Journal of civil engineering and transport **transEngin**

2025, Volume **7** Number **3** **ISSN 2658-1698, e-ISSN 2658-2120**

DOI: 10.24136/tren.2025.010

PEDESTRIAN SAFETY IN ROAD TRAFFIC IN POLAND 2007-2024

Andrzej **Rogowski** [1]

[1] Casimir Pulaski Radom University, Faculty of Transport, Electrical Engineering and Computer Science, Malczewskiego 29, 26-600 Radom, Poland, e-mail: a.rogowski@urad.edu.pl, https://orcid.org/0000-0002-9988-3805

Reviewed positively: 22.07.2025

Information about quoting an article:
Rogowski A. (2025). Pedestrian safety in road traffic in Poland 2007-2024. *Journal of civil engineering and transport*. 7(3), 151-181, ISSN 2658-1698, e-ISSN 2658-2120, DOI: 10.24136/tren.2025.010

Abstract – The article analyzes, based on the data of the National Police Headquarters, the changes in pedestrian safety in road traffic in Poland from 2007 to 2024. Changes in the number of accidents and victims of accidents involving pedestrians and accidents caused by pedestrians were analyzed. The influence of alcohol consumption on pedestrian safety, changes in the causes of accidents caused by pedestrians, the age structure of the injured in accidents and pedestrian perpetrators of accidents were analyzed. The situation of pedestrians was presented against the background of the general traffic situation. The percentage of pedestrians among victims is steadily declining although it is higher than the percentage of accidents. The percentage of accidents involving pedestrians that are caused by pedestrians is decreasing. The percentage of victims of accidents caused by pedestrians under the influence of alcohol in the total number of victims of accidents caused by pedestrians remains high. The age structure of pedestrian victims and pedestrian perpetrators is changing. Selected trend models of various indicators characterizing traffic safety were studied. For the number of accidents caused by pedestrians and pedestrians intoxicated and the number of injured, injured and fatalities, there are well-fitting trend models.
Key words – road safety, road accident, road accident victim, pedestrians in traffic, pedestrians under the influence of alcohol in traffic

JEL Classification – R41, O18, L99

INTRODUCTION

According to the latest European Road Safety Observatory (ERSO) report [1], in 2023, 900,861 road accidents were recorded in the European Union, claiming some 20,384 lives and injuring more than 1.14 million people. Compared to 2013, the number of accidents fell by 2% (since 2020, when the number of accidents was 749227, there has been a steady increase), the number of fatalities fell by 16% (since 2020, it has increased by 1591)[1]. In the case of Poland, the decrease in accidents was 42%, one of the highest in the EU (behind Cyprus 52% and Finland 45%)[2], the number of fatalities decreased by 44%, the highest among EU countries. Considering the indicator of fatalities per 1 million inhabitants in 2024, Poland ranks 21st in the EU (52 with an EU average of 44) [2]. A higher rate is observed in 6 countries[3]. "Car occupants (drivers and passengers) represented 44% of all fatalities, while users of powered two-wheelers (motorbikes and mopeds) accounted for 20%, pedestrians 18%, and cyclists 10%. The crash risk for powered two-wheelers (PTW) is particularly high (...) Among those aged 65+, pedestrians represent 30% of fatalities and cyclists 16% while among those aged 18-24, 62% of fatalities occur in cars and 24% are on powered two-wheelers. (...) Within urban areas, vulnerable road users (pedestrians, cyclists and users of powered two-wheelers and personal mobility devices) represent almost 70% of total fatalities." [2]. In 2023, 3,698 pedestrians died in accidents, including 2,612 in the urban area (70.6%), 876 (23.7%) in the rural area. The main cause was a collision with a car 2,378

[1] 2020 statistics disrupted due to Covid pandemic and resulting movement restrictions.
[2] However, it should be noted that the number of accidents in Cyprus is about 100 times lower and in Finland about 10 times lower than in Poland. In the Netherlands, the number of accidents has increased by 150% and is comparable to the number of accidents in Poland.
[3] Latvia, Portugal, Croatia, Greece, Bulgaria, Romania.

(1,665 urban area, 606 rural area), truck 866 (571, 212), bus or coach 172 (115, 19) and motorcycle 100 (87, 12).

According to ERSO [3], about 25% of all fatal traffic accidents in Europe are alcohol-related. At a BAC of 1.5 g/l, the fatal accident rate is about 200 times higher than for sober drivers [4]. In [5], the effect of BAC on accident and injury risk and perpetration was found to be stronger at higher BAC levels. Similar estimates can be found in [6-7]. In the case of Poland, between 2007 and 2023, the percentage of those killed in accidents involving intoxicated people ranged from 11% to 16.5%, and the total casualties in accidents caused by intoxicated traffic participants ranged from 8% to 13%. Extensive analyses related to various aspects of alcohol consumption in the context of traffic safety can be found in [4, 6-8]. In Polish journals, for example [9].

The response to accidents caused by drunk driving, including particularly drastic ones in which the victims were properly moving pedestrians, has been to lower the permitted blood alcohol limits, change public attitudes toward drunk driving, and increase the amount of penalties [10]. These remedies are not always effective, for example, lowering the blood alcohol limit in Scotland had no effect on road safety [11]. Alcohol interlocks are 40% to 95% more effective in preventing drunk driving recidivism than traditional measures such as license revocation or fines [4]. In the case of Poland, regulations have been tightened by introducing higher fines [12], higher penalty points [13] and introducing car confiscation [14]. However, few scientific studies have addressed the direct effect of these changes on statistics.

Studies of pedestrian accidents mainly focus on pedestrian crossing design, traffic organization at crossings, traffic-calming, pedestrian infrastructure (space planning - safe walking routes), education and intelligent transportation systems [15-20].

This article focuses on statistical analyses of pedestrian accidents and their consequences.

1. RESEARCH OBJECT

The object of the analysis is pedestrian safety in traffic. The basis of the analysis is the annual reports of traffic accidents prepared by the Police Headquarters [21]. The analysis covers the years 2007-2024, which is determined by the availability of statistical data. While detailed data on traffic accidents reported by the National Police Headquarters, their causes, perpetrators and consequences (allowing for the assumed analysis) have been available since 2001, the 2006 data is contradictory. In addition, the manner and scope of the reported data have been changed. The scope of the analysis is based on the available statistical data[4]. The analysis was carried out against the background of the general traffic situation; hence safety indicators were studied with regard to all traffic participants and pedestrians as a distinguished group. Only for this group was analyzed the impact of alcohol consumption on traffic safety with the percentage of accidents and accident victims in the built-up area[5]. In particular, changes were analyzed:

- the number of traffic accidents,
- the number of injured, injured victims and fatalities,
- the percentage of accidents and casualties caused by distinguished user groups in the total number of accidents and casualties, and as a distinguished subgroup of a given group,
- causes of accidents (according to the classification in [21]),
- the age structure of pedestrian accident victims (according to the classification in [21]),
- the age structure of pedestrian accident perpetrators (according to the classification in [21]).

A detailed list of the analyzed quantities (variables) and their designations is provided in Table 1.

Table 1. List of designations

Desig-nation	Variable	*
la1	number of accidents	Figure 1
la2	number of accidents involving pedestrians	
la3	number of accidents caused by pedestrians	
la4	number of accidents caused by pedestrians intoxicated	
l**xy**	number of fatalities (**x**=k)/injured (**x**=i)/victims (**x**=v) **y**	

[4] However, accident sites were not analyzed although such data is available.

[5] For other groups of traffic participants, see [22].

	y=1	in accidents			Figure 5, 10, 15
	y=2	pedestrians in accidents			
	y=3	in accidents caused by pedestrians			
	y=4	in accidents caused by pedestrians intoxicated			
	e.g.	li3 – number of injured in accidents caused by pedestrians			
paa1	percentage of accidents involving pedestrians in the total number of accidents				Figure 2
paa2	percentage of accidents caused by pedestrians in the total number of accidents				
paa3	percentage of accidents caused by pedestrians in the total number of accidents involving pedestrians				
paa4	percentage of accidents caused by pedestrians intoxicated in the total number of accidents caused by pedestrians				
paa5	percentage of accidents in non-built-up areas in the total number of accidents involving pedestrians				
pa**xy**	percentage of fatalities (**x**=k)/injuries (**x**=i)/victims (**x**=v) **y**				Figure 6, 11, 16
	y=1	pedestrians in total number x			
	y=2	pedestrians in accidents caused by pedestrians in total number x			
	y=3	pedestrians in accidents caused by pedestrians in total number x pedestrians			
	y=4	in accidents caused by pedestrians intoxicated in total number x in accidents caused by pedestrians			
	y=5	pedestrians in non-built-up areas in total accidents involving pedestrians			
	e.g.	pak3 – percentage of pedestrians' fatalities in accidents caused by pedestrians in the total number of pedestrians' fatalities			
		pav4 – the percentage of victims in accidents caused by pedestrians intoxicated in the number of victims in accidents caused by pedestrians			
s**za**y	the percentage of accidents caused by **y**, in the total number of accidents caused by pedestrians (**z**=1)/in the total number of accidents caused by pedestrians intoxicated (**z**=2)				Figure 3 Table 2, 3
	y=1	careless entry onto the roadway in front of a moving vehicle			
	y=2	careless entry onto the roadway from behind a vehicle, obstacle			
	y=3	crossing the roadway in an unauthorized place			
	y=4	entering the roadway at a red light			
	y=5	lying, sitting, kneeling, standing			
	y=6	walking on the wrong side			
	y=7	stopping, reversing			
	y=8	other causes			
s**zxy**	the percentage of **x** in accidents caused by **y** in the total number of **x** in accidents caused by **z**				Figure 7, 12, 17 Table 6, 7, 10, 11, 15, 16
	x=k	fatalities	z=1	pedestrians	
	x=i	injures	z=2	pedestrians intoxicated	
	x=v	victims			
	y = 1, 2, 3, 4, 5, 6, 7, 8	causes as above			
	e.g.	s1k6 – the percentage of fatalities, in the total number of fatalities in accidents caused by pedestrians, in accidents whose cause was walking on the wrong side of the road s2v3 – the percentage of victims, in the total number of victims in accidents caused by pedestrians intoxicated, in accidents whose cause was crossing the road in an unauthorized place			
p**xy**	the percentage of **x** pedestrians aged **y** in the total number of **x** pedestrians in accidents				Figure 8, 13, 18 Table 8, 12, 17
	x=1	fatalities	y = 0-6	aged 0-6 years	
	x=2	injures	y = 7-14	aged 7-14 years	
	x=3	victims	y = 15-17	aged 15-17 years	
			y = 18-24	aged 18-24 years	

			y = 25-39	aged 25-39 years	
			y = 40-59	aged 40-59 years	
			y = 60+	over the age of 59 years	
			y = bd	of undetermined age	
	e.g.	pv7-14 - the percentage of pedestrian victims aged 7-14 in the total number of pedestrian victims in accidents			
ppa0-6	the percentage of accidents caused by pedestrians aged 0-6 years in the total number of accidents caused by pedestrians				Figure 4 Table 4
ppa7-14	the percentage of accidents caused by pedestrians aged7-14 in the total number of accidents caused by pedestrians				
ppa15-17	the percentage of accidents caused by pedestrians aged 15-17 in the total number of accidents caused by pedestrians				
ppa18-24	the percentage of accidents caused by pedestrians aged 18-24 in the total number of accidents caused by pedestrians				
ppa25-39	the percentage of accidents caused by pedestrians aged 25-39 in the total number of accidents caused by pedestrians				
ppa40-59	the percentage of accidents caused by pedestrians aged 40-49 in the total number of accidents caused by pedestrians				
ppa60+	the percentage of accidents caused by pedestrians over the age of 59 in the total number of accidents caused by pedestrians				
ppabd	the percentage of accidents caused by pedestrians of undetermined age in the total number of accidents caused by pedestrians				
pp**xy**	the percentage of **x** in accidents caused by pedestrians aged **y** in the total number of **x** accidents caused by pedestrians				
	x=1	fatalities	z - age as above		Figure 9, 14, 19 Table 9, 13, 18
	x=2	injures			
	x=3	victims			
	e.g.	ppv25-39 – the percentage of victims in accidents caused by pedestrians aged 25-39 years in the total number of victims of accidents caused by pedestrians			

* – the numbers of tables and figures in which the values of the variables are given

2. METHODOLOGY

All calculations were performed in an Excel spreadsheet. The trend was determined:

– linear

$$y = at + b \tag{1}$$

– logarithmic

$$y = aln(t) + b \tag{2}$$

– hyperbolic

$$y = \frac{a}{t} + b \tag{3}$$

– parabolic

$$y = at^2 + bt + c \tag{4}$$

To determine the trend, the REGLINP function was used as an array variable, which made it possible to directly read the value of the coefficient of determination R^2, adjusted R^2 (after R^2 transformation) and determine the significance of the model and its parameters using t and F statistics. Parameters were assumed to be significant (reject the hypothesis that the parameter is equal to zero at the significance levelα) when α is less than 0.05 (in most cases, the p-value or the smallest of the p-values for groups of models was reported). In determining the trend, the periods from 1 to 18 were marked instead of the years 2007 to 2024. In addition, the Shapiro-Wilk test for testing the hypothesis of normality of the distribution of residuals [23], Durbin-Watson test for testing the autocorrelation of residuals [24] and:

– mean absolute deviation MAD:

$$MAD = \frac{1}{n}\sum_{t=1}^{n}|y_t - \hat{y}_t| \tag{5}$$

– standard deviation of the absolute deviation SMAD:

$$SMAD = \sqrt{\frac{1}{n}\sum_{n}^{1}(|y_t - \hat{y}_t| - MAD)^2} \tag{6}$$

where y_t value of the variable in period *t*, $\hat{y}_t$ value of the trend (regression) model in period *t*.
For comparisons of x_t, y_t values, the t-statistic was used **Błąd! Nie można odnaleźć źródła odwołania.**:

$$\mathrm{t} = \frac{\bar{Z} - m_0}{S}\sqrt{n-1} = \frac{\bar{Z} - m_0}{\hat{S}}\sqrt{n} \tag{7}$$

where $z_t = x_t - y_t$, the hypothesis being verified Ho: $EZ = \bar{Z} = m_0 = 0$.

To test the invariability over time of indicators or groups of indicators, the chi-square independence test was used. Failure to reject the hypothesis of independence allows not rejecting the hypothesis of invariability (over time) of indicators (group of indicators). This is since stochastic independence is equivalent to equality of conditional distributions. A significance level of α = 0.05 was adopted (in most cases, the p-value or the smallest of the p-values for groups of indicators was reported).

3. RESULTS AND DISCUSSION

ROAD ACCIDENTS IN POLAND BETWEEN 2007 AND 2024

The number of road accidents in Poland is on a clear downward trend[6]. Comparing 2007 with 2024, the number of road accidents la1 (Fig. 1) decreased by nearly 56.5% (from 49,536 to 21,519). The average annual rate of decline was 4.79%. During the same period, the number of accidents involving pedestrians la2 (Fig. 1) fell by more than 70% (from 15,934 to 4,719), and the average annual rate of decline was 6.91%. The percentage of accidents involving pedestrians in the total number of road accidents paa1 (Fig. 2) is from 20.84% to 32.17%. In 2024, it was 68% of the 2007 percentage, with an average annual rate of decline of 2.23%. About 90% of pedestrian accidents occur in built-up areas (Fig. 1), and only about 10% in non-built-up areas. This proportion appears to be constant (plus a random factor) however, a chi-square test contradicts this suggestion. The largest difference occurred between 2014 and 2024, with a difference of 1.53 percentage points, and the annual average rate of decline over this period was 1.56%.

The perpetrators of accidents involving pedestrians from 20.4% to 43.4% are pedestrians themselves. This percentage ppa3 is clearly decreasing (Fig. 2), although not monotonically. In 2024, it was 47.4% of the 2007 value, with an annual rate of decline of 4.29%. On the other hand, the percentage of accidents caused by pedestrians in the total number of ppa2 accidents is decreasing monotonically (Fig. 2). It fell from nearly 14% in 2007 to 4.5% in 2024, the annual rate of decline was 6.43%. In absolute numbers la3 (Fig. 1), we see a decline from 6,912 to 971 (monotonic decline), a decrease of almost 86%. The average annual rate of decline was 10.9%.

