Road safety in Poland Three Years After Limiting the Number of Speed Controls

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Abstract. Road safety is one of the key elements of every citizen's life. Every day journeys connected with professional and educational activity force us to do a trip, and this leads to inevitable conflicts between road users. One of the basic methods of assessing the state of road safety, and the effects of legal, educational and infrastructural activities of authorities, are the results of road incidents analyses, accidents and collisions, as well as the effects of these activities in previous years. Police databases carried out in most countries on a continuous basis, store records of road incidents in which Police officers intervened. Undoubtedly the speed is one of the most important element affecting the number and consequences of road incidents. High speed reduces the time necessary for the driver to react correctly to the traffic situation. The high speed increases the momentum, and thus the effects of road accidents. Changes in the scope of speed control of vehicles in Poland, including those entitled to do it, introduced 3 years ago, could significantly affect the state of road safety in Poland, on the network of urban and non-urban roads. This paper presents the results of road safety analyses for both nationally and more locally road networks - for the biggest cities in Poland. Based on the analysis of data from the Police's database records, it has been shown that since the introduction of legal changes, the number of road incidents on the road network has increased significantly. It also indicates unfavourable trends in the area of road safety in cities. Based on the above analyses the need for action to introduce a new program for road safety improvement, especially at the level of urban areas, is indicated.

1. Introduction
Every traffic accident, especially an accident with fatalities effect, forces us to reflect, arouses emotions and often discussed on our daily road safety. It seems natural to look for a guilty occurrence of an accident, and even for many guilty parties, because almost every road accident is a lot of components that lead to it [1], [2], [3], [4], [5]. The risk of damage to health as a result of a traffic accident affects each of us and every day. It is estimated that the risk of losing one's life as a result of a road accident is one of the most common causes of deaths after ischaemic heart disease and stroke, and cancer [6]. In 2016 road injuries killed 1.4 million people in 2016, about three-quarters (74%) of whom were men and boys. It is a natural consequence of our daily activities. Each of us since an early to old age actively participates in trips both on foot, bicycle or as part of public transport or individual transport. Everyday trips of city residents are common, mass, usually routine and are not subject to any control as air traffic for example. Regardless of the state of health, psychophysical predisposition or broadly understood fitness, we become participants of the road by exposing ourselves and other
participants to a traffic conflict and a road incident, resulting in material damage (a collision), and in a critical situation, loss of health or even life (an accident). Usually the routine in a journey affects the low concentration of travellers during their trips [7], [8]. Lots of drivers asked about their morning trip to work are not able to reconstruct it in details. Finally human habitual (travel) behaviour might cause unpredictable consequences for our future life.

This article is not intended to indicate the perpetrators of road accidents or to justify those responsible for transport infrastructure and traffic. The purpose of the article is to present the impact of the single one law legislation - the speed control limitation, on the road safety on the base of global road safety statistics. The article presents the characteristics of the road safety in Poland in the period of 11 years, i.e. for data since 2008 to 2018 recorded in the Collisions and Accidents Register System (CARS) kept by the Polish Police department, where all road incidents recorded by Police Department are stored. For the purpose of analyses, in order to give better background of current road safety situation, data for selected 11 large and medium cities were presented as well.

The remainder of the paper is organised as follows. The traffic system is shortly presented in Section 2. The description of the study area and statistical data are presented in the third section. In the next section the results of the analysis are presented and discussed, while conclusions are drawn in Section 6.

2. Traffic system
Reading about the traffic system, it is necessary to focus on the relationships and dependencies between the various elements of this system. This traffic system consists of three basic elements [9]: the road user, the road environment and the vehicle – the UEV (see Figure 1). The road environment and the vehicle are at the top of the traffic system in the most approaches, while the bottom consists of the road user – car driver, car passenger, pedestrian, cyclist, etc. That is why the present traffic safety professionals try to reduce the risks associated with traffic by involving holistically traffic safety multidisciplinary partnerships. And the systems approach focuses on the relationships and dependencies between the various elements of the traffic system. Each of these elements of the system

