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Evaluation of Exclusive Pedestrian Phase Safety Performance at One-Level Signalized Intersections in Vilnius

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Abstract: This work aims to identify the effectiveness of one-level signalized intersections with exclusive pedestrian phases in terms of vehicle-pedestrian crashes resulting in pedestrian injury or fatality. The work analyzes and evaluates specific exclusive pedestrian phases without diagonal crossing possibility at one-level signalized intersections in the city of Vilnius. Anonymized data on traffic accidents from the Lithuanian Police Department Accident Register were used for safety analysis purposes. The traffic accident data cover all traffic accidents with dead or injured persons. The traffic accident data was analyzed with the help of QGIS for selected time intervals (before and after analysis). The density of traffic accidents was calculated with the help of the comparative analysis method at 11 signalized intersections in Vilnius City, where an exclusive pedestrian phase without diagonal crossing was implemented. An exclusive pedestrian phase with diagonal crossing is usually implemented to increase pedestrian safety at a signalized intersection with a high pedestrian intensity. The analysis carried out indicates that the specific exclusive pedestrian phase without diagonal crossings in Vilnius reduced pedestrian traffic accidents by up to 100%. No traffic accidents occurred after the installation of the exclusive pedestrian phase at intersections where there were no pedestrian accidents prior to the installation.

Keywords: pedestrian safety; vehicle–pedestrian crashes; signalized intersections; one-level intersection; exclusive pedestrian phase; before and after analysis

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1. Introduction

According to data published by the World Health Organization [1], approximately 1.3 million people die each year as a result of road traffic crashes, and between 20 and 50 million people suffer nonfatal injuries, with many incurring a disability as a result of their injury. Road traffic accidents cost most countries 3% of their gross domestic product, and the number of deaths from road traffic continues to increase steadily [1,2]. Infrastructure design and improvement are some of the key measures that can significantly prevent fatalities and injuries in road traffic.

Based on data from the Lithuanian Traffic Accident Analysis System (also known as Onha LT), the highest number of deaths in Lithuania occurs when a car crashes into a pedestrian, and slightly fewer occur when two vehicles collide. These types of accidents account for more than 65% of all accidents during recent years (2015–2018). Analysis of detailed accident data indicates that when cars hit pedestrians, 3.3–4.1% of pedestrians were killed and 46.03–46.79% of pedestrians were injured, during the period of 2015–2018. According to the Lithuanian Traffic Accident Analysis System, in most cases, pedestrians are fatally injured at places where there is no pedestrian crossing. Such circumstances are the most common cause of pedestrian death in Lithuania, that is, pedestrians receive fatal injuries when trying to cross a road in places not designated for that purpose. However, the second most dangerous place, according to the frequency of pedestrian traffic accidents, is the intersection area that is believed to have pedestrian crossings, or other means of safety management.

Traffic accidents at intersections are caused by various risk factors: the speed of vehicles, the intensity of pedestrian traffic, non-compliance with road traffic rules, the number of conflict points at the intersection, and other factors. Proper assessment and management of all of these factors individually at each intersection is the key to solving the pedestrian safety problem at the intersections [3].

Several studies have shown that most pedestrians survive a car hit at a maximum speed of 30 km/h, but the chances of a pedestrian surviving at a speed of 50 km/h are low. The level of injury also depends on the shape and rigidity of the vehicle surface, but speed is often the deciding factor [4]. Therefore, if the speed of a turning vehicle at an intersection is greater than 30 km/h, the chances of a pedestrian surviving a hit decrease exponentially. This problem can be solved by implementing traffic safety measures at intersections that physically slow vehicles, or by separating pedestrians from vehicles, that is, eliminating conflicts between vehicles and pedestrians.

