https://doi.org/10.38109/2225-1685-2018-2-16-27

ISSN 2225-1685 (Print)
ISSN 2305-0748 (Online)

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DEPENDENCE OF MORTALITY FROM CARDIOVASCULAR SYSTEM DISEASES ON METEOROLOGIC FACTORS AMONG POPULATION OF BAKU AND GUBA

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SUMMARY

The article presents the results of study dependence of mortality from cardiovascular system diseases on meteorologic factors among population of Baku and Guba. Air temperature and rainfall have been taken as the main meteorological indicator for months. Increased risk of death from cardiovascular diseases in both cities was observed more in the spring-winter months than in the summer, which was associated with a high amount of precipitation at this time of the year and with a lower temperature.

Keywords: *meteorologicalfactors,diseasesofthecardiovaskulyar system,the risk of death,air temperature,rainfall,population of Guba and Baku.*

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For citation: Azizov V.A., Hatamzade E.M., ahimova A.S., Alekperova A.K., Sadigova T.A., Mamedzade A.Y. Dependence of mortality from cardiovascular system diseases on meteorologic factors among population of Baku and Guba. Eurasian heart journal. 2018, May 25; 2: 22-27.

Diseases of the circulatory system (DCS) are one of the leading causes of mortality in the world [1,2,9]. Meteorological factors, as air temperatures and precipitation, are poorly studied mortality risk factors for DSC.

Environmental problems are intensifying and the World Health Organization, as well as the United Nations, are calling for urgent measures to protect the ecosystem. The impact of environmental changes on the health of the population has not been sufficiently studied, although there are a number of scientific studies.

There are number of works by scientists from different countries about seasonal changes in the hospitalization level for cardiovascular diseases [3,16,22]. Seasonal dependence of hospitalization was associated with acute myocardial infarction and angina [28]. It is also believed that seasonality is characteristic for cases of hospitalization due to heart failure [13].

Kyseli, J., et al. confirm the role of meteorological conditions as a risk factor for morbidity and mortality [24]. There was a direct effect of weather on human health in the mid-latitudes, during and after the summer heat. The increase of mortality risk with decreasing temperature in winter is also noted in many regions. It is believed that the risk of mortality due to cardiovascular and respiratory diseases increases under the influence of cold in elderly patients.

American scientists gave information on the role of air temperature in increasing risk of mortality [14,17, 23]. Different works showed the importance of extreme weather conditions in the formation of the mortality risk [17]. A number of researchers provided a comparative estimate of the risk of mortality from high and low air temperatures [10,11,21]. An attempt was made to compile estimates of the mortality rate of the population in large regions of the United States of America [8, 18, 29, 33]. There is evidence of the effect of air temperature, which occurred during the period from 1973 to 2006 [5, 1932]. According to the forecasts of American scientists, a significant increase in the risk of mortality is expected by 2030, 2050 and 2100 years [25,27]. There are forecasts for individual regions and cities, taking into account the likely change in air temperature [15, 23].

The role of heat in increasing the mortality risk was confirmed in the works of many scientists [12,26]. And the main causes of death caused by heat, are cardiovascular diseases [30,31]. A reliable link between the risk of mortality and air temperature was confirmed in Greece, Beirut, Australia, Europe [24,33], as well as in Cyprus, where the climate is predominantly subtropical. In Cyprus, the daily average winter temperatures varying from 3 °C to 10 °C, and summer temperatures from 22 °C to 29 °C. Mortality data included deaths due to hypertension, IHD, DIC, and other cardiovascular diseases. The total number of deaths was 13889. The authors have established a relationship between high temperatures and mortality cases, due to cardiovascular pathologies. The greatest risk of mortality is observed on the day of temperature increase and persists until the next day. It is believed that in cases of obtaining forecasts of an increase in air temperature, it is necessary to carry out preventive measures.

Taking into account the objective conditionality of the influence of climatic factors on the state of human health, scientists try to find the most vulnerable groups of the population [4,7]. In this case, it is more important to search for threshold temperatures, above or below which the risk of mortality increases [6].

Howorth E.A. in his works draws attention to the role of public health in preventing the negative consequences of climate change [20]. It is believed that climate change is the greatest social problem of the 21st century. Therefore, public health should provide a sensitive to climate change monitoring of public health indicators (morbidity, mortality). Health services should be prepared to eliminate the negative effects of climate change.

Given the urgency of this problem, we conducted a comparative retrospective study in 2 Azerbaijan cities.

The purpose of the study was to study the dependence of the mortality risk due to DCS from meteorological factors in the city of Baku and the city of Guba.

