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EVALUATION AND PREDICTIVE METHODS OF EPIDEMICAL SITUATION IN THE AREA OF ACUTE ENTERIC INFECTIONS

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Increased attention to acute intestinal infections (AII) caused by unpredictable epidemical rises of the AII diseases, which cannot be prevented without assessing the epidemical situation of these infections and forecasting of the levels of sick rate. However, developed mathematical methods of forecasting in most cases do not take into account the risk factors, also they are time-consuming and it is difficult to calculate them; and developed special computer programs, which predict infectious sick rates, are often in the lack in the institutions of sanitary-epidemiological service.

At present, the epidemical situation in Ukraine is evaluated by the dynamics of epidemical process in perennial dynamics of AII sick rate. Despite the fact, that nowadays AII sick rate is decreasing, the aggravation of the epidemical situation is always there. It depends on condition of parasitic system and activity of risk factors, which can reduce or increase the sick rate. However, if the condition of parasitic systems mostly depends on evolutionary processes and it is quite difficult to predict its changes, the activity of social and environmental factors is glaringly obvious. An urgent problem for today is establishing of the most influential social and environmental factors, which can make a contribution to the spread of AII.

Social and environmental monitoring, which is implemented in the institutions of the State Sanitary and Epidemiological Service, involves the study of public health and the environment. However, this method is descriptive, and it does not allow establishing quantitative dependence between social and climatic factors and the AII sick rate. It is connected to the lack of appropriate mathematical methods of systematization and generalization of demographic and climatic data in quantitative terms. The usage of results of this monitoring would give an opportunity to establish a cause-and-effect relationship between the AII sick rate and risk factors; it would also determine the groups and areas with risk to catch these infections.

The effectiveness of epidemiological surveillance depends on the orientation of preventive measures and, as a result, on setting of right accents in assessing the significance of every factor, involved in the spread of infection. There is a method of epidemiological assessment of sanitary conditions, which is aimed to prevent intestinal infections [1], which provides for retrospective ranking of indicators, characterized the conditions of water supply of a particular territory, according to their severity. As a result of a comprehensive assessment, we can make a conclusion about the degree of epidemiological risk of a territory (1 degree – low risk, 2 – increased, 3 – high). Besides the fact, that this method does not allow to evaluate other possible routes of transmission, except water, its drawback is that it is based on usage of rather laborious method of gathering of retrospective data of sick rate and sanitary-hygienic conditions of the territory. The methodology of it also cannot be considered as accurate due to the fact, that not all ranked indicators reflect the safety of drinking water, relatively to pathogenic intestinal viruses. In another method of factors quantitative assessment, that contributes to the spread of intestinal infections [2], can be used an intercept survey of local population. Should be formed study and control groups, which differ in the presence or absence of investigated factors. Then should be compared a sick rate in these groups. It is necessary to highlight the risk factor that caused a significantly increased sick rate. It is needed to make a quantitative assessment of its epidemiological significance among other reasons of infection spreading. For making it, should be determined: E – the number of patients in the study group, exposing to all other factors except the role of investigated factor: $E = \frac{A \times D}{B}$,

where: A – a number of people in the group, influenced by investigated factor; B – the number of people in the group not influenced by investigated factor; D – the number of infected people in the group without investigated factor. Should be defined: F = CE, where F – the number of people, connected with the action of the investigated factor, that reflects the difference between the number of patients in the group, influenced by investigated factor (C), and the number of patients in the group, influenced by all other factors except the possible influence of investigated factor (E). Then it is necessary to calculate the epidemiological significance of investigated factors, which make a quantitative assessment of risk factors, according to this formula:

$$K = \frac{F \times 100\%}{C+D}$$

The advantage of this method involves in its possibility to evaluate quantitatively the epidemiological significance of sanitary-hygienic factors (type of housing, availability of hot water, sewage, etc.) and to predict their influence on the epidemic process of AII in a particular area. And the disadvantage of this method involves in ignoring the influence of many nature- and social-based factors, which can be decisive in many cases. In addition to the previous methods, there are also the other described and well-known methods: the method of analysis and prognosis of the epidemical situation, caused by socially significant airborne infections [3], and the method of the assessment of the epidemical situation of droplet controlled infections [4]. However, these methods do not allow transferring them to the AII.

