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ANALYSIS OF THE LOCAL ACCIDENT HAZARD IN INDIVIDUAL REGIONS OF POLAND

ANALIZA LOKALNEGO ZAGROŻENIA WYPADKOWEGO W POSZCZEGÓLNYCH REGIONACH KRAJU

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Summary

The analysis of road accident data was carried out to explore the impact of local factors on the values of accident hazard indicators and to identify some reasons for the territorial diversity in the accident hazard observed in various regions of Poland. In particular, the objective of this work was to find the causative factors and the reasons for the occurrence of excessive numbers of road accidents in some regions and to show the possible ways of reducing this hazard. Within this study, the impact of the demographic factor and of the diversity in road infrastructure and in the numbers of vehicles in specific regions was examined.

Based on a relevant and adequate dataset collected, the values of several characteristic indicators were calculated and variations in these data recorded in the years 2010-2016 were shown. The relations between this hazard and the population size, total road length, and total number of vehicles in individual regions were assessed. The territorial distribution of this hazard in Poland was shown, with using special indicators that made it possible to eliminate to a considerable extent

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the significant influence of the region size on the result of assessment of the accident hazard. The calculation results became a basis for establishing a multidimensional space of hazard indicators in which consideration is given to diverse features of individual regions. This made it possible to select the regions for which the values of the accident hazard indicators were particularly high and low.

Keywords: road accidents, road traffic safety, accident hazard indicators, density of accidents

Streszczenie

Prowadzona analiza danych o wypadkach drogowych ma na celu rozpoznanie wpływu czynników lokalnych na wartości wskaźników zagrożenia wypadkowego i wskazanie niektórych przyczyn występowania zróżnicowania terytorialnego zagrożenia wypadkowego między regionami naszego kraju. Poszukuje się czynników sprawczych oraz przyczyn występowania nadmiernej liczby wypadków drogowych w niektórych regionach, aby na tej podstawie wskazać możliwości redukcji tego zagrożenia. Rozważono wpływ czynników demograficznego, zróżnicowania infrastruktury drogowej i liczby pojazdów w regionach.

Po zgromadzeniu odpowiednich danych obliczono wartości kilku charakterystycznych wskaźników oraz pokazano ich zmienność w latach 2010-16. Dokonano oceny powiązania tego zagrożenia z liczbą mieszkańców, długością dróg i liczbą pojazdów w regionie. Pokazano terytorialny rozkład tego zagrożenia w Polsce przy wykorzystaniu wskaźników, które w znacznym stopniu umożliwiły wyeliminowanie istotnego wpływu wielkości regionu na rezultat oceny tego zagrożenia. Wyniki obliczeń stały się podstawą do utworzenia wielowymiarowej przestrzeni wskaźników zagrożenia, które uwzględniają zróżnicowane cechy poszczególnych regionów. To umożliwiło wskazanie regionów z wysokimi i niskimi wartościami wskaźników zagrożenia wypadkowego.

Słowa kluczowe: wypadki drogowe, bezpieczeństwo ruchu drogowego, wskaźniki zagrożenia wypadkowego, gęstość wypadków

1. Introduction

The very high number of road accidents occurring in Poland shows the need to identify the regions with the highest values of the indicators of accident hazard to the local population and the local factors that may have a considerable impact on the regional level of this hazard. The reasons for the regional diversity in the number of accidents are said to include the factors related to such issues as the level of economic and social development and the existing road infrastructure, according to publications [2, 4, 10]. The possibility of such an interrelation has been indicated in [7], where calculations made for the data of 2012 have revealed that the highest numbers of accidents per 1 000 vehicles were recorded in Mazowieckie, Łódzkie, and Małopolskie Voivodships, i.e. in the regions with the largest populations and with a dense road network. However, a more detailed approach to the distribution of road accidents [6] has shown that differences exist between the territorial distribution of the numbers of accidents and the nationwide average density of accidents in Poland. In [11], the state of road traffic safety in individual voivodships in the years 2010-2013 was analysed as being simultaneously affected by the seasonality of variations in the number of accidents and by the diversity in the proportions of intoxicated drivers in all the vehicle drivers participating in the road traffic.

This paper has been prepared with taking into account demographic factors and diversity in road infrastructure and in the numbers of vehicles in specific regions. These factors may affect not only the number of accidents but also the unit accident costs specified by regions [1, 4, 5].

In the analysis, the following several relative measures of accident hazard were considered:

- demographic indicator;
- density of accidents;
- vehicle accident rate.

