

Implementation of rumble strips at centreline

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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.

1. Summary

Noella, K., June 2017



1.1. COLOUR CODE: GREEN

Both centreline rumble strips and a combination of centre- and edgeline rumble strips are found to reduce accidents.

1.2. KEYWORDS

rumble strips; road marking; median

1.3. ABSTRACT

Rumble strips are rows of raised pavement markers placed along or adjacent to a road's edgeline or centreline. Centreline plus shoulder rumble strips have been shown to reduce the frequency of crashes on road segments. Results for centreline rumble strips: head-on collisions, running off the road on the left side, side-impact collisions with vehicles in the oncoming lane on the left hand side, which are the target accidents, showed a 37% reduction. Results for centre- and edgeline: head-on collisions, running off the road on either side, side swipe accidents between vehicles travelling in opposite directions showed a 32% reduction. The presented results are for all accident severities as no differences were found for different degrees of accident severity. No differences were found for studies with and without control for regression to the mean. The results do not seem to be affected by publication bias, and do not contain significant heterogeneity, with the exception of edge- and centreline rumble strips for all accidents.

1.4. BACKGROUND

1.4.1. What are rumble strip

Rumble strips are a road safety feature installed at the centre or edge of paved roads that alert drivers when they are about to leave the travel lane by causing a tactile vibration and audible rumbling transmitted through the wheels into the vehicle interior. Shoulder rumble strips are a longitudinal safety feature installed on a paved roadway shoulder near the outside edge of the travel lane. It is made with a series of milled elements intended to alert inattentive drivers through vibration and sound that their vehicle has left the travel lane. Centreline rumble strips are in principle similar to shoulder rumble strips but placed at the centre of roads to alert drivers who may encroach into opposing lanes.

1.4.2. How does the installation of rumble strips affect road safety?

Rumble strips are intended to increase alertness and reduce the risk of drivers running off the road or straying across the centreline. Consequently, they help to reduce crashes caused by driver inattention or fatigue because the tactile vibration and audible rumbling generated by the strips serve as a 'wake-up' signal before a crash occurs. Rumble strips have been shown to reduce the number of road accidents with greatest effects on target accidents i.e. head-on collisions, running off the road on the left side, side-impact collisions with vehicle in the oncoming lane on the left hand side, running off the road on either side, side swipe accidents between vehicles travelling in opposite direction. The implementation of centreline rumble strips serves as a caution for drivers to adhere to their travel lanes which may result in a reduction of the number of head-on collisions.

1.4.3. Which safety outcomes are affected by the installation of rumble strips?

In the international literature, the effect of the implementation of rumble strips on road safety has been measured using as outcome accident frequency (number of accidents occurred).

1.4.4. How is the effect of the installation of rumble strips studied?

International literature indicated that the effect of the installation of rumble strips is usually examined by comparing the frequency of accidents on roads with and without rumble strips through before-after studies.

1.4.5. Which factors influence the effect of the installation of rumble strips on road safety?

Rumble strips have a negative impact on cycling as they are virtually impossible to ride a bicycle over. They can cause a cyclist to lose control of their bike and fall. Consequently, cyclists will avoid riding over them. When rumble strips leave no room on the shoulder, cyclists will have no other option than to face the risk of riding in the travel lane. Centre rumble strips may also excessively shift the lateral placement of vehicles in the travel lane toward the shoulder, which could increase the potential for vehicle-bicycle collisions. There is also the concern that drivers accustomed to right-side shoulder rumble strips will "jerk" the steering wheel to the left when encountering the centre rumble strips

1.5. OVERVIEW RESULTS

1.5.1. Main results

According to results in the meta-analysis, the implementation of rumble strips generally improves road safety. From literature review, two studies that compared effects during the day and at night found greater effects at night. The literature review covers effects on driver behaviour, motorcyclists and bicyclists which have not been coded. Centreline rumble strips are associated with 37% reduction in the number of target accidents (head-on collisions, running off the road on the left side, side-impact collisions with vehicle in the oncoming lane on the left hand side) while centre- and edgeline rumble strips are associated with 32% reduction in target accidents (head-on collisions, running off the road on either side, side swipe accidents between vehicles travelling in opposite direction). These results are for all accident severities since no differences were found for different degrees of accident severity. No differences were found for studies with and without control for regression to the mean.

1.5.2. Transferability

Overall, a meta-analysis including several studies was found, the topic has been studied to a sufficient extent. The studies included in the meta-analysis are from North America (the United States, Canada) and Europe (Denmark).