Unfortunately, more than a fifth of accidents caused by pedestrians are pedestrians intoxicated by alcohol ppa4 (Fig. 2). The percentage of these accidents does not show a downward trend, fluctuating within a few percentage points (the spread is 6.77 percentage points). In absolute numbers, intoxicated pedestrians caused between 207 (year 2024) and 1,519 (year 2007) accidents (la4, Fig. 1). The decrease was more than 86%, and the average annual rate of decline was 11.06%. Note that the rate of decline in the number of accidents caused by pedestrians and drunken pedestrians is much greater than the rate of decline in the number of accidents and the number of accidents involving pedestrians. One could conclude that this is the result of an increase in awareness of the dangers and culture of participation in traffic, but it is more likely (according to the author) that this is due to the expansion and modernization of infrastructure.

[6] A clear downward trend can be observed from 1998, in which 66586 accidents occurred [21].

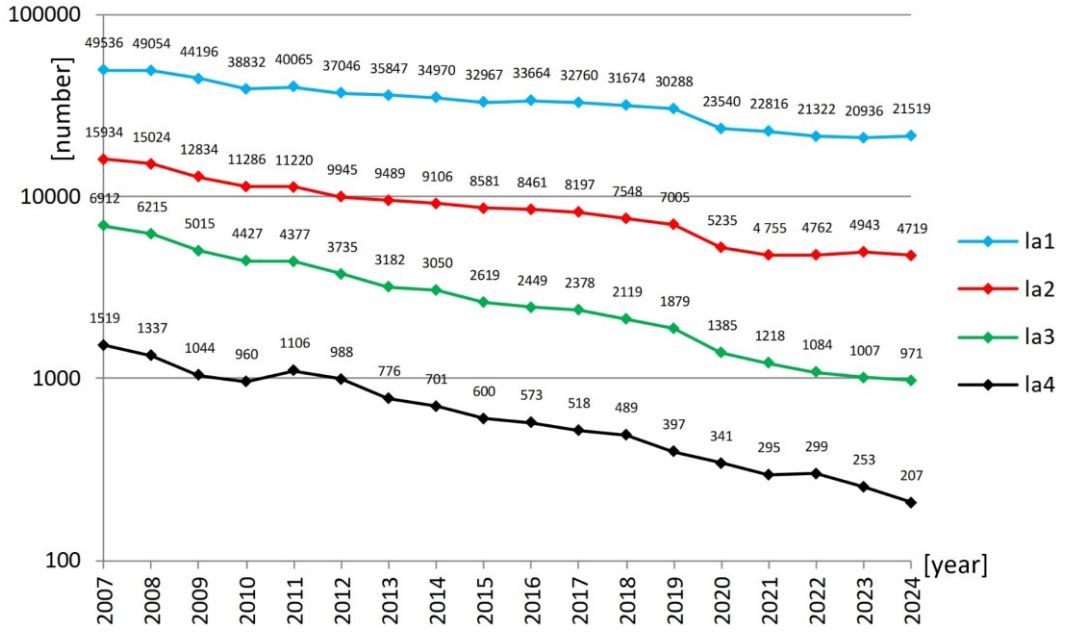

Fig. 1. Number of road accidents in Poland in 2007-2024 in selected groups of traffic participants
Designations as in Table 1. Source: own study based on [21].

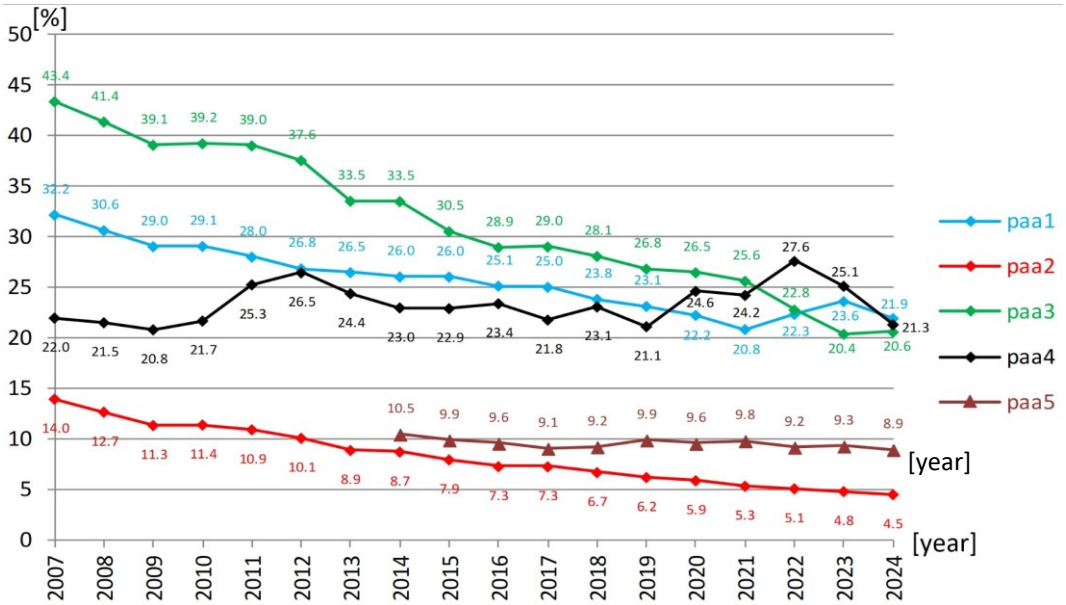

Fig. 2. The percentage of road accidents in Poland between 2007 and 2024 of selected groups of road traffic participants [%]
Designations as in Table 1. Source: own study based on [21].

In the statistics of the Police Headquarters' reports on road accidents, there are 8 categories of causes of road accidents (s1a, Table 1). However, until 2015, the statistics included 7 categories – there was no "other causes" category. The percentage of accidents, in the total number of accidents caused by pedestrians and pedestrians intoxicated by cause of accidents, is shown in Tables 2 and 3 and Fig. 3. The main cause of accidents caused by pedestrians is careless entry onto the roadway in front of a moving vehicle (s1a1, s2a1). It accounts for 46% to 58% of all accidents caused by pedestrians and 39% to 59% of accidents caused by pedestrians intoxicated. The percentage is on a clear downward trend. The importance of the cause (s1a7, s2a7) referred to as "stopping, backing up" is declining and is currently negligible. In the past 5 years, the number of accidents from this cause has ranged from 2 to 6, and pedestrians intoxicated have not caused an accident from this cause. The distribution of causes of accidents caused by pedestrians and pedestrians intoxicated is not constant. Only for s2a4, s2a5, s2a6 and possibly s2a2 can the percentages be said to be constant in a statistical sense - the p-values for the chi-square independence test are 0.108, 0.077, 0.058 and 0.027, respectively.

Table 2. The percentage of accidents, in the total number of accidents caused by pedestrians, by the cause of the accident [%]

	Variable							
Year	**s1a1**	**s1a2**	**s1a3**	**s1a4**	**s1a5**	**s1a6**	**s1a7**	**s1a8**
2007	57.58	11.00	11.95	8.12	5.79	4.85	0.72	
2008	57.35	11.41	12.26	8.25	5.33	4.62	0.79	
2009	57.79	10.95	11.61	8.14	5.94	4.73	0.86	
2010	56.92	11.86	10.89	8.00	6.44	5.13	0.77	
2011	56.96	11.03	11.38	8.98	5.62	5.41	0.62	
2012	55.45	11.59	11.81	8.30	6.40	5.52	0.94	
2013	55.72	11.09	11.25	9.05	7.23	4.87	0.79	
2014	55.87	11.70	10.62	8.56	6.85	5.61	0.79	
2015	55.90	10.27	11.15	8.25	7.03	5.54	0.88	0.99
2016	52.02	11.19	11.15	9.43	6.00	4.53	0.57	5.10
2017	49.79	11.27	12.15	10.39	5.42	4.50	0.59	5.89
2018	48.66	11.37	12.36	9.53	6.09	4.86	0.52	6.61
2019	50.08	10.70	11.60	8.25	6.28	5.48	0.53	7.08
2020	50.61	9.31	11.55	9.68	7.94	5.20	0.43	5.27
2021	50.41	11.90	11.41	8.70	7.31	5.17	0.33	4.76
2022	49.72	12.73	10.15	8.86	7.38	7.01	0.18	3.97
2023	51.24	10.53	10.82	9.73	7.94	5.66	0.60	3.48
2024	46.24	11.23	14.01	12.56	5.97	6.90	0.21	2.88
A	80.31	102.09	117.20	154.80	103.22	142.37	28.47	
min	46.24	9.31	10.15	8.00	5.33	4.50	0.18	0.99
max	57.79	12.73	14.01	12.56	7.94	7.01	0.94	7.08
B	-1.28	0.12	0.94	2.60	0.19	2.10	-7.12	

A - ratio of the 2007 value to the 2024 value in [%], B - average dynamics of change from 2007 to 2024 in [%], other designations as in Table 1.
Source: own study based on [21].

Table 3. The percentage of accidents, in the total number of accidents caused by pedestrians intoxicated, by the cause of the accident [%]

	Variable							
Year	**s2a2**	**s2a2**	**s2a3**	**s2a4**	**s2a5**	**s2a6**	**s2a7**	**s2a8**
2007	58.92	4.87	11.85	5.60	9.87	7.50	1.38	
2008	59.16	5.01	13.69	5.24	8.83	6.96	1.12	
2009	58.14	4.31	12.74	5.56	11.21	6.70	1.34	
2010	55.63	5.52	11.77	6.77	10.21	8.85	1.25	
2011	59.04	4.25	11.39	7.69	8.59	7.96	1.08	
2012	56.38	4.96	12.45	6.07	10.53	8.50	1.11	
2013	55.41	5.03	10.31	6.57	13.66	8.38	0.64	

2014	57.63	3.99	11.70	5.99	10.56	8.84	1.28	
2015	57.17	4.83	9.67	6.17	12.50	7.00	1.33	1.33
2016	53.93	4.01	10.12	6.28	9.77	8.03	0.70	7.16
2017	51.54	4.83	14.29	7.14	5.98	6.76	0.97	8.49
2018	48.67	4.70	10.02	7.36	11.25	9.41	0.61	7.98
2019	51.13	4.53	8.56	6.05	12.85	9.07	0.00	7.81
2020	51.91	3.52	12.32	6.16	12.02	9.38	0.00	4.69
2021	54.24	4.75	13.56	4.75	10.17	8.14	0.00	4.41
2022	53.51	2.34	9.70	8.03	10.37	10.70	0.00	5.35
2023	49.01	3.95	11.46	7.91	12.25	10.28	0.00	5.14
2024	39.13	2.42	17.87	12.08	12.08	13.53	0.00	2.90
A	66.41	49.58	150.84	215.83	122.30	180.24	0.00	
min	39.13	2.34	8.56	4.75	5.98	6.70	0.00	1,33
max	59.16	5.52	17.87	12.08	13.66	13.53	1.38	8.49
B	66.41	49.58	150.84	215.83	122.30	180.24	0.00	

A - ratio of the 2007 value to the 2024 value in [%], B - average dynamics of change from 2007 to 2024 in [%], other designations as in Table 1.
Source: own study based on [21].

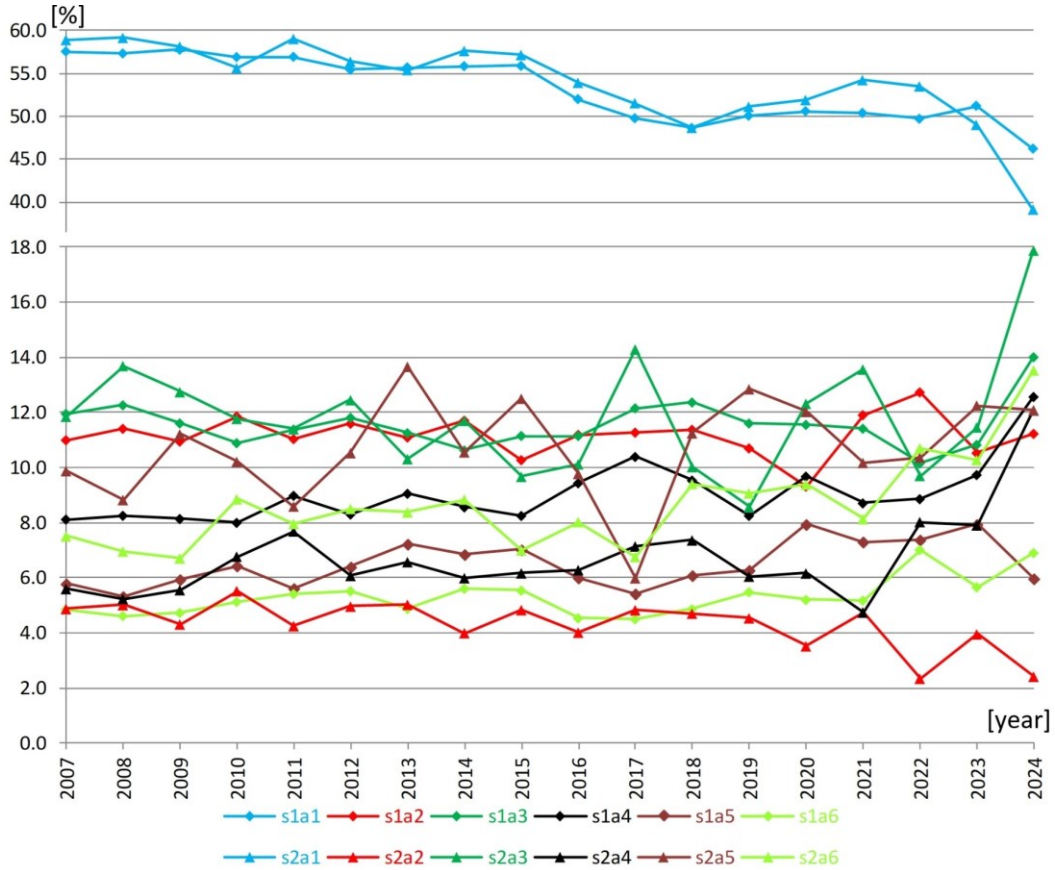

Fig. 3. The percentage of accidents, in the total number of accidents caused by pedestrians and by pedestrians intoxicated, by the cause of the accident [%]
Designations as in Table 1. Source: own study based on [21].

For age, both perpetrators and victims of accidents, the Police Headquarters statistics include 7 age categories (Tab. 1). In addition, a "no data" category was introduced. The percentage of accidents caused by pedestrians of a given category's age in the total number of accidents caused by pedestrians is included in Table 4 and Figure 4. Nearly 50% of accidents are caused by pedestrians over 49 years of age (ppa40-59 + ppa60+). The percentage of each of these categories generally exceeds 20%. In the case of ppa49-59 there is a marked decrease, in the case of ppa60+ there is a marked increase. We get a different picture if we consider the population of Polish residents of a given age. Taking the indicator of the number of accidents per thousand residents of a given age, we get the highest values for perpetrators aged 7-14 and 15-17. Perpetrators aged 60+ and 40-59 rank 3rd and 4th, respectively.

The trend models considered, except for the hyperbolic trend, show a very good fit (measured by R^2 and adjusted R^2 measure) to the empirical data. However, in most cases they do not meet other criteria – mainly the presence of autocorrelation of the random component or insignificance of the model parameters. The 5 models that meet the accepted criteria are shown in Table 5.

