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AN ASSESSMENT OF THE EFFECT OF THE AVERAGE SPEED ENFORCEMENT SYSTEMS ON LITHUANIAN ROADS

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Abstract. The speeding is a major road safety problem on the roads of Lithuania and many other countries. To reduce and control the speed of vehicles, engineering measures are installed on the roads of Lithuania and other countries – intelligent instantaneous and average speed enforcement systems, as well as many other engineering and structural speed reduction measures. The article presents good practices in the use of average speed enforcement systems, assessment of their effect on road safety. The article analyses the assessment results of the effect of the average speed enforcement systems installed on 25 sections of roads in Lithuania that have been operating

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for four years. Calculations of the effect factor of the installed average speed enforcement systems on road safety were performed using the before-and-after (B&A) method with a comparison group. Studies on the effect of application of speed control systems provide conditions for evaluating road safety, i.e., changes in road accidents linked to the effectiveness of implemented measures. The conclusions of the conducted study presented the calculations of the efficiency coefficients of the average speed enforcement systems on Lithuanian main and national roads. The analysis of the results of the conducted study allows stating that the installed average speed enforcement systems on 25 sections of Lithuanian roads increase overall road safety by 47%, reduce the number of collisions with animals by 80%, and the number of collisions with vehicles by 35%, as well as the number of other road accidents by 56%.

Keywords: average speed enforcement systems, road accident data, speeding, traffic rules.

Introduction

The number of road accidents and their consequences depend on many factors, among which the speed of vehicles is very significant. Exceeding the speed limit is a major road safety problem on the roads of Lithuania and many other countries. According to the 2021 Lithuanian Road Police data, not adhering to a safe driving speed or exceeding the permitted speed limit accounted for 53% of road accidents with fatalities and 22% of road accidents in which traffic participants were injured (Lithuanian Road Police Service, 2021). In 2021, the damage to the Lithuanian economy due to people killed and injured in road accidents amounted to 146.66 million euros (Transport Competence Agency, 2022).

In order to reduce and control the speed of vehicles, engineering measures are installed on the roads of Lithuania and other countries – fixed speed cameras and average speed enforcement systems (ASES), as well as many other engineering and structural speed reduction measures.

From September 2018, the average speed enforcement systems started operating on 25 roads sections in Lithuania. According to the data of the Lithuanian Road Administration, at the end of 2021, these systems were operating on the 81 sections of Lithuanian roads, and at the end of 2022, the average speed enforcement systems were operating on the 121 sections. Operation of the existing average speed enforcement systems requires assessment of their performance efficiency. This article presents the results of the assessment of the efficiency of the average speed enforcement systems installed on 25 sections of roads in Lithuania that have been operating for four years. There are 18 sections on the main roads, with a total length of 84 159 km, and there are 7 sections on national roads, with a total length of 19 599 km.

The evaluation of speed reduction and control measures is a process that includes data collection, their analysis, efficiency study and extraction of coefficients. This type of research is very important, as it identifies the advantages and disadvantages of certain implemented measures and their impact on road safety (Daniels et al., 2019). Research methods for speed reduction and control measures are used with the aim of conducting safety studies, investigating factors that may affect road safety and comparing safety indicators (Polders & Brijs, 2018).

1. Literature review

Based on the results of research conducted by European scientists, it can be stated that speed cameras are a traffic-related tool if the incidents are over-speeding due to traffic intensity and are clearly localized on specific road sections. The operation of the average speed enforcement systems has a significant impact on the reduction of accidents in the system operation section (Vaitkus et al., 2016). Montella et al. (2012) calculated the effectiveness of average speed measurement systems in their study. The research data from the A1 Milan-Naples highway, where the speed limit is 130 km/h, was used for the evaluation. The implementation of the system has a significant impact on the reduction of traffic accidents within the curves – a 43.3% reduction was determined after the system was implemented.

It should also be noted that average speed enforcement systems have a longer operating distance. They are mostly installed in 2–10 km sections. It is also possible to avoid sudden stops, which are typical of stationary point meters. Average speed enforcement systems are a relatively new speed control system. Average speedometers calculate the average speed for a section of road (usually 2–5 km). The vehicle is identified when it passes the start point (the first camera) and is captured again passing the end point (the second camera). The average speed can be calculated based on the time interval between these two points.