Researchers Pulugurtha and Sambraha [5] found that the increase in the number of pedestrians at a signalized intersection with an unprotected pedestrian phase increased the number of pedestrian accidents in North Carolina. Another group of researchers from Canada [6] found that a 30% reduction in pedestrian traffic reduced the number of pedestrians injured by 35%. The risk of pedestrian accidents would also be reduced by decreasing the number of vehicles performing turning maneuvers at intersections. This study indicates that with a higher number of pedestrians and vehicles, other ways of managing intersection traffic must be explored.

The introduction of a safety measure or a change in intersection management that improves pedestrian safety requires an assessment of how these changes are accepted by all road users, as any safety improvement can fail if people do not comply with the rules of road traffic. Raising people's awareness of road safety must be an ongoing process.

Researchers from Australia [7] found that pedestrians at a signalized intersection were eight times more likely to be involved in an accident if they violated traffic rules at the intersection (passing a crossing during a red light, etc.). Malaysian researchers [8] also conducted a comparative analysis and found that pedestrians who crossed an intersection at a red light were more likely to be involved in an accident than those who followed the rules of road traffic. Sophisticated signalized crossings require a lot of skill from vehicle drivers. Speeding at an intersection and overestimating personal capabilities are the most common causes of traffic accidents at signalized intersections [9].

At the intersections of roads, the directions of traffic of road users intersect. Such an intersection of directions is called a point of conflict. Pedestrian and car traffic together significantly increase the danger of the intersection, as all pedestrian conflicts with car traffic are the most dangerous. To increase the safety of intersections, various traffic management strategies are being developed to reduce or eliminate conflict points at intersections. The safety of an intersection where all road users are at the same level is determined by the way traffic is managed. There are various traffic organizations in Lithuania, and in other countries around the world, which are developing strategies which can be applied at one-level intersections after evaluating certain criteria.

To improve pedestrian safety and comfort, an exclusive pedestrian phase with a diagonal crossing (pedestrian scramble) was introduced in the 1940s; this remains in place today. The traditional approach to the road traffic system, which focused on improving the speed of vehicles and the capacity of the network, was changed to instead focus on the quality of pedestrian travel. Kansas City and Vancouver had such systems in the late 1940s, but H. Barnes popularized it in Denver in 1951 [10]. The pedestrian phase with a diagonal crossing was given the name 'Barnes dance' when a city hall reporter wrote that the crossings 'made people so happy that they are dancing on the streets'.

Barnes became the New York City traffic commissioner in 1962. He made plans for a test crossing on the intersection of Vanderbilt Avenue and East 42nd Street, near Grand Central Station. The crossing was operational in 10 days, and pedestrians had free reign for 23 s of every 90 s light cycle [11]. Pedestrians were very satisfied with this solution, so this solution was later implemented at other intersections. However, due to additional vehicle delays, these intersections were, and still are, under discussion. Today, exclusive pedestrian phases with diagonal crossings are gaining ground based on road safety, and have been installed in the USA, Canada, New Zealand, Australia, Japan, Taiwan, the Netherlands, and the United Kingdom.

The researcher Vaziri [12] conducted a study in Beverly Hills that compared accident statistics at six intersections using 20-year accident data: 10 years before the introduction of an exclusive pedestrian phase with a diagonal crossing, and 10 years after installation. After a comparative analysis, it was found that the number of pedestrian accidents decreased on average by 66% at intersections.

Research on the intersection with a diagonal crossing in New Zealand [13] indicated that pedestrians should walk an average of 5 to 7% shorter distances. This result was confirmed by researchers from California [14], who found that the exclusive pedestrian phase with a diagonal crossing reduced the pedestrian walking distance by an average of 13%, without an increase in mean pedestrian delay.

