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Assessment of sustainability of improving road safety process in the volga federal district

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Abstract. The article examines the issues of assessing the sustainability of traffic safety improvement process in the cities of the Volga Federal District of the Russian Federation. 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 stability of this process or, vice versa, on the chaotic state and weak expression. On the example of accident rate statistics in subjects of the Volga Federal District of Russia, 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 traffic 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, 3, 4, 5, 6, 7, 8, 9, 10, 11, 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 (Human Risk *HR* and Road Traffic Accident Severity Coefficient $C_{sev.\ RTA}$) in subjects of the Volga Federal District of Russia (VFD) of the Russian Federation.

Zero hypothesis of the research H0 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 H1 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 H1 and refute zero hypothesis H0. Two results are possible. In the case of the hypothesis H1 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 H1 is not proved, i.e. the zero hypothesis H0 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 H1 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 subjects of the Volga Federal District of Russia of the Russian Federation (totally 14 regions). 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 subjects of the VFD of Russia) 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 of road accident rate in subjects of the Volga Federal District of Russia (2015).

Subjects of the Volga Federal District	Numerical values (2015)			
	Road accidents, units [1]	Road fatalities, people [1]	*Human Risk HR*, deaths/ 100 K people	*Road Traffic Accident Severity Coefficient* $C_{sev.\ RTA.}$
Republic of Bashkortostan	4563	604	14.83	9.53
Republic of Mari El	1035	101	14.69	6.77
Republic of Mordovia	937	153	18.91	11.66
Republic of Tatarstan	4969	492	12.76	7.45
Udmurt Republic	1379	209	13.77	11.90
Chuvash Republic	1613	208	16.80	8.78
Perm Krai	4161	421	15.96	7.31
Kirov region	1689	192	14.72	8.04
Nizhny Novgorod Region	5342	522	15.96	7.11
Orenburg region	2362	353	17.64	10.53
Penza region	2097	233	17.19	7.73
Samara region	3883	430	13.38	7.73
Saratov region	3401	362	14.52	7.74
Ulyanovsk region	1670	196	15.52	8.50

Table 2. Characteristics of road accident rate in subjects of the Volga Federal District of Russia (2018).

Subjects of the Volga Federal District	Numerical values (2018)			
	Road accidents, units [1]	Road fatalities, people [1]	*Human Risk HR*, deaths/ 100 K people	*Road Traffic Accident Severity Coefficient* $C_{sev.\ RTA.}$
Republic of Bashkortostan	4406	550	13.58	9.06
Republic of Mari El	787	83	12.20	7.31
Republic of Mordovia	1096	148	18.60	8.85
Republic of Tatarstan	4612	379	9.72	6.24
Udmurt Republic	2003	157	10.42	5.96
Chuvash Republic	1250	162	13.24	8.93
Perm Krai	3444	293	11.22	6.24
Kirov region	1756	174	13.68	7.21
Nizhny Novgorod Region	5528	386	12.01	5.21
Orenburg region	2226	273	13.91	8.76
Penza region	1913	212	16.08	7.65
Samara region	4021	344	10.81	6.10
Saratov region	3213	321	13.15	6.99
Ulyanovsk region	1330	164	13.24	8.60

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 cities of VFD of Russia 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 subjects of the Volga Federal District of Russia of Russia.

Subjects of the Volga Federal District	Values of HR, deaths/100 K people		Shift of HR		Ranked number of shift
	Before (2015)	After (2018)	Factual	Absolute	
Republic of Bashkortostan	14.83	13.58	-1.25	1.25	4
Republic of Mari El	14.69	12.20	-2.49	2.49	7
Republic of Mordovia	18.91	18.60	-0.31	0.31	1
Republic of Tatarstan	12.76	9.72	-3.04	3.04	9
Udmurt Republic	13.77	10.42	-3.35	3.35	10
Chuvash Republic	16.80	13.24	-3.56	3.56	11
Perm Krai	15.96	11.22	-4.74	4.74	14
Kirov region	14.72	13.68	-1.04	1.04	2
Nizhny Novgorod Region	15.96	12.01	-3.95	3.95	13
Orenburg region	17.64	13.91	-3.73	3.73	12
Penza region	17.19	16.08	-1.11	1.11	3
Samara region	13.38	10.81	-2.57	2.57	8
Saratov region	14.52	13.15	-1.37	1.37	5
Ulyanovsk region	15.52	13.24	-2.28	2.28	6
Atypical shifts ranks sum Temp.					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 subjects of the Volga Federal District of Russia.