They are interpreted as defining the interrelations between the number of accidents and the population size, density of road network, and number of motor vehicles in a specific region. These factors vary with different nationwide rates, as shown in Fig. 1.

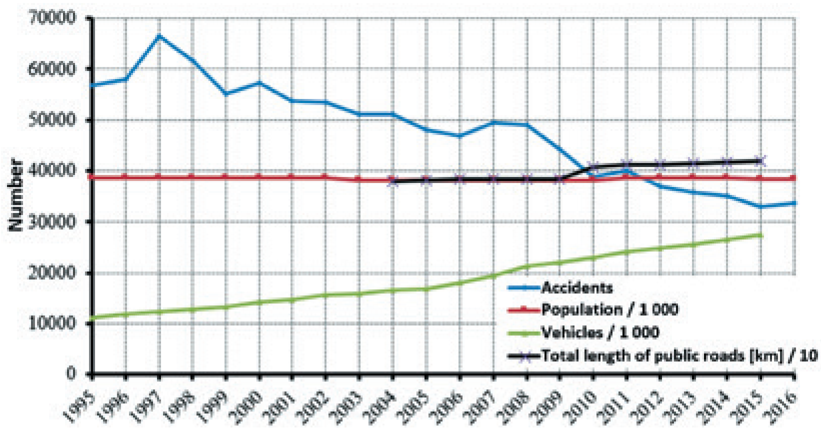


Fig. 1. Time histories of changes in the values of characteristic factors of the accident hazard in Poland

The changes in the regional accident hazard were analysed against the background of the general process of decline in the nationwide number of accidents. This means that the calculated indicator values were compared with the corresponding nationwide figures, which are treated here as the average values of the hazard level. Moreover, the regions were searched where the indicators took the Poland's highest and lowest values. The major changes in the indicator values were considered in medium-term (2010-2016) and short-term (2010-2012 and 2014-2016) time intervals for Poland as a whole and for individual regions, with each region being understood as the territory of an individual voivodship (province). The data obtained for the two short time intervals were treated as the initial and final states in the analysis. The medium-term changes were described by the values of slope of the regression line determined for the numbers of accidents recorded in monthly steps for seven years.

The data collected were analysed to identify and evaluate the relation between the values of local factors and the presence of diversity in the accident hazard observed in various regions of our country. Details about the accidents, used as input data for the analysis, were obtained from the General Headquarter of Police. In consideration of wide diversity of the regions in terms of their area, population size, and road network, the core part of the analysis was based on the values of relative and standardized indicators so devised that they significantly reduce the impact of these factors.

2. Indicators calculated

Based on numerical data about the distribution of road accidents among individual regions, values of the following indicators were calculated:

- demographic indicator, i.e. the number of road accidents per 100 000 people of the population of the j^{th} region:

$$W_{Dj} = \frac{W_j}{0.00001\, L_j}\;; \tag{1}$$

- density of accidents, i.e. the number of accidents per 100 km of public roads:

$$W_{Rj} = \frac{W_j}{0.01\, R_j}\;; \tag{2}$$

- vehicle accident rate, i.e. the number of accidents per 100 000 motor vehicles:

$$W_{Vj} = \frac{W_j}{0.00001\, V_j}\,. \tag{3}$$

The symbols used here have the following meaning:

j – a number to identify the j^{th} region of the country, $j = 1, 2, ..., n$;
R_j – total length of public roads in the j^{th} region;
V_j – total number of motor vehicles in the j^{th} region;
W_j – total number of road accidents in the j^{th} region;
L_j – population size of the j^{th} region.

In the analysis, some indicators were taken into account in the form of their measures [12], e.g.:

- slope a_{Pj} of the regression line, which shows the rates of changes in the number of accidents in the years 2010-2016 (expressed in percentage terms relative to the initial figure taken for the analysis);

$$y_j = a_{Pj}x + b_j \tag{4}$$

where: y – number of road accidents, in percentage terms, relative to the initial figure taken for the analysis [8];

x – independent variable in the regression function; its example values are laid off on the axes of abscissae in the graphs in Fig. 1;

– average values of indicators W_D, W_R, and W_V; calculated for periods 2010-2012 and 2014-2016, they are denoted by subscripts "10" and "14", respectively (e.g. W_{D10} and W_{D14});

– yearly average change in the value of an indicator W_j (i.e. ΔW_j) in the period 2010-2016 relative to the initial figure.