Another study from Japan [15] based on modelling found that with a large number of pedestrians, an exclusive pedestrian phase with a diagonal crossing could improve the capacity by up to 36%; however, the calculations included vehicles and pedestrians. Therefore, if there were more than 4800 pedestrian crossings during peak hours, then installing a diagonal crossing was beneficial despite vehicle flows. It was also found that an exclusive pedestrian phase saved time when 1200 vehicles and 2000 pedestrians were using such an intersection. The researchers concluded that the lower the vehicle flow and the higher the pedestrian flow, the more beneficial it was to implement an exclusive pedestrian phase with a diagonal transition in terms of time savings. Singaporeans have also conducted a comparative study on intersection management [16]. An exclusive pedestrian phase with a diagonal crossing reduced the delay for the road user in the event of high traffic flows. Researchers concluded that it was important to assess the overall delay of all road users (both vehicles and pedestrians) when modeling the intersection and selecting the appropriate management.

A study was conducted in Calgary, Canada [17] that evaluated the impact of exclusive pedestrian phases with diagonal crossings on pedestrian safety. The researchers collected data on pedestrian conflicts for six weeks. The results obtained showed a decrease in the number of pedestrian and vehicle conflicts, but an increase in the number of pedestrian violations. They found that 40% of all violations occurred at the end of the pedestrian phase, during the flashing green light phase. The study results were confirmed by a Pennsylvania researcher [18], who found that pedestrian violations increased by 21% at an intersection with an exclusive pedestrian phase due to an extended traffic light cycle. Researchers from Connecticut [19] investigated signalized intersections with concurrent and exclusive pedestrian phasing, and later performed a comparative analysis. The violation of pedestrian rules at the intersection with the exclusive pedestrian phase was found to increase on average by approximately 50%.

Other researchers from Canada [20] conducted a pedestrian survey three months after changes in intersection management that employed exclusive pedestrian phasing. A survey conducted by the City of Toronto found that 89% of pedestrians believed intersection management was more appropriate than it had been previously, and 78% of those surveyed indicated that the intersection was crossed diagonally. About two-thirds of the pedestrians stated that they did not notice any additional delay for either vehicles or pedestrians. The results of a survey in the city of Calgary showed that 79% of the respondents supported the installation of an exclusive pedestrian phase. Approximately 70% of the pedestrians believed that an exclusive pedestrian phase with a diagonal crossing improved intersection safety, compared to a traditional method of crossing the intersection. However, an organization for visually impaired people expressed some concerns about such a diagonal crossing. Their main concern was that blind and visually impaired people used the sound of vehicles moving in parallel as a hint that they are travelling in the right direction. There was no vehicle movement at the intersection with the diagonal crossing, and pedestrians moving in different directions caused confusion even when traveling with a guide dog. After discussions with stakeholder groups, the following decisions were made: during the exclusive pedestrian phase with diagonal crossing, the voice message 'diagonal crossing' was repeated twice per cycle; and during vehicle movement, commonly accepted tones were activated. These signals helped with navigation for visually impaired, blind, and even distracted pedestrians.

Researchers indicated the benefits of an exclusive pedestrian phase, as it improves the safety of all pedestrians by giving them full priority and the ability to cross the intersection at a normal speed, without having to worry about vehicles constantly moving at the intersection [21]. Therefore, there are several studies that indicate that an exclusive pedestrian phase with a diagonal crossing installed at an intersection increases vehicle delay [14,18,20,22]. Table 1 demonstrates the multidimensionality of the questions related to diagonal crossings, and the importance of further data analysis.

Table 1. Advantages and disadvantages of the introduction of an exclusive pedestrian phase with a diagonal crossing for pedestrians and vehicle drivers.

	Pedestrians	Vehicle Drivers
Advantages	- safer conditions for pedestrians—reduced number of conflicts and accidents (on average 66%) [12,17]; - priority for pedestrians at intersection - a step towards a pedestrian-friendly city [20]; - shorter distance for diagonal crossings (average walking distance reduced from 5 to 13%) [13,14]; - proper application could decrease the mean delay for pedestrians [15,16];	- by selecting the appropriate traffic light cycle and phase duration, the delay can be minimized [15,16]; - there are no obstacles at the intersection, vehicles can move freely according to established phases [21];
Disadvantages	- increased number of traffic violations among pedestrians 21–50% [17–19]; - possible problems for visually impaired or blind pedestrians [20].	- the installation of the junction could increase the delay of vehicles [14,18,20,22].

