Heterogeneity of road traffic accident rate in the Russian cities and the need of usage various methods of transport safety management

A I Petrov[1] **and D A Petrova**[2]

[1]Tyumen Industrial University, Volodarskogo str., 38, Tyumen, 625000, Russia
[2]Ural Federal University named after the first President of Russia B.N. Yeltsin, Ekaterinburg, Russian Federation

E-mail: ArtIgPetrov@yandex.ru

Abstract. The article considers one of the topical problems of road safety management at the federal level - the problem of the heterogeneity of road traffic accident rate in Russian cities. The article analyzes actual statistical data on road traffic accident rate in the administrative centers of Russia. The histograms of the distribution of the values of two most important road accidents characteristics - Social Risk HR and Severity Rate of Road Accidents - formed in 2016 in administrative centers of Russia are presented. On the basis of the regression model of the statistical connection between Severity Rate of Road Accidents and Social Risk HR, a classification of the Russian cities based on the level of actual road traffic accident rate was developed. On the basis of this classification a differentiated system of priority methods for organizing the safe functioning of transport systems in the cities of Russia is proposed.

1. Introduction.

The Federal target program on road safety of Russia, as one of the main instruments for the implementation of the Transport Strategy of Russia, regulates the targets for perspective work in the field of traffic safety. However, only general targets are presented in this document, for example, it is indicated that the purpose of the federal target program on road safety in 2013-2020 is the reduction in the number of deaths as a result of road traffic accidents by 2020 by 8 thousand people (28.82%) compared to 2012 [1-15].

There are about 1100 cities in Russia [10], in which, as of 01.01.2014, 74.2% of the country's population or 106.549 million people reside [13]. In 2016, 8752 people died in road accidents in Russian cities [13] (38% of the total number of deaths in road accidents). It is clear that the main share of accidents and the main traumatism and death of people are formed on roads outside of cities (62%), however in cities the processes of the road traffic organization are the most manageable [1-3, 9]. In this regard, it is most expedient to conduct analytical work to determine the specifics of the formation of road accidents for the cities. One of the most important techniques in this work is the classification of researched objects (in this case, the cities of the Russian Federation in terms of the road accidents characteristics) [4-9].

2. Basic data

It is practically impossible to collect detailed statistics of road accidents for all cities of the Russian Federation, however, for administrative centers this problem solves quite simply (Total in the Russian

Federation in 2016 - 85 administrative territorial units, 79 of them had the data necessary for calculating the characteristics of the accident). The source of this information is the website of the Traffic police of the Ministry of Internal Affairs of Russia [13].

Table 1 shows the calculated values of the most important traffic accident rates indicators [11, 12] - Social Risk (HR) and Severity Rate of Road Traffic Accidents (SR of RTA) - for regional centers - cities with more than 1 million people population (2016). In other cities - the administrative centers of Russia - the value of the Social Risk HR varies in the range from 1.98 deaths in road traffic accidents per 100 thousand people (Murmansk) to 26.80 people killed in road traffic accident per 100 thousand people (Khanty-Mansiysk), the value of the Severity Rate of Road Traffic Accidents - in the range from 1.17 (Blagoveshchensk) to 10.78 (Grozny) [13].

Table 1. Indicators characterizing road traffic accident rate in Russian cities with more than 1 million people population in 2016 [13]

| Russian cities with more than 1 million people population	Indicators characterizing road traffic accident rate (RTA) in 2016					
	Population, pers.	Road Traffic Accidents (RTA)	Quantity, pers.		Victims	HR, fatalities in RTA per 100 thousand pers.	Severity Rate of RTA
			Fatalities	Injured			
Moscow	12330120	9045	561	10326	10887	4.54	5.15
St. Petersburg	5225690	6104	239	7208	7447	4.57	3.21
Novosibirsk	1584138	1548	74	1792	1866	4.67	3.96
Ekaterinburg	1444439	805	85	1029	1114	5.88	7.63
N. Novgorod	1266871	1954	61	2263	2324	4.81	2.62
Kazan	1216965	2092	52	2372	2424	4.27	2.14
Chelyabinsk	1191994	1736	59	2173	2232	4.95	2.64
Omsk	1178079	2320	56	2924	2980	4.75	1.88
Samara	1170910	1130	52	1346	1398	4.44	3.72
Ufa	1121000	1858	48	2328	2376	4.28	2.02
Rostov-on-Don	1119875	1643	71	1976	2047	6.34	3.47
Krasnoyarsk	1066934	1766	53	2080	2133	4.97	2.48
Perm	1041976	1894	70	2264	2334	6.72	3.00
Voronezh	1032382	1145	83	1375	1458	8.04	5.69
Volgograd	1016137	1221	90	1545	1635	8.86	5.50

3. Methods and results of assessing the heterogeneity of accidents in the Russian cities

In order to assess the heterogeneity of road traffic accidents in Russian cities, a method of constructing histograms of the distribution of the values of road traffic accidents selected indicators was used.

