Identification of sustainability of road safety improvement in Russian cities with a population of more than 1 million people

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Abstract. The article examines the issues of assessing the sustainability of road safety improvement process in Russian cities with a population of more than 1 million people. In 2015...2018 a sharp decrease in the overall level of road traffic accidents in the Russian Federation was recorded. However, in different regions and cities of the country this positive process runs extremely heterogeneously, with various speeds and different levels of qualitative changes in the field of road safety. The T-Wilcoxon criterion is an instrument, used in analyzing accident rate statistics, which can help in the argumentation of the opinion on the sustainability of this process or, vice versa, on the chaotic state and weak expression. On the example of accident rate statistics in Russian cities with a population of more than 1 million people, the article proves that improvement of road safety can be characterized as sustainable.

1 Introduction

A significant decrease [1] in the number of road accidents, dead and injured people in road accidents in the last four years (2018/2015) in Russia is the cause for the formulation of general conclusion about the success of road safety Federal Program realization. How stable is this positive trend? Whether everywhere the process of road safety improvement can be considered as qualitative? To answer these questions, we will use the T-Wilcoxon criterion.

2 Methods of assessment of researched process stability

T-Wilcoxon criterion is designed to compare two dependent samples between themselves regarding the attribute expression [2-12]. Particularly, with its help, it is possible to determine the degree of changes intensity in dependent selections at different time periods. T-criterion is based on the ranking of the absolute values of the difference between two sets of sample values in the first and second experiments. In our case, the data sets for 2018 and 2015 will be compared by two most important characteristics of road traffic accidents

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(Human Risk HR and Road Traffic Accident Severity Coefficient $C_{sev. RTA}$) in Russian cities with a population of more than 1 million people.

Zero hypothesis of the research H_0 usually [3, 5] formulated as «Intensity of shifts in the typical direction doesn't exceed the intensity of shifts in the atypical direction». Applied to our case, it consists in the absence of statistical differences between the time distributions defined for the same selections of 2015 and 2018. According to the zero hypothesis, differences between selections values of different years of research are not enough to accept that non-random factors cause this difference.

Hypothesis H_1 classically [3, 5] formulated as «Intensity of shifts in the typical direction exceeds the intensity of shifts in the atypical direction», i.e. the change in the data distribution on the characteristics of the accident rate of 2018, relative to similar data distribution of 2015, did not occur accidentally - some specific factors had an impact on this data shift, e.g. organizational and managerial efforts that were invested in the solution of increasing road safety problem.

The essence of the research is to prove hypothesis H_1 and refute zero hypothesis H_0 . Two results are possible. In the case of the hypothesis H_1 evidence, it is necessary to conclude the non-randomness of the shift and the effectiveness of some managerial influence, aimed at changing the actual situation in the sphere of road safety. If hypothesis H_1 is not proved, i.e. the zero hypothesis H_0 will be confirmed, then it can be claimed that the quality of the road safety management leaves much to be desired. When using the methods of mathematical statistics, level of statistical significance p -level, in other words, «probability that we found differences as significant, but they are actually accidental», plays an important role [8]. In statistics, three levels of statistical significance are distinguished: the lowest (5% or $p = 0.05$); sufficient (1% or $p = 0.01$) and the highest (0.1% or $p = 0.001$). If the probability of randomness of received results is more than 5% ($p = 0.05$), then the lowest level of statistical significance is not reached, and hypothesis H_1 is not proved.

3 Used road safety statistics

To study the quality of road safety improvement process comparisons between two sets of data about road accidents with victims (2015 and 2018) were made in Russian cities with a population of more than 1 million people (totally 15 cities). The initial information was received on the website of the State Inspection for Road Traffic Safety of the Ministry of Internal Affairs of Russia [1].

Tables 1 and 2 shows the initial (for the Russian cities with a population of more than 1 million people) information, necessary for calculation values of such significant characteristics of accident rate [6, 7] as Human Risk HR and Road Traffic Accident Severity Coefficient $C_{sev. RTA}$.

Table 1. Characteristics (2015) of road accident rate in Russian cities with a population of more than 1 million people.