Subjects of the Volga Federal District	Values of Csev. RTA.		Shift of Csev. RTA.		Ranked number of shift
	Before (2015)	After (2018)	Factual	Absolute	
Republic of Bashkortostan	9.53	9.06	-0.47	0.47	4
Republic of Mari El	6.77	7.31	0.54	0.54	5
Republic of Mordovia	11.66	8.85	-2.81	2.81	13
Republic of Tatarstan	7.45	6.24	-1.21	1.21	9
Udmurt Republic	11.90	5.96	-5.94	5.94	14
Chuvash Republic	8.78	8.93	0.15	0.15	3
Perm Krai	7.31	6.24	-1.07	1.07	8
Kirov region	8.04	7.21	-0.83	0.83	7
Nizhny Novgorod Region	7.11	5.21	-1.90	1.90	12
Orenburg region	10.53	8.76	-1,77	1.77	11
Penza region	7.73	7.65	-0,08	0.08	1
Samara region	7.73	6.10	-1,63	1.63	10
Saratov region	7.74	6.99	-0,75	0.75	6
Ulyanovsk region	8.50	8.60	0,10	0.10	2
Atypical shifts ranks sum Temp.					10

Atypical shifts ranks sum (in tables 3 and 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 Temp. = 0 (for the case of HR) and Temp. = 10 (for the case of Csev. RTA.) with tabular (Tcr.) values of T-Wilcoxon criterion (Tcr. = 15 for the case p = 0.01, N = 14) it can be concluded that Temp. < Tcr., i.e. Temp. is in the zone of significance and changes of values of HR and Csev. RTA. are not accidental and hypothesis **H1** is proved.

6. Explanation of the results

Studies [6, 13] show that sharp improvement of level of traffic safety has become possible in the Russian regions 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 article [14]. Article [15] is devoted to assessment of spatial features of road and transport accident rate in regions of Russia.

7. Conclusion

On the example of subjects of the Volga Federal District we draw a conclusion that process of road safety improvement is quite sustainable in cities of Russian Federation and its quality can be assessed as positive.

References

[1] State Inspection for Road Traffic Safety of the Ministry of Internal Affairs of Russia Official website Indicators of security status of traffic Available at: https://www gibdd ru/stat/
[2] Donnelly R A 2007 (jr) Statistics Moscow: Astrel-AST
[3] Yeliseyeva I I and Yuzbashev M M 2004 General theory of statistics Moscow: Finance and statistic
[4] Morozov E A A 2014 step-by-step algorithm of actions when using methods of mathematical statistics in psychology and pedagogical researches *Scientific dialogue* **3(27)** 29–45
[5] Orlov A I 2004 Application-oriented statistics Moscow: Examinatio
[6] Petrov A I 2015 Peculiarities of the formation of the motor transport accident rate in space and time Tyumen: TSOGU

[7] Petrov A I 2013 City Transport External environment Stability of public transport in the conditions of adverse influence of the external environment Tyumen: TSOGU
[8] Sidorenko E V 2002 Methods of mathematical processing in psychology: practical guidance St Petersburg: Speech
[9] G N Uilkinkson Steady statistical methods of assessment of data / Under the editorship of RL Loner, 1984 Moscow: Mechanical engineering
[10] Wilcoxon F 1945 Individual comparisons by ranking methods *Biometrics Bulletin* **1(6)** 80–3
[11] Siegel S 1956 Non-parametric statistics for the behavioral sciences New York: McGraw-Hill
[12] Berestneva O G, Marukhina O V and Shevelev G E 2012 Application of mathematical statistics Tomsk: TPU
[13] Petrov A I 2018 Road Traffic Accident Rate as an Indicator of the Quality of Life Economic and Social Changes-Facts Trends Forecast **3(45)** 154-72
[14] Kolesov V and Petrov A 2017 Cybernetic modeling in tasks of traffic safety management *Transportation Research Procedia* **20** 305-10
[15] Petrov A and Petrova D 2018 Assessment of Spatial Unevenness of Road Accidents Severity as Instrument of Preventive Protection from Emergency Situations in Road Complex IOP Conference Series: *Materials Science and Engineering* **142** 012116