Table 4. The percentage of accidents caused by pedestrians of a given age in the total number of accidents caused by pedestrians [%]

	Variable							
Year	ppa0-6	ppa7-14	ppa15-17	ppa18-24	ppa25-39	ppa40-59	ppa60+	ppabd
2007	4.30	15.32	4.80	9.75	15.36	29.25	19.52	1.69
2008	4.01	16.20	5.29	9.35	15.11	28.93	19.74	1.37
2009	4.29	16.27	5.50	9.35	14.56	27.56	20.78	1.69
2010	3.98	17.64	5.04	8.99	14.48	27.42	20.78	1.67
2011	4.50	15.08	5.19	10.21	16.95	26.71	19.65	1.71
2012	4.04	15.26	5.19	10.39	17.83	26.61	19.76	0.91
2013	5.09	14.96	5.44	9.59	14.96	27.09	21.24	1.63
2014	4.62	15.11	4.46	10.43	16.43	24.75	22.30	1.90
2015	3.93	13.55	4.77	9.05	18.44	26.16	22.60	1.49
2016	3.23	13.96	4.61	8.66	17.76	25.15	25.36	1.27
2017	3.99	12.83	4.04	8.12	17.33	25.61	26.03	2.06
2018	4.25	14.06	3.78	7.60	18.55	23.31	26.47	1.98
2019	3.30	10.64	5.06	7.66	17.88	25.71	26.61	3.14
2020	3.25	9.75	3.47	6.86	17.98	29.89	26.35	2.45
2021	5.17	14.61	4.35	5.75	16.58	28.41	22.99	2.13
2022	3.78	14.58	4.61	7.01	19.00	25.09	23.25	2.68
2023	3.28	12.02	5.26	6.36	15.39	25.72	28.60	3.38
2024	3.50	15.65	4.43	4.84	15.96	24.10	27.39	4.12
A	81.49	102.17	92.20	49.64	103.89	82.38	140.36	243.37
min	3.23	9.75	3.47	4.84	14.48	23.31	19.52	0.91
max	5.17	17.64	5.50	10.43	19.00	29.89	28.60	4.12
B	-1.197	0.126	-0.477	-4.036	0.225	-1.134	2.015	5.371

A - ratio of the 2007 value to the 2024 value in [%], B - average dynamics of change from 2007 to 2024 in [%], other designations as in Table 1. Source: own study based on [21].

Table 5. Selected trend models of road accidents

variable/ indicator	model	a	b	c	R^2	adjusted R^2	MAD	SMAD	S-W test value	model significance
la3(?)	logarithmic	-2214,6	7479,08	–	0,981	0,980	185,690	147,854	0,9741	10^{-14}
la4	parabolic	3,116	-130,00	1558,936	0,970	0,966	45,727	47,118	0,9244	0,00052
paa1(?)	parabolic	0,000257	-0,010588	0,327281	0,952	0,945	0,0048	0,0049	0,9469	0,0032
paa2	parabolic	0,000179	-0,008714	0,144587	0,992	0,991	0,0018	0,0016	0,9434	10^{-5}
paa3(?)	linear model	-0,013362	0,441273	–	0,978	0,978	0,0081	0,0061	0,9515	10^{-14}

"?" – denotes indeterminacy of autocorrelation of the residuals, in other cases, no autocorrelation. Source: own study based on [21].

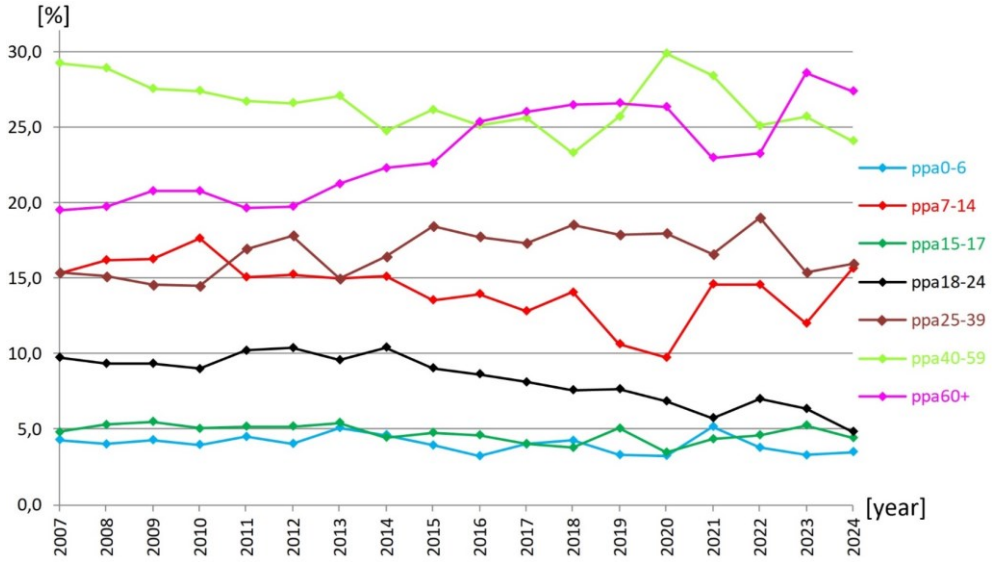

Fig. 4. The percentage of accidents caused by pedestrians of a given age in the total number of accidents caused by pedestrians [%]

Designations as in Table 1. Source: own study based on [21].

FATALITIES IN ROAD ACCIDENTS IN POLAND IN THE YEARS 2007-2024

In the statistics of road accidents in Poland, the highest number of accident fatalities was recorded in 1991, with 7,901 fatalities in 54,038 accidents, in which 73142 people were injured (including fatalities) [21]. The number of fatalities accounted for 12.11% of all victims. However, this is not the highest percentage. The highest was recorded in 1977 – 12.981%. From 2007 to 2024, the highest percentage of fatalities was recorded in 2020 – 9.413%, and the lowest in 2017 – 7.173%. In 2024, the percentage was 7.651%. In that year, 1,896 people died in accidents, which accounted for 34% of the number of fatalities in 2007. The average annual rate of decline contributed 6.16% and was higher than the number of accidents la1 (4.79%), the number of injured li1 (5.36%) and victims lv1 (4.79%)[7].

The number of pedestrians killed in traffic accidents (lk2, Fig. 5) has been steadily declining (the exception was 2011, which saw a 14% increase). It fell by more than 78% from 1,951 to 428. The average annual rate of decline contributed 8.54% and was much higher than that of all fatalities. This is confirmed by the decline in the percentage of pedestrians among accident fatalities (pak1, Fig. 6). It fell from 34.9% to 22.6% with an average annual rate of decline of 2.54%. Unfortunately, it is always higher (from 0.5 to 8.8 percentage points, the p-value of the t-statistic is 10^{-6}) than the percentage of accidents. This also means that, on average, more people die in accidents involving pedestrians than in a statistical accident. The number of fatalities per 100 accidents is higher by 0.2 to 3.1. Between 43% and 57% of pedestrians killed were killed in accidents caused by pedestrians (pak3, Fig. 6). The percentage is declining, the average annual rate of decline is 1.52%. The percentage of pedestrians' fatalities in accidents caused by pedestrians in the total number of fatalities pak2 is also declining. It has fallen from 19.8% to 9.9%. However, it is always higher than paa2 (from 5.35 to 8.92 percentage points, the p-value of the t-statistic is 10^{-14}). Between 31% and nearly 38% of fatalities occurred in the undeveloped area (pak5, Fig. 6). This percentage has increased markedly in the last two years. This contrasts with the percentage of paa5 accidents, which is around 9%. This indicates that the statistical impact of a pedestrian accident in an undeveloped area is much more severe than in a built-up area.

A significant proportion of pedestrian fatalities in accidents caused by pedestrians are victims of accidents caused by drunk pedestrians (pak4, Fig. 6). This percentage generally does not fall below 15% (the exception being 2010, when it was 12.9%) reaching 23.7% (2012). However, it is always smaller than paa4 (from 2.77 to

[7] For more on this topic, see [22].

8.52 percentage points, the p-value for the t-statistic is 10^{-10}). In absolute numbers, the decline was more than 83% from 1105 to 187 (Fig. 5, average annual rate of decline 9.92%).

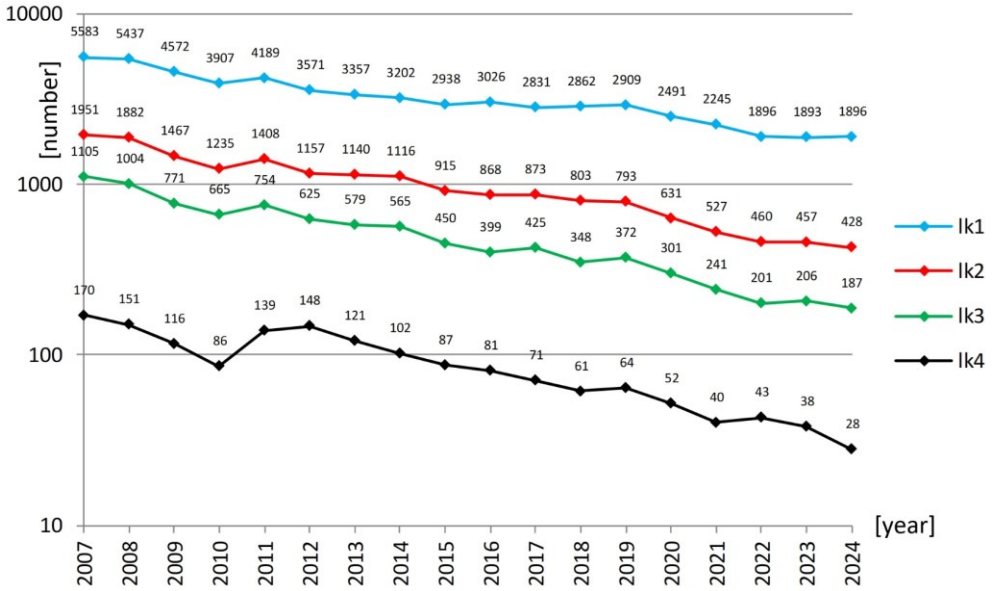

Fig. 5. Number of fatalities in road accidents in Poland from 2007 to 2024 in selected groups of road traffic participants
Designations as in Table 1. Source: own study based on [21].

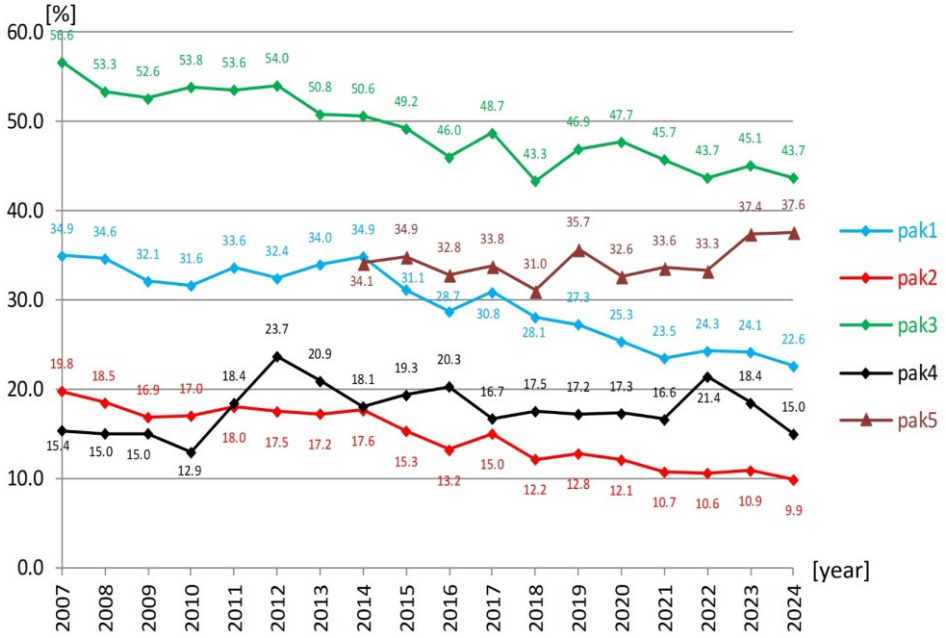

Fig. 6. The percentage of fatalities in road accidents in Poland from 2007 to 2024 in selected groups of road traffic participants [%]
Designations as in Table 1. Source: own study based on [21].

The percentage of fatalities, by cause of accident, is shown in Tables 6 and 7 and Figure 7. The main cause of accidents caused by pedestrians, including pedestrians intoxicated, is careless entry onto the roadway in front of a moving vehicle s1k1, s2k1 (42% to 53% and 31% to 58%, respectively). A significant difference is seen between s1k5 and s2k5 (lying down, sitting, kneeling, standing). The rate of s2k5 is higher (except in 2017) than s1k5. Analyzing the graph (Fig. 7), it seems that s1k5 does not have an upward trend, in the case of s2k5 this trend can be observed. However, the chi-square test indicates that there is no trend in both cases (p-value 0.1 and 0.92, respectively). Analyzing the results of the chi-square test, it can be concluded that the distribution of causes of accidents caused by pedestrians is variable over time[8]. For indicators s1k3, s1k4, s1k5, s1k6 and s1k7, there is no basis for rejecting the hypotheses of independence (p-value greater than 0.084). In the case of indicators s1k3, s1k4, s1k5, s1k6 and s1k7, there are no grounds to reject the hypotheses of independence (p-value greater than 0.084).Thus, one can assume the constancy of these indicators over time (plus a random factor). Note, however, that the cause of "stopping, reversing" in practice no longer occurs (from 2 to 6 cases in the last 5 years). The situation is different for accidents caused by pedestrians intoxicated. The distribution of causes can be considered constant over time (plus a random factor) – the p-value for the chi-square test is 0.216[9]. However, it should be noted that indicators s1k2, s2k6, s2k7 and s2k8 are insignificant in practice due to their "trace" occurrence (in absolute numbers).

Table 6. The percentage of fatalities, out of the total number of fatalities in accidents caused by pedestrians, by cause of accident [%]

	Variable							
Year	s1k1	s1k2	s1k3	s1k4	s1k5	s1k6	s1k7	s1k8
2007	52.67	4.52	10.32	4.80	17.74	9.59	0.36	
2008	51.39	4.98	11.65	5.78	16.43	9.26	0.50	
2009	52.79	4.15	12.32	5.06	18.68	6.74	0.26	
2010	51.28	4.51	11.88	4.81	18.95	8.12	0.45	
2011	51.46	2.79	12.86	5.44	16.98	9.95	0.53	
2012	47.20	4.16	13.44	4.48	20.48	9.92	0.32	
2013	48.70	3.11	12.78	4.84	21.93	7.77	0.86	
2014	49.73	3.89	9.56	5.13	21.06	10.62	0.00	
2015	46.22	2.67	10.00	4.67	22.89	12.44	0.00	1.11
2016	43.11	6.02	12.53	5.26	20.30	8.52	0.75	3.51
2017	44.24	4.24	13.65	5.65	17.18	9.65	0.24	5.18
2018	42.53	4.02	15.23	5.17	20.11	6.61	0.29	6.03
2019	41.94	2.96	14.52	3.76	19.89	11.29	0.27	5.38
2020	45.51	3.99	10.96	5.32	22.26	7.97	0.66	3.32
2021	46.47	3.73	11.20	4.56	21.16	7.88	0.00	4.98
2022	44.28	4.98	10.45	3.48	21.89	11.44	0.00	3.48
2023	42.72	4.37	11.65	5.83	22.33	11.17	0.00	1.94
2024	44.39	4.81	12.83	7.49	16.58	11.76	0.00	2.14
A	84.27	106.36	124.40	156.09	93.46	122.64	0.00	
min	41.94	2.67	9.56	3.48	16.43	6.61	0.00	1,11
max	52.79	6.02	15.23	7.49	22.89	12.44	0.86	6.03
B	84.27	106.36	124.40	156.09	93.46	122.64	0.00	

A - ratio of the 2007 value to the 2024 value in [%], B - average dynamics of change from 2007 to 2024 in [%], other designations as in Table 1.
Source: own study based on [21].

Table 7. The percentage of fatalities, out of the total number of fatalities in accidents caused by intoxicated pedestrians, by cause of accident [%]

	Variable							
Year	s2k2	s2k2	s2k3	s2k4	s2k5	s2k6	s2k7	s2k8
2007	50.59	2.94	8.24	2.35	24.71	10.59	0.59	
2008	49.67	2.65	5.96	5.96	25.17	10.60	0.00	

[8] Due to the small group sizes combined in the test group s1k7 and s1k8.

[9] Due to small group sizes, the combined s2k2, s2k6, s2k7 and s2k8 groups were combined in the test.