MATERIAL AND METHODS OF THE RESEARCH

Cases of death due to DCS for long periods in 2 cities (Baku, Guba) of the country were analyzed. An adequate source of such materials was the database of the State Statistics Committee of the Republic of Azerbaijan, which is available on its website (www.stat.gov.az). Using the materials of official statistical information,

Table 1. The connection of the average daily deaths due to DCS in the city of Baku with an average daily mean air temperature

The average daily temperature (x)	Average daily cases death from DCS (y)	The equation regression	Monthes of the year	The average daily temperature of air x	Average daily cases of death	M_t	M_c	The equation Regression
0,8	29	y=0,0003x4-0,02x3+0,4452x2- 3,7617x +31,043 (R2=0,3947)	January	3,5	20	12,08± 4,17	24,22± 1,49	$y=0,013x^4-0,0699x^3+1,1425x^2-6,2485x+33,742$ (R2=0,8767)
3,5	20		February	0,8	29			
5,5	24,3		March	5,5	24,3			
6,4	18,8		April	16,6	26,6			
12,7	20,4		May	21,3	19,9			
16	26,6		June	25,4	25,5			
19,9	20,1		July	26,4	19,6	19,30± 3,39	19,48± 0,26	$y=0,0001x^5+0,0113x^4-0,3983x^3+6,5567x^2-49,649x+154,68$ (R2=10)
21,3	19,9		August	28	19,0			
22,4	19,0		September	22,4	19,0			
25,4	25,5		October	19,9	20,1			
26,4	19,6		November	12,7	20,4			
28	19		December	6,4	18,8			
Correlation coefficient 0,63 t=2,6; P<0,01			The results of a two-sample F test for variance of indicators: in January-June, July-December			F=1,5 P=0,33	F=30,7 P<0,001	

the share of DCS among all causes of mortality in the dynamics for 1970-2011 was determined. It was assumed that this information will allow us to trace the main trend of the dynamics of the share of DCS among the causes of mortality of the population. To identify trends in the dynamics of the share of BSC among the causes of mortality, the least squares method was used with the Excel program. When the line of dynamics was smoothed, exponential, linear, logarithmic, polynomial, power lines were tested. To describe the trend, regression equations were selected that have the largest approximation value (R_2 is the determination coefficient).

The main criteria for determining the role of circulatory system diseases in mortality were:

- the mortality rate of the population from all causes and due to DCS;
- the share of DCS among all causes of mortality.

Dependence of the mortality risk due to DCS from meteorological factors was studied according to materials from the cities of Baku and Guba, where stationary weather stations of the Ministry of Ecology and Natural Resources of the Republic of Azerbaijan operate. Data on the daily temperature of air, the amount of precipitation was obtained from these meteorological stations.

To identify the link between the risk of mortality due to DCS and air temperature, several testing options were tested:

- Study of the correlation between the average daily air temperature and the average daily deaths due to DCS by months of the year.

- Comparison of the arithmetic mean parameters of the average daily air temperature and the average daily deaths due to the DCS for the six-month period (January-June, July-December).

- Compilation of variants of variable parameters of meteorological factors (based on moving averages) and average daily deaths due to DCS (including IHD, MI, DIC), obtaining a descriptive statistical characteristic and evaluating the reliability of the difference between the t (Student-Fisher) and F (dispersion analysis).

RESULTS AND DISCUSSION

The primary data of the average daily air temperature and the average daily deaths due to DCS, IHD and MI are given in Table 1.

The correlation coefficient between the average daily air temperature (x) and the average daily death rate due to the DCS (y) was 0.63 ($t = 2.6$, $P<0.01$). The risk of mortality due to DCS depends on the air temperature and there is an inverse correlation between them.

The average daily air temperature for the first half of the year (January-June) was 12.08±4,17°C and did not differ significantly from that in the second half of the year (19.30±3,39°C). In these periods, the average daily deaths (24.20±1.49 in the first half, 19.48±0.26 in the second half of the year) differ significantly from one another ($F = 30.7$, $P<0.001$). This example also confirms the association of the mortality risk due to DCS with air temperature. The relatively high (19.30±3,39°C) compared to the relatively low (12.08±4,17°C) air temperature is associated with a significantly low mortality rate due to DCS.

Attention is drawn to the more pronounced connection between the risk of mortality due to DCS and the average daily temperature for a separate analysis of the connection for the first and second half of the year.

The general conclusion from these data: low air temperature is associated with high risk, and high air temperature – low risk of mortality due to DCS.

Data on the average daily deaths due to DCS for different variants of the average monthly precipitation in Baku are shown in Table 2.