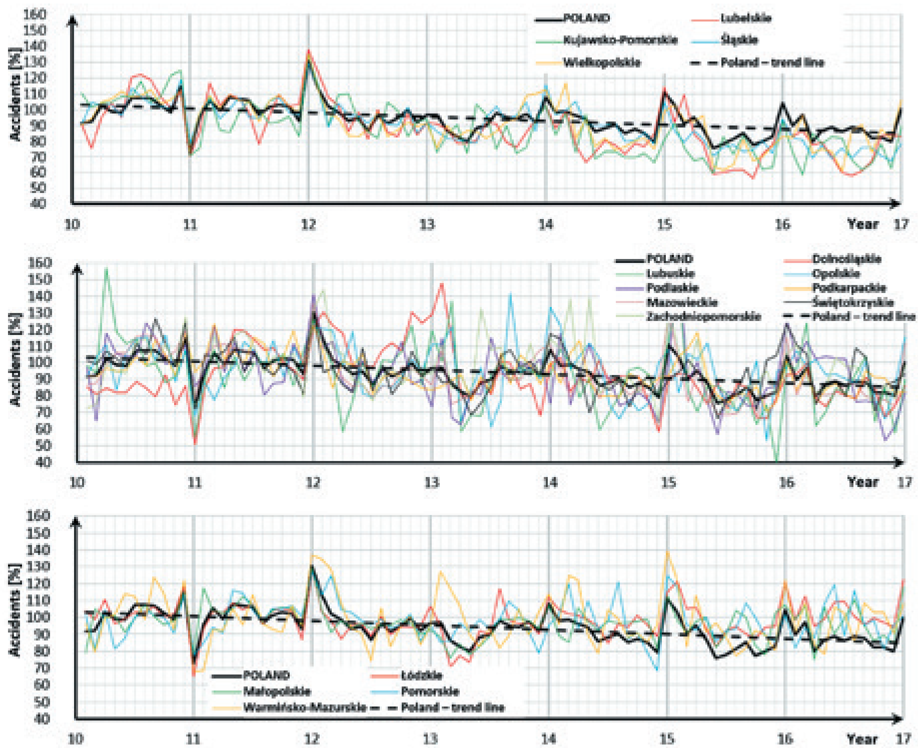


Fig. 2. Time histories of the numbers of accidents, in percentage terms

3. Demographic indicator (W_D)

The calculation results gathered in Table 1 show the relation between the course of changes in the number of accidents (represented by a_{Pj}) and the values of indicator W_D in the years 2010-2016. Negative values ($a_{Pj} < 0$) of the slope of the medium-term regression line predominate, indicating a favourable decline in the numbers of accidents in 15 regions (except for Łódzkie Voivodship). The values characterizing the initial state of indicator W_{D10} were calculated as the average values for the period 2010-2012. For the years 2010-2016, a decrease in the demographic indicator values (negative ΔW_D values) was observed in all the regions of Poland.

Table 1. Values of regression line slope a_{Pj}, indicators W_{D10} and W_{D14}, and ΔW_D

Region (Voivodship)	Slope a_{Pj} of the regression line of the percentage number of accidents in 2010-2016	Average W_{D10} value, initial	Average W_{D14} value, final	Yearly average percentage change ΔW_D relative to the initial value [%]
Poland	−2.64	100.5	88.2	−3.05
Dolnośląskie	−2.58	97.4	81.0	−4.20
Kujawsko-Pomorskie	−5.71	66.0	49.3	−6.34
Lubelskie	−5.23	81.1	61.1	−6.15
Lubuskie	−3.71	80.6	66.8	−4.30
Łódzkie	0.01	164.0	163.3	−0.11
Małopolskie	−0.85	121.8	115.8	−1.23
Mazowieckie	−3.5	92.5	77.6	−4.01
Opolskie	−1.97	81.9	73.6	−2.53
Podkarpackie	−2.9	92.2	80.5	−3.15
Podlaskie	−2.89	67.9	58.2	−3.57
Pomorskie	−0.4	121.3	117.6	−0.78
Śląskie	−4.65	106.9	87.0	−4.66
Świętokrzyskie	−2.19	118.1	106.4	−2.46
Warmińsko-Mazurskie	−0.72	114.9	111.4	−0.77
Wielkopolskie	−4.16	81.7	66.2	−4.74
Zachodnio-pomorskie	−1.88	86.1	78.8	−2.10

In the period under consideration, there were four regions, i.e. Kujawsko-Pomorskie, Lubelskie, Śląskie, and Wielkopolskie Voivodships, where the highest rates of decrease in the number of accidents (from −4.16 % to −5.71 % a year) and the highest rates of the yearly average drop in the demographic indicator values (from −4.66 % to −6.34 %) were observed. At the same time, the initial values of indicator W_D in these regions (except for Śląskie Voivodship) were lower by more than 20 % than the nationwide average, which was 100.5. On the other hand, a great accident hazard to the local population, manifesting itself in an extremely high value of $W_D = 164.0$, was initially observed in Łódzkie Voivodship. Such ha value of this indicator exceeded the then nationwide value by more than 60 %.