1.6. NOTES ON ANALYSIS METHODS

The synopsis is based on a meta-analysis study. The studies included in the meta-analysis are from the United States, Canada and Denmark. Most of the included studies have compared the frequency of accidents on roads with and without rumble strips. The results of studies on the safety effects of audio-tactile lane-markings varied greatly and no summary estimates were calculated. The results do not seem to be affected by publication bias, and do not contain significant heterogeneity, with the exception of edge- and centreline rumble strips for all accidents.

2. Scientific overview



2.1. DESCRIPTION OF AVAILABLE STUDIES

2.1.1. Analysis of study designs and methods

Results are based on a meta-analysis carried out in 2015. According to the literature search results it seems that there is a lack of research on rumble strips from 2015.

13 studies were considered in the meta-analysis by Høye, 2015. Research has been carried out in the United States, Canada and Denmark.

Most of the studies compared the frequency of accidents on roads equipped with rumble strips with the frequency of accidents on roads without rumble strips. No summary estimates were calculated due to the high variability of results of studies on the safety effect of audio-tactile lane-markings. The results do not seem to be affected by publication bias.

Table 1 illustrates an overview of the main aspects of the coded study (sample, method and outcome).

Author(s), Year , Country	Sample and study design	Method of analysis	Outcome indicator
Høye, A., 2015, Norway	13 studies based on a before-after design.	Meta-analysis. Random effects	Number of accidents

2.1.2. Study results

The studies included in the meta-analysis show that the rumble strips generally have a positive effect on road safety. The results can be differentiated according to the specific context examined.

Centreline rumble strips: The effects of the implementation of centreline rumble strips are highest on target accidents (head-on collisions, running off the road on the left side, side-impact collisions with vehicle in the oncoming lane on the left hand side) with a positive significant reduction in the number of accidents such as head-on, run off road (ROR) to the left and sideswipe with a vehicle on the left-hand side oncoming lane. Results of the meta-analysis indicate that they are associated with a 37% reduction of target accidents.

Centre- and edgeline rumble strips: The combination of centre- and edgeline rumble strips also exhibits a significant positive effect on road safety through a reduction in the number of target accidents (head-on, ROR to left/right, sideswipe with vehicle travelling in the opposite direction). This have been associated with a 32% reduction in the target accidents.

2.1.3. Description of analysis carried out

Review-type analysis

Considering the recent meta-analysis it was decided that neither a meta-analysis nor a vote-count analysis can be conducted. Hence, to find an overall estimate for the installation of centreline rumble strip a review-type analysis was chosen.

The results above present a positive effect for the installation of centreline rumble strips. It can be summarised that implementation of rumble strips at centreline mainly leads to a significant positive effects on road safety.

Hence, on the basis of both study and effect numbers, it can be argued that the installation of centreline rumble strips has a positive effect of road safety. There were clearly more significant positive than negative effects listed. As mentioned before, the chosen studies are of sufficient quality and mainly consistent in their result. Hence, results show that the installation of centreline rumble strips decreases road safety risk. As such, a green colour code was assigned.

2.2. CONCLUSION

Studies on the effect of the installation of rumble strips on road safety identified in the meta-analysis mainly focus on accident frequency.

According to the recent meta-analysis the implementation of rumble strips at centreline is associated with a statistically significant reduction in crash occurrence. In addition, the combination of centre- and edgeline rumble strips also exhibits a significant positive effect on road safety.

3. Supporting document

3.1. METHODOLOGY

3.1.1. Literature Search strategy

The literature search was conducted in January-March 2017. The search strategy aimed at identifying recent quality studies to estimate the effectiveness of the implementation of rumble strips at centre- and edge lines, thus considering not only rumble strip implementation but also its position on the road (centre and edge). During the screening phase the search focused on installation of rumble strips.

A meta-analysis carried out in 2015 is available in The Handbook of Road Safety Measures (online version). As this meta-analysis is available, only recent journal studies (after 2015) in the field of Engineering and Social science were considered from "Scopus". No "grey" literature was examined.

Search terms used to identify relevant papers included, but were not limited to: "rumble strip", "rumple strips", "audible lines". A total of 16 pieces of potentially eligible studies were identified (Table 2). After a preliminary abstract screening text, no studies were found to be eligible to the topic.

Table 2 Literature search strategy (Scopus database) - Date: 3rd April 2017

search no.	search terms / operators / combined queries	hits
#1	TITLE-ABS-KEY("rumble strip*" or "sleeper line*" or "rumple strip*" or "audible lines" or "drunk bumps") AND (LIMIT-TO (PUBYEAR,2017) OR LIMIT-TO (PUBYEAR,2016))	16

3.1.2. Exploratory analysis of results

The number of studies included in the meta-analysis indicate that the topic has been thoroughly investigated. The results are based on several types of studies from a range of years. Most of the included studies have compared the frequency of accidents on roads with and without rumble strips.