Figure 1 and figure 2 show the histograms of the distribution of the values of the Social Risk HR and the Severity Rate of Road Accidents, determined from the statistics of accidents in administrative centers of Russia in 2016 (79 administrative centers in total).
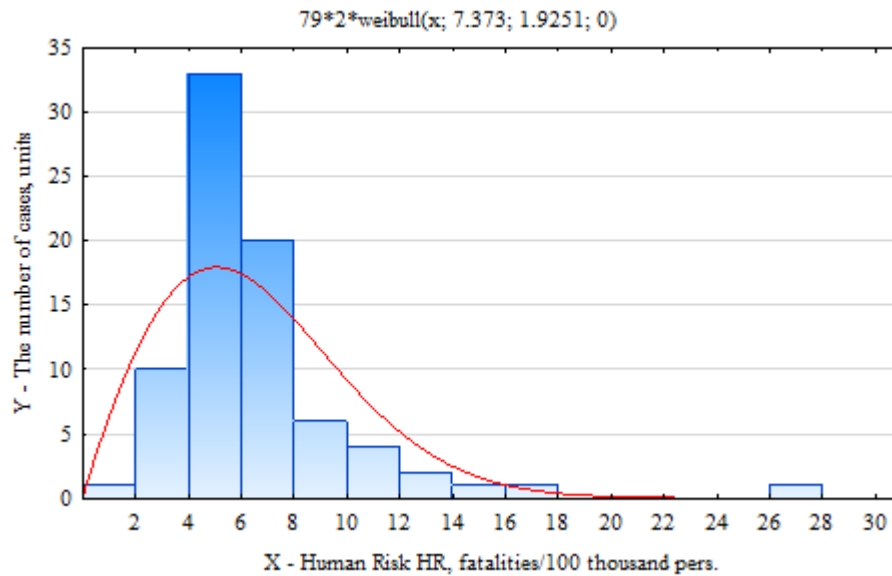
Figure 1. Distribution of Social Risk HR values in administrative centers of Russian Federation (2016)
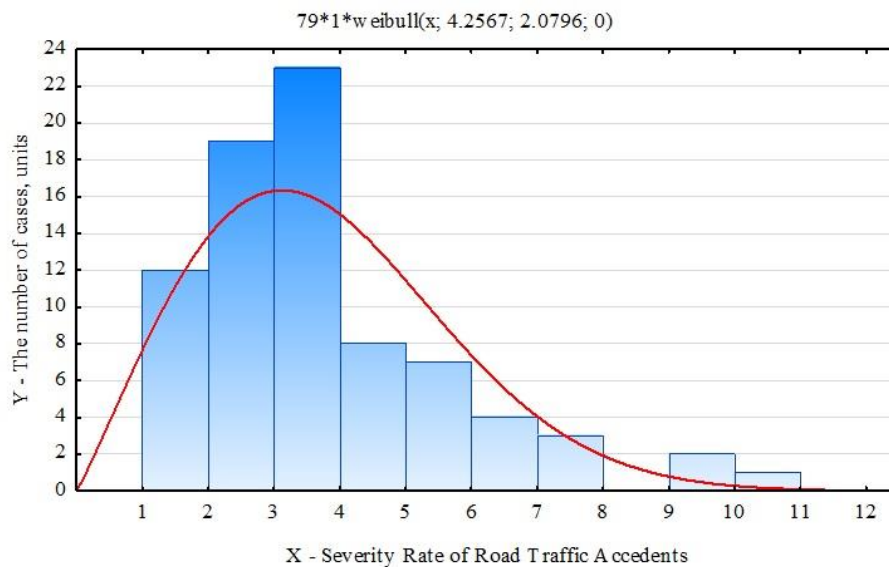
Figure 2. Distribution of Severity Rate of Road Traffic Accidents values in administrative centers of Russian Federation (2016)

The investigated samples of the values of the Social Risk HR and the Severity Rate of Road Accidents are described by the Weibull distribution law, i.e. a variety of values of accident rates in cities is formed in a non-random way.

4. Results and Discussion

Usually this fact is the basis for formulating a hypothesis about the presence of any obvious causes of an increased road traffic accident rate in some cities of the country. Factor analysis that can help to identify these causes is needed a large database characterizing the specificity of the city, the specifics of the road safety organization in it, the specificity of the transport behavior of the population. Usually

for organizers of road safety information is not widely available or completely absent. In such situation cities are usually classified according to some characteristics and cities with a marked deviation from the trend are detected.

Figure 3 shows the regression model of statistical connection between the Social Risk HR and the Severity Rate of Road Traffic Accidents (Coefficient of severity RTA) defined for databases of administrative centers (in total 79 cities).

