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Orginal Article



# The influence of the police on vehicle speed in built-up areas

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**Abstract:** In many cases, the effects of road accidents have significant impact on human health. This translates directly into society, in both material and emotional terms. The severity of the injury in a road event depends largely on the speed of the vehicles. Excessive vehicle speed is of particular concern in incidents involving vulnerable road users. As confirmed by literature analysis and research, in most cases drivers do not respect the speed limits introduced by the road signs. Existing solutions allow to introduce permanent or temporary speed control. This paper investigates speeding and driver behaviour in built-up areas near schools and pedestrian crossings. The aim of the research described in the paper is to determine the influence of the effectiveness of police actions on speed reduction and improvement of road safety.

**Keywords:** speed limits, traffic safety, the police, road accidents

## 1. Introduction

In Poland, in 2018, most road accidents took place in built-up areas. Road accidents in these areas account for 71.2% of all road accidents. The most frequent causes of accidents are: failure to give right of way, failure to adjust the speed to the traffic conditions, and failure to give priority to a pedestrian at a pedestrian crossing. Drivers often do not comply with speed limits in built-up areas. This leads to collisions and road accidents. In the case of unprotected road users, incidents at speeds above 50 km/h often result in their death. Accidents and their consequences in the form of injuries and casualties cause significant losses to the state and society. In Poland, the cost of road accidents is about 2% of GDP [1]. By improving road traffic safety and reducing the number of accidents, their cost to the state budget can also be reduced [2]-[3]. The studies indicate the dependence of the number of accidents on the average speed and speed fluctuations [4]. Depending on the structure of traffic, an increase in average speed may cause an increase in the number of accidents, as in the case of the studies carried out in Bahrain [4]. In the case of studies carried out in the United Kingdom the speed

fluctuations were more significant [4]. This may result from the characteristics of drivers' behaviour in different places, vehicle park, the shape of roads and prevailing weather conditions. Moreover, models for forecasting accidents have their limitations and are not universal enough. The number of accidents also depends on other traffic parameters, which should be taken into account in the models [5]. Determining the number of incidents is important when assessing safety and planning investments to improve safety [6]. In Poland, the results of police analyses indicate that drivers do not observe speed limits in situations where there is no control (supervision). Road managers and the police apply different methods of enforcing speed limits. Depending on the type of road, different measures may also be applied. In the case of motorways, these may be variable signs on which a change in the speed limit will depend, for example, on the prevailing road conditions. Research carried out in Canada [7] has indicated that the use of variable speed limits may reduce the number of accidents by 5-17%. However, there is a problem with legally regulating the above in Canada.

Traffic calming solutions are often used on the roads, e.g., speed bumps. However, this solution is ineffective, as shown by studies carried out in Italy among others [8]. This solution works only locally, similar to the use of speed cameras. Drivers often accelerate considerably after passing the obstacles. The shape of the speed bump is also of great importance. Should it be poorly designed, it may result in the lack of respect for the limit or may threaten to damage vehicles passing through an elevated plane. In the case of built-up areas in the vicinity of schools, housing estates, cultural centres and sports facilities, it is common to use all possible forms of physical traffic calming. The Netherlands has the richest experience in this field, which since 70 the beginning has commonly applied the traffic calming principles [9]. A review of reports from European countries shows the effectiveness of such solutions [10].

Traffic calming is used in virtually all countries around the world. This solution is increasingly popular because of its benefits. An example of such a solution is the traffic calming applied, in Ghana, where a significant speed reduction was observed [12]-[13]. The application of such solutions brings many benefits, among others, a positive impact on the environment. One of them may be the reduction of road noise, as indicated by studies carried out in Poland [14]. The traffic calming also has an impact on the emission of exhaust fumes and many other issues, which generate significant benefits [15]. An example of a properly designed road and traffic calming solutions are the 20 km/h speed zones in large cities in Great Britain [16]. In order to adjust and improve the quality of this method for each area, new manuals for the design of geometric traffic calming are developed, an example of which is the Polish manual [17]. The problem may be to assess the effectiveness of the traffic calming. In this case, the appropriate selection of measurement methods is important [12].