These systems work continuously, so there is a very minimal chance that a vehicle that does not comply with the safe speed will not be caught.

In Belgium, the effect of average speed control on speed was investigated on two motorway sections (Vanlommel et al., 2015). According to the researchers, it was possible to reduce the average driving speed of vehicle traffic by 15 km/h in the studied sections and make it more homogeneous.

Reviewing all the conducted studies and their conclusions, it can be stated that average speed enforcement systems are effective in areas with a high concentration of traffic accidents and help ensure long safe road sections.

2. Methodology

Road safety is characterised by the number of road accidents and their consequences (injured and killed road users) (Høye & Elvik, 2019). Wang et al. (2011) claim that with the significant increase in the number of vehicles, the number of road accidents also increases. In this context, speed is singled out as one of the main road safety risk factors, increasing the probability of growth in the number of road accidents and their severity. In order to ensure greater road safety, the responsible authorities use various measures to limit and control speed (De Pauw et al., 2014). There are various research methods that can be used to assess different safety measures, enabling the evaluation of how they can reduce the risks arising on the roads (Before-and-after studies using crash data and iRAP protocols, 2011). The study focuses on the analysis and forecasting of road accidents.

These studies are useful for two reasons: the studies provide an opportunity to identify places with a high probability of road accidents, and also to determine how different types of road accidents are related to road geometry, environmental factors and traffic conditions. The prediction of road accidents and the identification of their causes make it possible to understand the general process and implement solutions related to the implementation of effective safety measures (Wang et al., 2011). B&A methods can be successfully used to make decisions about road infrastructure design and the implementation of speed reduction and control measures (Mauro et al., 2013). Studies on the effectiveness of application of speed control systems provide conditions for evaluating road safety, i.e., changes in road accidents linked to the effectiveness of implemented measures. This type of research also provides an opportunity to assess how the severity of road accidents can change after the introduction of certain driving control measures. Moreover, B&A studies play an important role in the evaluation of economic investments in implemented safety measures (Division of traffic engineering guidelines: safety programs/before&after studies, 2017).

When evaluating the effectiveness of a safety measure, a B&A study is usually used, which compares the number of road accidents after the implementation of a certain safety measure with the number of road accidents before the implementation of the safety measure (De Pauw et al., 2014). Different B&A methods can be used for these types of studies (see Figure 1). An essential difference between the methods is the control of confounders. A confounder is defined as any external variable that affects the number or outcome of road accidents. If this variable is not assessed, the effect may be incorrectly calculated (De Peauw et al., 2014).

The rationale for a before-and-after study with a comparison group is the same as for a matched comparison group method. However, this application of this method does not require a one-to-one matching of study and comparison group members. The essence of the method is that the larger the selected comparison group, the more accurate the estimate is (Before-and-after study technical brief, 2009).

In this evaluation method, the paths of the comparison group do not have to be very similar to the paths of the treatment group. When performing an assessment according to this method, historical data of the study and comparison groups must be collected. The collection and use of these data in the study constitute an advantage over the before-and-after method with a matched comparison group, but do not address the issue of bias associated with the error of the regression mean (Before-and-after study technical brief, 2009). It should also be noted that this method is similar to the matched comparison group method, as it cannot determine the effectiveness of the measure effect if the number of road accidents in the comparison group during before and after period is zero. If the comparison group has a limited number of cohort members, a before-and-after method with a matched comparison group is the best choice.

Definitions of selected effects reveal the fact that even without the implementation of certain road safety measures it would be possible to observe changes in a certain road section. Based on the definition of the