Theoretically, pedestrians at the signalized intersection are safer when either an exclusive pedestrian phase with a diagonal crossing or an exclusive pedestrian phase without diagonal crossing possibility are installed, because during these phases pedestrians are completely separated from vehicle traffic and can cross the intersection safely, without active conflict points. Furthermore, a diagonal crossing installed at the intersection can reduce the average time loss experienced by pedestrians at the intersection and shorten the walking distance. The exclusive pedestrian phases with diagonal crossings are quite popular in the world's largest cities, but there is no broader evaluation of traffic safety and justifications at these crossings for relatively smaller cities, such as Vilnius. Moreover, the exclusive pedestrian phase without a diagonal crossing is much less discussed in both the scientific and practical contexts.

Pedestrian safety is an important issue in Lithuania now, as for instance, Great Britain, Germany, and the Netherlands have very low road traffic death rates, but these rates for both Poland and Lithuania are more than 14 times as high [23,24].

There is not much analysis of exclusive pedestrian phases without the possibility of diagonal crossing on traffic safety, therefore the novelty of this work jointly contributes to the development of global and national knowledge, identifies the usefulness of such one-level signalized intersections with exclusive pedestrian phase without the possibility of diagonal crossing, and quantifies its benefits in terms of road safety. This work also aims to contribute to increasing pedestrian safety in the road network system, and performs an analysis of Vilnius City's intersections, where an exclusive pedestrian phase without a diagonal crossing has been implemented.

2. Materials and Methods

Vilnius is both the capital of and the largest city in Lithuania, where the country's most important political, social, cultural, and economic institutions operate, and traffic safety is a key national and municipal issue. According to data published by the Lithuanian Department of Statistics for 2020, the number of permanent residents of Lithuania was 2.77 million, including 0.56 million residents of Vilnius, which was 20.2% of the total number of citizens of the country [25].

At the time of this study taking place, diagonal pedestrian crossings were not regulated by standards in Lithuania; therefore, intersections in Vilnius were analyzed, where an exclusive pedestrian phase was installed in the traffic light cycle. Two specific types of exclusive pedestrian phase were being installed at Vilnius city intersections (see Figures 1 and 2):

(a) An exclusive pedestrian phase was installed in the traffic light control cycle, during which pedestrians could cross intersections in four directions (diagonal crossing was prohibited). Pedestrian traffic was not allowed during vehicle movement phases. This type of control was used to ensure pedestrian safety when a large number of vehicles turn around (see Figure 1a).

(b) An exclusive pedestrian phase was installed in the traffic light control cycle, during which pedestrians could cross the intersection in four directions (diagonal crossing was prohibited). During the vehicle movement phase (on the main street), pedestrian traffic was allowed together with vehicles moving in parallel. This type of control was implemented to reduce the waiting time for pedestrians at pedestrian crossings when there were few vehicles turning (see Figure 1b).

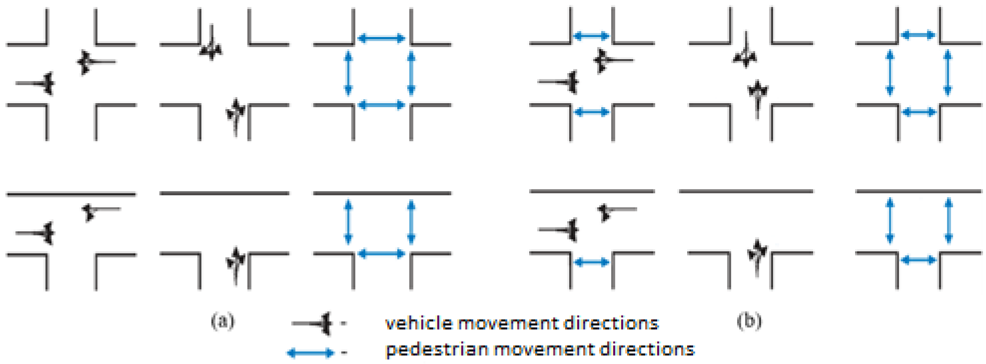

Figure 1. Exclusive pedestrian phases in Vilnius city. (**a**) is four directional pedestrian cross with no vehicle movement, (**b**) is a pedestrian crossing with possible vehicle movement.