Speed reduction is particularly important in the case of accidents with unprotected traffic participants who are most at risk of serious injury or even death. One of the most at-risk groups are children, who are often injured on their way to or from school, or at pedestrian crossings [18]. Parents' perception of the way to school as dangerous may result in limiting the independent travel of children, whichmay result in the exclusion of the child from additional activities and may cause limitations in their development. Up to 47% of the roads to schools in Canada are considered as dangerous by parents [19]. The method of speed reduction in school zones and using special markings can theoretically achieve the intended effect of speed reduction. Traditional signs are less respected by drivers in relation to the presence of police in a dangerous place. The tests indicate that only flashing lights together with a text message or sign affect the speed reduction effect [20]. The location of signs, their visibility, colour and size also affect the result and in turn, children's safety [21].

The article attempts to determine the influence of police on the speed of drivers in the school areas. The aim of the research was to indicate the effectiveness of such actions in previously selected places in cooperation with the Voivodeship Police Headquarters in Lublin.

## 2. Objectives

The aim of the research was to determine the impact of preventive actions of the police on road traffic safety in built-up areas. The research was to indicate the extent to which the presence of the police in the analysed areas would affect the reduction of vehicles speed. The assumed impact of police presence in the analysed sections on speed reduction and improvement of safety is obvious to the authors. However, it was important in these studies to confirm that thanks to appropriate planning and coordination of police activities in built-up areas, it is possible to significantly reduce speed and improve road safety, which is also indirectly connected with increased comfort of people living in the vicinity of the road. The results obtained in the research will be used to formulate conclusions concerning appropriate planning of the speed controls on the analysed roads.

## 3. Methodology

The pilot study was planned on the territory of the Lublin Voivodship on the sections of voivodship roads in built-up areas and streets of the city of Lublin. Two measurement points were located at the entries to the city, the third was located at the pedestrian crossing near the primary school. In all the sections studied, the speed limits were 50 km/h. The speed was measured with a transverse radar and a normal manual radar. Measurements were made for one hour in the first and second stages. This time allowed the necessary number of vehicles to be measured. A precise speed recorder was set up in the measurement sections, which measured speed and other traffic parameters. Below, in Table 1, are the characteristics of the individual measurement locations.

Table 1. Parameters of the analysed sections. *Source: Authors*

| DW 747 – Matczyn | Sławinkowska | Aleja Jana Pawła II |
|---|---|---|
| Single carriageway section | Single carriageway section | Single carriageway section |
| Footpaths | Footpaths | Footpaths |
| Bicycle paths | Bicycle paths | Bicycle paths |
| Inlet to the city | A large number of exits | Longitudinal slope below 2% |
| A large number of exits | Longitudinal slope below 2% | |
| Longitudinal slope below 2% | | |

The measurement was carried out in two stages. The first stage was the measurement in the assistance of the police at full visibility for drivers. Police officers carried out speed control of vehicles, did not stop vehicles and did not punish the drivers. The second stage was to perform tests without the presence of police. The measurements were taken in May and September 2020.

## 4. Results and Discussion

During the measurements, the number of vehicles with a division into a traffic structure was recorded in the 15-minute intervals (Q). The results were compared for the three analysed sections. The traffic intensity, the share of heavy vehicles (uc) and the average speed (v) in the

analysed 15 minutes were given. The results were summed up and the average for an hour of time, 85 quantile, minimum speed, maximum speed, and standard deviation were calculated. The results are presented in Table 2.

Table 2. The results of measurements of the road traffic parameters on the analysed sections. *Source: Authors*

| | Matczyn | | | Sławinkowska | | | Aleja Jana Pawła II | | |
|---|---|---|---|---|---|---|---|---|---|
| Quarter of an hour | Q /veh/15 [min.] | uc [%] | v [km/h] | Q /veh/15 [min.] | uc [%] | v [km/h] | Q /veh/15 [min.] | uc [%] | v [km/h] |
| 1 | 107 | 11 | 67.4 | 147 | 13 | 52.8 | 331 | 12 | 61.9 |
| 2 | 127 | 19 | 68.0 | 117 | 18 | 51.3 | 262 | 17 | 63.8 |
| 3 | 121 | 11 | 65.8 | 123 | 11 | 54.6 | 299 | 15 | 59.6 |
| 4 | 107 | 11 | 71.4 | 139 | 15 | 54.0 | 314 | 17 | 61.4 |
| Sum/average | 462 | 13 | 68.1 | 526 | 14 | 53.2 | 1206 | 15 | 61.7 |
| k15 | 0.91 | | | 0.89 | | | 0.91 | | |
| V max | 113 | | | 91 | | | 99 | | |
| V min | 42 | | | 41 | | | 40 | | |
| Standard deviation | 12.3 | | | 8.2 | | | 9.1 | | |
| $V_{85}$ | 84 | | | 64 | | | 75 | | |