2009	50.00	1.72	3.45	0.86	34.48	9.48	0.00	
2010	47.67	3.49	5.81	3.49	29.07	9.30	1.16	
2011	52.52	2.16	6.47	4.32	23.74	10.07	0.72	
2012	39.86	2.70	10.81	3.38	33.78	9.46	0.00	
2013	42.98	2.48	7.44	2.48	37.19	7.44	0.00	
2014	44.12	1.96	8.82	1.96	28.43	14.71	0.00	
2015	49.43	2.30	3.45	5.75	29.89	8.05	0.00	1.15
2016	48.15	3.70	2.47	1.23	29.63	8.64	1.23	4.94
2017	47.89	2.82	7.04	4.23	15.49	14.08	1.41	7.04
2018	44.26	0.00	6.56	0.00	32.79	13.11	0.00	3.28
2019	31.25	1.56	7.81	1.56	39.06	15.63	0.00	3.13
2020	36.54	1.92	7.69	1.92	28.85	15.38	0.00	7.69
2021	45.00	2.50	12.50	2.50	25.00	7.50	0.00	5.00
2022	58.14	0.00	0.00	0.00	25.58	13.95	0.00	2.33
2023	47.37	0.00	5.26	0.00	36.84	10.53	0.00	0.00
2024	35.71	3.57	7.14	3.57	35.71	10.71	0.00	3.57
A	70.60	121.43	86.73	151.79	144.56	101.19	0.00	
min	31.25	0.00	0.00	0.00	15.49	7.44	0.00	1,15
max	58.14	3.70	12.50	5.96	39.06	15.63	1.41	7.69
B	-2.03	1.15	-0.83	2.49	2.19	0.07	-100.00	

A - ratio of the 2007 value to the 2024 value in [%], B - average dynamics of change from 2007 to 2024 in [%], other designations as in Table 1.
Source: own study based on [21].

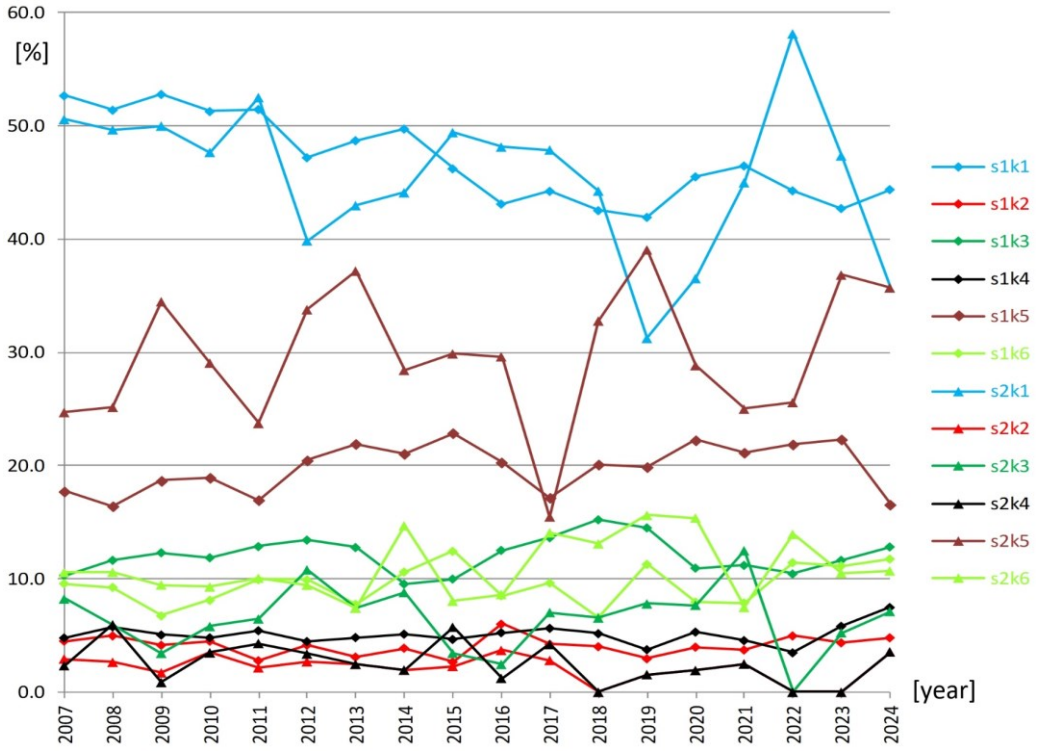

Fig. 7. The percentage of fatalities, out of the total number of fatalities in accidents caused by pedestrians and by intoxicated pedestrians, by the cause of the accident [%]
Designations as in Table 1. Source: own study based on [21].

Table 8. The percentage of fatalities by age in the total number of pedestrians' fatalities in traffic accidents [%]

	Variable							
Year	pk0-6	pk7-14	pk15-17	pk18-24	pk25-39	pk40-59	pk60+	pkbd
2014	0.81	2.15	1.08	5.73	13.71	33.33	42.65	0.54
2015	0.55	1.31	1.42	4.92	13.88	32.46	45.36	0.11
2016	0.69	1.15	1.38	3.69	15.32	32.26	45.39	0.12
2017	0.69	1.37	0.80	2.98	13.63	30.36	49.83	0.34
2018	0.00	2.49	1.74	3.24	12.08	28.64	51.56	0.25
2019	0.50	1.39	1.13	5.17	11.98	28.50	50.32	1.01
2020	0.63	1.43	0.95	3.17	12.52	33.28	47.70	0.32
2021	0.76	1.33	1.33	3.61	12.71	32.83	46.87	0.57
2022	0.87	1.52	1.96	4.78	12.17	28.26	49.78	0.65
2023	0.22	2.41	1.53	3.72	12.91	24.95	53.83	0.44
2024	1.40	2.57	1.64	3.74	12.62	25.23	51.87	0.93
A	173.83	119.51	152.10	65.19	92.03	75.70	121.61	173.83
min	0.00	1.15	0.80	2.98	11.98	24.95	42.65	0.11
max	1.40	2.57	1.96	5.73	15.32	33.33	53.83	1.01
B	5.685	1.798	4.283	-4.189	-0.827	-2.745	1.976	5.685

A - ratio of the 2014 value to the 2024 value in [%], B - average dynamics of change from 2007 to 2024 in [%], other designations as in Table 1. Source: own study based on [21].

The largest percentage of those fatalities in traffic accidents are residents over the age of 59 (pk60+, Fig. 8, Tab. 8). This percentage ranges from 43% to 54% and has a clear upward trend, with an average annual growth rate of 1.97%. The second most significant group is the group of residents aged 40-59 (pk40-59) with a percentage of 25-33%, with a clear downward trend – the average rate of decline is 2.745%. The groups aged 18-24 and 25-29 – so adults – still have a significant percentage. The percentage of the remaining groups (minors) ranges from 0% to 2.6%, and the total from 2.9% to 5.6%. The situation is analogous if we consider the number of fatalities per 10,000 residents of a given age. For indicators pk0-6, pk7-14, pk15-17 and pk25-39, the values can be considered constant (plus a random factor, the p-value for the chi-square test ranges from 0.282 to 0.785). For the pk18-24 indicator, the p-value is 0.0495.

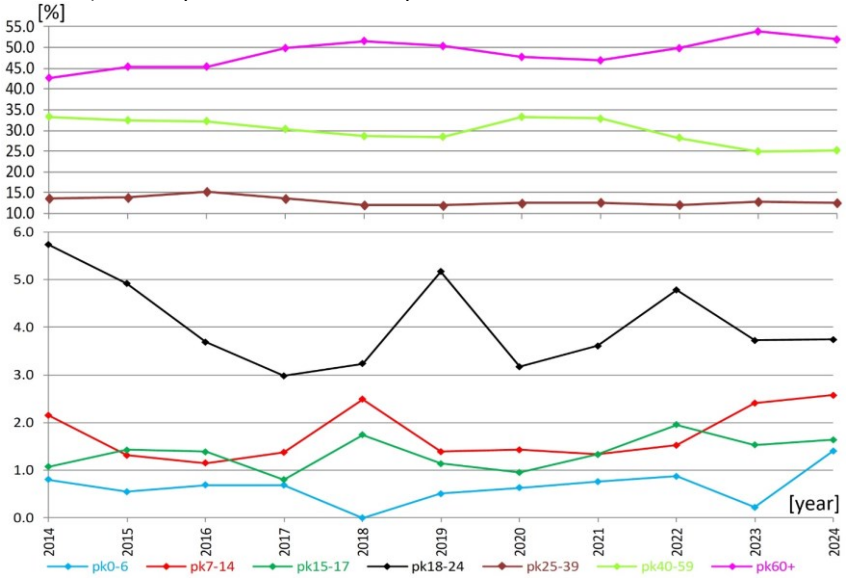

Fig. 8. The percentage of fatalities by age in the total number of pedestrians' fatalities in traffic accidents [%]

Designations as in Table 1. Source: own study based on [21].

Police Headquarters statistics [21] report the number of fatalities (and injuries and victims combined), regardless of age, in accidents caused by pedestrians of a given age (Tab. 9, Fig. 9).

The statistics show that the highest number of fatalities is in accidents caused by pedestrians over the age of 59. The percentage of these ppk60+ victims ranges from 28% to 47% and has an upward trend (average annual growth rate is 1.835%). The age group 40-59 (ranked second) has a downward trend (average annual rate of decline is 1,.609%). The values of the ppk40-59 indicator range from 28% to 42%. For indicators ppk0-6, ppk15-17 and ppk25-39, the values can be considered constant (plus a random factor, the p-value for the chi-square test ranges from 0.332 to 0.878). For the ppk18-24 indicator, the p-value is 0.017.

In the case of the number of fatalities, for all the subgroups considered, there are well-fitting trend models that meet all the accepted criteria. However, in the case of the trend analysis of the percentage of fatalities, only for the pak1 indicator is there a model that meets all the adopted criteria. These models are included in Table 10.

Table 9. The percentage of fatalities, in the total number of fatalities in accidents caused by pedestrians, by age of the perpetrator [%]

	Variable							
Year	ppk0-6	ppk7-14	ppk15-17	ppk18-24	ppk25-39	ppk40-59	ppk60+	ppkbd
2007	0.72	1.81	1.18	6.88	15.57	39.46	31.40	2.99
2008	0.70	1.69	1.39	6.47	15.64	42.33	29.48	2.29
2009	0.78	2.33	1.30	5.45	15.69	39.04	32.30	3.11
2010	0.45	1.50	1.20	5.56	13.38	42.11	33.68	2.11
2011	1.19	1.86	1.06	6.50	18.70	40.98	27.72	1.99
2012	0.80	1.44	1.76	7.04	18.40	40.96	29.12	0.48
2013	1.38	1.73	1.04	4.66	14.51	41.62	34.72	0.35
2014	0.88	2.30	0.88	7.79	16.11	36.81	34.69	0.53
2015	0.22	1.11	1.33	6.00	16.00	40.00	35.11	0.22
2016	0.25	0.75	1.25	6.77	18.80	38.60	33.33	0.25
2017	0.71	0.94	0.71	3.29	19.53	34.35	39.76	0.71
2018	0.00	2.01	0.29	2.87	15.52	35.63	43.10	0.57
2019	0.81	1.61	0.54	5.38	15.32	35.22	39.52	1.61
2020	0.66	1.00	0.66	3.65	15.61	39.53	38.21	0.66
2021	0.00	1.24	1.66	3.73	13.69	41.08	37.76	0.83
2022	1.00	1.99	0.50	7.96	15.42	37.31	34.33	1.49
2023	0.49	0.97	1.94	3.40	17.48	28.16	46.60	0.97
2024	1.60	3.21	1.07	4.28	15.51	29.95	42.78	1.60
A	221.59	177.27	90.91	62.20	99.63	75.90	136.23	53.72
min	0.00	0.75	0.29	2.87	13.38	28.16	27.72	0.22
max	1.60	3.21	1.94	7.96	19.53	42.33	46.60	3.11
B	4.792	3.425	-0.559	-2.754	-0.022	-1.609	1.835	-3.589

A - ratio of the 2007 value to the 2024 value in [%], B - average dynamics of change from 2007 to 2024 in [%], other designations as in Table 1. Source: own study based on [21].

Table 10. Selected trend models of road fatalities

variable/ indicator	model	a	b	c	R^2	adjusted R^2	MAD	SMAD	S-W test value	model significance
lk1	linear	6009,344	1356,301	–	0,954	0,951	185,784	140,385	0,9624	10^{-11}
lk1(?)	parabolic	9,461171	378,2401	5751,591	0,949	0,943	309,161	125,570	0,9653	0,0027
lk2	linear	-556,443	2131,277	–	0,947	0,943	88,835	50,293	0,9563	10^{-10}
lk2	parabolic	3,185178	-143,2294	1993,65	0,956	0,951	72,764	57,925	0,9783	0,0063
lk3	logarithmic	-331,5945	1181,474	–	0,963	0,961	43,531	25,281	0,9486	10^{-12}
lk3	parabolic	2,333011	-92,95878	1120,757	0,964	0,959	39,347	31,141	0,9322	10^{-6}
lk4	linear	7,569	160,680	–	0,859	0,850	11,132	11,304	0,9269	10^{-7}
pak1(?)	parabolic	-0,000374	-0,00025	0,3428	0,892	0,878	0,0111	0,0080	0,9613	0,0225

"?" – denotes indeterminacy of autocorrelation of the residuals, in other cases, no autocorrelation. Source: own study based on [21].

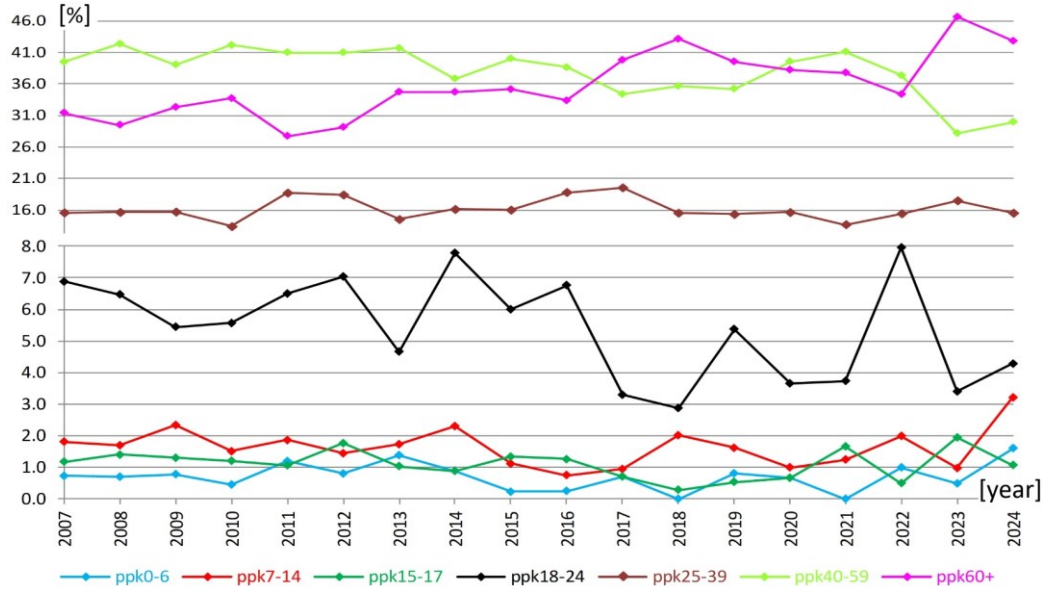

Fig. 9. The percentage of fatalities, in the total number of fatalities in accidents caused by pedestrians, by age of the perpetrator [%]

Designations as in Table 1. Source: own study based on [21].

INJURES IN ROAD ACCIDENTS IN POLAND IN THE YEARS 2007-2024

Between 2007 and 2024, the number of injuries in li1 road accidents fell by more than 60% (Fig. 10), with an average annual rate of decline of 5.36%. It was higher than the decrease in the number of accidents (4.786%) but lower than the number of fatalities (6.155%). However, the indicator of the number of injuries per 100 accidents decreased by only 10% [22] (from 127.63 to 115.16, the lowest value of 112.42 reached in 2020), with an average annual rate of decline of 0.60%.

The number of injured pedestrians li2 decreased by more than 79% (Fig. 10), from 14,798 to 4,395. The average annual rate of decline was 6.892%. The percentage of injured pedestrians pai1 among injured traffic accidents (Fig. 11) ranges from 16.29% (in 2021) to 23.41% (in 2007). The decrease between 2007 and 2024 was more than 24%, with an average annual rate of decline of 1.619%. The percentage is always lower than paa1 (pedestrian accidents) by 4.19 to 8.76 percentage points – an average of 6 percentage points (the p-value of the t-statistic is 10^{-12}). The vast majority of pedestrians were injured in accidents in built-up areas. In non-built-up areas, the figure is 6.2% to 7.6% (average 6.8%). This percentage (pai5) is significantly (always) lower than paa5 (from 2.26 to 3.24 percentage points, average 2.7).