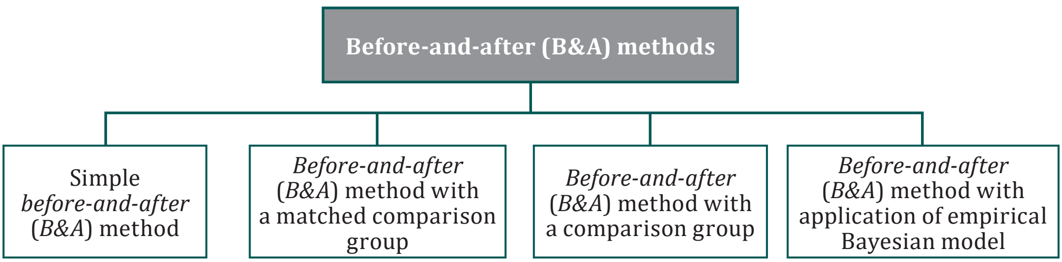

Figure 1. *Before-and-after (B&A)* methods (Before-and-after study technical brief, 2009)

above four effects, it can be concluded that even if no safety treatment had been applied to the facility, it would have been likely to observe a change in accident frequency from the before to the after periods. Consequently, analysts must recognize the impact of each of these effects on their evaluation results and must employ techniques that seek to minimize or account for these extraneous effects (Before-and-after study technical brief, 2009).

In conclusion, it can be stated that the before-and-after (B&A) methods are extremely significant in assessing road safety and its changes in the planned periods, according to the implemented measures to ensure road safety and according to the selected variables. However, it should also be mentioned that the four before-and-after methods are not suitable for identifying safety changes in all cases. This is due to the fact that all before-and-after methods have their advantages and disadvantages, and the amount of data they require differs. Despite this fact, these methods are constantly being improved in order to reduce possible errors and ensure the most accurate efficiency of implementing road safety measures.

A study flow chart was prepared for the purposes of the study according to the B&A method with a comparison group. There are six stages of calculation of the effect coefficient of the average speed enforcement systems, which are carried out sequentially:

- Formation of treatment group T;
- Formation of the comparison group C;
- Compilation of road accident data set;
- Assessing the appropriateness of the comparison group C;
- Calculation of the effect factor of the average speed control systems.

Average speed enforcement systems were installed on the roads of the treatment group and were put into operation on 1 September 2018. Since the measure was installed on the roads of the treatment group at

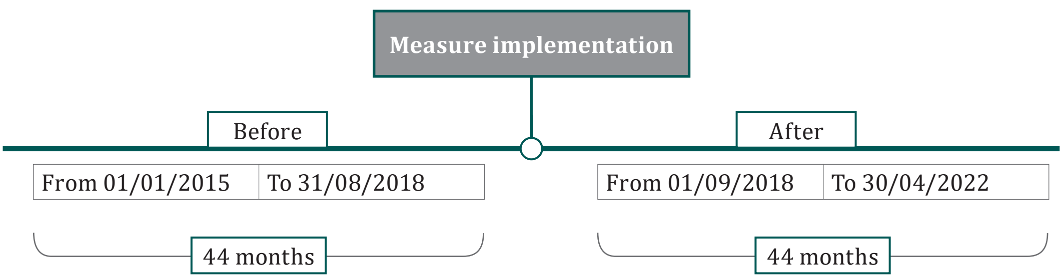

Figure 2. Study data collection period

the end of the year, based on Høye & Elvik (2019), it was assumed that the number of road accidents might not have decreased in the first year, but in the following one or two years. This is an effect called the error of the regression mean.

When collecting data for the assessment of the implementation of average speed enforcement system, data must be collected for a period of at least 2 years before and after, and the most accurate results are obtained when a period of 3–5 years is chosen before and after the implementation of certain safety measures (Division of traffic engineering guidelines: safety programs/ before & after studies, 2017). In a B&A study, the data collection periods must be of equal length. It is also important that the data required for the study are collected taking into account similar traffic conditions (van der Horst et al., 2017).

The study period covers 01/01/2015–04/30/2022. The study period is divided into "before" and "after" introduction of the average speed enforcement systems on 1 September 2018 (see Figure 2).

The information required for the study, i.e., study data according to the planned periods are collected in each group and used for the necessary calculations. Before conducting the study, the appropriateness of the comparison group is verified. According to the roads selected in the treatment and comparison groups, an analysis of the road accidents that occurred on them was carried out in the sections where average speed enforcement systems were implemented in the treatment group.

The analysed road sections of the treatment and comparison groups are located on main and national roads.