Based on the results obtained, similar values of the traffic parameters on Sławinkowska Street and the voivodship road in Matczyn were found. Due to a larger number of lanes, Aleja Jana Pawła II is characterized by higher traffic volumes. The share of heavy vehicles is similar on all sections. The vehicles were in free traffic. On the basis of the results obtained, it is not possible to state the effect of traffic intensity or the share of heavy vehicles on the average speed, as it is in the case with significantly loaded road sections [22]-[23]. In all the sections studied, the speed limits were 50 km/h. In case of all sections, speeding was observed. The greatest speed difference between the 50 km/h limit value is 18.1 km/h for the voivodship road in Matczyn. The second highest exceeding of the admissible speed was Aleja Jana Pawła II and the difference between the average vehicle speed in the analysed hour and the limit was 11.7 km/h. The smallest difference was recorded in Sławinkowska Street. In the case of Matczyn, the measuring point was located just before the end of the built-up area and a sign of the speed limit cancellation was visible. This situation caused drivers to start accelerating in the speed limit zone and in the pedestrian crossing area. Other drivers' offences such as overtaking at the pedestrian crossing were also observed (Fig.1).

Aleja Jana Pawła II is a two-roads street with two lanes. The geometry on this section (2 roads with two lanes each), which is beneficial for drivers, allowed them to feel comfortable, which is visible in the form of significantly increased average speed. The last section is Sławinkowska Street where the average speed in relation to the speed limit has been minimally increased. In the case of average speed, it does not sufficiently reflect the danger resulting from speeding in relation to the road accidents. It is important to analyse how many drivers exceed the given limits at what speed.

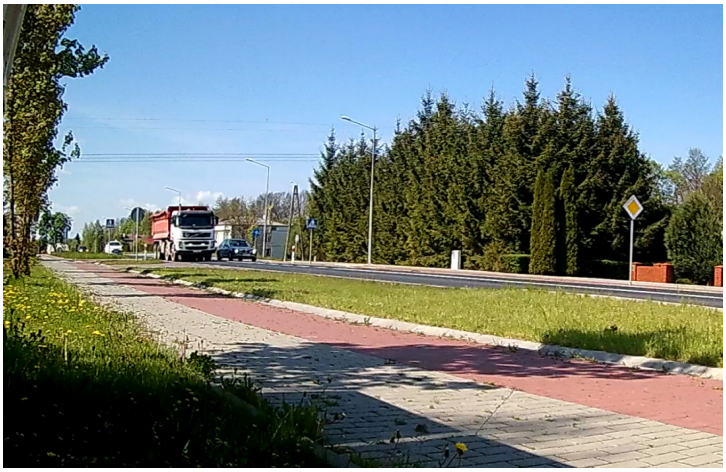

Fig. 1. Unauthorized overtaking manoeuvre at the pedestrian crossing in Matczyn. *Source: Authors*

Fig. 2 presents the results in the form of frequency histograms and speed distribution for the voivodship road in Matczyn. A group of drivers is visible, which moves at a much faster speed exceeding the allowed value by more than 10 km/h. The most numerous is the group traveling at a speed of 60-70 km/h at a speed limit of 50 km/h. There is a custom among drivers in Poland at a speed of plus 10 km/h to the limit by suggesting that they will not be stopped by the police in this case. The obtained results indicate that drivers most often move at a speed of 10-20 km/h higher than the permissible value. Despite the threat of losing their driving license, a group of drivers can be seen moving at a speed of over 90 km/h in a built-up area – it is 12 vehicles, which represents 8% of the tested vehicles. Comparing the entire study population, 83% of drivers move above 50 km/h and the $V_{85}$ quantile is equal to 83 km/h.