The aim of this work was to improve the method of assessment and prediction of epidemic situation of AII by identifying the influence of climatic and demographic factors on the sick rate of salmonellosis, shigellosis, acute intestinal infection, caused by other determined agents (AIIDA), acute intestinal infections of unknown etiology (AIIUE).

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Materials and methods

In order to determine the influence of meteorological and demographic factors on the epidemic process of acute intestinal infections the official reports of the State Sanitary and Epidemiological Service of Ukraine in Sumy region, the Department of Statistics, Sumy Regional Center for Hydrometeorology and Environmental Monitoring have been studied.

Results and discussion

People living space is formed under the influence of external factors, which can change the living conditions for the better or worse. Natural, abiotic, biotic, social, economic and technological factors have direct or indirect influence on human health and life activity [5, 6]. Exogenous factors, which cause diseases or death in a process of influencing on people, but at the same time cannot be the direct reason of it, are regarded as risk factors. The current period is characterized by significant changes in the epidemical process of acute intestinal infections, which indicates a new phase in its evolution and shows a shift of etiological structure towards viral infections; changes in annual dynamics of the sick rate with consistently high level of registration [7, 8, 9].

However, the influence of environmental factors of life's activity on the intensity and dynamics of the epidemic process of diarrheal infections is not fully-investigated.

The work on the evaluation of the epidemiological situation of the AII begins from collecting data, according to the AII sick rate. The main source of this information is the logbook of infectious diseases, which recorded all sick people that were found in the area. Besides, can be used the information from the areal case investigation forms. An additional source of the information can be: emergency message, child's record, dispensary record, hospital record, registration logs of microbiological, parasitological, biochemical and immunological studies of sick and healthy people and other accounting records. It is necessary to gather the initial information, calculate the sick rate and monthly distribution of AII cases on investigated area and evaluate the tendency.

It stands to mention, that before processing and analyzing of collected material, makes an evaluation of its completeness and correctness. An analysis of incomplete and inaccurate data can lead to erroneous conclusions and actions. To verify the completeness and correctness of the initial information, the cases of disease, registered in various accounting and reporting documents (log of infectious diseases, case investigation form, and emergency message), can be nominally compared. If in a process of AII registration there is a prevalence of nosological entity with hard or moderate course of a disease, it suggests about hypodiagnostics of diseases with subclinical course of infection. High rate of mortality and lethality against low sick rate is also a sign of undercount.

At the same time with accounting of AII cases on investigated territory, takes place a monitoring of air temperature, humidity and rainfall. This material should be divided into groups, according to selected features, years and months. These groups should also be calculated.

Simultaneously, should be gathered the information about the population on the investigated area, its density (for 1 km^2), natural and migratory movement. When the information is gathered, begins the stage of analytical research. At first, determines the long-term tendency of the sick rate, using a formula: $T_{gr.(red.)} = b / I_{av.} \cdot 100$ %, where: $T_{gr.(red.)}$ is an average time of growth or reduction of the sick rate, $I_{av.}$ - an average number of diseases for several years, which is counted according to the formula: $I_{av.} = \Sigma (x \cdot I_{fact.}) / n$, where: Σ is the index of summation, n - number of researching years, b - coefficient, that determines the difference between the theoretical levels of the sick rate for adjacent years, which is counted according to the formula: $b = \Sigma (x \cdot I_{fact.}) / \Sigma x^2$, where x – modified (or transformed) for simplifying of calculations interval, which is represented as positive integers, symmetrically arranged up and down, in pursuant to 0.

For having: $I_{av.}$, $x \cdot I_{fact.}$ and x^2, makes a calculation according to:

Years	x	$I_{fact.}$	$x \cdot I_{fact.}$	x^2
Σ n	$\Sigma x = 0$	$\Sigma_{fact..}$	$\Sigma x \cdot I_{fact.}$	Σx^2

If the average time of growth of the sick rate ranges from 0 to 1.0% - the epidemiological situation of this nosology is good, ranges from 1.1% to 5.0% - unstable, more than 5.0 % - bad.

To assess the impact of natural and social "risk factors" on acute intestinal infections, use the computer program "medstatistic".