The roads of the treatment and comparison groups (see Table 2) were chosen purposefully, i.e., meeting the criteria provided in the methodology. The treatment and comparison groups consisted of 25 sections each. Road sections in both groups are selected according to their type, i.e., main and national roads. The selection of sections for the comparison group was more complicated than for the treatment group, in order to ensure that their suitability matched the roads of the treatment group. The data of both groups were collected during the period of 44 months before the implementation of the safety measure of the system and 44 months after the implementation of the safety measure. The AADT of the treatment and comparison groups were similar. The variation of the number of road accidents was different in the treatment and comparison groups.

The comparison group is very important in B&A studies because it is used to calculate trends. Road sections in the comparison group must have similar characteristics (AADT, geometrical parameters, etc.) as sections in the treatment group. In order to assess the appropriateness of the comparison group, it is necessary to calculate the value of the odds ratio (*OR*) according to Equation (1) (De Pauw et al., 2014):

$$OR = \frac{R_t / R_{t-1}}{C_t / C_{t-1}}, \tag{1}$$

where:
R_t – the number of road accidents in the treatment group in year t;
R_{t-1} – the number of road accidents in the treatment group in year t–1;
C_t – the number of road accidents in the comparison group in year t;
C_{t-1} – the number of road accidents in the comparison group in year t–1.

When the odds ratio (*OR*) value is about 1, the comparison group is comparable with the investigated road (street) sections and intersections. The maximum standard deviation should not be higher than 0.20. If the *OR* value of the comparison group corresponds to these indicators, it means that the comparison group is properly formed (De Pauw et al., 2014).

Data on road accidents are grouped according to the study period. In order to calculate the efficiency coefficients for different groups of road accidents, the accident data are also grouped into three groups of road accidents: road accidents with animals, collisions with vehicles and other road accidents.

The appropriateness of the average speed enforcement systems is calculated according to the *k*-test Equation (2):

$$k = \frac{b / a}{d / c} = \frac{A_{\mathrm{T_{after}}} / A_{\mathrm{T_{before}}}}{A_{\mathrm{C_{after}}} / A_{\mathrm{C_{before}}}}, \tag{2}$$

where:
A_{Tafter} – the number of road accidents in the treatment group T after the intervention, i.e., implementation of the system.
A_{Tbefore} – the number of road accidents in the treatment group T before the intervention, i.e., implementation of the system;
A_{Cafter} – the number of road accidents in the comparison group C after the intervention, i.e., implementation of the system;
A_{Cbefore} – the number of road accidents in the comparison group C after the intervention, i.e., implementation of the system.

The k test shows the change in the number of road accidents after the introduction of a road safety measure in the treatment group, after evaluating the change in the number of road accidents in the comparison group:

– in the event that $k < 1$, a decrease in road accidents is observed in the treatment group;
– in the event that $k = 1$, there are no changes in road accidents in the treatment group;

– in the event that $k > 1$, an increase in road accidents is observed in the treatment group.

3. Results

In order to calculate the effectiveness coefficient of the implemented measures, the treatment and comparison (see Table 1) groups were created. In the treatment group, the road sections were distinguished where on 1 September 2018 systems for measuring the average speed had started to operate, while the road sections of the comparison group did not have these systems or these systems had been installed after the planned reference year. The AADT of the treatment and comparison groups are similar.

After collecting the data of the treatment and comparison groups, an analysis of road accidents in both groups was carried out. Road accidents that occurred before and after the implementation of the measure were considered (see Table 2). Four periods for the treatment group are used for calculations:
Period I: 01/01/2015–30/11/2015;
Period II: 01/12/2015–30/10/2016;
Period III: 01/11/2016–30/09/2017;
Period IV: 01/10/2017–31/08/2018.

Table 1. Data of main and national road sections of the treatment group and road sections of the comparison group

No.	Road significance	Treatment group		Comparison group	
		Number of sections	Section length, km	Number of sections	Section length, km
1.	National road	18	84 159	15	126 546
2.	Main road	7	32 373	10	7449
3.	Total	25	116 532	25	201 036

Table 2. Historical road accidents of the treatment and comparison groups before implementation of the measure

	Road accidents in period I	Road accidents in period II	Road accidents in period III	Road accidents in period IV
Treatment group	13	11	18	16
Comparison group	9	11	25	24

Four periods were also selected in the comparison group:
Period I: 01/09/2018–30/07/2019;
Period II: 01/08/2019–30/06/2020;
Period III: 01/07/2020–30/05/2021;
Period IV: 01/06/2021–30/04/2022.