![Figure 1. This traffic system model: the road user, the road environment and the vehicle – UEV.](image)

has its own individual characteristics, which, in connection with the rest, form the entire traffic system related to residents' trips. These features directly translate into the quality and efficiency of transport, including the security of trips. The road user is undoubtedly the weakest element of this system - user of transport infrastructure, indicated in almost every case as a direct perpetrator of an accident. Because he usually makes a mistake, which leads to the occurrence of a single road incident, including on average in 7% of cases to road accidents (database on CARS for Poland, since 2016 to 2018), in which at least one of the users bears a health scar. However, there is no doubt and this is evidenced by road incidents statistics, that in the majority of cases these road users’ mistakes are made in the
weakest, from the point of view of traffic, areas of the transport network. This applies to places where the road user - driver, usually needs to be more focused, requiring more decisions to be taken simultaneously, as well as those less understandable and unusual. Thus, on the road network there are particularly places with the highest risk of road accidents, often called black spots. These are the places where the largest number of road incidents are observed: collisions and accidents. A vehicle appears between the road user and the environment – day by day better, faster, more comfortable, giving the feeling of independence, power on the road and the safety of its user. The above-mentioned elements of the transport system are an integral part of the travel process, and therefore each of these elements should be taken into account at the stage of travel safety analysis.

3. Study area and data
The study area is located in Poland, the Centre Europe, where eleven big and middle cities were selected for analyses. It must be noticed, in 2005, when Poland was accepted to European Union members, 5444 deaths of road accidents were registered, while in 2018 only 2859, i.e. almost half as many as in 2005, but it still means one of the leading places on the list of European Union members in terms of the highest risk of death in traffic. This is the effect of many component factors, among which a number of road safety measures should be mentioned, including transport investments. Some background data on road infrastructure of the study area is presented below.

The massive development of transport systems, which has been carried out for last years in Poland, co-financed in a significant part from the EU budget, undoubtedly influences the dynamic development of Poland, and the investments contribute greatly to the quality of life of the inhabitants. This applies to both non-urban areas, where the expanded network of high-speed roads (motorways and expressways) and urbanized areas plays a key role. The rapid growth of motorization rate in Poland (323 passenger cars per 1,000 inhabitants in 2005 to 571) [10] directly forced further transport investments within the public transport (tram lines, new rolling stock etc.) and private transport (motorways and expressways, new sections of streets, road junctions and intersections, bridges). Investments serve both residents and economic development of cities. There is no doubt that a well-connected urban area is an attractive place for investors, new investments for new work places and new tax receipts, and this serves the further development and prosperity that contemporary society strives for.

It is difficult to undermine the successes of the authorities of Polish cities in the field of transport investments in recent years. A number of new road sections, interchanges, a significant improvement in the quality of rolling stock in public transport is evident proof of the development of urban areas, improving the conditions for increasing the mobility of residents by, among others, shortening travel time, improving air quality by eliminating traffic congestion, improving economic competitiveness. However, these activities are full of compromises between different groups of urban space users - residents and business (companies, offices, shopping centres), pedestrians and cyclists and car drivers, cyclists and pedestrians, etc. Moreover, there are more and more voices that intensify such development they take the urban space of its inhabitants, destroying its character, turning it into a space dominated by motor vehicles, by road traffic. Such action is the source of increasingly frequent conflicts between residents as pedestrians and cyclists, and residents in vehicles - conflicts between weaker, unprotected participants of everyday trips [11], with stronger ones armed with armour in the form of a vehicle body and more and better safety systems for travellers in vehicles. Annual accident statistics from Polish cities indicate that on average in cities 2/3 of road incidents are recorded as incidents with this group of road users. In these incidents, usually defined as road accidents, where victims are on both sides of such conflict. While the first group is usually exposed to loss of health or life, the second one usually suffers material losses and, what is extremely important, moral damage. The perpetrators of road accidents for many years, and even the rest of their lives, have to deal with the psychological burden of being guilty or complicit in someone's disability or death.
The cities selected for analysis are presented in Figure 2, where Warsaw and Cracow are the biggest one, with 1.76 million and 0.77 million of inhabitants, Łódź - 0.69 and Wrocław 0.64, Poznan 0.54 and below 0.50 million of inhabitants, Gdańsk, Szczecin, Bydgoszcz, Lublin, Białystok and Katowice. All these cities are characterised by the high motorization rate over 600 passengers’ cars per 1000 inhabitants, and problems of congestions mainly during the pick hours. In recent years in Poland, including the above cities, since 2015, one could observe a decrease in road safety preventive activities. The rights of the municipal guard for speed controls were limited, the number of speed cameras and roadside inspections was significantly reduced. The so-called black speed cameras were removed, and only yellow ones remained. Limiting the rights of the municipal guard, commonly criticized for massive driver training, for speed controls serving the self-government budget, has significantly contributed to the reduction of preventive measures, and thus gave the driver a green light for speed limits violation. The problem was noticed by press and online articles, and the impact of speed cameras on road safety was presented in [12]. Nowadays, there are 1.53 speed radars per 1000 km² in Poland [13], while in Hungary there - 2.5 of them, and in Sweden 3.11. As shown in Table 3 and Figure 3, the leaders in this field are Belgians (37.6) and British (22.3), as well as Italians (19.52) and Dutch (19.21) [13]. In neighbouring Germany this indicator is equal 10.9. It excellent proves how weak the system of speed cameras in Poland is.
Activities for the road safety improvement are carried out in most highly developed countries, for which the safety of its citizens is one of the priorities. They refer to each of the above-mentioned elements of the traffic system: the road user – by his education, advertising, training, information campaigns, the vehicles - by introducing newer active and passive safety systems, better car lights etc., the road environment - by a series of improvements in transport infrastructure, new geometric solutions (like roundabouts, road users separations etc.), new road signs, intelligent ITS transport systems etc. In Poland, such activities have been carried out since the 1990s, where the problem of road safety had become one of the critical problems of the state. Many important investments to improve road safety had been implemented, the National Road Safety Improvement Program Gambit [14], [15] was partly implemented as well as local road safety programs.