Russian cities with a population of more than 1 million people	Numerical values						
	Amount (2015) [1]					HR , deaths / 100 K people	$C_{sev. RTA}$.
	City population, thousand people	Road accidents, units	Road fatalities, people	Injured, people	Victims (fatalities + injured), people		
Moscow	12197596	10396	673	11903	12576	5.52	5.35

St. Petersburg	5191690	7243	354	8512	8866	6.82	3.99
Novosibirsk	1567087	1762	79	2012	2091	5.04	3.78
Ekaterinburg	1428042	1014	91	1285	1376	6.37	6.61
Nizhny Novgorod	1267760	2072	71	2509	2580	5.60	2.75
Kazan	1205651	1970	66	2261	2327	5.47	2.84
Chelyabinsk	1183387	1962	87	2391	2478	7.35	3.51
Omsk	1173854	2591	94	3157	3251	8.01	2.89
Samara	1171820	1125	79	1380	1459	6.74	5.41
Rostov-on-don	1114806	1725	72	2136	2208	6.46	3.26
Ufa	1105667	1916	66	2409	2475	5.97	2.67
Krasnoyarsk	1052218	1904	77	2193	2270	7.32	3.39
Voronezh	1023570	1160	105	1356	1461	10.26	7.19
Perm	1036469	2092	100	2547	2647	9.65	3.78
Volgograd	1017451	1032	87	1195	1282	8.55	6.79

Table 2. Characteristics (2018) of road accident rate in Russian cities with a population of more than 1 million people.

Russian cities with a population of more than 1 million people	Numerical values						
	Amount (2018) [1]					<i>HR</i> , deaths / 100 K people	<i>C_{sev.}</i> <i>RTA</i> .
	City population, thousand people	Road accidents, units	Road fatalities, people	Injured, people	Victims (fatalities + injured), people		
Moscow	12615882	9151	465	10469	10934	3.69	4.25
St. Petersburg	5383890	6463	232	7693	8157	4.31	2.84
Novosibirsk	1618039	1463	80	1807	1887	4.94	4.24
Ekaterinburg	1483119	978	61	1254	1315	4.11	4.64
Nizhny Novgorod	1253511	2312	62	2700	2762	4.95	2.24
Kazan	1251969	2030	49	2351	2400	3.91	2.04
Chelyabinsk	1200719	1772	72	2229	2301	6.00	3.13
Omsk	1164815	2300	77	2870	2947	6.61	2.61
Samara	1156608	1404	44	1681	1725	3.80	2.55
Rostov-on-don	1133307	1270	57	1545	1602	5.03	3.56
Ufa	1124226	1936	61	2412	2473	5.43	2.47
Krasnoyarsk	1095286	1528	46	1699	1745	4.20	2.64
Voronezh	1054111	1176	64	1467	1531	6.07	4.18
Perm	1053934	1486	42	1798	1840	3.99	2.28
Volgograd	1013468	1093	61	1402	1463	6.02	4.17

4 Results of calculation of Wilcoxon T-critrion for researched data sets

Tables 3 and 4 show results of T-Wilcoxon criterion assessment [10] relatively changes of Human Risk *HR* and Road Traffic Accident Severity Coefficient *C_{sev.}* *RTA*. values in Russian cities with a population of more than 1 million people during 2015-2018 «Increasing of value» is taken as an atypical shift.

Table 3. Calculations of atypical shifts ranks sum $T_{emp. (2018/2015)}$ relative to characteristic of Human Risk HR in Russian cities with a population of more than 1 million people.

Russian cities with a population of more than 1 million people	Values of HR , deaths/100 K people		Shift of HR		Ranked number of shift
	Before (2015)	After (2018)	Factual	Absolute	
Moscow	5.52	3.69	-1.83	1.83	8
St. Petersburg	6.82	4.31	-2.51	2.51	10
Novosibirsk	5.04	4.94	-0.10	0.10	1
Ekaterinburg	6.37	4.11	-2.26	2.26	9
Nizhny Novgorod	5.60	4.95	-0.65	0.65	3
Kazan	5.47	3.91	-1.56	1.56	7
Chelyabinsk	7.35	6.00	-1.35	1.35	4
Omsk	8.01	6.61	-1.40	1.40	5
Samara	6.74	3.80	-2.94	2.94	12
Rostov-on-don	6.46	5.03	-1.43	1.43	6
Ufa	5.97	5.43	-0.54	0.54	2
Krasnoyarsk	7.32	4.20	-3.12	3.12	13
Voronezh	10.26	6.07	-4.19	4.19	14
Perm	9.65	3.99	-5.66	5.66	15
Volgograd	8.55	6.02	-2.53	2.53	11
Atypical shifts ranks sum $T_{emp.}$					0

Table 4. Calculations of atypical shifts ranks sum $T_{emp. (2018/2015)}$ relative to characteristic of Road Traffic Accident Severity Coefficient $C_{sev. RTA.}$ in Russian cities with a population of more than 1 million people.