Table 3 presents information on the main outcomes of coded studies on the implementation of rumble strips at centre- and edgeline.

Table 3 Main outcomes of coded studies on the implementation of rumble strips at centre- and edge lines.

Author, Year, Country	Exposure variable	Study Type	Outcome variable / Outcome type	Effects for road safety*	Main outcome - description
Høye., 2015 International	Centreline rumble strips	Meta-analysis	All accident types	↘ -10% (-14;-5)	Significant positive effect on road safety
	Centreline rumble strips	Meta-analysis	Target accidents: head-on, ROR to the left, sideswipe with vehicle in the left hand side oncoming lane	↘ -37% (-42;-31)	Significant positive effect on road safety
	Centre-and edgeline rumble strips	Meta-analysis	All accidents	↘ -14% (-23;-3)	Significant positive effect on road safety
	Centre-and	Meta-	Target accidents: head-on, ROR to	↘ -32% (-36;-29)	Significant positive

	edgeline rumble strips	analysis	left/right, sideswipe with vehicle travelling in the opposite direction			effect on road safety
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*Significant effects on road safety are coded as: positive (↘)

3.2. LIST OF STUDIES

3.2.1. Meta-analyses

Høye, A. (2015). The Handbook of Road Safety Measures, Norwegian (online) version.

<http://tsh.toi.no/index.html?147175>

The following studies were included in the Meta-analysis:

Briese, M. Safety effects of centerline rumble strips in Minnesota. 2008 Report MN/RC 208-44. St Paul Minnesota, Minnesota Department of Transport.

Karkle, D. E. Effects of centerline rumble strips on safety, exterior noise, and operational use of the travel lane. 2011 Dissertation. Manhattan, Kansas: Kansas State University.

Kay, J. J., Savolainen, P. T., Gates, T. J., Datta, T. K., Finkelman, J., & Hamadeh, B. Safety Impacts of a Statewide Centerline Rumble Strip Installation Program. 2015 Transportation Research Board 94th Annual Meeting.

Kubas, A., Kayabas, P., Vachal, K., & Berwick, M. Rumble Strips in North Dakota: A Comparison of Road Segments, Safety, and Crash Patterns. 2013 Fargo: Upper Great Plains Transportation Institute North Dakota State University.

Lyon, C., Persaud, B., & Eccles, K. Safety Evaluation of Centerline Plus Shoulder Rumble Strips. 2015 Report FHWA-HRT-15-048. Vienna VA/Toronto, Ontario: Vanessa Hangen Brustlin, Inc (VHB) Persaud Lyon, Inc.

Mohamud, M. J. Centerline Rumble Strips – Safety Evaluation. 2011 Aalborg: Faculty of Engineering and Science, Aalborg University.

Noyce, D. A. & Elango, V. V. Safety evaluation of centerline rumble strips: A crash and driver behavior analysis. 2004 83rd Annual meeting of the Transportation Research Board, Washington, D.C. Paper Nr. 04-3932.

Outcalt, W. Centerline rumble strips. 2001 Report CDOT-DTD-R-2001-8. Colorado Department of Transportation Research Branch.

Persaud, B. N., Retting, R. A. & Lyon, C. A. Crash reduction following installation of centerline rumble strips on rural two-lane roads. 2004 Accident Analysis & Prevention, 36(6), 1073-1079.

Sayed, T., deLeur, P., & Pump, J. Impact of Rumble Strips on Collision Reduction on Highways in British Columbia, Canada. 2010 Transportation Research Record, 2148, 9-15.

Sin, J. G. N. Safety impact study of centerline rumble strips in Georgia. 2014 Georgia Institute of Technology.

Torbic, D. J., Hutton, J. M., Bokenkroger, C. D., Bauer, K. M. & Harwood, D. W. Guidance for the design and application of shoulder and centerline rumble strips. 2009 NCHRP Report 641. Washington DC: Transportation Research Board.

Van Schalkwyk, I. & Washington, S. Cost effective safety improvements on two-lane rural state roads in Washington State. 2008 Report WA-RD 695.1. Tempe, AZ: Arizona State University, Department of Civil and Environmental Engineering.

3.2.2. References on further background information

Elvik, R.; Høy, A.; Vaa, T.; Sørensen, M. (2009): The Handbook of Road Safety Measures. Second edition. Emerald Group. Bingley