The share of injured pedestrians in accidents caused by pedestrians in the total number of injured pai2 (Fig. 11) ranges from 3.27% to 9.41% and has a clear downward trend (it has decreased by more than 65%, the average annual rate of decline is 6.028%). It is always significantly smaller than paa2 (from 1.24 to 4.55 percentage points, mean 2.53, p-value of t-statistic is 10^{-8}). A significant proportion of injured pedestrians were injured in accidents caused by pedestrians. In most, the perpetrator was also a victim. This percentage (pai3, Fig. 11) ranges from 17.8% to 40.2% and is significantly decreasing (the average annual rate of decline is 4.481%).

Although the number of injuries in accidents caused by pedestrians intoxicated lk4 (Fig. 10) has been steadily decreasing (a reduction of nearly 87%, the average annual rate of decline is 11.209%), the percentage pai4 (Fig. 11) does not show such properties. It is always higher than the paa4 percentage of accidents caused by pedestrians intoxicated (from 0.39 to 2.28 percentage points, the average is 1.1, the p-value of the t-statistic is 10^{-7}). This is further evidence in support of the thesis – alcohol significantly contributes to the consequences (severity) of traffic accidents.

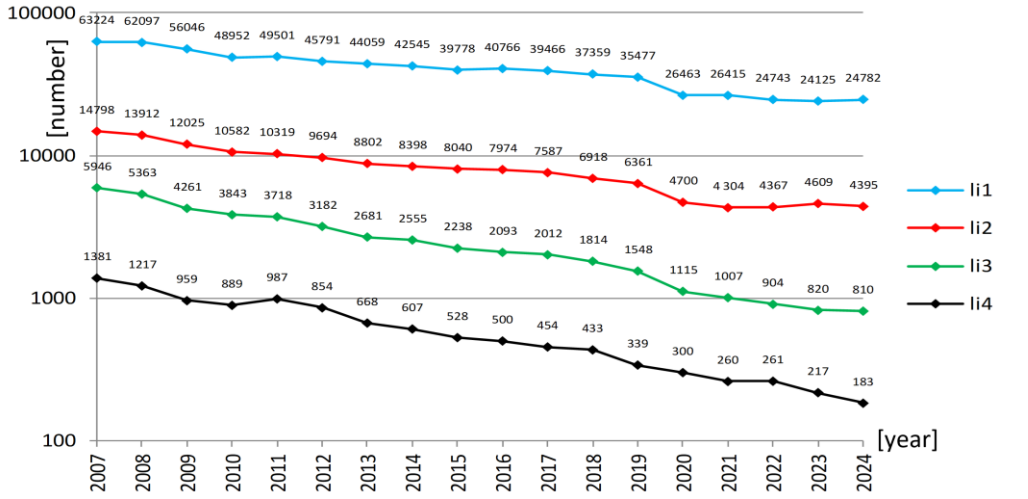

Fig. 10. Number of injured in road accidents in Poland from 2007 to 2024 in selected groups of road traffic participants
Designations as in Table 1. Source: own study based on [21].

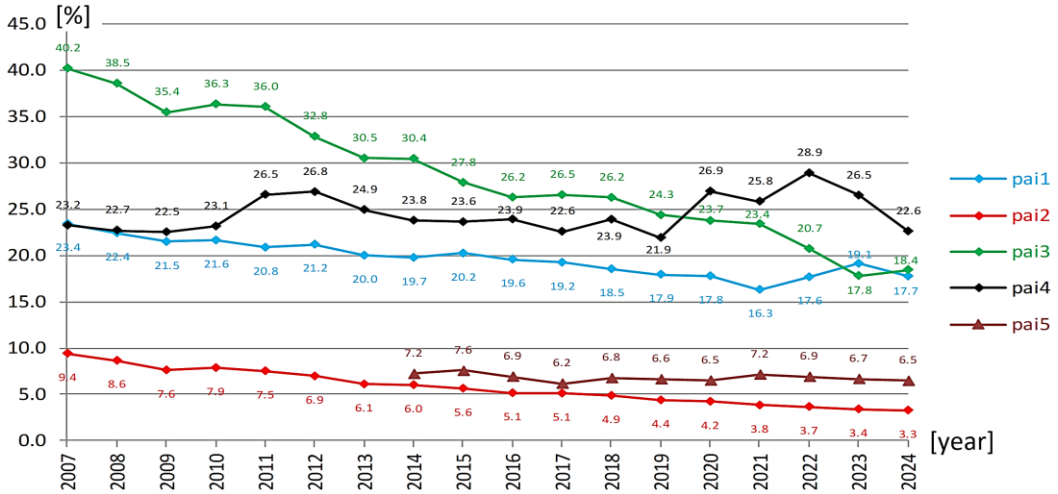

Fig. 11. The percentage of injured in road accidents in Poland from 2007 to 2024 in selected groups of road traffic participants [%]
Designations as in Table 1. Source: own study based on [21].

The main cause of traffic accidents caused by pedestrians, in which traffic participants were injured, is careless entry onto the roadway in front of a moving vehicle. The percentage of s1i1 injured from this cause (Fig. 12, Tab. 10), among those injured in accidents caused by pedestrians, ranges from 47% (2024) to 60% (2009). It has a clear downward trend. Between 2007 and 2024, the decrease was more than 19%, the average rate of decline was 1.240%. Significant contributions (from 8% to 14%) come from s1i2, s1i3 and s1i4, with s1i4 showing an upward trend. The remaining causes have a small contribution, with s1i7's percentage to be considered a trace. The distribution of cause percentages is variable over time (for the chi-square independence test, the p-value is 0). However, for causes s1i3, s1i5, s1i6, s1i7, there is no basis for rejecting the hypothesis of independence (the p-value of the chi-square test ranges from 0.1 (s1i7) to 0.461 (s1i5)). Therefore, it can be assumed that the percentage is constant (plus a random factor).

For accidents caused by pedestrians intoxicated (Tab. 11, Fig. 12), the situation is similar. Still the main cause is entering the roadway in front of a moving vehicle (s2i1). The percentage has a clear downward trend – a decline of nearly 32% with an average annual rate of decline of 2.213% (s2i1 ranges from 41% to 60.5%). The percentage of s2i7 in the last 6 years was 0, the percentage of s2i2 is disappearing. The distribution of the percentages of causes is variable over time (for the chi-square independence test, the p-value is 0). For causes s2i4, s2i5, s2i7, there is no reason to reject the hypothesis of independence (the p-value of the chi-square test is 0.06 (s1i7) to 0.217 (s1i4). Thus, it can be assumed that the percentage is constant (plus a random factor). In addition, for s2i3 and s2i6, the p-value is 0.042 and 0.017, respectively.

Table 10. The percentage of injured, out of the total number of injured in accidents caused by pedestrians, by cause of accident [%]

	Variable							
Year	s1i1	s1i2	s1i3	s1i4	s1i5	s1i6	s1i7	s1i8
2007	58.46	12.16	12.19	8.75	3.65	4.00	0.79	
2008	58.55	12.46	12.31	8.73	3.24	3.90	0.82	
2009	60.06	12.32	11.66	8.75	3.83	4.74	0.99	
2010	58.13	12.96	10.69	8.46	4.27	4.68	0.81	
2011	58.34	12.59	10.92	9.82	3.31	4.41	0.62	
2012	56.85	13.04	11.53	9.05	3.77	4.71	1.04	
2013	57.67	12.57	10.70	10.07	4.10	4.14	0.75	
2014	57.06	13.35	10.84	9.59	3.60	4.62	0.94	
2015	57.82	11.57	11.26	8.89	3.98	4.47	1.07	0.94
2016	53.37	12.18	10.85	10.32	3.25	3.97	0.53	5.54
2017	50.75	12.57	11.83	11.38	3.18	3.48	0.70	6.11
2018	49.94	12.79	11.69	10.75	3.25	4.41	0.55	6.62
2019	52.07	12.60	10.72	9.37	2.97	4.13	0.58	7.56
2020	52.02	10.67	11.48	11.03	3.95	4.48	0.36	6.01
2021	51.94	13.80	11.22	9.63	3.77	4.47	0.40	4.77
2022	50.55	14.71	10.18	10.07	3.98	5.97	0.22	4.31
2023	53.90	11.95	10.61	10.49	4.15	4.27	0.73	3.90
2024	47.28	12.35	14.20	13.70	3.33	5.68	0.25	3.21
A	80.88	101.53	116.44	156.70	91.34	141.88	31.24	
min	47.28	10.67	10.18	8.46	2.97	3.48	0.22	0.94
max	60.06	14.71	14.20	13.70	4.27	5.97	1.07	7.56
B	-1.24	0.09	0.90	2.68	-0.53	2.08	-6.62	

A - ratio of the 2007 value to the 2024 value in [%], B - average dynamics of change from 2007 to 2024 in [%], other designations as in Table 1.
Source: own study based on [21].

Table 11. The percentage of injured, out of the total number of injured in accidents caused by intoxicated pedestrians, by cause of accident [%]

	Variable							
Year	s2i1	s2i2	s2i3	s2i4	s2i5	s2i6	s2i7	s2i8
2007	59.96	5.00	12.17	6.01	8.25	7.17	1.45	
2008	60.48	5.26	14.38	5.26	6.82	6.57	1.23	
2009	58.92	4.48	13.66	5.94	8.55	6.88	1.56	
2010	56.81	5.62	12.26	6.97	8.44	8.66	1.24	
2011	59.98	4.46	11.85	8.41	6.59	7.60	1.11	
2012	58.67	5.50	12.88	6.44	6.67	8.55	1.29	
2013	57.63	5.39	10.78	7.34	9.73	8.38	0.75	
2014	59.97	4.28	12.19	6.75	7.41	7.91	1.48	
2015	58.90	5.11	10.42	6.06	9.47	7.20	1.52	1.33

2016	54.80	4.00	11.20	7.00	6.80	8.00	0.60	7.60
2017	52.64	5.07	15.20	7.71	4.41	5.51	0.88	8.59
2018	49.65	5.31	10.39	8.55	8.08	8.78	0.69	8.55
2019	54.28	5.01	8.55	7.08	7.96	7.96	0.00	9.14
2020	54.00	3.67	13.00	6.67	9.00	8.67	0.00	5.00
2021	56.54	5.00	13.46	5.00	7.69	8.08	0.00	4.23
2022	52.49	2.68	11.11	9.20	7.66	10.34	0.00	6.51
2023	49.31	4.61	12.90	9.22	7.83	10.14	0.00	5.99
2024	40.98	2.19	19.13	13.11	8.20	13.66	0.00	2.73
A	68.36	43.75	157.22	218.21	99.30	190.57	0.00	
min	40.98	2.19	8.55	5.00	4.41	5.51	0.00	1.33
max	60.48	5.62	19.13	13.11	9.73	13.66	1.56	9.14
B	-2.21	-4.75	2.70	4.70	-0.04	3.87	-100.00	

A - ratio of the 2007 value to the 2024 value in [%], B - average dynamics of change from 2007 to 2024 in [%], other designations as in Table 1.
Source: own study based on [21].

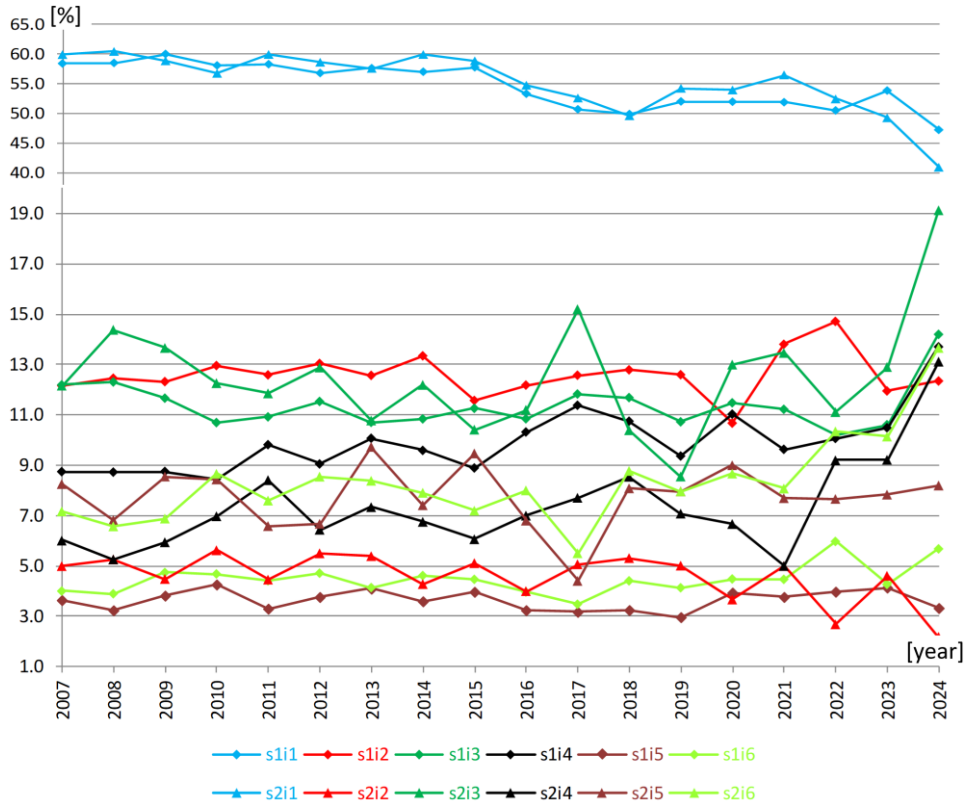

Fig. 12. The percentage of injured, out of the total number of injured in accidents caused by pedestrians and by intoxicated pedestrians, by the cause of the accident [%]
Designations as in Table 1. Source: own study based on [21].

If we consider the age of the injured pedestrians, the largest percentages are for pedestrians aged 59+ (pi60+, Tab. 12, Fig. 13, takes values from 30% to 36% showing an increasing trend) and those aged 40-59 (pi40-59, takes values from 21.4% to 25.7%). The 0-6 age group (pi0-6) is a percentage of about 2.5%. For the

25-39 age group (pi29-39), the percentage ranges from 13.5% to 17%. For the other groups, the percentage ranges from 5% to 11%, with pi19-25 showing a downward trend. The assessment changes significantly if we consider the numbers of each age group. Taking the number of injured people per 10,000 residents as an indicator, the rate assumes the highest values in the 15-17 (20-43), 60+ (15-30), 7-14 (11-30.5) and 18-24 (11-26.5) groups. As the overall number of injured in accidents decreases, the indicators are declining, but in recent years, for the youngest groups (0-24 years), a reversal of the trend can be seen. Note, the changes in the population of age groups – declining numbers for the youngest groups and increasing numbers for the oldest groups (mainly 60+).

Table 12. The percentage of injured by age in the total number of pedestrians injured in traffic accidents [%]

	Variable							
Year	pi0-6	pi7-14	pi15-17	pi18-24	pi25-39	pi40-59	pi60+	pibd
2014	3.13	11.05	6.19	10.87	15.79	22.42	30.30	0.24
2015	2.64	10.63	5.50	9.43	16.94	23.32	31.37	0.17
2016	2.48	10.21	5.43	10.02	16.89	22.39	32.54	0.04
2017	2.65	9.12	5.25	9.77	16.05	23.12	33.52	0.53
2018	2.86	9.68	5.36	8.93	16.15	21.38	35.46	0.17
2019	2.19	9.17	5.88	8.36	15.75	22.06	36.27	0.33
2020	2.23	7.70	4.72	8.00	16.28	25.72	35.06	0.28
2021	3.16	10.39	5.02	6.74	16.73	23.54	34.41	0.02
2022	2.18	10.01	6.07	7.74	14.98	23.08	35.95	0.00
2023	2.56	9.48	7.33	7.75	13.45	24.67	34.71	0.04
2024	2.32	9.22	6.58	7.99	14.61	23.07	36.15	0.07
A	74.11	83.39	106.20	73.46	92.51	102.90	119.30	28.66
min	2.18	7.70	4.72	6.74	13.45	21.38	30.30	0.00
max	3.16	11.05	7.33	10.87	16.94	25.72	36.27	0.53
B	-2.95	-1.80	0.60	-3.04	-0.78	0.29	1.78	-11.75

A - ratio of the 2014 value to the 2024 value in [%], B - average dynamics of change from 2007 to 2024 in [%], other designations as in Table 1.
Source: own study based on [21].