Russian cities with a population of more than 1 million people	Values of $C_{sev. RTA.}$, deaths/100 K people		Shift of $C_{sev. RTA.}$		Ranked number of shift
	Before (2015)	After (2018)	Factual	Absolute	
Moscow	5.35	4.25	-1.10	1.10	9
St. Petersburg	3.99	2.84	-1.15	1.15	10
Novosibirsk	3.78	4.24	0.46	0.46	5
Ekaterinburg	6.61	4.64	-1.97	1.97	12
Nizhny Novgorod	2.75	2.24	-0.51	0.51	6
Kazan	2.84	2.04	-0.80	0.80	8
Chelyabinsk	3.51	3.13	-0.38	0.38	4
Omsk	2.89	2.61	-0.28	0.28	2
Samara	5.41	2.55	-2.86	2.86	14
Rostov-on-don	3.26	3.56	0.30	0.30	3
Ufa	2.67	2.47	-0.19	0.19	1
Krasnoyarsk	3.39	2.64	-0.75	0.75	7
Voronezh	7.19	4.18	-3.01	3.01	15
Perm	3.78	2.28	-1.50	1.50	11
Volgograd	6.79	4.17	-2.61	2.62	13
Atypical shifts ranks sum $T_{emp.}$					8

Atypical shifts ranks sum (in tables 4 positive shifts are atypical) is formed during the process of summation of ranked numbers specific for positive shifts cases. The procedure of making decisions about detection of shifts or statistically significant differences between selections of 2015 and 2018 consists in the comparison of atypical shifts ranks sum values $T_{emp.}$ with tabular values T_{cr} . Table 5 shows the fragment of the table of T-Wilcoxon

criterion critical values ($T_{cr.}$) for two levels of statistical significance. Reasoning can be based on the results of comparison $T_{emp.}$ with $T_{cr.}$ ($p = 0.01$) [2, 3, 4, 5, 8, 9, 12].

Table 5. The fragment of table of T-Wilcoxon criterion critical values ($T_{cr.}$) [8].

n	Level of statistical significance		n	Level of statistical significance	
	p = 0.05	p = 0.01		p = 0.05	p = 0.01
5	0	-	13	21	12
6	2	-	14	25	15
7	3	0	15	30	19
8	5	1	16	35	23
9	8	3	17	41	27
10	10	5	18	47	32
11	13	7	19	53	37
12	17	9	20	60	43

Rule of acceptance the hypothesis H_1 : if the empirical value of criterion $T_{emp.} \leq T_{cr.}$, appropriate to the level of statistical significance $p = 0.01$, then promoted statistical hypothesis is considered to be proved [2, 3, 4, 5, 8, 9].

5 Results of research

Comparing the value of atypical shifts ranks sum $T_{emp.} = 0$ (for the case of HR) and $T_{emp.} = 8$ (for the case of $C_{sev. RTA.}$) with tabular ($T_{cr.}$) values of T-Wilcoxon criterion ($T_{cr.} = 19$ for the case $p = 0.01$, $N = 30$) it can be concluded that $T_{emp.} > T_{cr.}$, i.e. $T_{emp.}$ is not in the zone of significance and changes of values of HR and $C_{sev. RTA.}$ are accidental and hypothesis H_1 is not proved.

6 Explanation of the results

Studies [13] show that sharp improvement of level of traffic safety has become possible in Russian cities with a population of more than 1 million people because of increase in attention of the state to questions of people's life quality in recent years. The analysis of the process of transformation of living conditions of the people in the safety performance of traffic dedicated to the articles [14]. Articles [15] are devoted to assessment of spatial features of road and transport accident rate in regions of Russia. However, this trend is not typical for all Russian cities. The all-russian trend of improving road safety is not yet typical for the Far East and Siberia.

7 Conclusion

On the example of Russian cities with a population of more than 1 million people we draw a conclusion that process of road safety improvement is quite sustainable.

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