The odds ratio for the treatment group before the implementation of the measure is calculated according to Equation (3) for the first and second periods.

$$OR_{1(1-2)} = \frac{(13\times 11)\div(11\times 9)}{1+\frac{1}{11}+\frac{1}{9}} = 1.20 \quad (3)$$

Similarly, the odds ratio is calculated according to the formula for the second and third periods.

$$OR_{1(2-3)} = \frac{(11\times 25)\div(18\times 11)}{1+\frac{1}{18}+\frac{1}{11}} = 1.21 \quad (4)$$

The odds ratio is calculated according to the formula for the third and fourth periods.

$$OR_{1(3-4)} = \frac{(18\times 24)\div(16\times 25)}{1+\frac{1}{16}+\frac{1}{25}} = 0.98 \quad (5)$$

The calculations show that the obtained values fall within the confidence interval [0.75…1.23], since [0.75<…<0.98<…<1.20<…<1.21<…1.23], and the sum value of the sample mean is close to one.

The odds ratio for the treatment group after the implementation of the measure is calculated according to the Equation (6) for the first and second periods.

Table 3. Historical road accidents of the treatment and comparison groups after implementation of the measure

	Road accidents in period I	Road accidents in period II	Road accidents in period III	Road accidents in period IV
Treatment group	11	7	5	5
Comparison group	22	14	13	13

$$OR_{2(1-2)} = \frac{(11 \times 14) \div (7 \times 22)}{1 + \frac{1}{7} + \frac{1}{22}} = 0.84 \quad (6)$$

Similarly, the odds ratio is calculated according to the formula for the second and third periods.

$$OR_{2(2-3)} = \frac{(7 \times 13) \div (5 \times 14)}{1 + \frac{1}{5} + \frac{1}{14}} = 1.12 \quad (7)$$

The odds ratio is calculated according to the formula for the third and fourth periods.

$$OR_{2(3-4)} = \frac{(5 \times 13) \div (5 \times 13)}{1 + \frac{1}{5} + \frac{1}{13}} = 0.78 \quad (8)$$

The next step is grouping the road accidents data in three groups: road accidents with animals, road accidents with vehicles and other road accidents.

The data of Table 4 show that the number of accidents during the period after the installation of the ASES is lower by 30 units than during the period before installation. Most road accidents that occurred before the installation of the ASES were "Other" accidents – 29. In Lithuania, a large proportion of road accidents are categorised as other accidents. By examining each of them separately, some of the accidents can be attributed to other types and it can be assumed that they are directly linked to a non-compliance with a safe speed limit. However, there is a type of road accident in the records of police data – other accidents. Meanwhile, after the installation of the ASES, most of the accidents that occurred were collisions with vehicles – 17. There were 3 collisions with animals before implementation of the ASES, while no accidents happened after. Table 5 has been formed similarly. It provides a systematic historical road accident of the comparison group road accidents according to groups of participants.

Table 4. The distribution of road accidents of the treatment group

No.	Road No.	Before implementation of ASES												Total	After implementation of ASES												Total	Variation
		Period I			Period II			Period III			Period IV				Period I			Period II			Period III			Period IV				
		A	V	O	A	V	O	A	V	O	A	V	O		A	V	O	A	V	O	A	V	O	A	V	O		
Sections of main roads																												
1	A3					1						1		2													0	–2
2	A4			1			1				1	1		4												1	1	–3
3	A5													0													0	0
4	A6													0													0	0
5	A6		1						1					2						1							1	–1
6	A7					1			1					2		2							1		1		4	+2
7	A8		1			1				1			1	4						1			1				2	–2
8	A8													0		1				1							2	+2
9	A9					1				1				2		1				1							2	0
10	A10									1				1		1			1								2	+1
11	A11													0													0	0
12	A12			1					2					3													0	–3
13	A12											1		1		1			1								2	+1
14	A12									1				1		1											1	0
15	A13					1			1			1	2	5													0	–5
16	A15		1	1					1				2	5													0	–5
17	A16			1			1					1	1	4								1			1		2	–2
18	A16						1					2		3													0	–3
Sections of national roads																												
19	102			2						2				4			1								1		2	–2
20	130							1						1								1					1	0
21	141			1			1							2		1											1	–1
22	164	1				1				1				3					1								1	–2
23	103								1				1	2			1						1				2	0
24	122		1	1			1		2	1				6											1		1	–5
25	141												1	1			1										1	0
Total:		1	4	8	0	6	5	1	9	8	1	7	8	58	0	8	3	0	3	4	0	2	3	0	4	1	28	–30