The correlation coefficient can be marked (+) while the growth of one phenomenon increases another too, or (-) when with increasing of one phenomenon, another is decreasing. The strength of the connection between the phenomena may be weak (correlation coefficient - 0 - 0.29), medium (0.3 -0.69) or strong (0.70 - 0.99). The condition of the probability of the correlation coefficient is its excessing of its own triple error - $R_{xy} > 3mR_{xy}$, where m - the average error, calculated by the formula: $mR_{xy} = \sqrt{1 - R_{xy} / n-2}$.

If it was founded an authentic correlation ($p<0.05$) between the average monthly rates of air temperature, humidity, rainfallы, number and density of population (per 1 km^2), natural and migratory movements, and the sick rate of the AII nosological entities, the AII epidemical situation, in a case of increasing of the indicators of abovementioned "risk factors", will be also considered as unstable, which requires immediate elaboration and implementation of the targeted preventive steps.

Let`s consider the example of using this method in the evaluation of the epidemiological situation of shigellosis, salmonellosis, and AIIDA and AIIUE in Sumy region, taking into account demographic and environmental factors in the region. According to industry reports, initially was identified the AII sick rate (Table. 1). According to the formula $T_{gr.(red.)} = (b / I_{cep.} \cdot$

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100 % it was calculated a longstanding tendency of the AII sick rate.

As a result, the study found, that in current conditions in Sumy region the epidemical situation of shigellosis, AIIDA and AIIUE is good, according to $T_{red.}^{av.}$= -10.5 % for shigellosis, and $T_{gr.}^{av.}$ = +0.57 % for AIIDA and AIIUE; epidemical situation of salmonellosis is unstable, because: $T_{gr.}^{av.}$= +2.32 %.

Table 1. AII sick rate in Sumy region (per 100 thousand people)

Nosological entity	Year of investigation													
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Shigellosis	42.3	20.6	13.9	12.3	12.3	3.9	3.8	11.1	2.2	1.5	0.8	4.2	3.7	1.5
Salmonellosis	13.0	7.0	15.2	10.1	10.1	15.8	12.4	14.2	17.5	17.4	16.4	21.7	18.0	16.4
AIIDA and AIIUE	140.3	148.6	137.6	143.3	141.3	130.2	127.2	132.6	138.7	169.4	146.3	152.4	160.0	163.4

Next, determines the influence of demographic and environmental factors on the current epidemiological situation. To do this, firstly, gathers the information about the population in the investigated area, its density (1 km^2), natural and migratory movement (Table. 2), and secondly, investigates monthly indicators of air temperature, humidity and rainfall in the region (Table. 3). Thus, according to the record logs of infectious diseases and other additional sources of information, such as emergency messages, we can determine the seasonal distribution of the certain nosological entities of AII (Fig. 1).

The correlation regressive analysis was an instrument with the help of which the hypothesis about the dependence can be checked and the strength of dependence of the illness rate on the changing of demography and natural factors can be measured.

Table 2. Demographic rate in Sumy region (2001-2014 years)

Year	The population (thous. persons)	The movement of population (%)		Population density (persons per 1 km^2)
		natural	migratory	
2001	1317.8	-11.1	-5.2	55.0
2002	1299.7	-11.1	-3.4	55.0
2003	1279.9	-11.4	-3.8	54.0
2004	1261.7	-11.5	-3.4	54.0
2005	1243.9	-12.1	-2.7	53.0
2006	1226.3	-10.1	-2.6	52.0
2007	1211.4	-10.2	-2.3	52.0
2008	1196.8	-9.6	-1.3	50.0
2009	1184.0	-8.9	-1.2	50.0
2010	1172.3	-8.4	-1.0	49.0
2011	1161.5	-7.2	-0.8	49.0
2012	1152.3	-6.9	-1.2	48.0
2013	1143.2	-7.7	-1.5	47.5
2014	1133.0	-8.0	-0.4	47.1

Table 3. Average monthly rate of meteorological factors in Sumy region (2001-2014 years)

Factor	Average monthly rate											
	January	February	March	April	May	June	July	August	September	October	November	December
Air temperature (°C)	-5.3	-5.3	0.4	8.8	15.8	18.5	21.2	20.0	13.8	7.3	2.1	-3.2
Humidity,%	85.3	85.3	77.9	67.1	64.7	68.2	70.4	67.4	74.7	81.3	7.1	87.2
Rainfall, mm	42.2	36.1	39.4	31.5	56.9	57.5	76.2	43.2	53.4	46.2	36.1	37.6