Table 2. The average daily deaths due to DCS, depending on the average monthly rainfall in Baku

Variants of the average monthly precipitation level mm (x)	Average daily deaths as a result of (y)	Average daily deaths as a result of CHD (y)	Average daily deaths due to MI (y)	Average daily deaths due to the DVC (y)
0 3,7±2,16	26,6 26,6±1,35	17,7 17,8±0,95	2,2 2,2±0,11	8,8 8,8±0,49
8,4±0,09	24,47±2,57	16,36±1,76	1,97±0,26	8,1±0,86
12,7±2,67	22,7±3,16	15,2±2,15	1,83±0,28	7,6±1,07
18,8±3,55	19,36±0,36	12,9±0,25	1,57±0,03	6,4±0,13
23,4±3,55	19,3±0,3	12,8±0,18	1,63±0,03	6,4±0,1
30,3±3,45	19,5±0,26	13,0±0,18	1,63±0,03	6,5±0,08
34,2±3,12	19,8±0,12	13,1±0,09	1,63±0,03	6,5±0,05
41,0±3,68	20,0±0,23	13,2±0,20	1,63±0,03	6,5±0,09
47,8±5,72	22,0±1,77	14,5±1,26	1,8±0,15	7,2±0,62
58,7±6,35	21,6±2,02	14,4±1,33	1,8±0,15	7,2±0,62
63,9±6,45	22,2±3,35	14,8±2,2	1,9±0,25	7,4±1,0
70,3	18,8	12,6	1,6	6,4
	Y_{DCS}=-0,0002x^3+ 0,024x^2 -0,8336x+28,36 (R^2=0,6067)	Y_{IHD}=-0,0001x^3+ 0,0157x^2 -0,5549x+18,941 (R^2=0,598)	Y_{MI}=0,0003x^3-0,0255x +2,1426 (R^2=0,3683)	Y_{DVS}=0,0013x^2-0,1063x+8,6882 (R^2=0,4194)

The smallest average daily deaths due to DCS were observed in the months when the average monthly rainfall was 18.8±3.55, 23.4±3.55, 30.3±3.45 and 34.2±3.12 mm (respectively: 19.4±0.36, 19.3±0.3, 19.5±0.26 and 19.8±0.12 cases). Compared to these months, significantly high daily mean deaths due to DCS were observed in the months when the amount of precipitation per month is 3.7±2.16 mm (26.6±1.35, P <0.01), 8.4±3.09 mm (24.47±2.57, P<0.05). The highest mortality risk (26.6 cases) is observed with a low level of precipitation (less than 8.4±3.09 mm), with an increase in the amount of precipitation, the risk of mortality decreases, which reaches a minimum at a precipitation level of 34.2±3.12 mm (19.8±0.12 cases, 95% confidence interval: 19.56 – 20.04). The subsequent increase in precipitation is associated with an increased risk of mortality. Obviously, the increase in the amount of precipitation is associated with a wavy change in the risk of mortality due to DCS. The optimum in terms of mortality risk due to DCS are the periods of the year when the average monthly rainfall is in the range from 18.8±3.55 to 34.2±3.12 mm. Below and above this interval, the amount of precipitation is associated with an increase in the likelihood of mortality due to DCS.

Data on the average daily deaths due to BSC in the cities of Guba, depending on the average daily air temperature and the average monthly rainfall are given in Table 3.

At an average daily air temperature of less than 3.8±1.940 °C, the average daily deaths in the city of Guba were 1.04±0.05 and 1.06±0.06. With an increase in the average daily air temperature, the daily average deaths increase. In the period when the average daily temperature was 8.3±3.64 °C, the average daily deaths due to DCS were statistically significantly higher (1.31±0.06) than the average daily deaths due to DCS in periods when the average daily temperature was less than 3.8±1.94 °C (1.04±0.05 and 1.06±0.06). Obviously, there is a connection between the average daily air temperature and the average daily deaths due to DCS. The subsequent increase in mean daily air temperature is associated with a periodic decrease and an increase in the average daily death rate, but because of the large size of the mean error, the reliability of the difference is not confirmed. The smallest average daily deaths due to DCS in Guba were observed in the period when the average daily temperature was 17.4±0.98°C (0.89±0.26, 95% confidence interval 0.37-1.141). The highest average daily deaths due to DCS were observed when the average daily temperature was 23.2±0.52°C (1.39±0.16, 95% confidence interval 1.07-1.71). Comparison of these indicators by the Student Fisher criterion (t) does not give a basis (t = 1.66, P>0.05) to refute the null hypothesis.

The lowest level of average daily deaths due to DCS (1.03±0.08, 95% confidence interval 0.87-1.19) was observed in the period when the average monthly precipitation was 74.7±3.73 mm. The highest level of average daily deaths (1.49±0.12) is associated with a period when the average monthly rainfall is 18.1±2.94 mm. The difference between these indicators is significant (t = 3.3, P<0.01). Obviously, there is a link between the risk of mortality due to DCS and fluctuations in the average monthly rainfall.