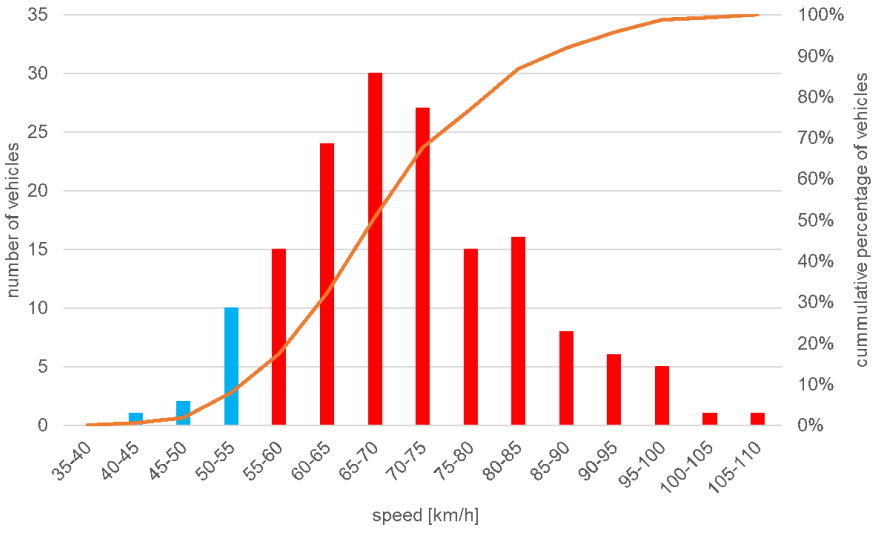


Fig. 2. The graph of the vehicle speed distribution in Matczyn. *Source: Authors*

In the case of Sławinkowska, the most numerous group are drivers travelling at a speed of 40-60 km/h. However, there is a large group of vehicles travelling at the speed of 60-70km/h – this is 27% of the surveyed population. Despite the correct marking of the pedestrian crossing in the school area and the speed limit, a group of drivers travelling at speeds above 70 km/h and one driver who was travelling at speeds above 90 km/h appear. In the case of Sławinkowska, 32% of the surveyed people exceeded the limit speed. The $V_{85}$ quantile of speed is 64 km/h. The results are shown in Fig. 3.

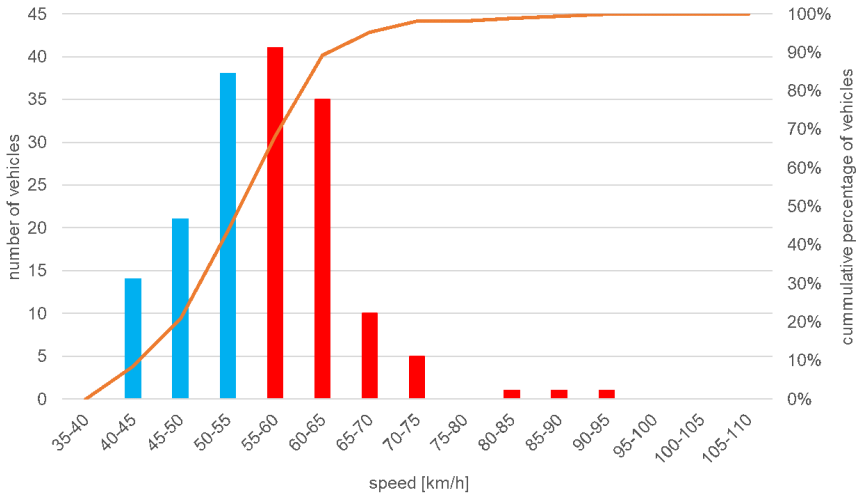


Fig. 3. The graph of the vehicles speed distribution on Sławinkowska. *Source: Authors*

On the Aleja Jana Pawła II most of the drivers, i.e., 70% exceed the allowed speed. The most numerous group are vehicles travelling at 60-70 km/h. Two drivers have exceeded the permitted speed by more than 40 km/h. The $V_{85}$ quantile of speed is 75 km/h. The results are shown in Fig. 4.