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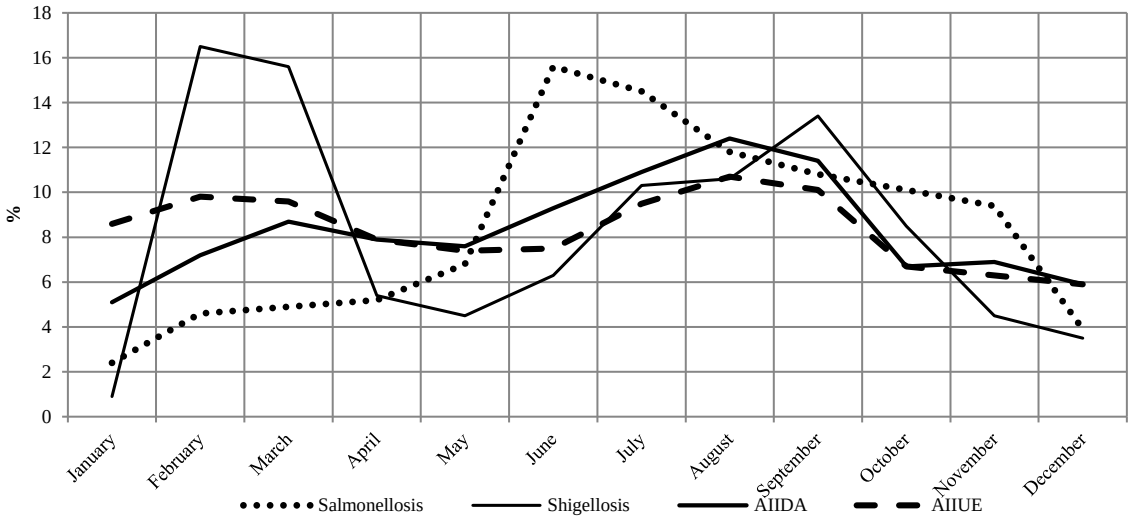

Figure 1. Seasonal distribution of AII

Calculations were performed as follows: $R_{xy} = \Sigma d_x \bullet d_y / \sqrt{.\Sigma d_x^2 \bullet d_y^2}$. It was found, that the number and density of population (1 km^2) (coefficients of correlation and regression analysis Pearson (R_{xy}) were, respectively, 0.824 (y = -176.32446 + 0.15324 • x) and 0.732 (y = -138.00979 + 2.88259 • x)) have the influence on increasing of the sick rate of shigellosis (Table 4).

Table 4. Correlation between the sick rate of salmonellosis and shigellosis, salmonellosis seasonal distribution, AIIDA, AIIUE and social and meteorological "risk factors" in Sumy region

Characteristic		Nosological entities				
		shigellosis	salmonellosis	AIIDA and AIIUE	AIIDA	AIIUE
Social	number of population	0.824*	-0.739	-0.478	-	-
	density of population (per 1 km^2)	0.730*	-0.785	-0.552	-	-
	natural movement of population	-0.608	0.824*	0.533*	-	-
	migratory movement of population	-0.856	0.596*	0.425	-	-
Climatic	air temperature	0.074	0.833*	-	0.789*	0.257
	humidity	-0.057	-0.494	-	-0.649	-0.315
	rainfalls	0.066	0.692*	-	0.486	0.199

Note: *($p<0.05$)

Similar relationships were also found between the levels of salmonellosis sick rate and net migration rate ($R_{xy} = 0.596$, y = 18.34987 + 1.66337 • x) and natural population movement ($R_{xy} = 0.824$, y = 32.16028 + 1.82237 • x). On the seasonal distribution of salmonellosis sick rate affected temperature and rainfall.

Between the abovementioned indicators existed, accordingly, strong quantitative direct correlation ($R_{xy} = 0.833$, y = 5.50033 + 0.36089 • x), and moderate quantitative correlation ($R_{xy} = 0.692$, y = -2.63717 + 0.23665 • x).

From the average daily temperature levels, to some extent, depended a frequency of cases, in which people with AIIDA asked for medical service ($R_{xy} = 0.789$, y = 6.92423 + 0.17950• x).