CONCLUSIONS

The average daily deaths from all causes during the winter-spring period (35.8±1.57) were statistically significant (P<0.05), differing from the average daily deaths from all causes during the summer-autumn period (31.3±1,49). Thus, in the city of Baku there is a winter-spring increase in the risk of mortality of the population.

The average daily deaths due to DCS were relatively higher in February (29.3), April (26.6) and June (25.5), and relatively less in December, August and September (18.8, 19.0). The trend for the monthly dynamics of the average daily deaths due to DCS is well described by the polynomial regression equation (Table 8.1). The trend line has only one peak (the February peak of growth).

Thus, despite the moderate climatic conditions of the city of Baku, the nature of the seasonal dynamics of the mortality risk from DCS corresponds to those in regions with different climatic and geographic conditions. Apparently, winter, and according to our data, the winter-spring rise in the risk of mortality is a general pattern. Taking into account the obtained data and the results of their comparison, one can come to the conclusions:

- In the city of Baku, the average daily deaths from all causes and diseases of the circulatory system in spring (respectively: 34.8±1.45 and 23.6±1.2) and in winter (34.4±2.27 and 22, 5±1.4) are not significantly different

Table 3. The average daily deaths due to DCS, depending on the average daily air temperature and the average monthly rainfall in the city of Guba.

Variants of average daily air temperature ⁰C	The average daily deaths due to				Variants of the average monthly rainfall (mm)				
	DCS	IHD	MI	DVC		DCS	IHD	MI	DVC
-3,1	1,14	0,76	0,09	0,38	10	1,26	0,84	0,07	0,42
-1,0±1,35	1,04±0,05	0,7±0,03	0,08±0,003	0,35±0,01	11,2±0,92	1,14±0,38	0,76±0,25	0,09±0,01	0,37±0,12
0,7±1,18	1,06±0,06	0,71±0,04	0,09±0,01	0,35±0,02	13,8±2,2	1,16±0,38	0,77±0,25	0,11±0,01	0,38±0,13
3,8±1,94	1,15±0,09	0,77±0,06	0,09±0,01	0,38±0,03	18,1±2,94	1,49±0,12	0,99±0,08	0,12±0,01	0,49±0,03
8,3±3,64	1,31±0,06	0,87±0,04	0,1±0,01	0,43±0,02	23,1±2,88	1,30±0,08	0,86±0,05	0,12±0,01	0,43±0,02
12,7±2,48	1,05±0,31	0,7±0,21	0,1±0,01	0,34±0,01	29,8±4,42	0,2±0,11	0,8±0,07	0,09±0,01	0,39±0,03
16,2±1,05	1,05±0,31	0,7±0,21	0,12±0,01	0,35±0,1	37,6±5,34	1,12±0,05	0,75±0,03	0,09±0,01	0,37±0,01
17,4±0,98	0,89±0,26	0,59±0,17	0,09±0,03	0,29±0,08	48,6±6,66	1,17±0,07	0,78±0,05	0,09±0,01	0,39±0,02
19,7±1,38	1,33±0,23	0,88±0,15	0,09±0,03	0,44±0,07	59,1±6,76	1,23±0,03	0,82±0,02	0,10±0,01	0,4±0,1
21,2±1,41	1,28±0,23	0,85±0,15	0,08±0,01	0,42±0,07	67,7±3,43	1,14±0,10	0,76±0,07	0,08±0,02	0,37±0,03
23,3±0,52	1,39±0,16	0,93±0,11	0,09±0,01	0,46±0,05	74,7±3,73	1,03±0,08	0,69±0,05	0,07±0,02	0,34±0,02
24,2	1,26	0,84	0,07	0,42	82	0,97	0,65	0,08	0,32

from each other, but significantly exceed those in summer (31.7±1.76 and 21.4±1.1) and in autumn (31.0±1.82 and 19.8±0.4).

- The trend in the monthly dynamics of the average daily deaths from all causes and diseases of the circulatory system can be described by polynomial regression equations that have a good approximation ($R2 \leq 0.67$). The trend line of the monthly dynamics of total mortality has two peaks (February and November), and mortality due to diseases of the circulatory system is one peak (February).
- Seasonal dependence of the mortality risk is more adequately assessed by comparing the average daily mortality rate, since the days in the months of the year are different and this can distort the true trend.

The results determine the role and place of cardiovascular diseases as the leading mortality of the population in the cities of Baku and Guba, depending on the temperature of the air and the amount of precipitation, and this can serve as a prioritization of preventive measures in public health on the ground.

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Approved for publication:10.04.2018 г.