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ASSESSMENT OF EPIDEMIOLOGIC SAFETY OF DRINKING WATER BY MICROBIOLOGIC INDICATORS IN THE RUSSIAN FEDERATION AND THE REPUBLIC OF BASHKORTOSTAN

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The aim of the study was to assess the epidemiologic safety of drinking water for the population based on the correlation-regression relationship between the incidence of intestinal infections and drinking water samples that do not meet sanitary and microbiologic indicators. Official data on the quality of water from drinking water supply sources and morbidity rates of the population were used for the analysis.

Correlation and regression analysis calculations were performed using the data analysis package in Microsoft Excel. The dependent variable y is the share of water samples non-compliant by microbiological indicators, and the independent variable x is the morbidity rate per 100,000 population by individual nosologies. The sample is equal to n=10 for 2013 and 2022. Variables x are dependent on each other, to exclude multicollinearity between variables, regression analysis was performed stepwise (y1-x1, y1-x2, etc.). Calculations were performed between variables with medium and high correlation coefficients.

The obtained mathematical model can be improved and used to find the relationship between poor-quality drinking water and morbidity of the population also in other diseases.

Keywords: water supply, acute intestinal infections, distribution network, water supply.

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Introduction. Epidemiological safety of drinking water depends on compliance with all requirements at the stage of water treatment and the absence of re-contamination during transportation to the consumer [3]. Acute intestinal infections are a serious public health problem with unfavorable risk factors for the population, such as - unfavorable sanitary living conditions, poor personal hygiene and low public awareness [20, 36].

The World Health Organization (WHO) estimates that unsafe water supply conditions are the cause of non-compliance of drinking water with sanitary and hygienic standards [24, 37, 41]. Contamination of water supplies with pathogenic microorganisms leads to outbreaks of acute intestinal infections of bacterial and viral etiology [4, 12, 13]. State reports indicate that in 9 regions of the Russian Federation (RF) water supplies do not meet sanitary and epidemiological requirements, 17 subjects do not have the necessary complex of treatment facilities, 6 subjects do not have a sufficient number of disinfection plants, also in 14 territories of the RF bacteria of the genus Legionella were detected in tap water, in 10 subjects an increase in the degree of influence of microbiological contamination of drinking water on public health was registered [17].

To control epidemiological safety of drinking water by sanitary-microbiological indicators are used indicators: total microbial count (TMC), thermotolerant coliform bacteria (TCB), total coliform bacteria (TCB), enterococci, coliphages, spores of sulfide-reducing clostridia. TSS characterizes the total content of microorganisms in water without qualitative characterization. TSS are detected in surface, stormwater, or domestic wastewater contamination. When TCB are detected in drinking water samples, coliphages (bacterial viruses) are identified, followed by an emergency reanalysis of the sample and testing for enteroviruses. The Legionella pneumophila indicator was introduced to control the quality of drinking water of hot centralized water supply. Esherechia coli indicator was introduced instead of TCB indicator as an indicator of recent fecal contamination of water [4, 9, 11, 15, 23, 32].

Bacteria of the genus Salmonella and Shigella can be transmitted through drinking water [13, 22-30, 33, 40, 35]. Among the causative agents of acute intestinal infections of viral etiology, rotaviruses and noroviruses can be transmitted via the waterborne route of infection. The causative agent of rotavirus infection belongs to the family Reoviridae, very resistant to low temperatures, stable in the environment [18, 13, 19-26, 31-40]. According to the study of Kosova A.A. [18] it is known that norovirus infection can be contracted not only through drinking water, but also through the water of recreational water sources. The aquatic route of transmission of acute intestinal pathogens is not sufficiently studied. Drinking water is not the main source of acute intestinal infections [1, 5].

The aim of the study was to assess the epidemiologic safety of drinking water for the population based on the correlation-regression relationship between the incidence of intestinal infections and drinking water samples non-compliant with sanitary and microbiological indicators.

Material and methods of the study. Data of socio-hygienic monitoring from the state reports on the Russian Federation and the Republic of Bashkortostan for the period 2013-2022 were used as materials. For statistical processing in the correlation-regression analysis were used annual data on morbidity per 100 thousand population and the proportion of drinking water samples that do not correspond to microbiological indicators. The calculations were performed using a statistical package of data analysis in Microsoft Excel, which is manually configurable (Data analysis tools - correlation, regression). As a variable y is the proportion of water samples (water supply, centralized and non-centralized water supply), and as variables x is the incidence of diseases by individual nosologies (hepatitis A, norovirus, rotavirus, salmonella, shigella) [16, 17]. Since x variables are correlated with each other (multicollinearity), regression analysis was performed separately for each variable (y1-x1, y1-x2, etc.). The results of regression analysis are statistically significant ($p<0.05$), reject the null hypothesis and confirm the alternative hypothesis. When the correlation coefficient < 0.30 - the relationship was evaluated as weak, r = 0.30-0.69 - medium, r ≥ 0.70 - strong.

Results. Research results (Table) showed statistically significant correlation between water samples that do not comply with microbiological indicators and morbidity rates per 100 thousand population (salmonellosis, shigellosis, hepatitis A, norovirus, rotavirus).