Thus, despite the fact, that in the current conditions of Sumy region, epidemical situation of shigellosis and AIIDA is considered as good, accordingly: $T_{red.av.} = -10.5$ % і $T_{gr.av} = +0.57$ %, increasing of number and density of population and average daily temperature in this region can cause increase the sick rates of shigellosis and acute intestinal infection, caused by other determined agents.

The epidemical situation of salmonellosis at the time of research was unstable ($T_{gr.av.} = 2.32$ %), but if the indicators of the natural and migratory movement of population are increasing, the situation will be worse. Although, climatic factors haven`t got a direct relation to the transmission of salmonellosis agents, and not directly related to it, but they influence on the dynamics of this disease. Increasing of air temperature and rainfalls can be used as a prognostic sign of the aggravation of salmonellosis epidemiological situation.

So, in a case of growth of number and density of population, can exist the favourable conditions for increasing of shigellosis epidemical process; rising of natural and migratory movements and levels of daily

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average temperature and rainfall promote the probability of salmonellosis; rising of environmental temperature promotes the probability of AIIDA. To avoid the aggravation of the AII epidemical situation, when the levels of natural and social "risk factors" are growing up, it is necessary to organize and take the prophylactic measures immediately. This method can be used by Hygienic and Epidemiological Center in conducting of epidemiological surveillances of intestinal infections for optimizing of preventive measures.

References

1. Guidelines for the epidemiological assessment of sanitary and hygienic conditions for the prevention of intestinal infections / Approved. Zam. Minister of Health. USSR, Ch. State. Sanitize. Doctor of the USSR P.N. Burgasov June 6, 1986 N 28-6 / 20 // Sat. Basic instructional and methodological documents on sanitation and hygiene. 1991. Vol. 1. P.451-474.
2. Method for quantifying the factors contributing to the spread of intestinal infections: pat. 2335235 Russian. Number 20060135889; appl. 10.10.2006.; publ. 10.10.2008, Bull. Number 16 (Vol. 1). 80 pp.
3. A method for analyzing and predicting the development of an epidemic situation caused by socially significant airborne infections: pat. 2572227 Russian. Number 2014042457; appl. 31.03.2014.; publ. 27.12.2015, Bull. Number 8 (Vol. 1). 120 pp.
4. Assessment method epidemic situation of controlled droplet infection: pat. 92826 Ukraine. Number 201402039; appl. 28.02.2014.; publ. 10.09.2014, Bull. Number 17. 110 pp.
5. Fridman K.B., Kryukova T.V. Urbanization - a factor of increased risk to health // Hygiene and sanitation. 2015. N1. P. 8-12.
6. Vinokurova M.V., Vinokurov M.V., Voronin S.A. Influence of the automobile-road complex of Surgut on air pollution and public health //Hygiene and sanitation. 2015. N1. P. 57-61.
7. Revich B.A., Shaposhnikov D.A., Avaliani S.L. et al. Assessment of the danger to the health of the population of Moscow high temperature and air pollution // Hygiene and sanitation. 2015. N1. P. 36-41.
8. Estévez A, Arvelo W, Hall AJ, et al. Prevalence and genetic diversity of norovirus among patients with acute diarrhea in Guatemala // J Med Virol. 2013 Jul. N 85(7). P. 1293-8.
9. Wikswo ME, Hall AJ. Centers for Disease Control and Prevention.Outbreaks of acute gastroenteritis transmitted by person-to-person contact – united States, 2009-2-10 // MMWR Surveill Summ. 2012 Dec. N14 (9). P.1-12.

