trafikinstitut (VTI).

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