The overall analysis covered 11 intersections in the city of Vilnius in which an exclusive pedestrian phase was installed. It can be noted that around the intersections there were either high/medium density residential areas or high-density multipurpose district centers. There were large supermarkets, educational or medical facilities, and public transport stops near these intersections. The surroundings of the intersections generated attractions, so residents were making daily trips to work, shop, or go to educational or medical institutions on foot, and therefore the use of the intersections was intensive. The safety benefits of intersections with exclusive pedestrian phases without diagonal crossings were one of the most essential criteria that should be determined in a further detailed analysis.

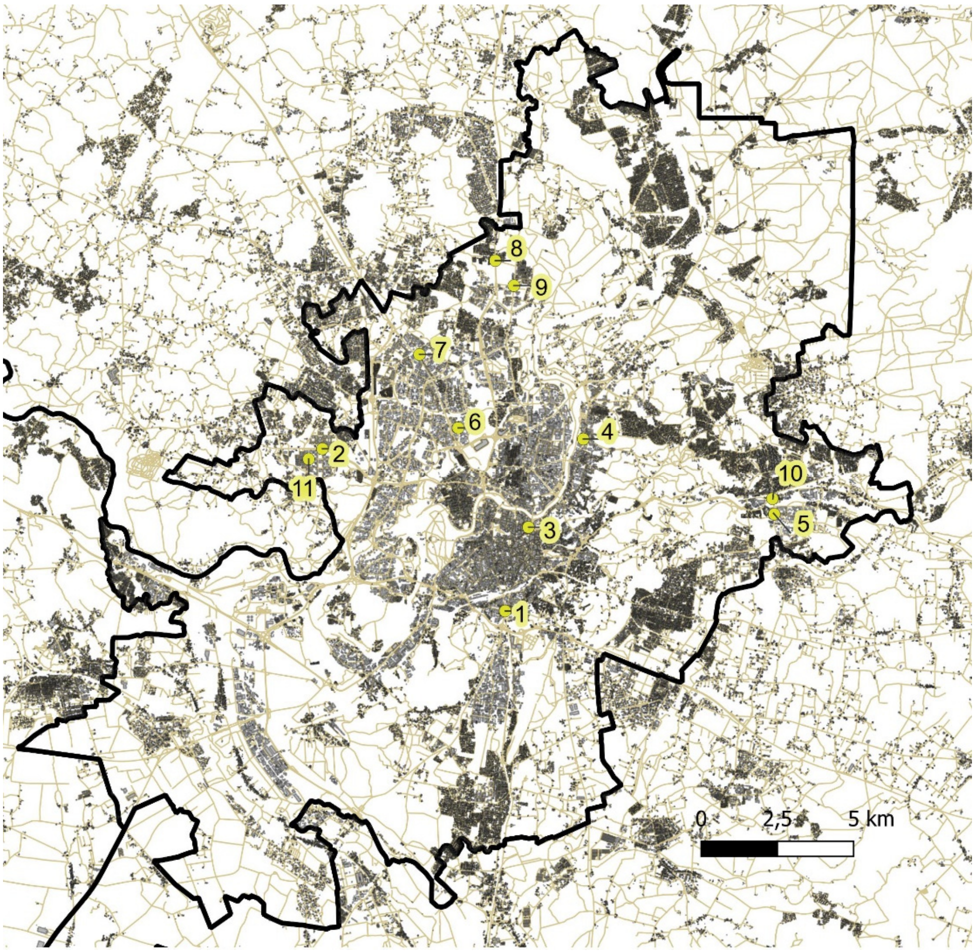

Figure 2. Locations of intersections with exclusive pedestrian phases in the city of Vilnius (prepared by authors, numbering of the intersections is explained in Table 2).