Model *Coefficient of severity RTA = f(HR)* served as a basis for the classification of cities in the Russian Federation in terms of road accident rate (figure 4, Table 2).

Table 2. Classification of Russian cities from the perspective of road accident rate

Characteristics	Classes of Russian cities from the perspective of road safety				
	I	II	III	IV	V
Level of road safety	Hight	Medium	Below the average	Very low	Unacceptably low
Examples of cities	Murmansk, Petrozavodsk, Vologda, Kostroma, Orel	Kazan, Ufa, St.Petersburg	Yaroslavl, Stavropol, Kaliningrad	Kurgan, Yekaterinburg, Makhachkala	Khanty-Mansiysk, Kyzyl, Nalchik, Grozny

$$Y = -1.7564 + 7.0807 \cdot \log10(x)$$
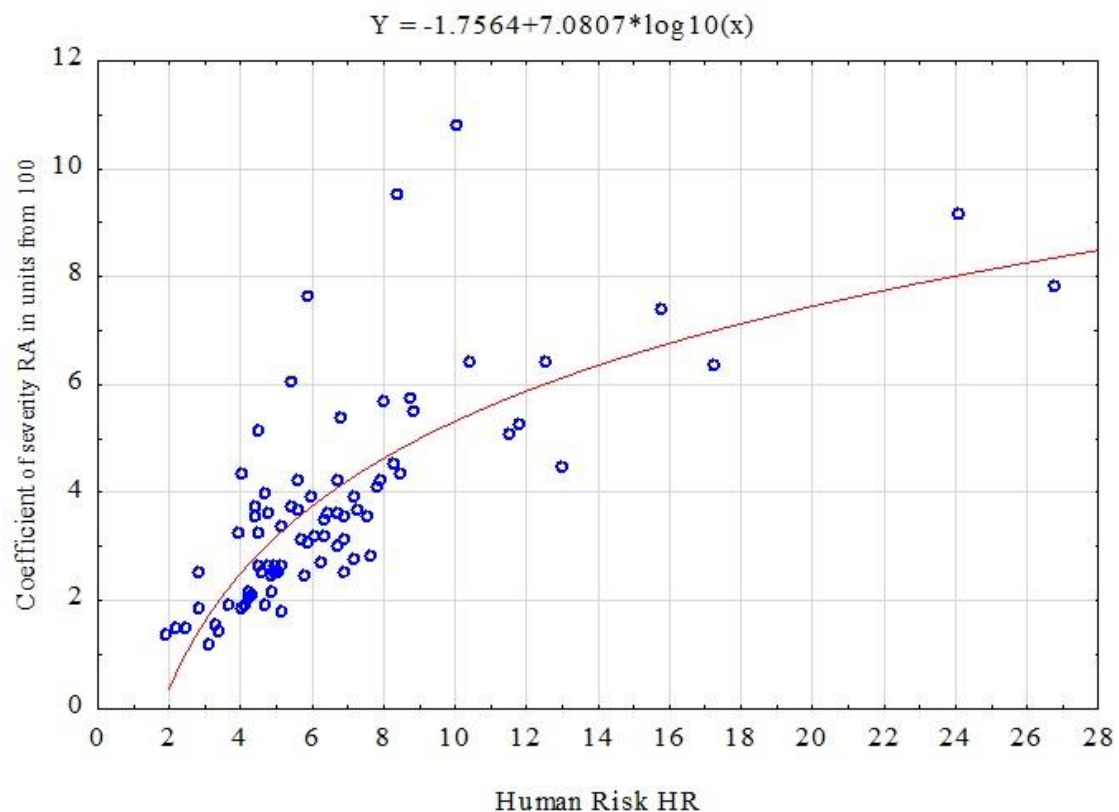
Figure 3. Regression model *Coefficient of severity RTA = f(HR)* for database «Administrative centers of Russia» (2016)
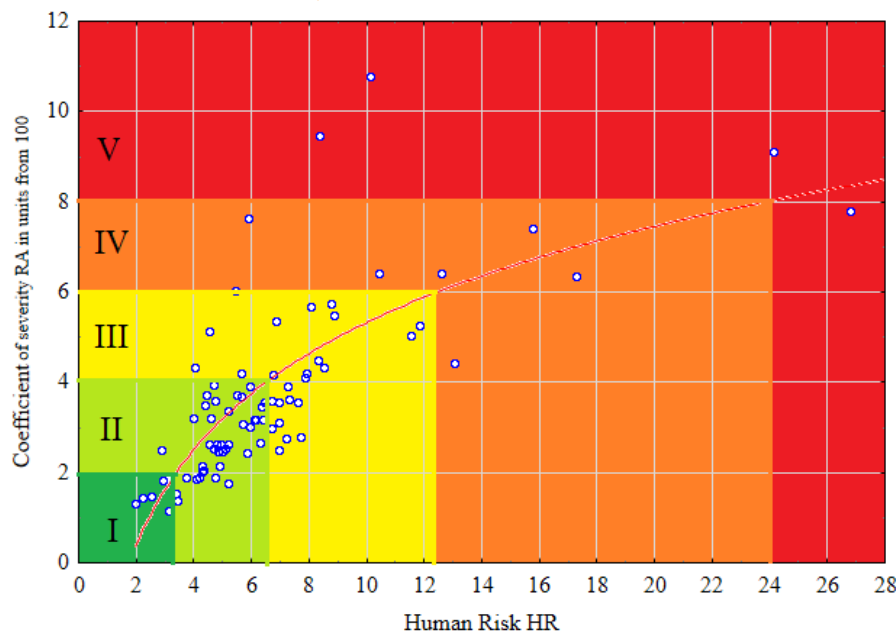
Figure 4. Classification of administrative centers of Russia in terms of road accident rate (2016)