Simultaneously, that region was the only one where no downward trend could be seen in the number of accidents (the slope of the regression line was $a_{Pj} > 0$) and the yearly average rate of decline in the demographic indicator was very low, amounting to –0.11 % a year, which was almost as little as 1/28 of the nationwide figure calculated for the years 2010-2016.

In the next step of the assessment of accident hazard to the population of a region, characteristic relations were sought between the number of accidents and the population size for individual regions. With this objective in view, four regions with the maximum (MAX) population size and another four regions characterized by the minimum (MIN) population size were selected. Similarly, four regions with the maximum (MAX) number of accidents and another four regions with the minimum (MIN) number of accidents were picked. In 2010-2012, as an example, the four most populated regions were Mazowieckie, Śląskie, Wielkopolskie, and Małopolskie Voivodships and those least populated were Lubuskie, Opolskie, Podlaskie, and Świętokrzyskie Voivodships [3]. As regards the regions with the highest and lowest numbers of accidents in the same years, the former group consisted of Mazowieckie, Śląskie, Łódzkie, and Małopolskie Voivodships and Lubuskie, Opolskie, Podlaskie, and Kujawsko-Pomorskie Voivodships were counted in the latter group [8]. Such a juxtaposition makes it possible to answer a question whether any connection exists between the population size and the number of accidents. Table 2 shows that three of four regions simultaneously met both of the criteria, i.e. MAX number of accidents with MAX population size or MIN number of accidents with MIN population size, in both time intervals under analysis.

Table 2. Regions with the MAX number of accidents and population size and with the MIN number of accidents and population size

Regions (Voivodships) meeting both MAX criteria in 2010-2012	**Regions (Voivodships) meeting both MAX criteria in 2014-2016**	**Regions (Voivodships) meeting both MIN criteria in 2010-2012**	**Regions (Voivodships) meeting both MIN criteria in 2014-2016**
Małopolskie; Mazowieckie; Śląskie	Małopolskie; Mazowieckie; Śląskie	Lubuskie; Opolskie; Podlaskie	Lubuskie; Opolskie; Podlaskie

A conclusion of this juxtaposition, clearly visible in Table 2, confirms the existence of a connection between the number of road accidents and the local population size. However, are the demographic indicator values for the regions grouped as above similar to each other, too? No, they are not, as the WD values determined for the same region groups are widely scattered. The spread of these values has been presented in Fig. 3 in the form of dark bars.

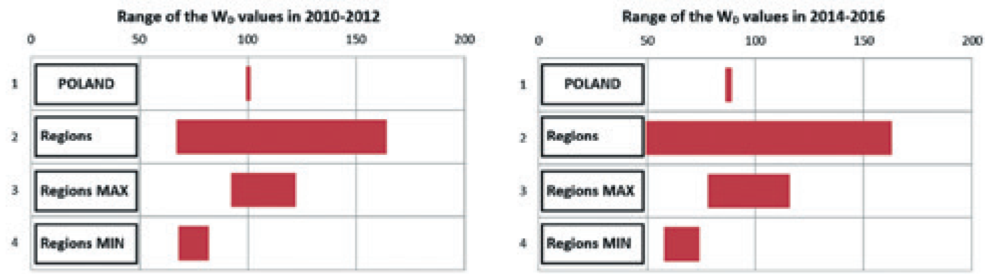


Fig. 3. Spread of the W_D indicator values in the initial and final period under analysis

4. Density of accidents (W_R)

Based on the calculation results brought together in Table 3, the relation between the number of accidents and the state of development of the road infrastructure in a specific region was analysed. This was done with using the W_R indicator and with comparing the values of W_{R10}, W_{R14}, and ΔW_R.