Lithuanian drivers were not required to call for road police, wait for the arriving crew, and deal with papers for technical accidents since 2008 if there were no injuries or fatalities during the accident, two vehicles were (usually) involved in the accident, and the drivers agreed on the circumstances of the accident. Since 2008, it has been possible to fill out accident declarations and deal with insurance companies. This meant that only part of technical accidents were recorded in the Lithuanian Police Department Accident Register since 2008. Other technical accidents were registered by private companies by completing accident declarations. However, data from private companies were not publicly available.

Anonymized data on traffic accidents with people killed or injured, obtained from the Lithuanian Police Department Accident Register, were used for safety analysis purposes [26]. The traffic accident data (see Table 2) was analyzed with the help of QGIS for selected time intervals. A more detailed breakdown by period intervals is presented in the Results chapter.

Table 2. Data on traffic accidents at the analyzed intersections.

No.	Name of the Intersection	Traffic Accidents				Year of the Implementation of Exclusive Pedestrian Phase
		With People Killed before Implementation (A1)	With People Injured before Implementation (A2)	With People Killed after Implementation (A1)	With People Injured after Implementation (A2)	
1.	Dariaus ir Girėno—Šaltkalvių—Kapsų g.	0	8	0	3	2016
2.	Pilaitės pr.—Įsruties g.	0	0	0	0	End of 2016
3.	Gedimino pr.—Šventaragio—T. Vrublevskio g.	0	2	0	1	July 2016
4.	Antakalnio—Žolyno g.	0	1	0	0	July 2016
5.	Parko—Pergalės g.	1	2	0	0	End of 2017
6.	Šeškinės—Paberžės g.	0	0	0	0	August 2018
7.	S. Neries g. 14 next to shopping center	0	0	0	0	2016
8.	Molėtų—Skersinės g.	0	1	0	0	2015
9.	Santariškių—Santaros g.	0	0	0	0	2018
10.	Pergalės-Pramonės g.	0	0	0	0	July 2016
11.	Vydūno-Karaliaučiaus g.	0	0	0	0	2018

The safety of the intersection could be assessed by calculating the accident rate. Accident density (AD) is an accident rate that shows the number of accidents per kilometer per year. As the intersection was a point object in the variable of the street network system, the road length was not included in the formula, so the AD at intersections was calculated according to a modified and adapted formula:

$$\mathrm{AD} = \frac{(A_1 \times 11) + (A_2 \times 1)}{m} \tag{1}$$

where:

A_1—the number of traffic accidents with pedestrians killed at the intersection during the period under consideration;

A_2—the number of traffic accidents with pedestrians injured at the intersection during the period under consideration;

m—the number of years under consideration;

Coefficients 11 and 1 expressed the complexity of the traffic accident, that is, 1 accident with a pedestrian killed is equivalent to 11 accidents with injured pedestrians. The coefficients were calculated based on the traffic accident cost rates specified in the Lithuanian Road Investment Manual. According to this manual, the cost of an accident with fatalities was estimated at 596,899 €, and the cost of an accident with injured people is estimated at 54,201 € [27].

The AD, calculated according to the modified formula, showed preliminary figures on the impact of the exclusive pedestrian phase on safety. The Lithuanian black spot analysis methodology [28] recommended a four-year period for before and after analysis, as it was considered to be a relevant period during which the results may less depend on external factors, such as significant changes in traffic intensity, traffic composition, the condition of the street (road) during the period under assessment, etc. However, a shorter period could be used for the initial assessment. The AD was calculated based on the available data sample, that is, if the change in traffic light phases took place in the second half of 2016, then the AD before the change was calculated by dividing the number of traffic accidents by 3.5 years, and the AD after the change by dividing the number of traffic accidents by 2.5 years.