Table 5. The distribution of road accidents of the comparison group

No.	Road No.	Before implementation of ASES												Total	After implementation of ASES												Total	Variation
		Period I			Period II			Period III			Period IV				Period I			Period II			Period III			Period IV				
		A	V	O	A	V	O	A	V	O	A	V	O		A	V	O	A	V	O	A	V	O	A	V	O		
Sections of main roads																												
1	A8			2									1	3		1			1			1					3	0
2	A12						1		2					3						2					1		3	0
3	A14	1							1			1	1	4					1		1						2	−2
4	A4									1		1		2		3	1						2				6	+4
5	A11					2						1		3		1										1	2	−1
6	A4	1				1				1				3						1						1	2	−1
7	A14													0													0	0
8	A4										1	1		2												1	1	−1
9	A6								1					1						1		1					2	+1
10	A4						1					2		3		3						2					5	+2
11	A8			1								1	1	3						1						1	2	−1
12	A2									1			1	2									1		1		2	0
13	A2							2	1	2			2	7		1				2		1					4	−3
14	A13						1			1				2	1		1	1									3	+1
15	A16									1				1						1							1	0
Sections of national roads																												
16	220						1						1	2			1							1			2	0
17	140	1							1					2			1						1				2	0
18	151					1							1	2					1						2		3	−1
19	141									2				2			1										0	−2
20	141													0													0	0
21	164		1				2					2	1	6			1			1						1	3	−3
22	129			2					1	1		1		5										1		1	2	−3
23	102								1	2			4	7		1	3						2				6	−1
24	128								1	1				2		1			1				1				3	+1
25	129				1				1					2			1								1		2	0
Total:		3	1	5	1	4	6	2	10	13	1	10	13	69	1	11	10	1	4	9	1	5	7	2	5	6	62	−9

In the comparison group, the largest number of rated road accidents before the installation of the ASES occurred in the group 'other road accidents' – 37. Meanwhile, after the implementation of the measure in the group, other road accidents amounted to 32 accidents. There were 25 road accidents of collision with vehicles both before and after the installation of the measure. Accidents with animals decreased from 7 to 5 after the measure was implemented. According to Tables 4 and 5, a simplified table of road accidents was created, where road accidents were divided by types of road users, which was used for further calculations.

After collecting the necessary data on the treatment and comparison groups and after performing the analysis of the rated road accidents, the coefficient of average speed enforcement systems is evaluated according to the *k-test* (Equation (9)).

$$k = \frac{b/a}{d/c} = \frac{A_{\mathrm{T_{after}}} / A_{\mathrm{T_{before}}}}{A_{\mathrm{P_{after}}} / A_{\mathrm{P_{before}}}} = \frac{28/58}{62/69} = \frac{0.482}{0.898} = 0.53 \quad (9)$$

Percentage reduction in road accidents:

$(1 - k) \times 100\% = (1 - 0.53) \times 100\% = 47\%$.

The effect factor of the safety measure is equal to 0.53, i.e., $k < 1$. These results show that the percentage reduction of road accidents after the installation of the ASES is 47%. Taking this into account, it is stated that the implemented average driving speed control measure has a direct influence on the reduction of the rated road accidents.