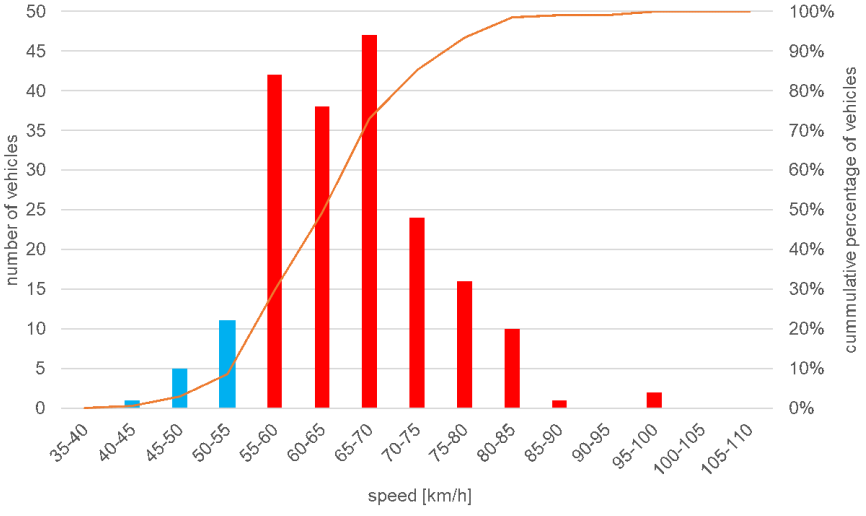


Fig. 4. The graph of the vehicles speed distribution on the Aleja Jana Pawła II. *Source: Authors*

These results indicate a lack of respect for the speed limits. In the case of road accidents, their consequences are directly related to the speed of vehicles, especially in the case of pedestrian crossing zones where tests indicate significant speeding [24].

Comparing the places where road accidents occur in the European Union, it can be observed that 38% of the events concern built-up areas (Fig. 5) [25].

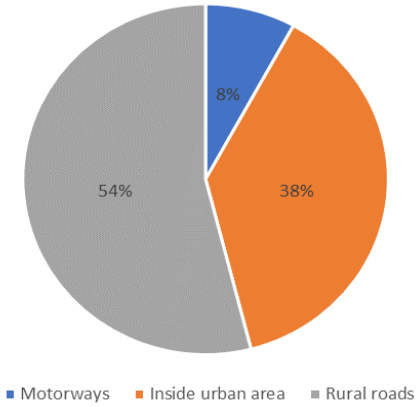


Fig. 5. Division of road accidents in the European Union by location. *Source:* [25]

In the case of the analysed roads, most accidents happened on Aleja Jana Pawła II. The smallest number of them was in Matczyn. Comparing individual months in individual years, most accidents in Matczyn occurred in February, in case of Sławinkowska in September, and in the case of Aleja Jana Pawła II in October. In all sections a large number of events took place in September at the start of the school year. Table 3 presents a summary of information on accidents for the period from 2007 to 2019.

Table 3. Summary of the total number of road accidents on the analysed sections in particular months for the period from 2007 to 2019. *Source:* [26]

| Month | Matczyn | | Sławinkowska Street | | Aleja Jana Pawła II | |
|---|---|---|---|---|---|---|
| | Number of accidents | % | Number of accidents | % | Number of accidents | % |
| January | 4 | 6% | 19 | 10% | 175 | 9% |
| February | 12 | 19% | 15 | 8% | 149 | 7% |
| March | 3 | 5% | 12 | 7% | 139 | 7% |
| April | 6 | 10% | 13 | 7% | 138 | 7% |
| May | 5 | 8% | 23 | 13% | 157 | 8% |
| June | 2 | 3% | 12 | 7% | 173 | 9% |
| July | 1 | 2% | 11 | 6% | 155 | 8% |
| August | 5 | 8% | 14 | 8% | 130 | 6% |
| September | 10 | 16% | 26 | 14% | 189 | 9% |
| October | 4 | 6% | 12 | 7% | 226 | 11% |
| November | 4 | 6% | 8 | 4% | 202 | 10% |
| December | 7 | 11% | 16 | 9% | 187 | 9% |

The analysis of the number of accidents was carried out from 2007 to 2019. The change in the number of accidents in particular years is shown in Figs. 6 and 7. Sławinkowska Street and the voivodship road in Matczyn retain similar accident values in the analysed period without major changes. In the case of the Aleja Jana Pawła II, an increase in events since 2010 is visible.