3. Results of the AD Analysis

Data from the AD analysis are presented in Table 3. It can be seen that at intersections with previous pedestrian accidents, the AD decreased by up to 100% after the introduction of the exclusive pedestrian phase. Furthermore, at intersections where no previous accidents with pedestrians were recorded, no traffic accidents occurred after changing the control of the intersection.

Table 3. AD analysis at Vilnius intersections with exclusive pedestrian phases without a diagonal crossing.

No. and Type		Name of the Intersection	Number of Years before/after Implementation	AD		Change in AD, %
				Before	After	
1.	I	Dariaus ir Girėno—Šaltkalvių—Kapsų g.	**3**	2.67	1.00	−62.6
2.	II	Pilaitės pr.—Įsruties g.	n/a	0	0	0
3.	I	Gedimino pr.—Šventaragio—T. Vrublevskio g.	3.5	0.57	0.29	−49.1
4.	II	Antakalnio—Žolyno g.	3.5	0.29	0	−100.0
5.	I	Parko—Pergalės g.	3.5	3.71	0	−100.0
6.	I	Šeškinės—Paberžės g.	n/a	0	0	0
7.	I	S. Neries g. 14 next to shopping center	n/a	0	0	0
8.	I	Molėtų—Skersinės g.	2	0.5	0	−100.0
9.	I	Santariškių—Santaros g.	n/a	0	0	0
10.	I	Pergalės-Pramonės g.	n/a	0	0	0
11.	I	Vydūno-Karaliaučiaus g.	n/a	0	0	0

4. Discussion

The presented work analyzes macro safety effects at the intersections in which an exclusive pedestrian phase, without the possibility of diagonal crossing, was installed. In the methodological sense, the study had several obvious limitations: the number of covered intersections was relatively low, there was only one fatal accident, and the study covered the macro level and did not analyze in detail the circumstances of the accidents. The AD was calculated based on the available data sample (11 intersections), that is, the analysis of accidents performed at intersections with quite recent changes in traffic light phases. The life span of the changes is presented in Table 3, and depends on the data collected. As previously mentioned, the Lithuanian black spot analysis methodology recommended a four-year period for before and after analysis, as it was considered to be a relevant period during which the results may have less depended on external factors, but a shorter period could be used for the initial assessment. Future work could cover much larger data samples and longer periods, and it could potentially better reveal the impact of pedestrian phases on road safety.

An overview of the experiences of the installation of exclusive pedestrian phases with a diagonal crossing in various geographical areas shows that the recommendations depend on the local characteristics, i.e., pedestrian flow intensity, percentage of pedestrians crossing diagonally, permissible length of diagonal crossing, geometry of the intersection, and the pattern of traffic accidents with pedestrians. After the analysis of the city intersections, it was found that two specific types of exclusive pedestrian phases are used at the intersection (diagonal crossing is prohibited). The first type is that pedestrian traffic takes place only during the exclusive phase. The second is that pedestrian traffic takes place not only during the exclusive pedestrian phase, but also during the main phases of vehicles, when pedestrian traffic is allowed together with vehicles moving in parallel. However, diagonal intersection crossing is not formally regulated by standards in Lithuania, and such exclusive pedestrian phases are quite rare in other countries.