In order to analyse the result of above mentioned activities and the current state of road safety in Poland, the national automotive data and data from the CARS system were compiled. The results are presented in the Table 1 and in the Figure 4.

Table 1. Road incidents and accidents’ victims, and number of vehicles in Poland

| Year | Number of vehicles | Number of incidents | Change % | Number of fatalities | Change % | Number of seriously injured | Change % | Number of injured | Change % |
|------|--------------------|---------------------|----------|----------------------|----------|-----------------------------|----------|-------------------|----------|
| 2008 | 21 336 913         | 100.0               | 411 976  | 100.0                | 5 437    | 100.0                        | 16 042   | 100.0             | 46 055   | 100.0             |
| 2009 | 22 024 697         | 103.2               | 415 275  | 100.8                | 4 572    | 84.1                         | 13 689   | 85.3              | 42 358   | 92.0              |
| 2010 | 23 037 149         | 108.0               | 454 907  | 110.4                | 3 908    | 71.9                         | 11 491   | 71.6              | 37 461   | 81.3              |
| 2011 | 24 189 370         | 113.4               | 406 658  | 98.7                 | 4 189    | 77.0                         | 12 587   | 78.5              | 36 930   | 80.2              |
| 2012 | 24 875 717         | 116.6               | 376 535  | 91.4                 | 3 570    | 65.7                         | 12 046   | 75.1              | 33 743   | 73.3              |
| 2013 | 25 683 575         | 120.4               | 391 762  | 95.1                 | 3 357    | 61.7                         | 11 670   | 72.7              | 32 387   | 70.3              |
| 2014 | 26 472 274         | 124.1               | 382 977  | 93.0                 | 3 202    | 58.9                         | 11 696   | 72.9              | 30 849   | 67.0              |
| 2015 | 27 409 106         | 128.5               | 395 176  | 95.9                 | 2 938    | 54.0                         | 11 200   | 69.8              | 28 578   | 62.1              |
| 2016 | 28 601 037         | 134.0               | 440 278  | 106.9                | 3 026    | 55.7                         | 12 077   | 75.3              | 28 688   | 62.3              |
| 2017 | 29 149 178         | 136.6               | 469 226  | 113.9                | 2 831    | 52.1                         | 11 103   | 69.2              | 28 363   | 61.6              |
| 2018 | 29 656 238         | 139.0               | 468 076  | 113.6                | 2 859    | 52.6                         | 10 934   | 68.2              | 26 375   | 57.3              |
Figure 4. Trends in number of road incidents and victims in Poland

The same analyse was done for selected 11 the biggest cities. The results are presented in the Figure 5 and 6, and in the table 2, but for better visualization, only for five, the biggest cities. And Figure 6 presents main reasons of road incidents basing on sample of 940 thousand of Police Department records (CARS) since 2008 to 2018.