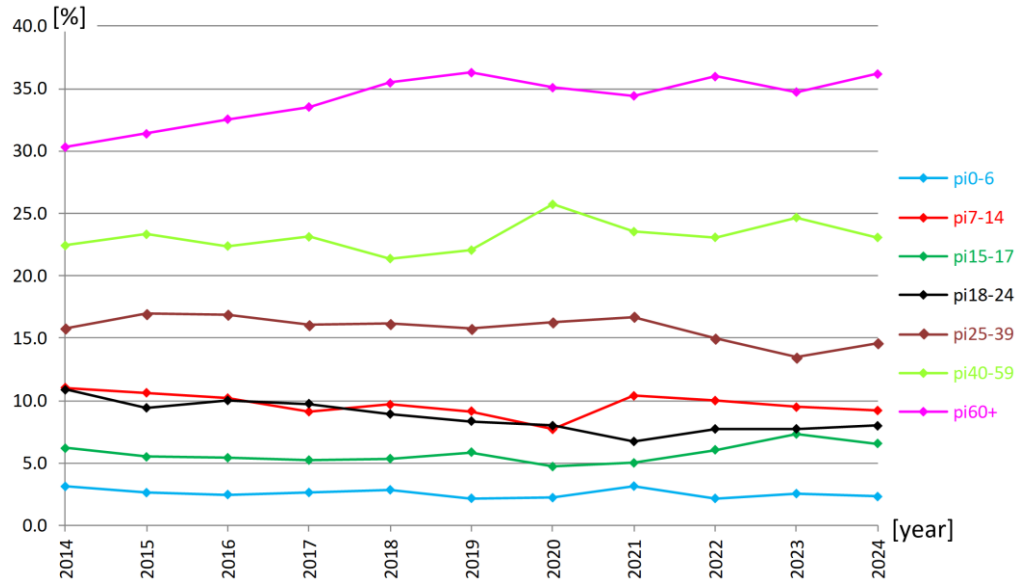

Fig. 13. The percentage of injured by age in the total number of pedestrians of injured in traffic accidents [%]
Designations as in Table 1. Source: own study based on [21].

Considering the percentage of those injured in accidents caused by pedestrians according to the age of

the perpetrator of the accident (Fig. 14, Tab. 13), the largest proportions of those injured in accidents caused by perpetrators aged 40-59 (ppi40-59, from 21% to 27. The trend is downward), those aged 60+ (ppi60+, from 17% to 24%, an upward trend), those aged 7-14 and 25-39. Only for the 15-17 age group can it be assumed that the percentage of injured (ppi15-17) is constant (the p-value of the chi-square test is 0.085). If we consider the population size of the age groups (the indicator of the number of injured per 10,000 people of the perpetrator's age group), in general, except for groups 7-14 and 15-17 (the indicator is significantly higher), no significant differences are observed.

Only two models fully meet the adopted criteria. These are the models of the number of injured pedestrians li3 and pedestrians intoxicated li4 – a logarithmic model and a parabolic model, respectively. The parabolic model of the trend of the percentage of injured pedestrians in the total number of injured pai1 can still be taken into account. However, the significance of the model in this case is 0.0339. The models are shown in Table 14.

Table 13. The percentage of injured, in the total number of injured in accidents caused by pedestrians, by age of the perpetrator [%]

	Variable							
Year	**ppi0-6**	**ppi7-14**	**ppi15-17**	**ppi18-24**	**ppi25-39**	**ppi40-59**	**ppi60+**	**ppibd**
2007	4.96%	17.81%	5.50%	10.33%	15.29%	27.48%	17.10%	1.53%
2008	4.55%	18.80%	6.00%	9.92%	15.07%	26.25%	17.90%	1.51%
2009	4.79%	18.46%	6.21%	10.04%	14.52%	25.82%	18.71%	1.44%
2010	4.61%	20.14%	5.78%	9.55%	14.99%	24.77%	18.50%	1.67%
2011	5.08%	17.62%	6.16%	10.89%	16.70%	23.86%	17.99%	1.69%
2012	4.62%	17.79%	5.85%	11.35%	17.82%	23.57%	17.98%	1.04%
2013	5.78%	17.49%	6.42%	10.56%	14.92%	24.10%	18.35%	2.39%
2014	5.36%	18.00%	5.24%	11.04%	16.48%	21.96%	19.45%	2.47%
2015	4.60%	15.91%	5.41%	9.56%	19.08%	23.77%	19.71%	1.97%
2016	3.73%	16.44%	5.21%	9.03%	17.53%	22.65%	23.70%	1.72%
2017	4.67%	15.21%	4.67%	9.05%	16.70%	24.06%	22.91%	2.73%
2018	5.02%	16.15%	4.47%	8.49%	19.35%	20.67%	23.04%	2.81%
2019	3.88%	12.79%	6.07%	8.33%	18.35%	23.39%	23.45%	3.75%
2020	3.86%	11.84%	4.30%	7.89%	18.83%	27.17%	22.96%	3.14%
2021	6.45%	17.78%	4.87%	6.36%	17.38%	25.32%	19.27%	2.58%
2022	4.42%	17.48%	5.42%	6.86%	19.91%	22.35%	20.69%	2.88%
2023	3.90%	15.00%	5.98%	7.07%	15.37%	24.76%	23.90%	4.02%
2024	3.95%	18.27%	5.19%	4.81%	15.93%	23.70%	23.33%	4.81%
A	79.63%	102.59%	94.28%	46.63%	104.18%	86.26%	136.42%	314.60%
min	3.73%	11.84%	4.30%	4.81%	14.52%	20.67%	17.10%	1.04%
max	6.45%	20.14%	6.42%	11.35%	19.91%	27.48%	23.90%	4.81%
B	-1.33%	0.15%	-0.35%	-4.39%	0.24%	-0.87%	1.84%	6.97%

A - ratio of the 2007 value to the 2024 value in [%], B - average dynamics of change from 2007 to 2024 in [%], other designations as in Table 1. Source: own study based on [21].

Table 14. Selected trend models of injured in traffic accidents

variable/ indicator	model	a	b	c	R^2	adjusted R^2	MAD	SMAD	S-W test value	model significance
li3(?)	logarithmic	1021,974	6436,727	–	0,981	0,980	165,767	121,742	0,9779	$10^{-1}4$
li4	parabolic	3.201045	-125,6382	1431,674	0,977	0,974	38,885	36,381	0,9683	10^{-4}
pai1(?)	parabolic	0,000155	-0,006189	0,237606	0,886	0,871	0,0044	0,0043	0,9360	0,0339

"?" – denotes indeterminacy of autocorrelation of the residuals, in other cases, no autocorrelation. Source: own study based on [21].

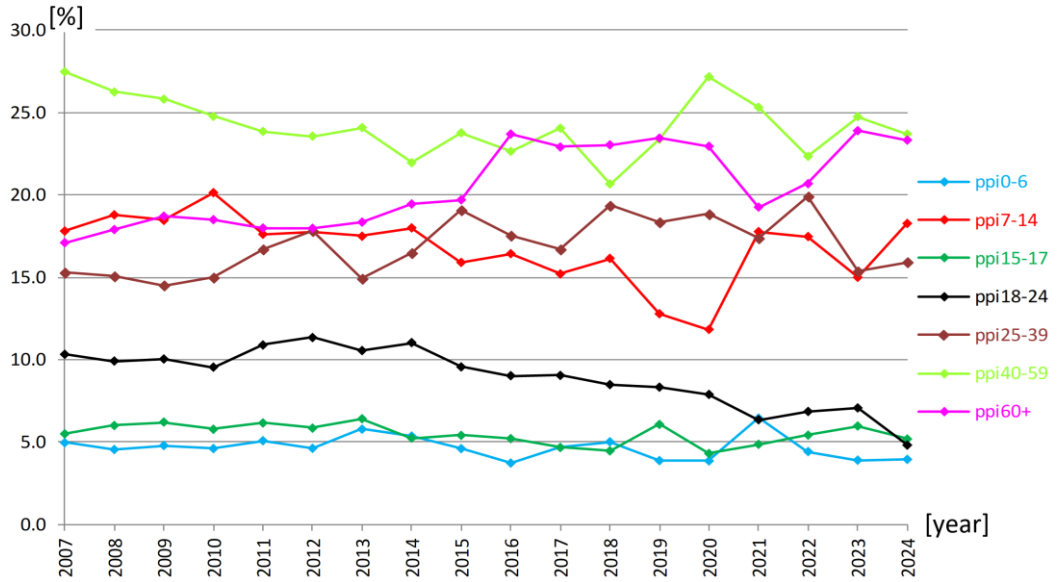

Fig. 14. The percentage of injured, in the total number of injured in accidents caused by pedestrians, by age of the perpetrator [%]

Designations as in Table 1. Source: own study based on [21].

VICTIMS IN ROAD ACCIDENTS IN POLAND IN THE YEARS 2007-2024

The number of victims of accidents lv1 (Fig. 15) is the sum of fatalities lk1 and injuries li1. Thus, changes in the number of victims are the resultant of changes in lk1 and li1. As both are decreasing (albeit with different dynamics), the number of accident victims is also decreasing. Between 2007 and 2024, lv1 declined by more than 61% (slightly less than li1, more than lk1), with an average annual rate of decline of 6.155%. Importantly, the rate of decline in lv1 is much higher than the rate of decline in la1 accidents. This means a reduction in the impact of a statistical traffic accident, as measured by the number of victims (fatalities and injuries)[10]. Pedestrian victims are falling even faster. The decrease was more than 71% (the average annual rate of decline is 7.06%). The percentage of pedestrian victims pav1 (Fig. 16) in the total number of victims is always smaller than the percentage of accidents with pedestrians paa1 in the total number of accidents (the p-value of the t-statistic is 10^{-11}). The decrease was more than 25%, the average annual rate of decline is 1.735%. This is due to the specific nature of accidents involving pedestrians. In the vast majority of accidents, the only person injured is the pedestrian (in recent years, about 102 victims per 100 accidents involving pedestrians, of which about 90% are injured). For other types of accidents, such as those caused by drivers of passenger cars, the number of victims per 100 accidents (in recent years) is about 130 (including about 8 fatalities) [22]. Between 9% and 10.5% of the injured were injured in an non-built-up area. This percentage is declining slightly, with an average annual rate of decline of 1.153%.

More than 20% of pedestrian victims are victims in accidents caused by pedestrians (the victim is also the perpetrator). This percentage (pav3) is declining – a decrease of nearly 51% with an average annual rate of decline of 4.097%. The percentage of pav2 in the total number of victims is also declining – a decrease of more than 63.5%, with an average annual rate of decline of 5.761%. This percentage (pav2) is always smaller (although the difference is decreasing) than the percentage of paa2 accidents (the p-value for the t-statistic is 10^{-7}).

Between 21% and 27.5% of pedestrian accident victims (pav4) are victims of accidents caused by pedestrians intoxicated.

[10] The indicator is the number of casualties, fatalities and injured victims per 100 accidents. For more on the evolution of this indicator, including for different groups of traffic users (other than pedestrians) see [22].

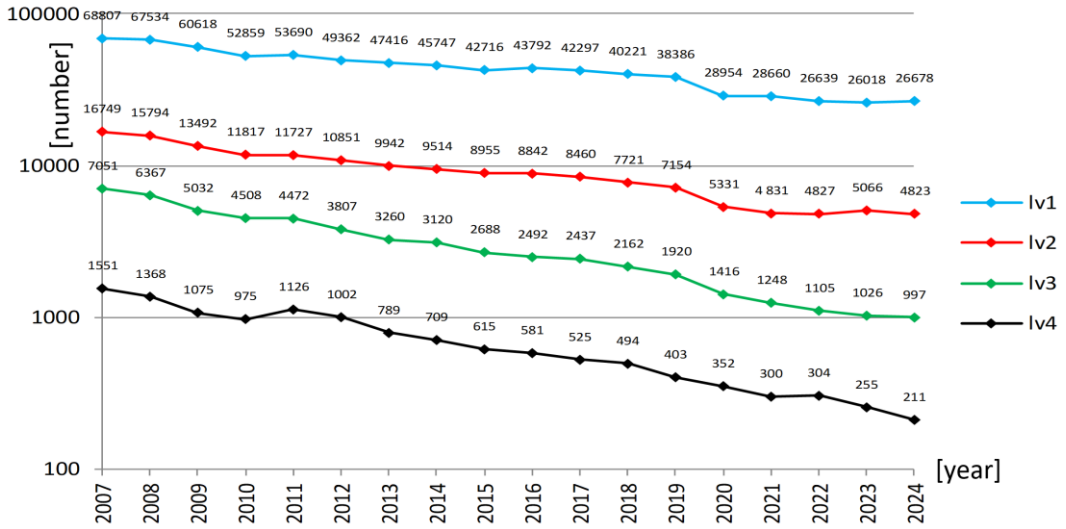

Fig. 15. Number of victims in road accidents in Poland from 2007 to 2024 in selected groups of road traffic participants

Designations as in Table 1. Source: own study based on [21].

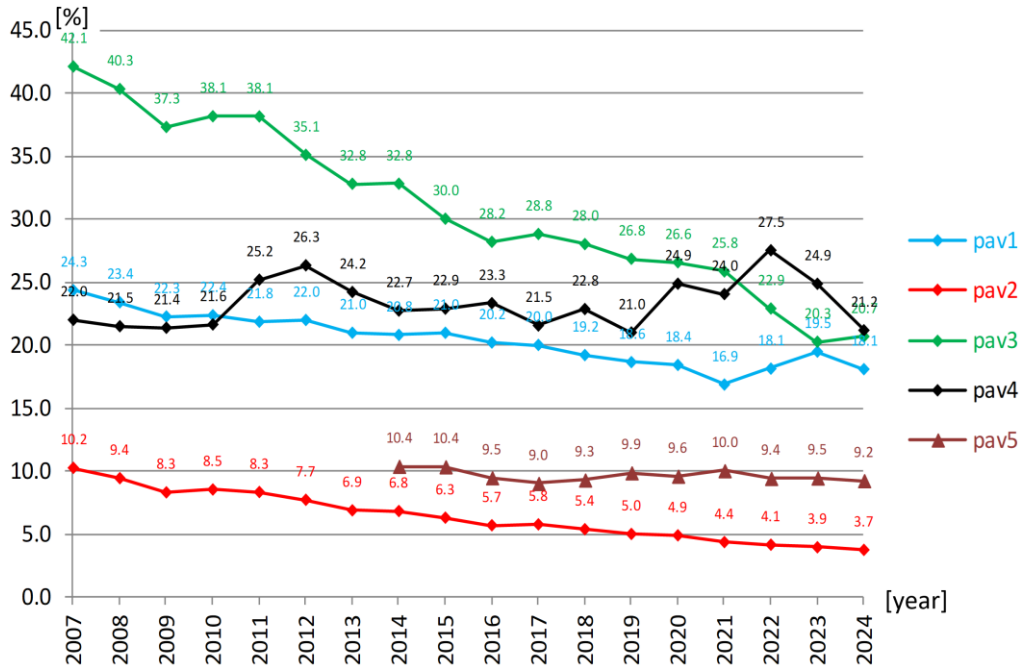

Fig. 16. The percentage of victims in road accidents in Poland from 2007 to 2024 in selected groups of road traffic participants [%]

Designations as in Table 1. Source: own study based on [21].