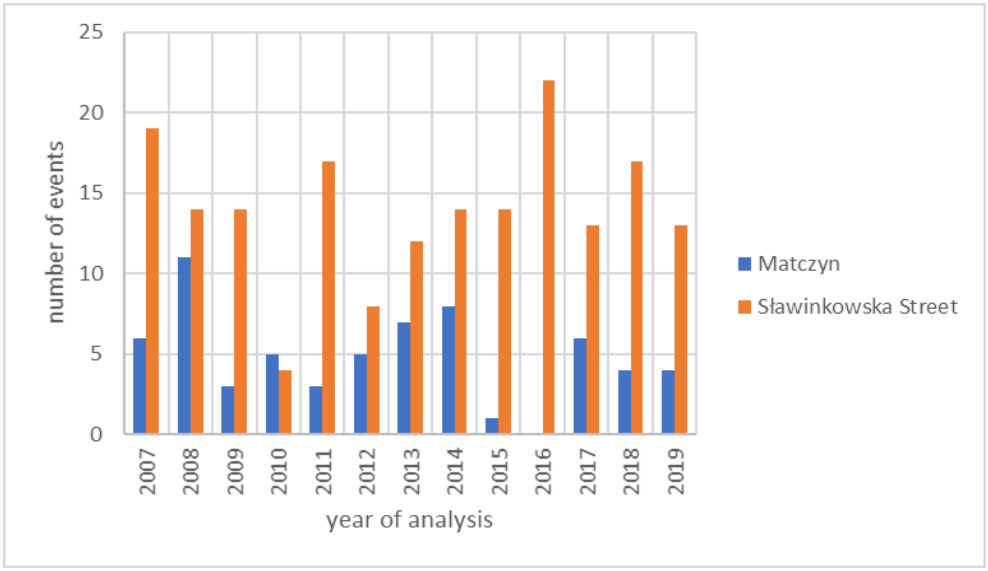


Fig. 6. Number of accidents in particular years on the Sławinkowska and DW 747. *Source:* [26]

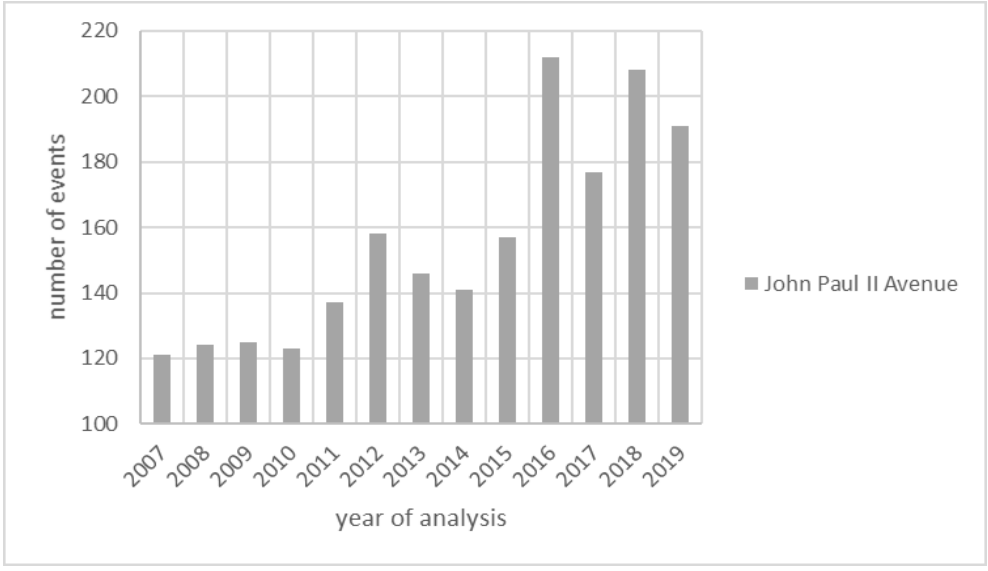


Fig. 7. Number of accidents in particular years on the Aleja Jana Pawła II. *Source:* [26]

The list of types of accidents on the tested sections is presented in Table 4. The most common type of events was a vehicle collision. In all cases, there were 54 pedestrian runovers, some of which took place at pedestrian crossings. In the case of Sławinkowska Street this is the third type in terms of accidents occurring in this section.