For RF, the results of correlation and regression analysis (Table) show the relationship:

- between drinking water samples from water pipelines non-compliant by microbiological indicators and incidence of (a) hepatitis A (r=0.50, R2=0.86), (b) salmonellosis (r=0.89, R2=0.96), and (c) shigellosis (r=0.93, R2=0.98);

- between drinking water samples from the distribution network, non-compliant by microbiological indicators and incidence of (d) hepatitis A (r=0.73, R2=0.91), (e) salmonellosis (r=0.95, R2=0.99), (f) shigellosis (r=0.96, R2=0.94);

- between drinking water samples from non-centralized water supply that do not correspond to microbiological indicators and norovirus (g) infection morbidity (r=0.60, R2=0.82);

For RB, the correlation and regression analysis (Table) shows an average relationship:

- between water samples from the distribution network, non-compliant by microbiological indicators and (h) AKI (r=0.38, R2=0.89);

- between samples of water from non-centralized water supply that do not correspond to microbiological parameters and (i) OKI (r=0.35, R2=0.89);

Discussion. The analysis shows that the situation is better in Belarus than in the Russian Federation as a whole. In

Results of correlation-regression analysis of the relationship between the proportion of non-compliant samples and morbidity per 100,000 population in the Russian Federation and RB

n=10 (number of observations 2013-2022)				correlation r	Regression			
Y		X						
Share (%) of samples non-compliant by microbiological indicators		Incidence per 100,000 population			R^2	F	F significance	P-designation
For the Russian Federation								
Y1	From the water pipes	***X1***	***Hepatitis A***	***0,50***	***0,86***	***67***	***0,00001***	***0,0000054***
		X2	Norovirus	-0,75	-	-	-	-
		X3	Rotavirus	0,23	-	-	-	-
		X4	***Shigellosis***	***0,89***	***0,96***	***249***	***0,00000002***	***0,000000007***
		X5	***Salmonellosis***	***0,93***	***0,98***	***563***	***0,0000000004***	***0,00000000009***
Y2	From the distribution network of centralized water supply systems	X1	***Hepatitis A***	***0,73***	***0,91***	**118**	***0,0000007***	***0,0000003***
		X2	Norovirus	-0,87	-	-	-	-
		X3	Rotavirus	0,37	-	-	-	-
		X4	***Shigellosis***	***0,96***	***0,94***	***178***	***0,0000001***	***0,00000004***
		X5	***Salmonellosis***	***0,95***	***0,99***	***964***	***0,00000000003***	***0,000000000005***
Y3	From non-centralized water supply	X1	Hepatitis A	-0,29	-	-	-	-
		X2	***Norovirus***	***0,60***	***0,82***	***52***	***0,00003***	***0,00002***
		X3	Rotavirus	0,05	-	-	-	-
		X4	Shigellosis	-0,66	-	-	-	-
		X5	Salmonellosis	-0,73	-	-	-	-
Republic of Bashkortostan								
Y1	From the distribution network of centralized water supply systems	X1	Hepatitis A	0,44	0,75	27	0,0008	0,0006
		X2	***Acute intestinal infections (AIE)***	***0,38***	***0,89***	***75***	***0,00002***	***0,00001***
		X3	Enterovirus infections	-0,28	-	-	-	-
Y2	From non-centralized water supply	X1	Hepatitis A	0,41	-	-	-	-
		X2	***Acute intestinal infections (AIE)***	***0,35***	***0,89***	***76***	***0,00002***	***0,00001***
		X3	Enterovirus infections	0,32	0,32	0,69	20	0,002

Belarus, acute intestinal infections of bacterial etiology are more often registered in the pediatric population, and the connection between the water route of transmission is doubtful. Literature data show that food poisoning, causative agents of which are bacteria of the genus Salmonella, is registered in RB. The total incidence of acute intestinal infections (AII) for each year includes the incidence of salmonellosis, dysentery, AII of established and unestablished etiology. Norovirus and rotavirus infections also affect children more frequently. Disease incidence among children is registered in kindergartens and has a group character. Such infections as typhoid fever and polyemelitis have not been registered for many years [2, 14, 17, 18].

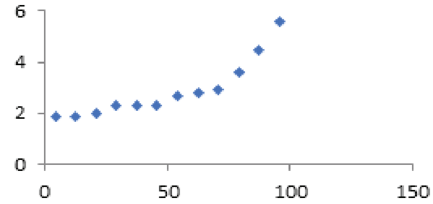
For the Russian Federation, general summary data are given for all regions, including those with unfavorable sanitary conditions. For example, the state reports of the Russian Federation state that the Republic of Dagestan recorded cases of outbreaks of acute intestinal infections of waterborne character. This tells us that for correct calculations it is necessary to take several regions and conduct separate correlation and regression calculations with a large sample (for 20 years n=20). According to the latest literature data, the regions that twice exceed the average Russian level of AKI morbidity are the Sakhalin and Tomsk Oblast, Yamalo-Nenets Autonomous Okrug and Khanty-Mansiysk Okrug [16, 17]. Also in RB it is not possible to establish a correlation between drinking water samples and the incidence of rotavirus and enterovirus, as the annual sample contains zero values, and outbreaks of these diseases are rarely registered.