Table 2. Road incidents in the main Poland cities

| Year | Warsaw | Change % | Cracow | Change % | Lodz | Change % | Wroclaw | Change % | Poznan | Change % |
|------|--------|----------|--------|----------|------|----------|----------|----------|--------|----------|
| 2008 | 31 732 | 100.0    | 10 531 | 100.0    | 9 034| 100.0    | 9 777    | 100.0    | 7 055  | 100.0    |
| 2009 | 28 417 | 89.6     | 11 134 | 105.7    | 9 052| 100.2    | 8 367    | 85.6     | 6 368  | 90.3     |
| 2010 | 25 419 | 80.1     | 12 704 | 120.6    | 9 917| 109.8    | 8 357    | 85.5     | 8 071  | 114.4    |
| 2011 | 20 400 | 64.3     | 10 011 | 95.1     | 9 501| 105.2    | 8 901    | 91.0     | 8 460  | 119.9    |
| 2012 | 17 914 | 56.5     | 8 740  | 83.0     | 9 112| 100.9    | 9 066    | 92.7     | 7 513  | 106.5    |
| 2013 | 21 956 | 69.2     | 9 573  | 90.9     | 9 603| 106.3    | 9 434    | 96.5     | 7 394  | 104.8    |
| 2014 | 24 331 | 76.7     | 9 312  | 88.4     | 10 026| 111.0   | 10 298   | 105.3    | 6 918  | 98.1     |
| 2015 | 24 999 | 78.8     | 9 787  | 92.9     | 10 175| 112.6   | 11 107   | 113.6    | 7 044  | 99.8     |
| 2016 | 28 269 | 89.1     | 9 966  | 94.6     | 11 155| 123.5   | 11 723   | 119.9    | 8 488  | 120.3    |
| 2017 | 30 407 | 95.8     | 10 433 | 99.1     | 11 548| 127.8   | 12 131   | 124.1    | 8 899  | 126.1    |
| 2018 | 30 363 | 95.7     | 10 839 | 102.9    | 11 957| 132.4   | 11 943   | 122.2    | 9 105  | 129.1    |

*Note: Underline numbers mark the last year of normal speed radars operation.

The next table presents economic costs of road incidents per one given city inhabitant and per year in euros [16]. The following equation was used:
\[ AC_{i,y} = \frac{\sum_{k=1}^{N_i,y} (NF_k C_F + NH_k C_H + NI_k C_I + C_A)}{N_i,y} \]  

where \( AC_{i,y} \) - the average road incidents cost in the selected city \( i \), and the year \( y \);
\( N_{i,y} \) – number of road incidents in the selected city \( i \), and the year \( y \);
\( NF_k \) – number of fatalities of the \( k \) road accident;
\( NH_k \) – number of seriously injured (hospitalised 3 or more days) of the \( k \) road accident;
\( NI_k \) – number of injured (no hospitalised or hospitalised less than for 3 days) of the \( k \) road accident;
\( C_F \) – the average cost of one fatality of road accident;
\( C_H \) – the average cost of one seriously injured of road accident;
\( C_I \) – the average cost of one injured of road accident;
\( C_A \) – the average cost of one road incident,

and the following assumption were done for Poland: one fatality \( C_F = 486.1 \) thousand €, one seriously injured \( C_H = 532.4 \) thousand €, one injured and not hospitalised \( C_I = 6.2 \) thousand €, the average other cost per one road incident \( C_A = 9.4 \) thousand €. The costs are assumed to be the same for all years of analyse what enable their comparison.

### Table 3: Economic costs of road incidents per one city inhabitant and per year [€/year]

| City      | 2008 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|-----------|------|------|------|------|------|------|------|------|------|------|
| Warszawa | 269  | 182  | 183  | 165  | 199  | 198  | 182  | 217  | 212  | 211  |
| Kraków   | 408  | 425  | 422  | 381  | 353  | 364  | 341  | 344  | 365  | 353  |
| Łódź      | 682  | 263  | 549  | 742  | 759  | 856  | 837  | 859  | 849  | 890  |
| Wrocław  | 353  | 285  | 311  | 339  | 330  | 420  | 400  | 389  | 395  | 378  |
| Poznań   | 508  | 377  | 365  | 319  | 299  | 294  | 318  | 406  | 404  | 434  |
| Gdańsk   | 241  | 162  | 189  | 202  | 183  | 198  | 213  | 305  | 312  | 358  |
| Szczecin | 493  | 391  | 386  | 440  | 419  | 435  | 425  | 357  | 355  | 385  |
| Bydgoszcz| 415  | 292  | 258  | 245  | 225  | 198  | 201  | 229  | 222  | 220  |
| Lublin   | 806  | 598  | 579  | 506  | 473  | 476  | 506  | 544  | 641  | 689  |
| Białystok| 377  | 253  | 296  | 316  | 286  | 310  | 333  | 477  | 487  | 560  |
| Katowice | 673  | 534  | 527  | 601  | 571  | 594  | 580  | 487  | 485  | 526  |

**Figure 5.** Trends in number of road incidents in Polish cities.
Figure 6. Trends in number of victims of road accidents in Polish cities.