The analysis of the AD at 11 existing intersections with exclusive pedestrian phases in Vilnius showed that the number of pedestrian accidents, after the introduction of the exclusive pedestrian phase without the possibility of diagonal crossing, decreased by up to 100%. Remarkably, no traffic accidents occurred after the installation of the exclusive pedestrian phase at intersections where there were no accidents before the installation, and no adverse effects on traffic safety were observed. The reduction in traffic accidents at the Vilnius city intersections with the introduction of an exclusive pedestrian phase supports the conclusions of scientists that the exclusive pedestrian phase at the intersection reduces the number of traffic accidents and conflicts [12,17,21,29], although these studies analyzed safety with the possibility of diagonal pedestrian crossings at intersections, or other pedestrian signal phasing strategies. There is not much analysis of the exclusive pedestrian phase without the possibility of diagonal crossing on traffic safety; therefore, based on the safety analysis, such a traffic organization might be used if there are technical constraints at the intersection (e.g., elevations, barriers, or visibility limitations) or legal particularities prohibiting the use of diagonal pedestrian crossings.

The Department of Planning, Transport and Infrastructure of the Government of South Australia has prepared a document for the installation and operation of Scramble (diagonal) pedestrian crossings [30]. The requirements are intended to improve pedestrian safety and ensure both reasonable flexibility in signaling and proper traffic management at the intersections.

The traffic intensity of pedestrians and vehicles at almost all Vilnius intersections meets the requirements of South Australia's document, which states that a diagonal pedestrian crossing can be installed if there is a heavy pedestrian flow (at least 300 pedestrians/hour, at least 4 h per day) and low transport intensities (approximately 2000 vehicles/ hour). The analysis of scientific research and the analysis of existing intersections in Vilnius with an exclusive pedestrian phase indicate that the exclusive pedestrian phases improve pedestrian safety at the intersections. It should also be mentioned that from the analysis of Vilnius city intersections, it is not possible to assess the impact of the change in intersection management on the increase of delays at Vilnius city intersections.

5. Conclusions

After the analysis of worldwide experiences on the exclusive pedestrian phase with a diagonal crossing at the intersection, and the analysis of the existing intersections with the exclusive pedestrian phase without the possibility of diagonal crossing in Vilnius city, the following conclusions were drawn:

1. Researchers indicated that the introduction of an exclusive pedestrian phase with a diagonal crossing was quite a popular safety measure, and reduced the number of pedestrian–vehicle conflicts and accidents on average by 66%. Research in the literature has shown that an exclusive pedestrian phase reduced the average pedestrian distance at an intersection from 5% to 13%.
2. The best practice of foreign countries has shown that proper public information about the introduction of an exclusive pedestrian phase with a diagonal crossing at the intersection is essential to ensure the proper behavior of all road users. The examples provided and the surveys conducted have shown that well-informed pedestrians know how to behave at an intersection and understand the exact benefits of such changes. It is noticeable that the exclusive pedestrian phase with a diagonal crossing can cause difficulties for visually impaired and blind individuals; therefore, it is very important to identify solutions to help people with visual impairments.

3. After the analysis of Vilnius' intersections, it was found that two specific types of exclusive pedestrian phases are used at the intersection (diagonal crossing is prohibited). The first type is when pedestrian traffic takes place only during the exclusive phase. The second type is when pedestrian traffic takes place not only during the exclusive pedestrian phase, but also during the main transport phases on the street, moving in parallel with vehicles. An analysis of the urban land use environment revealed that such intersections with exclusive pedestrian phases are located in residential areas of high or medium intensity, or in city district centers with mixed high intensity areas. There are also large grocery stores, educational or medical facilities, and public transport stops near such intersections.
4. The density of pedestrian-related accidents at existing intersections with specific exclusive pedestrian phases in Vilnius decreased by up to 100% after the introduction of the exclusive pedestrian phase. No traffic accidents occurred after the installation of the exclusive pedestrian phase at intersections where there were no accidents before the installation, and no adverse effects on traffic safety were observed. The one-level signalized intersections with the exclusive pedestrian phase without the possibility of diagonal crossing gives a positive impact on traffic safety, and may be used as a substitute to similar intersections with the possibility of diagonal crossing where technical or legal obstacles arise. However, the study may be subject to a small sample size problem, but with the further introduction of such specific pedestrian phases in Vilnius, it will be possible to analyze a larger data sample and cover longer periods.

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