Table 3. Slope a_{Pj} of the regression line of the percentage number of accidents, indicator W_R, and yearly average changes ΔW_R in this indicator in individual regions

Region (Voivodship)	Slope a_{Pj} of the regression line of the percentage number of accidents in 2010-2016	Average W_{R10} value, initial	Average W_{R14} value, final	Yearly average percentage change ΔW_R relative to the initial value [%]
Poland	−2.64	9.4	8.1	−3.33
Dolnośląskie	−2.58	12.0	10.0	−4.19
Kujawsko-Pomorskie	−5.71	5.2	3.8	−6.53
Lubelskie	−5.23	5.1	3.7	−6.48
Lubuskie	−3.71	6.0	4.6	−6.04
Łódzkie	0.01	15.7	15.6	−0.16
Małopolskie	−0.85	13.5	13.0	−0.98
Mazowieckie	−3.5	9.2	7.8	−4.01
Opolskie	−1.97	7.3	6.7	−1.87
Podkarpackie	−2.9	10.4	8.3	−5.03
Podlaskie	−2.89	3.2	2.6	−4.40
Pomorskie	−0.4	12.4	11.7	−1.41
Śląskie	−4.65	18.6	15.5	−4.16
Świętokrzyskie	−2.19	8.8	7.8	−2.73
Warmińsko-Mazurskie	−0.72	7.2	7.0	−0.69
Wielkopolskie	−4.16	7.1	5.7	−4.86
Zachodnio-pomorskie	−1.88	7.8	6.9	−2.90

In 2010-2016, the density of accidents W_R favourably declined in all the regions of Poland. However, the rates of this decline were very diverse, from the best value of –6.53 % a year in Kujawsko-Pomorskie Voivodship to a very weak downward trend, at a rate of –0.16 % a year, in Łódzkie Voivodship. In the group of regions with the highest rates of decrease in the number of accidents (Kujawsko-Pomorskie, Lubelskie, Śląskie, and Wielkopolskie Voivodships), as selected previously, high ΔW_R values (from –4.16 % to –6.53 % a year) were also observed. However, there were only two regions in this group, namely Kujawsko-Pomorskie and Lubelskie Voivodships, where the highest rates of decline, represented by the a_{Pj} and ΔW_R values, were recorded (see Table 3). The very favourable trends in changes in the a_{Pj} and ΔW_R values as shown above insufficiently coincided with the regions where high WR values, indicating high road accident hazard, were recorded, i.e. Śląskie, Łódzkie, and Małopolskie Voivodships (the W_{R10} value ranged there from 13.5 to 18.6 and declined in the subsequent years to a level of W_{R14} equal to 13.0 to 15.6). These values were almost twice as high as the nationwide average level of road accident hazard. It only happened in Śląskie Voivodship that although a very high W_R value was observed there, a favourable downward trend, with a rate of –4.16 % a year, was simultaneously recorded. The unfavourable situation in the road accident hazard was made even worse by the fact that in Łódzkie and Małopolskie Voivodships (with high W_R values), the rate of decline in this indicator was among the Poland's lowest figures: it amounted to –0.16 % to 0.98 % a year as against the national average of –3.33 % a year (Table 3).

At the beginning of the period under analysis, the lowest W_R values (3.2-6.0) were recorded in Kujawsko-Pomorskie, Lubuskie, Lubelskie, and Podlaskie Voivodships and in three of them (Kujawsko-Pomorskie, Lubuskie, and Lubelskie Voivodships), the highest rates of decline in these values (from –6.04 % to –6.53 % a year) were observed in 2010-2016. The rate of this downward trend was twice as high as the national average. These two factors (low W_R and negative ΔW_R values) have highlighted the group of regions with low accident hazard on public roads.

Following the analysis of the trends describing the processes of changes in the road accident hazard, attention was paid to absolute values, i.e. to a juxtaposition of the number of accidents and the total length of public roads in individual regions. An answer was sought to a question whether the numbers of accidents were the highest in the regions with the greatest total length of public roads. Table 4 presents results of a juxtaposition of characteristic values of the numbers of accidents as published in [8] and the total lengths of public road networks in individual regions. Four regions with the maximum (MAX) total lengths of public road networks (i.e. Mazowieckie, Wielkopolskie, Lubelskie, and Małopolskie Voivodships, according to [9]) and another four regions characterized by the minimum (MIN) total lengths of public road networks (Opolskie, Lubuskie, Świętokrzyskie, and Zachodniopomorskie Voivodships) were selected. Similarly, four regions with the maximum (MAX) number of accidents and another four regions with the minimum (MIN) number of accidents were picked (from [6]). Table 4 shows that only two of the four regions of each group simultaneously met both of the criteria MAX or both of the criteria MIN.