This classification defines five classes of cities from the perspective of road accident rate. In cities, that belong to different classes from the perspective of traffic accidents, it is necessary to use various methods of organizing the safe functioning of transport systems (Table 3). It should be noted that the ideology of a differentiated approach in the selection of means and methods for managing road traffic safety, that is confessed by the author of this article, implies that on the territory of one large country, such as Russia, different approaches of stimulation of road traffic accidents reduction can and should be used.

Table 3. Priority ways of organization the safe functioning of transport systems in Russian cities

Classes of Russian cities in terms of safety	Priority ways of organization the safe functioning of transport systems in Russian cities
I	Maintenance of existing system of organization safe functioning of the transport system in the city; monitoring of the situation and point changes of the system.
II	Usage of standard measures to improve traffic safety (monitoring compliance with traffic rules).
III	Usage of increased, relative to the standard, security measures including speed control of road users.
IV	Usage of technologies for separation of transport and pedestrian flows in time and space.
V	Usage of emergency methods to control the transport behavior of road users (total control of compliance with the requirements of the Road Traffic Regulations, high fines, powerful restrictions on the rights of drivers, etc.).

5. Conclusion
Below main conclusions are showed.
- In administrative centers of Russia road accident rates widely vary.

- Statistical distributions of actual values of the Social Risk HR and the Severity Rate of Road Accidents in administrative centers of Russia are described by the Weibull distribution law, i.e. a variety of values of accident rates in cities is formed in a non-random way.
- The regression model *Coefficient of severity RTA = f(HR)* can be served as a basis for the classification of cities in the Russian Federation in terms of road accident rate.
- All Russian cities can be classified into five classes in terms of road accident rate.
- For each class of cities, it is proposed to use a specific set of measures designed to improve road safety.

In conclusion, it should be noted that for such a large country as Russia, in which the living conditions of the population are extremely different and the usual methods of organizing traffic safety are very heterogeneous, it is necessary to diversify the methods of managing the road safety system.

Reference

[1]   Adams J G D 1985 *Risk and Freedom: the record of road safety regulation* (Cardiff: Transportation Publishing Projects) p 202
[2]   Cerwenka P et al 2012 *Traffic Engineering and Control* **53(4)** 149
[3]   Chiou Y and Fu C 2013 *Accident Analysis & Prevention* **vol 50** 73
[4]   Cole T B 2004 *The Journal of American Medical Association* **vol 291** 2531
[5]   Elvic R 2015 *Accident Analysis & Prevention* **vol 82** 36
[6]   Haight F et al 1988 *Reducing Traffic Injury - A Global Challenge* (Melbourne Australia: Volvo Traffic Safety Award) p 156
[7]   Jin T G, Saito M and Eggett D L 2008 *Accident Analysis & Prevention* **vol 40 iss 6** 2015
[8]   Kerner B S 2013 *Traffic Engineering and Control* **54 (4)** 47
[9]   Petrov A I 2015 *Features of formation of motor transportation accident rate in space and time* (Tyumen: TSOGU) p 254
[10] Russian national population census 2010. Volume 1. The number and location of the population http://www.gks.ru/free_doc/new_site/perepis2010/croc/perepis_itogi1612.htm
[11] Smeed R J 1949 *The Journal of Royal Statistical Society. Series A (Statistics in Society)* **1** 1
[12] Smeed R J 1968 *Traffic Engineering and Control* **10** p 364
[13] Statistical information// Traffic police of the Ministry of Internal Affairs of Russia – Traffic security status indicators – archive. http://www.gibdd.ru/stat/archive/
[14] The Federal target programme on road safety of Russia 2013-2020. http://www.fcp-pbdd.ru/
[15] Transport Strategy of Russia. http://www.mintrans.ru/activity/detail.php?SECTION_ID=2203