Figure 7. Main reasons of road incidents in Polish cities.
4. Results and discussion

In the last 11 years, the number of motor vehicles on Polish road network increased by nearly 40% from 21.3 million to 29.7 million (see Table 1), while the number of accidents decreased by over 33% (including fatalities by nearly a half), and the increase of all incident by 13.6%. The average ratio of fatalities per 100 accidents in Poland equals 8.6 [persons/100 accidents]. Undoubtedly, such favourable results in terms of a decrease in the number of road accidents with a drastic increase in the number of motor vehicles is the result of a significant improvement in the quality of transport infrastructure, including construction of high-speed roads, greater public awareness, and safer, newer and more efficient motor vehicles equipped with new security systems. However, this does not change the fact that the index of the number of fatal accidents per 1 million inhabitants equals 75, locates Poland in the fourth place among EU countries (according to data in 2017). This index is only higher in Romania (98 deaths per million inhabitants), Bulgaria (96) and Croatia (80).

As mentioned above, nationwide statistics of changes in the number of fatalities in Poland indicate a very favourable trend in the number of road accidents and casualties of these accidents. The situation is not so similar in most Polish cities, where the total number of accident victims (fatalities and injured) declined till 2012, and after the trend seems to be inexpedient. Moreover, the statistics of Polish cities in terms of the number of road incidents look different. In recent years, there has been a significant increase in the total number of road incidents (accidents and collisions - see the Table 2 and the Figure 4), and the number of road accident victims seems to increase year by year. For example in Warsaw, the biggest city (1.76 million of inhabitants), the capital of Poland, one can noticed decrees of road accidents victims by 35.5% in 2012 comparing to the number of victims recorded in 2008, while in 2017 and 2018 only by 4.2%. In Cracow (767 thousand of inhabitants), the second biggest city in Poland, the 17% decrees of road accidents victims was recorded, while in 2018 the increase by 3%. More over in Wroclaw (639 thousand of inhabitants), the same comparison indicates decrees of road accidents victims by 7.3% in 2012, and the increase by 22.2% in 2018. Not better situation one can observe in Gdansk (464 thousand of inhabitants) - decrees of road accidents victims by 9.7% in 2012, and the increase by 40.5% in 2018. All those numbers prove, the road safety level in Polish cities gets worse and worse. And the economic cost of road accidents per one inhabitant and per year (see the Table 3) are in selected cities on the level of the average minimum salary, while the smaller city the higher cost per inhabitant. Such situation seems to be the critical one and not acceptable. The Figure 6, where the main reasons of road incidents in Polish cities are presented, points the speed is the third on this list with index of 15.8% of all road incidents, after two the most obvious reasons in cities.

5. Conclusions

This paper presents the results of road incidents trends in Poland, and in eleven the biggest Polish cities with 300 thousand and over inhabitants. It clearly presents the trend in the road safety, whilst after a few years of positive trends, it has turned into very negative one. That’s why there is a high demand to start new actions to change this phenomena, and the new national and local road safety plans should be prepared and implemented in the near future.

The following conclusions were reached by the results of the study:

1. In recent years the national statistics indicated a favourable trend in the number of road accident victims, but the number of road incidents has been rising again since 2014.

2. The situation in Polish cities is different, in which stabilization is observed, and even the number of accident victims’ increases.
3. The above conclusions indicate that favourable trends in the decrease of road accident victims concern non-urban areas in which the emergence of high-speed roads has had a positive effect on the road safety condition.

4. Vehicle speed not adopted to road condition was one of the main reasons of road incidents, which contributed to 15.8% of all road incidents in cities. Therefore, it is necessary to take action in the area of speed control and prevention in these areas.

5. At the same time, an urgent need must be pointed to develop a new national road safety improvement program, particularly directed to Polish cities, to make the traffic system much more user friendly and secure of road users.

6. The traffic system, being the environment of everyday inhabitants trips, should be the objects of a new national road safety improvement program. All its element should be pointed that is, apart from the road environment improvement perceived commonly as the most important one, also road users and their vehicles should be detailly included in it.

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