Table 15. The percentage of victims, out of the total number of victims in accidents caused by pedestrians, by cause of accident [%]

Year	Variable							
	s1v1	s1v2	s1v3	s1v4	s1v5	s1v6	s1v7	s1v8
2007	57.55	10.96	11.90	8.13	5.86	4.88	0.72	
2008	57.42	11.28	12.20	8.26	5.32	4.74	0.77	
2009	58.94	11.07	11.76	8.19	6.10	5.05	0.87	
2010	57.12	11.71	10.87	7.92	6.43	5.19	0.75	
2011	57.18	10.93	11.25	9.08	5.61	5.34	0.60	
2012	55.27	11.58	11.85	8.30	6.51	5.57	0.92	
2013	56.07	10.89	11.07	9.14	7.27	4.79	0.77	
2014	55.74	11.63	10.61	8.78	6.76	5.71	0.77	
2015	55.88	10.08	11.05	8.18	7.14	5.80	0.89	0.97
2016	51.73	11.20	11.12	9.51	5.98	4.70	0.56	5.22
2017	49.61	11.12	12.15	10.38	5.62	4.55	0.62	5.95
2018	48.75	11.38	12.26	9.85	5.97	4.76	0.51	6.52
2019	50.10	10.73	11.46	8.28	6.25	5.52	0.52	7.14
2020	50.64	9.25	11.37	9.82	7.84	5.23	0.42	5.44
2021	50.88	11.86	11.22	8.65	7.13	5.13	0.32	4.81
2022	49.41	12.94	10.23	8.87	7.24	6.97	0.18	4.16
2023	51.66	10.43	10.82	9.55	7.80	5.65	0.58	3.51
2024	46.74	10.93	13.94	12.54	5.82	6.82	0.20	3.01
A	81.21	99.72	117.17	154.28	99.32	139.80	27.73	
min	46.74	9.25	10.23	7.92	5.32	4.55	0.18	0.97
max	58.94	12.94	13.94	12.54	7.84	6.97	0.92	7.14
B	-1.22	-0.02	0.94	2.58	-0.04	1.99	-7.27	

A - ratio of the 2007 value to the 2024 value in [%], B - average dynamics of change from 2007 to 2024 in [%], other designations as in Table 1. Source: own study based on [21].

Table 16. The percentage of victims, out of the total number of victims in accidents caused by intoxicated pedestrians, by cause of accident [%]

Year	Variable							
	s2v1	s2v2	s2v3	s2v4	s2v5	s2v6	s2v7	s2v8
2007	58.93	4.77	11.73	5.61	10.06	7.54	1.35	
2008	59.28	4.97	13.45	5.34	8.85	7.02	1.10	
2009	57.95	4.19	12.56	5.40	11.35	7.16	1.40	
2010	56.00	5.44	11.69	6.67	10.26	8.72	1.23	
2011	59.06	4.17	11.19	7.90	8.70	7.90	1.07	
2012	55.89	5.09	12.57	5.99	10.68	8.68	1.10	
2013	55.39	4.94	10.27	6.59	13.94	8.24	0.63	
2014	57.69	3.95	11.71	6.06	10.44	8.89	1.27	
2015	57.56	4.72	9.43	6.02	12.36	7.32	1.30	1.30
2016	53.87	3.96	9.98	6.20	9.98	8.09	0.69	7.23
2017	52.00	4.76	14.10	7.24	5.90	6.67	0.95	8.38
2018	48.99	4.66	9.92	7.49	11.13	9.31	0.61	7.89
2019	50.62	4.47	8.44	6.20	12.90	9.18	0.00	8.19
2020	51.42	3.41	12.22	5.97	11.93	9.66	0.00	5.40
2021	55.00	4.67	13.33	4.67	10.00	8.00	0.00	4.33
2022	53.29	2.30	9.54	7.89	10.20	10.86	0.00	5.92
2023	49.02	3.92	11.76	7.84	12.16	10.20	0.00	5.10
2024	40.28	2.37	17.54	11.85	11.85	13.27	0.00	2.84
A	68.36	49.67	149.44	211.23	117.80	175.91	0.00	
min	40.28	2.30	8.44	4.67	5.90	6.67	0.00	1.30
max	59.28	5.44	17.54	11.85	13.94	13.27	1.40	8.38
B	-2.21	-4.03	2.39	4.50	0.97	3.38	-100.00	

A - ratio of the 2007 value to the 2024 value in [%], B - average dynamics of change from 2007 to 2024 in [%], other designations as in Table 1. Source: own study based on [21].

The main cause of accidents caused by pedestrians is careless entry onto the roadway in front of a moving vehicle. Accident victims from this cause (s1v1, Fig. 17, Tab. 15) account for between 47% and 59% of all pedestrian victims. The s1v1 indicator shows a downward trend. In general, it can be considered to be in line with the s1a1 accident percentage (p-value of the t-statistic is 0.134, two-sided hypothesis). The situation is analogous for the s1v4-s1v7 indicators (p-value is 0.186, 0.547, 0.119 and 0.062, respectively, for s1v2 and s1v3 the p-value of the t-statistic is 0.0358 and 0.0218). "Stopping, backing up" (s1v7) as a cause of accidents has negligible significance. The percentage of accident victims caused by this cause does not exceed 1%. The distribution of percentages is variable over time. Only for s1v3 and s1v7 can they be taken as constants (the p-value of the chi-square test is 0.229 and 0.151, for the s1v6 indicator is 0.043).

The situation is similar for victims of accidents caused by pedestrians intoxicated (Fig. 17, Tab. 16). The distribution is similar to the distribution of causes of accidents. The question of variability over time depends on the level of significance adopted (p-value for the chi-square test is 0.0368). For s2v5, s2v6 and s2v7, the constancy of the indicators can be assumed (p-value for the chi-square test is 0.175, 0.06 and 0.052, respectively). For s2v2 and s2v3, the p-value is 0.014 and 0.028.

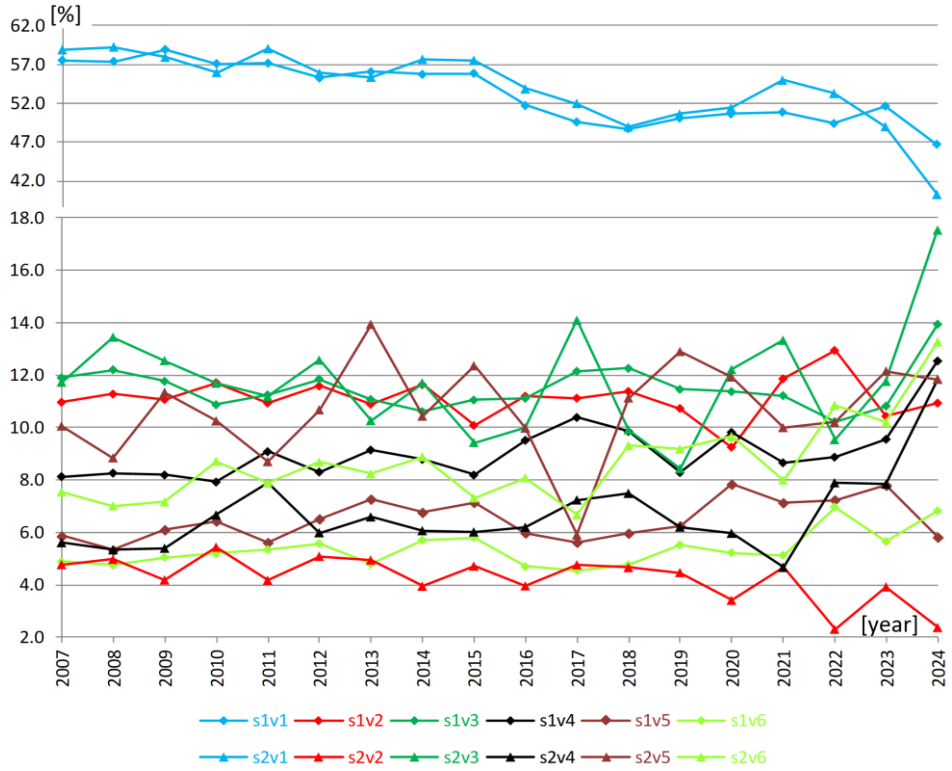

Fig. 17. The percentage of i victims, out of the total number of victims in accidents caused by pedestrians and by intoxicated pedestrians, by the cause of the accident [%]

Designations as in Table 1. Source: own study based on [21].

Of the 7 age groups of pedestrian accident victims, significant contributions are observed for 6 groups (Fig. 18, Tab. 17). The highest values are taken by the pv60+ indicator showing a clear upward trend (the average annual growth rate is 1.691%). The percentage of the 0-6 age group ranges from 2% to 3%. The distribution of percentages is variable over time both considered together for all groups and for each age group separately (p-value for the chi-square test below 10-5, for pv0-6 is 0.004). The situation is different if we consider the population size of a given age group. Using the indicator of the number of victims per 10,000 population, the highest values are observed for the age group 15-17 years, over 59 years, 7-14 years and 18-24 years.

Table 17. The percentage of victims by age in the total number of pedestrian victims in traffic accidents [%]

Year	Variable							
	pv0-6	pv7-14	pv15-17	pv18-24	pv25-39	pv40-59	pv60+	pvbd
2014	2.86	10.01	5.59	10.27	15.55	23.70	31.75	0.27
2015	2.42	9.68	5.08	8.97	16.63	24.25	32.80	0.17
2016	2.31	9.32	5.03	9.40	16.74	23.35	33.80	0.05
2017	2.45	8.32	4.79	9.07	15.80	23.87	35.20	0.51
2018	2.56	8.94	4.99	8.34	15.72	22.13	37.13	0.18
2019	2.00	8.30	5.35	8.01	15.33	22.77	37.82	0.41
2020	2.04	6.96	4.28	7.43	15.83	26.62	36.56	0.28
2021	2.90	9.40	4.62	6.40	16.29	24.55	35.77	0.08
2022	2.05	9.20	5.68	7.46	14.71	23.58	37.27	0.06
2023	2.35	8.84	6.81	7.38	13.40	24.69	36.44	0.08
2024	2.24	8.63	6.14	7.61	14.43	23.26	37.55	0.15
A	78.33	86.20	109.76	74.10	92.83	98.15	118.25	53.11
min	2.00	6.96	4.28	6.40	13.40	22.13	31.75	0.05
max	2.90	10.01	6.81	10.27	16.74	26.62	37.82	0.51
B	-2.41	-1.47	0.94	-2.95	-0.74	-0.19	1.69	-6.13

A - ratio of the 2007 value to the 2024 value in [%], B - average dynamics of change from 2007 to 2024 in [%], other designations as in Table 1.
Source: own study based on [21].

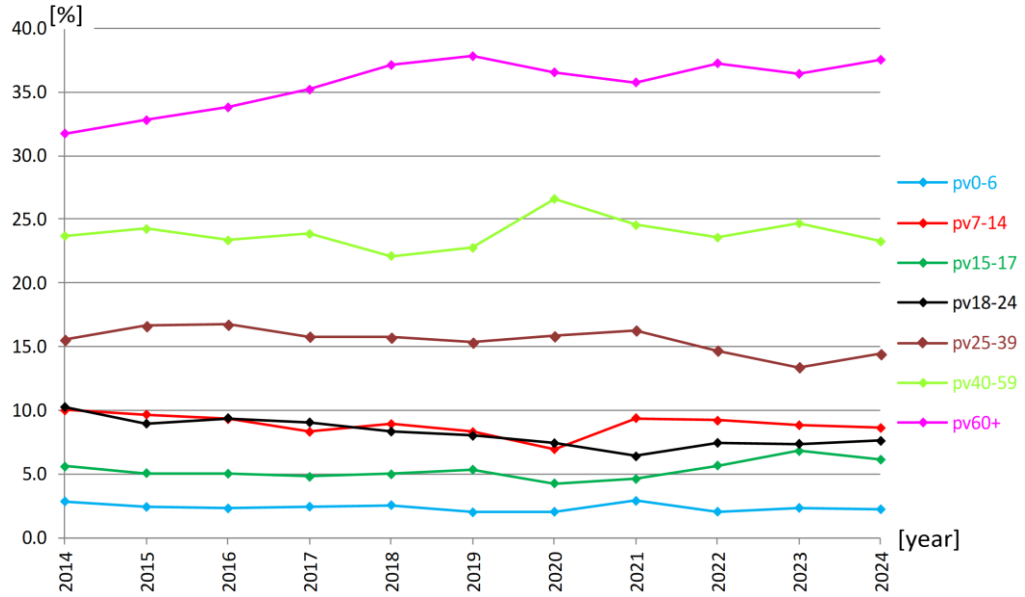

Fig. 18. The percentage of victims by age in the total number of pedestrian of victims in traffic accidents [%]
Designations as in Table 1. Source: own study based on [21].

Pedestrian perpetrators over the age of 59 and aged 40-59 cause accidents (Fig. 19, Tab. 18), in which 19% to 50% of all pedestrian-caused victims are injured and killed (total from 46% to 56%, the percentage is increasing, with the percentage increasing for the over 59% group, decreasing for the 40-59 group). The percentages of the 0-6, 15-17 and 18-24 age groups (ppv0-6, ppv15-17, 18-24) are on the order of 3-10.5% (total from 12.5% to 20% with a decreasing trend). The distribution of percentages is variable over time both considered together for all groups and for each age group separately (p-value for the chi-square test less than 10^{-9}). For ppv0-6 and ppv15-17, the p-value is 0.023.

Table 18. The percentage of victims, in the total number of victims in accidents caused by pedestrians, by age of the perpetrator [%]

Year	Variable							
	ppv0-6	ppv7-14	ppv15-17	ppv18-24	ppv25-39	ppv40-59	ppv60+	ppvbd
2007	4.30	15.30	4.82	9.79	15.33	29.36	19.34	1.76
2008	3.94	16.10	5.28	9.38	15.16	28.79	19.73	1.63
2009	4.19	16.04	5.48	9.35	14.69	27.81	20.75	1.70
2010	3.99	17.39	5.10	8.96	14.75	27.33	20.74	1.73
2011	4.43	14.96	5.30	10.15	17.04	26.74	19.63	1.74
2012	3.99	15.10	5.17	10.64	17.91	26.43	19.81	0.95
2013	5.00	14.69	5.46	9.51	14.85	27.21	21.26	2.02
2014	4.55	15.16	4.46	10.45	16.41	24.65	22.21	2.12
2015	3.87	13.43	4.72	8.97	18.56	26.49	22.28	1.67
2016	3.17	13.92	4.57	8.67	17.74	25.20	25.24	1.48
2017	3.98	12.72	3.98	8.04	17.19	25.85	25.85	2.38
2018	4.21	13.88	3.79	7.59	18.73	23.08	26.27	2.45
2019	3.28	10.63	5.00	7.76	17.76	25.68	26.56	3.33
2020	3.18	9.53	3.53	6.99	18.15	29.80	26.20	2.61
2021	5.21	14.58	4.25	5.85	16.67	28.37	22.84	2.24
2022	3.80	14.66	4.52	7.06	19.10	25.07	23.17	2.62
2023	3.22	12.18	5.17	6.34	15.79	25.44	28.46	3.41
2024	3.51	15.45	4.41	4.71	15.85	24.87	26.98	4.21
A	81.69	100.94	91.52	48.17	103.37	84.73	139.47	239.54
min	3.17	9.53	3.53	4.71	14.69	23.08	19.34	0.95
max	5.21	17.39	5.48	10.64	19.10	29.80	28.46	4.21
B	-1.18	0.05	-0.52	-4.21	0.20	-0.97	1.98	5.27

A - ratio of the 2007 value to the 2024 value in [%], B - average dynamics of change from 2007 to 2024 in [%], other designations as in Table 1.
Source: own study based on [21].

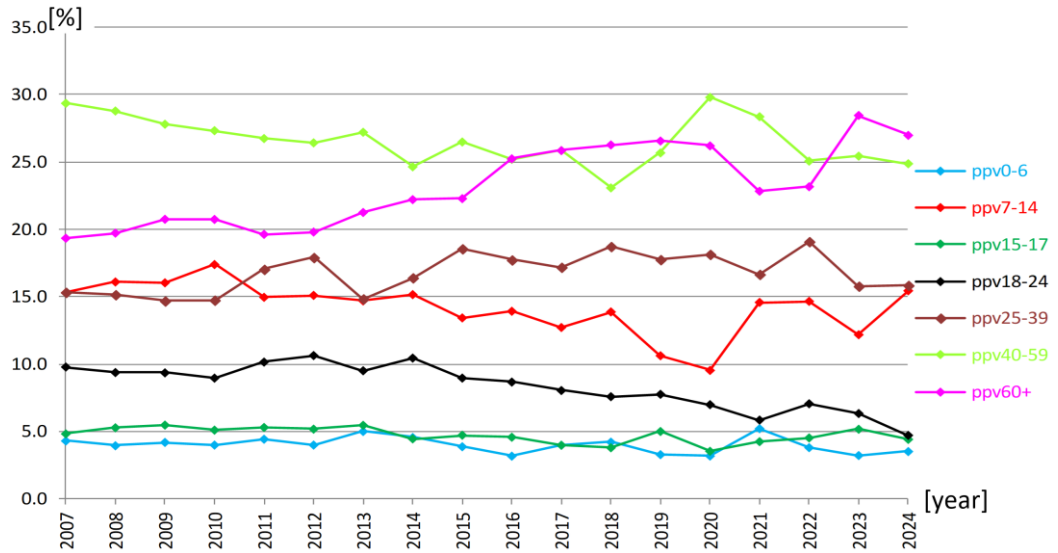

Fig. 19. The percentage of victims, in the total number of victims in accidents caused by pedestrians, by age of the perpetrator [%]

Designations as in Table 1. Source: own study based on [21].