Table 4. Regions with the biggest (MAX) number of accidents and the longest road network and with the smallest (MIN) number of accidents and the shortest road network

Regions (Voivodships) meeting both MAX criteria in 2010-2012	Regions (Voivodships) meeting both MAX criteria in 2014-2016	Regions (Voivodships) meeting both MIN criteria in 2010-2012	Regions (Voivodships) meeting both MIN criteria in 2014-2016
Małopolskie; Mazowieckie	Małopolskie; Mazowieckie	Lubuskie; Opolskie	Lubuskie; Opolskie

The result of this juxtaposition of the regions where both of the MAX criteria or both of the MIN criteria were simultaneously met shows that the connection between the number of accidents and the length of road network in individual regions was quite weak. A check whether the values of the density of accidents in the regions specified in Table 4 were similar to each other gave a negative answer as the W_R values were very widely scattered. In Fig. 4, this spread can be seen in the form of a dark bar of significant length, which confirms that the connection between the two factors analysed was weak.

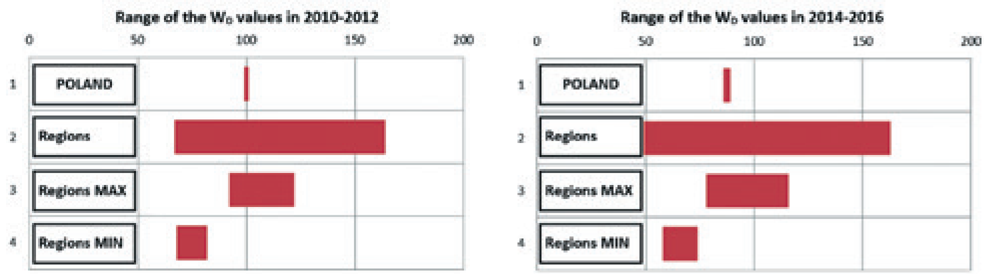


Fig. 4. Spread of the W_R indicator values in the initial and final period under analysis

5. Vehicle accident rate in regions (W_V)

In this part of the study, the relation between the number of accidents and the number of motor vehicles in individual regions is analysed. A direct juxtaposition of these figures is burdened with the impact of region size on comparison results. Therefore, the values of the following relative indicators were taken for the analysis:

– slope a_{Pj} of the regression line, which shows the changes in the number of accidents in the years 2010-2016;
– yearly average rate of changes in the W_V indicator value, i.e. rate of changes in the ratio of the number of accidents to the number of motor vehicles in relation to the initial figure, expressed in percentage terms and denoted by ΔW_V.

The regions with the highest rates of decrease in the number of accidents, highlighted previously (see Section 3), i.e. Kujawsko-Pomorskie, Lubelskie, Śląskie, and Wielkopolskie

Voivodships, were simultaneously characterized by high rates of drop in the W_V indicator, i.e. by high ΔW_V values, ranging in this group of regions from –6.86 % to –8.54 % (Table 5). These figures are very favourable, as they indicate a strong downward trend in the W_V indicator. In these four regions, the rates of drop in the W_V indicator values exceeded the nationwide average by 24-50 %. On the other hand, concern may be aroused by the wide spread of the W_V indicator values between different regions, as they ranged from 10.6 to 25.0 at the beginning of the period under analysis and remained high in the next years, too (from 7.0 to 22.1). In the initial period, the highest value of this indicator (W_{V10} = 25.0) was recorded in Łódzkie Voivodship (see Table 5). This figure may be interpreted (in a somewhat exaggerated way) as showing that the motor vehicles in that region were 2.4 times as conducive to accidents (aggressive?) as those operated in the neighbouring Kujawsko-Pomorskie Voivodship.

Obviously, a question arises about the factors that cause so big a difference between the W_V values. Are the motor vehicles operated in the two neighbouring regions so different from each other or, perhaps, the reason lies in the quality of roads, road traffic organization, or traffic management and control? In both regions, the obtaining of a driving licence is governed by identical rules and similar requirements; therefore, these causative factors were not analysed at the present stage of the work.

Has the number of vehicles a direct and strong impact on the number of accidents in a specific region? To answer this question, the authors selected four regions with the maximum (MAX) total numbers of vehicles (Mazowieckie, Śląskie, Wielkopolskie, and Małopolskie Voivodships) and another four regions characterized by the minimum (MIN) total numbers of vehicles (Lubuskie, Opolskie, Podlaskie, and Świętokrzyskie) [9]. Similarly, four regions with the maximum (MAX) number of accidents and another four regions with the minimum (MIN) number of accidents were picked (from [8]). The results of such a juxtaposition have been summarized in Table 6.