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Introduction. Despite the fact, that nowadays acute intestinal infections (AII) sick rate is decreasing, the aggravation of the epidemical situation is always there. Increased attention to AII caused by unpredictable epidemical rises of the AII diseases, which cannot be prevented without assessing the epidemical situation of these infections and forecasting of the levels of sick rate. However, developed mathematical methods of forecasting in most cases do not take into account the risk factors, also they are time-consuming and it is difficult to calculate them; and developed special computer programs, which predict infectious sick rates, are often in the lack in the institutions of sanitary-epidemiological service. An urgent problem for today is establishing of the most influential social and environmental factors, which can make a contribution to the spread of AII. The aim of this work was to improve the method of assessment and prediction of epidemic situation of AII by identifying the influence of climatic and demographic factors. **Materials and methods**. In order to determine the influence of meteorological and demographic factors on the epidemic process of acute intestinal infections the official reports of the State Sanitary and Epidemiological Service of Ukraine in Sumy region, the Department of Statistics, Sumy Regional Center for Hydrometeorology and Environmental Monitoring have been studied. **Results and discussion.** The work on the evaluation of the epidemiological situation of the AII begins from collecting data, according to the AII sick rate. The main source of this information is the logbook of infectious diseases, which recorded all sick people that were found in the area. It is necessary to gather the initial information, calculate the sick rate and monthly distribution of AII cases on investigated area and evaluate the tendency. At the same time with accounting of AII cases on investigated territory, takes place a monitoring of air temperature, humidity and rainfall. Simultaneously, should be gathered the information about the population on the investigated area, its density (for 1 km^2), natural and migratory movement. When the information is gathered, begins the stage of analytical research. At first, determines the long-term tendency of the sick rate. If the average time of growth of the sick rate ranges from 0 to 1.0% - the epidemiological situation of this nosology is good, ranges from 1.1% to 5.0% - unstable, more than 5.0 % - bad. The probability of the influence of natural and social "risk factors» (X) on the AII sick rate (Y) calculates according to this formula: $R_{xy} = \Sigma\, d_x \bullet d_y \,/\, \sqrt{\Sigma\, d_x^2 \bullet d_y^2}$, where R_{xy} - correlation coefficient; d_x - departure from the arithmetical average of levels of natural or social factors; d_y - departure from the arithmetical average of the annual sick rate or seasonal distribution. If it was founded an authentic correlation ($p<0.05$) between the average monthly rates of air temperature, humidity, rainfallы, number and density of population (per 1 km^2), natural and migratory movements, and the sick rate of the AII nosological entities, the AII epidemical situation, in a case of increasing of the indicators of abovementioned "risk factors", will be also considered as unstable, which requires immediate elaboration and implementation of the targeted preventive steps. a result, the study found, that in current conditions in Sumy region the epidemical situation of shigellosis, AIIDA and AIIUE is good, according to $T_{red.}^{av.}$= -10.7 % for shigellosis, and $T_{gr.}^{av.}$

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= +0.6 % for acute intestinal infection, caused by other determined agents (AIIDA) and acute intestinal infections of unknown etiology (AIIUE); epidemical situation of salmonellosis is unstable, because: $T_{gr.}^{av.}$= +2.3 %. It was found, that the number and density of population (1 km^2). Similar relationships were also found between the levels of salmonellosis sick rate and net migration rate and natural population movement. On the seasonal distribution of salmonellosis sick rate affected temperature and rainfall. From the average daily temperature levels, to some extent, depended a frequency of cases, in which people with AIIDA asked for medical service. Thus, despite the fact, that in the current conditions of Sumy region, epidemical situation of shigellosis and AIIDA is considered as good, accordingly: $T_{red.av.}$= -10.7 % i $T_{gr.av}$.= +0.6 %, increasing of number and density of population and average daily temperature in this region can cause increase the sick rates of shigellosis and acute intestinal infection, caused by other determined agents. The epidemical situation of salmonellosis at the time of research was unstable ($T_{gr.av.}$ = 2.3 %), but if the indicators of the natural and migratory movement of population are increasing, the situation will be worse. Although, climatic factors haven`t got a direct relation to the transmission of salmonellosis agents, and not directly related to it, but they influence on the dynamics of this disease. **Conclusion.** So, in a case of growth of number and density of population, can exist the favourable conditions for increasing of shigellosis epidemical process; rising of natural and migratory movements and levels of daily average temperature and rainfall promote the probability of salmonellosis; rising of environmental temperature promotes the probability of AIIDA. To avoid the aggravation of the AII epidemical situation, when the levels of natural and social "risk factors" are growing up, it is necessary to organize and take the prophylactic measures immediately. This method can be used by Hygienic and Epidemiological Center in conducting of epidemiological surveillances of intestinal infections for optimizing of preventive measures.

Key words: acute intestinal infections, epidemical situation, risk factors.

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