For the considered quantities characterizing road accident victims, for lv3, lv4, pav1, pav2 and pav3 the trend models meet the adopted criteria (analogous to the number of accidents). The models are shown in Table 19.

Table 19. Selected trend models of victims in traffic accidents

variable/ indicator	model	a	b	c	R^2	adjusted R^2	MAD	SMAD	S-W test value	model significance
lv3(?)	logarithmic	-2253.568	7618.201	–	0.924	0.919	375.827	311.874	0.9791	10^{-14}
lv3(?)	parabolic	17.84843	-667.698	7313.446	0.982	0.980	189.100	140.802	0.9361	10^{-5}
lv4	parabolic	3.24813	-134.1015	1595.336	0.972	0.968	45.330	47.291	0.9177	0.00346
pav1(?)	linear	-0.003569	0.238268	–	0.884	0.877	0.00476	0.00474	0.9375	10^{-8}
pav2(?)	linear	-0.003654	0.098842	–	0.972	0.970	0.00259	0.00191	0.9712	10^{-13}
pav2	parabolic	0.000099	-0.005535	0.105113	0.987	0.985	0.00153	0.00155	0.9041	0.000742
pav3(?)	linear	-0.012255	0.424595	–	0.972	0.971	0.00842	0.00666	0.9428	10^{-13}

"?" – denotes indeterminacy of autocorrelation of the residuals, in other cases, no autocorrelation. Source: own study based on [21].

CONCLUSIONS

The number of road accidents and their victims in Poland is on a clear downward trend. Comparing 2007 with 2024, the number of accidents fell by nearly 56.5%, fatalities by 66%, injuries by more than 60% and victims by 61%. The rate of decrease in the number of victims is much higher than the rate of decrease in the number of accidents, but the indicator of the number of victims per 100 accidents only decreased by 10.5%. During the same period, the number of accidents involving pedestrians fell by more than 70%. The percentage of accidents involving pedestrians in the total number of road accidents ranges from 20.84% to 32.17%. In 2024, it was 68% of the 2007 percentage. About 90% of accidents involving pedestrians occur in built-up areas, and only about 10% in non-built-up areas. The perpetrators of accidents involving pedestrians from 20.4% to 43.4% are pedestrians themselves. This percentage is clearly declining, in 2024 it was 47.4% of the 2007 value. Unfortunately, more than a fifth of accidents caused by pedestrians are pedestrians intoxicated. The percentage of these accidents does not show a downward trend. The rate of decline in the number of accidents caused by pedestrians and drunk pedestrians is much greater than the rate of decline in the number of accidents and the number of accidents involving pedestrians. The implication is that pedestrians are increasingly victims of accidents caused by other road users.

The number of pedestrians killed in traffic accidents is steadily declining - down by more than 78%, and the percentage of pedestrians among accident fatalities is also declining. Unfortunately, it is always higher than the percentage of accidents. This means that, on average, more people die in accidents involving pedestrians than in a statistical accident. Between 43% and 57% of pedestrians killed were killed in accidents caused by pedestrians. This percentage is declining, and the percentage of pedestrians killed in accidents caused by pedestrians in the total number of fatalities is also declining. Between 31% and nearly 38% of fatalities occurred in the undeveloped area. This percentage is several times higher than the accident percentage of about 9%. This indicates that the statistical impact of a pedestrian accident in an non-built-up area is much more serious than in a built-up area. More than 15% of pedestrian fatalities in accidents caused by pedestrians are victims of accidents caused by drunk pedestrians.

The number of injured pedestrians and the percentage of pedestrians among those injured in traffic accidents are decreasing. The decrease was 79% and 24%, respectively. The vast majority of pedestrians were injured in accidents in built-up areas. In non-built-up areas, the figure is between 6.2% and 7.6%. Pedestrians are increasingly less of the perpetrators of accidents involving injured pedestrians. Although the number of injured pedestrians in accidents caused by pedestrians intoxicated is steadily declining – a reduction of nearly 87%, the percentage does not show such properties. It is always higher than the percentage of accidents caused by pedestrians intoxicated. This is further evidence in support of the thesis that alcohol significantly contributes to the consequences (severity) of traffic accidents.

The number of lv1 accident victims is the sum of fatalities and injuries. As both are decreasing (albeit with different dynamics), the number of accident victims is also decreasing. Between 2007 and 2025, it decreased

by more than 61% – more than the number of accidents. This means a reduction in the impact of a statistical traffic accident, as measured by the number of victims per 100 accidents. The number of pedestrian victims is falling even faster. The decrease was more than 71%. The percentage of pedestrian victims in the total number of accident victims has also fallen. Between 9% and 10.5% of victims were injured in an non-built-up area. This percentage is declining slightly. More than 20% of pedestrian victims, are victims in accidents caused by pedestrians (the victim is also the perpetrator). This proportion is decreasing. Unfortunately, the percentage of victims of accidents caused by pedestrians intoxicated in the total number of victims of accidents caused by pedestrians remains high (from 21% to 27.5%).

The main cause of accidents caused by pedestrians is careless entry onto the roadway in front of a moving vehicle. It accounts for 46% to 58% of all accidents caused by pedestrians and 39% to 59% of accidents caused by pedestrians intoxicated. The percentage is on a clear downward trend. "Stopping, backing up" as a cause of accidents caused by pedestrians, including those intoxicated, no longer occurs in practice.

Nearly 50% of accidents are caused by pedestrians over the age of 49, with an increasing percentage of older people – over 60. However, considering the population of people of a given age, the relative number of accidents is highest among the youngest 7-17 years old. Also, the relative number of victims and injured victims is highest in this age group – a statistical member of this group of traffic participants causes the highest number of victims. However, for fatalities, the highest is in the 60+ age group.

Residents over the age of 59 make up the largest group of pedestrian victims (both injured and killed) of traffic accidents. Together with the 40-59 age group, they account for about 60% of all pedestrian victims. However, the relative number of victims and injured victims is highest in the 15-17 age group - nearly double that of the 60+ group. For fatalities, it is highest in the 60+ group.

For the number of accidents caused by pedestrians and pedestrians intoxicated and the number of victims, injured victims and fatalities, there are well-fitting trend models that meet all the accepted criteria. For the other considered subgroups of traffic participants, only for some parameters there are trend models that meet all criteria. However, in many cases, the criterion that is not met is the lack of autocorrelation of the residuals. In this case, you can perform a procedure to remove the autocorrelation of the random component and re-estimate the parameters of the linear regression model and check whether the adopted criteria are met.

In summary, the analyses show that:

- the rate of decline in the number of fatalities is significantly lower than that of accidents and accident victims,
- one-fifth of accidents caused by pedestrians are caused by pedestrians themselves, and this percentage is not decreasing,
- accidents involving pedestrians have more serious consequences than statistical accidents (measured by the number of fatalities), especially accidents in non-built-up areas,
- approximately 50% of pedestrians died in accidents caused by pedestrians,
- the percentage of accidents caused by pedestrians under the influence of alcohol remains consistently high,
- the structure of road users is changing, and with it the structure of accident victims and the causes of accidents; new categories are emerging, while others are becoming negligible.

Pedestrian safety requires a comprehensive approach – combining legal, engineering, educational, and technological measures. Reducing the number of victims, especially pedestrians, of road accidents is possible through:

- changing the law, which must go hand in hand with effective enforcement and education, in particular standardizing regulations concerning bicycle traffic, electric scooters, and other personal and mobility-assistive devices,
- expanding infrastructure, including:
  - separating pedestrian and bicycle traffic,
  - expanding bicycle infrastructure while maintaining the continuity of routes,
  - improving safety at crossings, including crossings on bicycle paths,
  - integrating pedestrians with public transport,
  - improving signage and visibility in areas where car and bicycle traffic collides with pedestrian traffic,
  - taking into account the specific needs of users (children, seniors),
- use of advanced safety systems in vehicles and infrastructure elements,
- promotion of intelligent traffic control and management systems.

BEZPIECZEŃSTWO PIESZYCH W RUCHU DROGOWYM W POLSCE 2007-2024

W artykule dokonano, na podstawie danych KG Policji, analizy zmian bezpieczeństwa pieszych w ruchu drogowym w Polsce w latach 2007-2024. Analizowano zmiany w liczbie wypadków i poszkodowanych w wypadkach z udziałem pieszych i wypadkach spowodowanych przez pieszych. Analizowano wpływ spożycia alkoholu na bezpieczeństwo pieszych, zmiany przyczyn wypadków spowodowanych przez pieszych, struktury wiekowej poszkodowanych w wypadkach i pieszych sprawców wypadków. Sytuację pieszych przedstawiono na tle ogólnej sytuacji w ruchu drogowym. Udział pieszych wśród ofiar śmiertelnych i rannych wypadków systematycznie maleje choć jest on zawsze wyższy niż udział wypadków. Piesi w coraz mniejszym stopniu są sprawcami wypadków, w których są ofiarami. Na wysokim poziomie utrzymuje się udział ofiar wypadków spowodowanych przez pieszych pod wpływem alkoholu w ogólnej liczbie ofiar wypadków spowodowanych przez pieszych. Ulega zmianie struktura wiekowa ofiar pieszych i pieszych sprawców wypadków. Badano wybrane modele trendu różnych wskaźników charakteryzujących bezpieczeństwo w ruchu drogowym. Stwierdzono, że dla liczby wypadków spowodowanych przez pieszych i pieszych pod wpływem alkoholu oraz liczby poszkodowanych, ofiar rannych i ofiar śmiertelnych istnieją dobrze dopasowane modele trendu. W przypadku innych rozpatrywanych podgrup uczestników ruchu drogowego, tylko dla niektórych wskaźników istnieją modele trendu spełniające wszystkie przyjęte kryteria.

Słowa kluczowe: bezpieczeństwo w ruchu drogowym, wypadek drogowy, ofiara wypadku drogowego, pieszy w ruchu drogowym, pieszy pod wpływem alkoholu w ruchu drogowym.

REFERENCES

[1] European Commission. (2025). Annual statistical report on road safety in the EU, 2025. European Road Safety Observatory. Brussels, European Commission, Directorate General for Transport.
[2] https://transport.ec.europa.eu/news-events/news/eu-road-fatalities-drop-3-2024-progress-remains-slow-2025-03-18_en
[3] https://road-safety.transport.ec.europa.eu/european-road-safety-observatory/statistics-and-analysis-archive/hazardous-behaviourpost-impact-care_en
[4] https://road-safety.transport.ec.europa.eu/european-road-safety-observatory/statistics-and-analysis-archive/esafety/alcohol-interlocks_en
[5] Høye A. K., Hesjevoll I.S. (2023). Alcohol and driving-How bad is the combination? A meta-analysis. *Traffic Inj Prev*. 24(5), 373-378. https://doi.org/10.1080/15389588.2023.2204984.
[6] Compton R.P., Blomberg R.D., Moskowitz H., et al. (2002). Crash rate of alcohol impaired driving. Proceedings of the sixteenth *International Conference on Alcohol. Drugs and Traffic Safety* ICADTS, Montreal.
[7] Compton R.P., Blomberg R.D. (2015). Drug and Alcohol Crash Risk. HTSA'S Office of Behavioral Safety Research. https://www.researchgate.net/publication/240629941_Crash_Risk_of_Alcohol_Impaired_Driving.
[8] Isalberti C., Van der Linden T., Legrand S.-A., et al. (2011). Prevalence of alcohol and other psychoactive substances in injured and killed drivers. DRUID Driving under the Influence of Drugs, *Alcohol and Medicines*.
[9] Głąbicka-Auleytner K. (2023). Road safety and alcohol consumption by drivers. Journal of civil engineering and transport. 5(4), 9-14, ISSN 2658-1698, e-ISSN 2658-2120, https://doi.org/10.24136/tren.2023.013.
[10] Alsop R. (2020). Drink Driving as the Commonest Drug Driving—A Perspective from Europe. *IJERPH*, 17(24), 9521; https://doi.org/10.3390/ijerph17249521.
[11] Francesconi M., James J. (2021). None for the Road? Stricter Drink Driving Laws and Road Accidents, *Journal of Health Economics*. 79, 102487. https://doi.org/10.1016/ j.jhealeco.2021.102487
[12] Rozporządzenie Prezesa Rady Ministrów z dnia 30 grudnia 2021 r. zmieniające rozporządzenie w sprawie wysokości grzywien nakładanych w drodze mandatów karnych za wybrane rodzaje wykroczeń (Prime Minister's Decree of December 30, 2021 amending the Decree on the amount of fines imposed by way of criminal fines for selected types of offenses). *DzU z 2021 poz. 2484*.
[13] Rozporządzenie Ministra Spraw Wewnętrznych i Administracji z dnia 15 września 2022 r. w sprawie ewidencji kierujących pojazdami naruszających przepisy ruchu drogowego (Decree of the Minister of Internal Affairs and Administration of September 15, 2022, on records of vehicle drivers violating traffic regulations). *DzU z 2022 r., poz. 1951*.
[14] Ustawa z dnia 7 lipca 2022 r. o zmianie ustawy – Kodeks karny oraz niektórych innych ustaw (Law of July 7, 2022, amending the Criminal Code and certain other laws). *DzU 2022 poz. 2600*.
[15] Dąbrowska-Lorenc M., Sicińska K.(2021). Survey of pedestrians and car drivers' attitudes at the area of pedestrian crossings over period of time. *Transport Problems*. 16(4). DOI: 10.21307/tp-2021-060.
[16] Xin X., Jia N., Ling S., He Z. (2023). The effect of the 'yield to pedestrians' policy on risky pedestrian behaviors: Is it a 'two-edged sword'?, *Transportation Research Part A: Policy and Practice*. 178, https://doi.org/10.1016/j.tra.2023.103870.
[17] Szagala P., Brzezinski A., Kiec M., et al. (2022). Pedestrian Safety at Midblock Crossings on Dual Carriageway Roads in Polish Cities. Sustainability, *MDPI*, 14(9), 1-13. RePEc:gam: jsusta:v:14:y:2022:i:9:p:5703-:d:811299.

[18] Dębowska-Mróz M., Ferensztajn-Galardos E., Krajewska R., Rogowski A., Methods for Safety Assessment of Unprotected Road Traffic Users. *Transport Means 2018*, Proceedings of the 22nd International Scientific Conference Part I, 57-65, ISSN 1822-296 X (print) ISSN 2351-7034 (on-line).
[19] European Commission. (2021). Road safety thematic report – Pedestrians. European Road Safety Observatory. Brussels, *European Commission*, *Directorate General for Transport*.
[20] Gua X., et al. (2023). Rethinking infrastructure design: evaluating pedestrians and VRUs' psychophysiological and behavioral responses to different roadway designs. *Scientific Reports*. 13, 4278. https://doi.org/10.1038/s41598-023-31041-9
[21] https://statystyka.policja.pl/st/ruch-drogowy/76562,wypadki-drogowe-raporty-roczne.html.
[22] Rogowski A. (2025). Influence of alcohol on road safety in Poland 2007-2023. *Journal of civil engineering and transport*. 7(2), 107-131, ISSN 2658-1698, e - ISSN 2658-2120, DOI: 10.24136/tren. 2025.008.
[23] Rogowski A. (2012). Podstawy metod probabilistycznych w transporcie (The Basics of Probabilistic Methods in Transport), *Monographs series*, *175*, Publishing House of the University of Technology and Humanities, Radom. ISSN 1642-5278.
[24] Savin N.E., White K.J. (1977). The Durbin-Watson Test for Serial Correlation with Extreme Sample Sizes or Many Regressors. *Econometrica*,45, 1989-1996.