Based on this, it was found that three of the four regions under consideration simultaneously met both of the criteria, i.e. MAX number of accidents with MAX number of vehicles or MIN number of accidents with MIN number of vehicles. Hence, an opinion may be formulated that there is quite a strong connection between the number of vehicles and the number of road accidents. Are then the vehicle accident rate values close to each other in the regions specified in Table 6? The answer is affirmative for the group of the three regions where both of the MIN criteria were met. The W_V values for this group of regions (see Fig. 5) were confined to narrow intervals of W_{V10} = 11.1-12.8 and W_{V14} = 8.6-9.9 and they were significantly lower than the nationwide average. For the group of the three regions where both of the MAX criteria were met, in turn, the WV values were very widely scattered, from 13.3 to 20.5 for W_{V10} and from 9.8 to 17.2 for W_{V14} (Table 5, Fig. 5). The very wide spread of these values means a weak connection of the number of accidents with the number of vehicles in this group of regions.

Table 5. Slope a_{Pj} of the regression line of the percentage number of accidents, indicator W_V, and yearly average changes ΔW_V in this indicator in individual regions

Region (Voivodship)	Slope a_{Pj} of the regression line of the percentage number of accidents in 2010-2016	Average W_{V10} value, initial	Average W_{V14} value, final	Yearly average percentage change ΔW_V relative to the initial value [%]
Poland	−2.64	16.0	12.4	−5.65
Dolnośląskie	−2.58	16.1	11.7	−6.92
Kujawsko-Pomorskie	−5.71	10.6	7.0	−8.48
Lubelskie	−5.23	12.6	8.3	−8.54
Lubuskie	−3.71	12.8	9.1	−7.07
Łódzkie	0.01	25.0	22.1	−2.93
Małopolskie	−0.85	20.5	17.2	−4.05
Mazowieckie	−3.5	13.3	9.8	−6.56
Opolskie	−1.97	12.4	9.9	−4.97
Podkarpackie	−2.9	15.9	12.1	−5.90
Podlaskie	−2.89	11.1	8.6	−5.73
Pomorskie	−0.4	20.1	17.1	−3.77
Śląskie	−4.65	18.6	13.5	−6.86
Świętokrzyskie	−2.19	18.3	14.8	−4.83
Warmińsko-Mazurskie	−0.72	20.3	17.4	−3.60
Wielkopolskie	−4.16	11.5	8.3	−7.02
Zachodnio-pomorskie	−1.88	14.9	11.9	−5.09

Table 6. Regions with the MAX number of accidents and number of vehicles and with the MIN number of accidents and number of vehicles

Regions (Voivodships) meeting both MAX criteria in 2010-2012	Regions (Voivodships) meeting both MAX criteria in 2014-2016	Regions (Voivodships) meeting both MIN criteria in 2010-2012	Regions (Voivodships) meeting both MIN criteria in 2014-2016
Małopolskie; Mazowieckie; Śląskie	Małopolskie; Mazowieckie; Śląskie	Lubuskie; Opolskie; Podlaskie	Lubuskie; Opolskie; Podlaskie

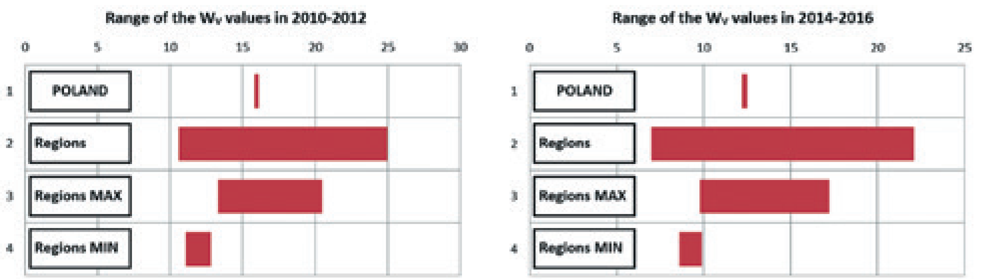
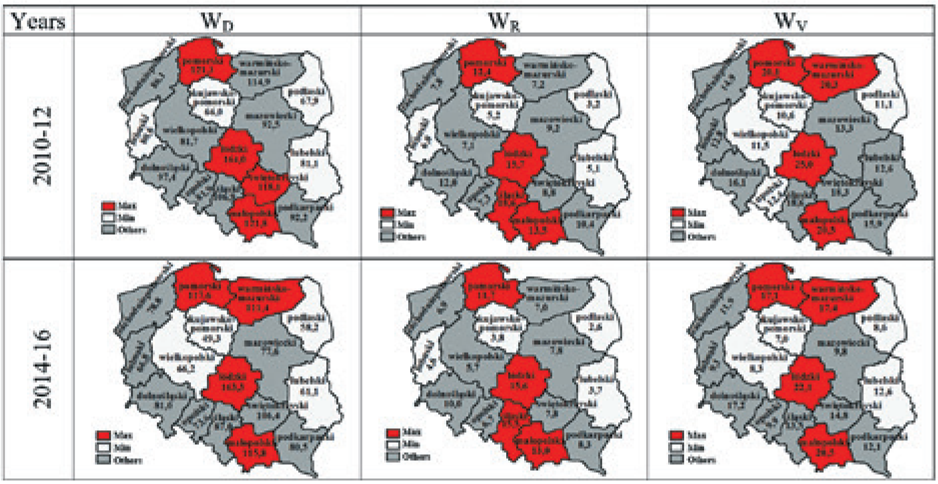