Table 4. Total number of road accidents on the analysed sections depending on the type of event in the 2007-2019 period. *Source:* [26]

| Type of event | Matczyn | | Sławinkowska | | Aleja Jana Pawła II | |
|---|---|---|---|---|---|---|
| | Number of events | % | Number of events | % | Number of events | % |
| Lateral vehicle collision | 23 | 36.5% | 84 | 46.4% | 880 | 43.6% |
| Rear-end vehicle collision | 12 | 19.0% | 39 | 21.5% | 897 | 44.4% |
| Overrunning a pedestrian | 2 | 3.2% | 12 | 6.6% | 40 | 2.0% |
| Overrunning an animal | 4 | 6.3% | 10 | 5.5% | 9 | 0.4% |
| Frontal vehicle collision | 8 | 12.7% | 8 | 4.4% | 37 | 1.8% |
| Vehicle overturning | 3 | 4.8% | 7 | 3.9% | 10 | 0.5% |
| Hitting a tree | 1 | 1.6% | 6 | 3.3% | 3 | 0.1% |
| Hitting a pole, a sign | 1 | 1.6% | 5 | 2.8% | 77 | 3.8% |
| Running into a hole, bump, hump | 5 | 7.9% | 3 | 1.7% | 2 | 0.1% |
| Others | 4 | 6.3% | 3 | 1.7% | 25 | 1.2% |
| Hitting a security barrier | - | | 2 | 1.1% | 16 | 0.8% |
| Hitting a vehicle that is immobilised | - | | 2 | 1.1% | 24 | 1.2% |

The speed of vehicles plays a major role in the occurrence of accidents. In the results of the measurements, a trend towards widespread speeding is observed. In many countries, including Poland, various solutions are sought [27]-[28].

One way may be to limit the speed, which always takes place when police patrol a given section. In order to investigate the influence of police presence on speed reduction, a measurement was carried out in the Matczyn section during the presence of the police patrol. Fig. 8 shows the results of average speeds for particular time intervals during examination with and without police. There is a significant difference between the maximum average speed without and with the presence of the police, which reaches even 30 km/h.

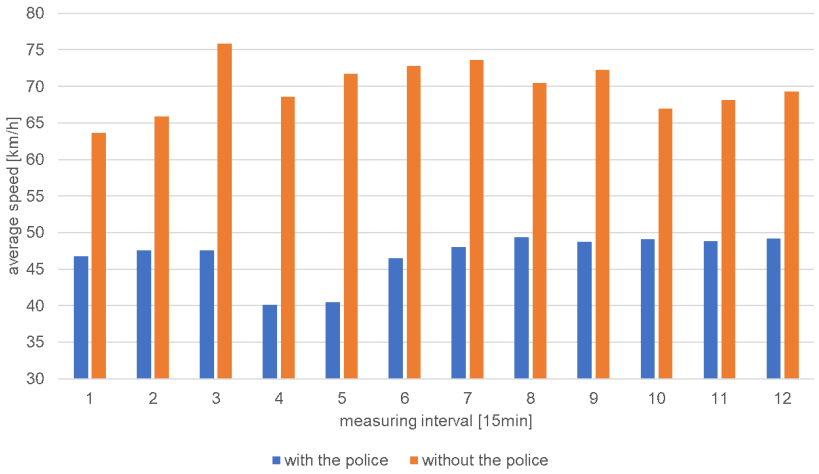


Fig. 8 Average speed in individual intervals during measurements with and without the presence of the police in Matczyn. *Source: Authors*

In all measurement intervals, it can be seen how effectively the presence of the police is influencing speed reduction. In the case of measurement without police, most drivers do not comply with the speed limits. During the presence of police, no driver exceeded the speed limit by more than 10 km/h. The results of these analyses are shown in Figure 9.