Pathogenic microorganisms are difficult to detect in drinking water because their content is lower than saprophytic microorganisms and they are less stable in the environment. According to the studies of some authors, the compliance of drinking water by microbiological indicators does not give us a guarantee of safety for public health [3, 4, 29, 33, 34]. The disadvantages of virological methods of research are: costliness, low sensitivity, duration, which makes it difficult to detect viral infections of aquatic nature [1, 37].

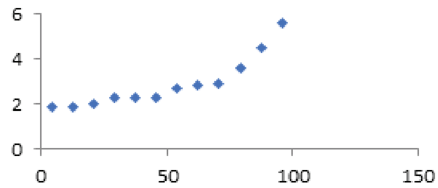
In our study we used annual data, but it is also worth considering the factor that outbreaks of some infectious diseases have their seasonality. For example, according to Rospotrebnadzor, annual monitoring is conducted during the flood period, as there is a possibility of acute intestinal infections through drinking water [16].

A

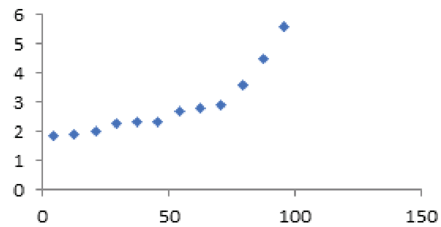
a



b



c



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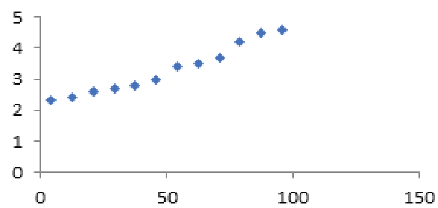
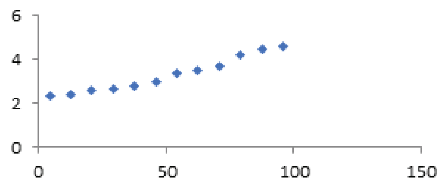
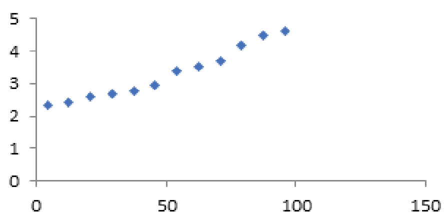


e



f



C

g

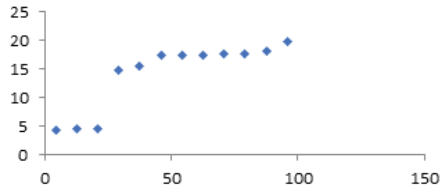
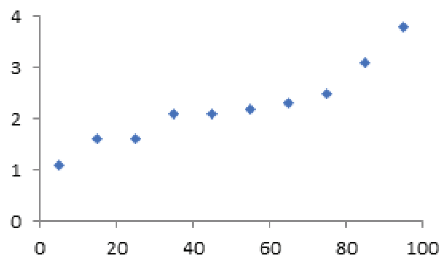


Fig.1. Graphs of the normality of the distribution of variables in the Russian Federation. The relationship between water samples: A – from water supplies and the incidence of: a – hepatitis A, b – salmonellosis, c – shigellosis; B – from the distribution network and incidence of: d – hepatitis A, e – salmonellosis, f – shigellosis; B – from non-centralized water supply and incidence of: g – norovirus infection

a



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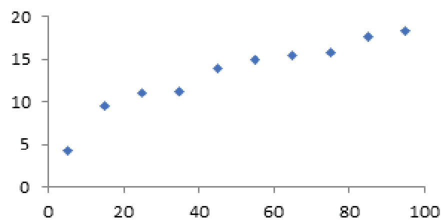

Fig. 2. Graphs of the normality of the distribution of variables in the Republic of Belarus. Dependence between water samples: a – from the distribution network and the incidence of acute intestinal infections, b – from non-centralized water supply and the incidence of acute intestinal infections

Conclusion. Conclusion. When plotting the normality of distribution of variables, a positive curvilinear dependence was found. The results of correlation and regression analysis do not prove a direct cause-and-effect relationship between the variables, for proof we need an experimental approach, for example, under unfavorable conditions - flood period, floods, as well as a large sample, the study of a separate area and the use of other statistical methods.

Literature analysis has shown that in some territories of the Russian Federation drinking water does not comply with microbiological indicators, and the reasons are the lack of sanitary protection zones, treatment facilities and disinfection plants. The majority of water pipelines and water supply sources do not meet the requirements [16]. To improve the quality of drinking water and its compliance with microbiological indicators, it is recommended to: bring centralized water supply sources to compliance with the requirements of sanitary legislation, provide the water treatment system with the necessary number of disinfection plants and complexes of treatment facilities, provide non-centralized water supply sources with sanitary protection zones.

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