Evaluation of average speed enforcement systems was performed according to the *k-test*, according to the groups of road accidents. The first evaluated RA type – collision with animals (Equation (10)).

$$k = \frac{b + \frac{1}{2} / a + \frac{1}{2}}{d + \frac{1}{2} / c + \frac{1}{2}} = \frac{A_{\mathrm{T_{po}}} + \frac{1}{2} / A_{\mathrm{T_{before}}} + \frac{1}{2}}{A_{\mathrm{P_{po}}} + \frac{1}{2} / A_{\mathrm{P_{before}}} + \frac{1}{2}} = \frac{0 + \frac{1}{2} / 3 + \frac{1}{2}}{5 + \frac{1}{2} / 7 + \frac{1}{2}} = \frac{0.143}{0.733} = 0.20 \quad (10)$$

Percentage reduction in road accidents:

$(1 - k) \times 100\% = (1 - 0.20) \times 100\% = 80\%$.

Table 6. Historical road accidents of the treatment and comparison groups

Group (Type) of road accidents	The number of road accidents in the treatment group		The number of road accidents in the comparison group	
	Before	After	Before	After
Collision with animals	3	0	7	5
Collision with vehicles	26	17	25	25
Other road accidents	29	11	37	32

The effect factor of the safety measure is equal to 0.20, i.e., $k < 1$. These results show that the percentage reduction of road accidents involving collisions with animals after the installation of a safety measure is 80%. Taking this into account, it is stated that the implemented measure has a direct effect on the reduction of rated RA involving collisions with animals.

After that, the type of RA – collision with a vehicle – is evaluated (Equation (11)).

$$k = \frac{b/a}{d/c} = \frac{A_{\mathrm{T_{after}}} / A_{\mathrm{T_{before}}}}{A_{\mathrm{P_{after}}} / A_{\mathrm{P_{before}}}} = \frac{17/26}{25/25} = \frac{0.653}{1} = 0.65 \qquad (11)$$

Percentage reduction in road accidents:

$(1 - k) \times 100\ \% = (1 - 0.65) \times 100\% = 35\%.$

The effect factor of the safety measure is equal to 0.65, i.e., $k < 1$. These results show that the percentage reduction of road accidents involving collisions with vehicles after the installation of a safety measure is 35%. Taking this into account, it is stated that the implemented vehicle speed reduction and control measure has a direct effect on the reduction of collisions with vehicles.

Type of TA assessed – other road accidents (Equation (12)).

$$k = \frac{b/a}{d/c} = \frac{A_{\mathrm{T_{after}}} / A_{\mathrm{T_{before}}}}{A_{\mathrm{P_{after}}} / A_{\mathrm{P_{before}}}} = \frac{11/29}{32/37} = \frac{0.379}{0.864} = 0.44 \qquad (12)$$

Percentage reduction in road accidents:

$(1 - k) \times 100\% = (1 - 0.44) \times 100\% = 56\%.$

The effect factor of the safety measure is equal to 0.44, i.e., $k < 1$. These results show that the percentage reduction of road accidents – other road accidents – after the installation of a safety measure is 56%. Taking this into account, it is stated that the implemented vehicle speed reduction and control measure has a direct effect on the rated road accidents – type 'other road accidents'.

The resulting calculations of the impact coefficients (see Table 7) allow drawing the conclusion that the average speed enforcement systems have a direct effect on the decrease in the number of rated road accidents.

Table 7. The efficiency coefficients of the ASES

	Effect coefficient (*k*)
Efficiency coefficient	0.53
Road accidents – collision with animals	0.20
Road accidents – collision with vehicles	0.65
Road accidents – other road accidents	0.44

Conclusions

1. Calculations of the effect factor of the average speed enforcement systems on road safety were performed using the *before-and-after* (*B&A*) method with a comparison group. The conclusions of the conducted study presented the calculations of the efficiency coefficients of the average speed enforcement systems on Lithuanian main and national roads.
2. The following effect coefficients of the average speed enforcement systems on road safety were determined in the study results: overall change in road safety on the roads – 0.53; road accidents – collision with animals – 0.20; road accidents – collision with vehicles – 0.65; road accidents – other road accidents – 0.44.
3. In the police data register of the Republic of Lithuania, a large number of road accidents are classified as 'other road accidents' type. When examining each road accident, it can be assumed that they can be registered in another type, and their cause is failure to comply with the safe speed limit.
4. The results of the study allow us to positively evaluate the Lithuanian Road Directorate's aspiration to expand the network of average speed measurement systems.

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