Fig. 5. Spread of the W_V indicator values in the initial and final period under analysis

6. Recapitulation and conclusions

The maps below (in Table 7) show the geographic situation of the four regions with the maximum and minimum values (denoted by "Max" and "Min", respectively) of the indicators taken into account (W_D, W_R, and W_V) at the beginning and end of the period under analysis, in the territory of Poland. The values of the accident hazard measures (i.e. the indicator values analysed, determined for individual regions) have been specified in percentage terms in relation to the corresponding nationwide average.

Table 7. Geographic situation of the characteristic regions in the territory of Poland



The W_D, W_R, and W_V indicator values constituted a basis for the assessment, which was presented with taking into account two observation periods, i.e. the initial and final periods of the years 2010-2016. As at a few previous stages, four regions with the highest values and another four regions with the lowest values of the indicators mentioned above were picked for the assessment. The regions thus selected have been marked in Table 7 in red and white as follows:

– The regions with the highest values of a specific indicator have been marked in red and the indicator values have been inscribed within the contours of the corresponding regions in the maps.
– The regions with the lowest values of the indicator have been marked in white.
– The grey colour indicates the regions that have not been classified in any of the groups thus selected, based on the indicator values.

An analysis of the geographic situation of the characteristic regions has led to some interesting conclusions:

– 92 % of the regions marked in red (Max) in the period 2010-2012 remained in the group with the highest indicator values in the period 2014-2016.
– 83 % of the regions that were "white" (Min) in the initial period remained in the same group for the whole period under analysis.

Thus, in spite of the flow of time and the downward trend in the number of accidents prevailing in Poland, the following has been ascertained:

- The composition of the groups of regions with the highest and lowest values of the accident hazard indicators remained practically unchanged.
- Although the highest and lowest values of indicators W_D, W_R, and W_V described the impact of definitely different factors on the level of accident hazard, they practically occurred in repeatable groups of regions (Table 7).
- The highest values of indicators W_D, W_R, and W_V occurred in Łódzkie, Małopolskie, Pomorskie, Świętokrzyskie, Śląskie, and Warmińsko-Mazurskie Voivodships. In the first three of these six regions, all the indicator values caused the regions to be classified in the Max group in both the initial and final period under analysis.
- The lowest values of the indicators in question were recorded in Kujawsko-Pomorskie, Podlaskie, Lubuskie, Lubelskie, Wielkopolskie, and Opolskie Voivodships; in two of them (Kujawsko-Pomorskie and Podlaskie Voivodships), the lowest values of all the indicators simultaneously occurred in the initial period under analysis while in the final period, it already happened that the lowest values of all the accident hazard indicators were simultaneously achieved in three regions (Kujawsko-Pomorskie, Podlaskie, and Lubelskie Voivodships).

Fig. 6. Groups of the regions with the highest (red) and lowest (white) values of the living standard indicator

Fig. 6, prepared on the grounds of [4], shows the regions arranged in groups according to the values of the synthetic living standard indicator. The said values have been determined with taking into account the impact of main regional factors on the social and economic development level. In the map, the same colour system has been adopted, i.e. the five regions marked in red are characterized by the highest values of this indicator and another five regions with the lowest indicator values have been marked in white. A comparison of the regions presented in Table 7 with those marked with the same colours in Fig. 6 shows only little conformity among the regions in terms of interrelation between the accident hazard indicators and the living standard of local population. Calculations have revealed that many analyses still have to be carried out to identify the factors that have an impact on the territorial distribution of road accidents. At the present stage, the territorial distribution of accidents has become a basis for establishing a multidimensional space of hazard indicators in which consideration is given to diverse features of individual regions. This has made it possible to identify the regions with high and low values of accident hazard indicators. This has also shown the dependence of the level of this hazard on population size, total length of public road network, and number of motor vehicles in a specific region, with eliminating at the same time the significant impact of the region size on the result of assessment of this hazard.

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