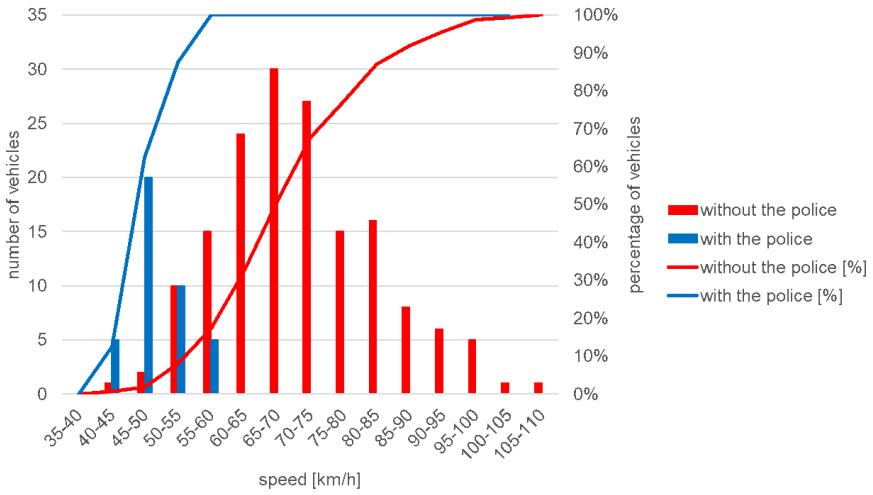


Fig. 9. The graph of the speed distribution of individual vehicles in Matczyn during measurements, with and without the police. *Source: Authors*

Analysis of the scattering of the measurement data confirms effective preventive actions of the police. The statistical analysis confirmed the significance of the measurement results. The results are presented in Fig. 10.

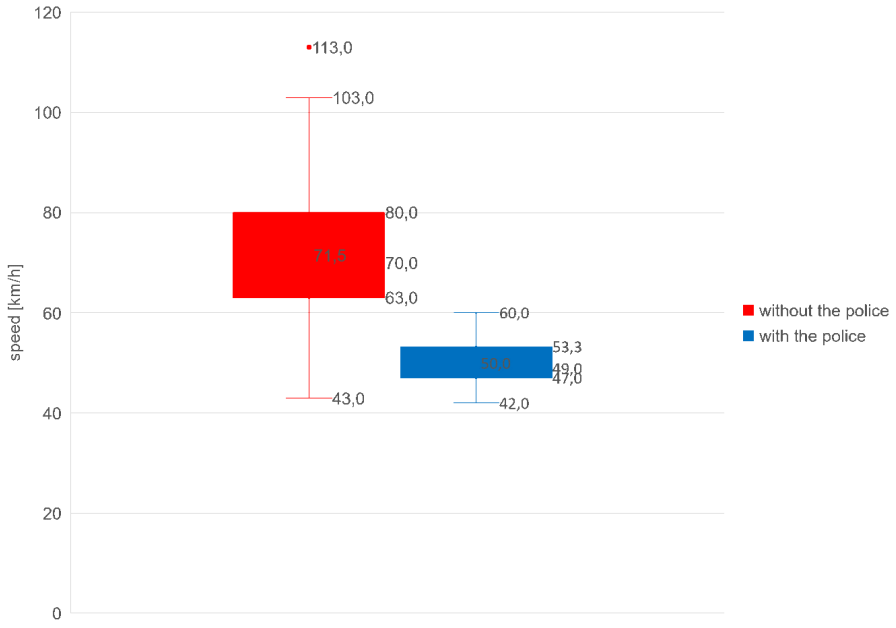


Fig. 10. A graph of the scattering of the speed results of individual vehicles in Matczyn during measurements, with and without the police. *Source: Authors*

Results obtained from the tests directly show the influence of the presence of the police on the speed of vehicles. The speed difference between the average values from the two measurement stages reaches almost 30 km/h. Individual results indicated even greater differences from the time when the police were at the place of measurements and when they drove away. This indicates the necessity to plan and implement preventive actions of the police. Another solution could be to use an imitation police patrol. This is a permanent solution. According to a study from Asia, it reduces the number of violations related to passing a red light and illegal turning [29]. In case of speeding, this solution may have a limited duration. Drivers may get used to the model and still not respect the speed limit.

## 5. Conclusion

Based on the results obtained, it was found that drivers do not adjust their speed to the applicable road regulations. Depending on the cross-section and location, 30% to 80% of them exceeds the permitted speed in the analysed places. The highest number of drivers and the highest exceedances were recorded on the voivodship road passing through Matczyn. The existing road signs do not sufficiently influence the speed of vehicles. In the analysed sections, the highest number of accidents occur during the school year. One of the most frequent types of accidents is overrunning a pedestrian. Preventive speed checks carried out by the police significantly reduce the speed of moving vehicles, which is indicated by the results of the research. This has a direct impact on road safety, especially in the case of unprotected road users, and in the vicinity of educational facilities with high child traffic. A partial solution to the problem of speeding in case of necessary speed limits may be frequent presence of police on dangerous road sections.

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