Journal of Information Systems Engineering and Management
2025, 10(4)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

Method For Assessing the Risk of Incidence from Weather and Climatic Factors

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ARTICLE INFO

Received: 15 Nov 2024

Revised: 30 Dec 2024

Accepted: 20 Jan 2025

ABSTRACT

Climate and weather are interdependent phenomena. Abrupt changes in the weather affect the health of the population, especially vulnerable groups - the elderly, people with chronic diseases and so on. The majority of the population practically does not feel sharp changes in atmospheric processes, however, a sharp change in meteorological parameters affects some people up to the onset of crisis situations. The paper proposes a method for assessing the risk of increase disease depending on meteorological characteristics based on multiple regression.

It is shown that as a result of a sharp change in meteorological characteristics, the number of diseases in a particular area may increase. The results of statistical processing of the dependence of the increase in morbidity on meteorological parameters based on hydrometeorological observations and medical statistics are presented. Multiple regression coefficients from 0.27 to 0.32 were obtained, which can be interpreted that meteorological parameters account for 30% of cases of diseases. About 70% are accounted for by other factors affecting the health of the population - genetic, environmental conditions, water supply, medical care, conditions and lifestyle.

Keyword: climate change, weather, public health, atmosphere.

Introduction.

The ongoing climate change has inevitably led to a change in the conditions for the formation of atmospheric processes that determine the weather. As noted in the IPCC report [1], there is an increase in the number of extreme atmospheric events, which change dramatically in a short period of time. For example, heatwaves in Europe, which are well above average. Factors affecting the health of the population are classified into the following types: social, economic, environmental, genetic, living conditions, individual indicators. Data from the World Health Organization [2] show that: at least 50% of a person's health depends on lifestyle; 20% is due to heredity; 20% - on the influence of the external environment; 10% - for health-related factors. The indicator of the influence of lifestyle on human

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health is of leading importance and amounts to half - 50%. The other half in the aggregate are factors of heredity, environmental influences, the health care system and others.

Climate change is already affecting public health in many ways, including death and disease from increasingly frequent extreme weather events such as heatwaves, hurricanes and floods, disruption of food systems, an increase in zoonoses and food, water and vector-borne diseases and mental health problems [2]. Climate-sensitive health risks are disproportionately felt by the most vulnerable and disadvantaged, including women, children, ethnic minorities, poor communities, migrants or displaced persons, older people and people with underlying health conditions [2]. Significant fluctuations in weather characteristics have an impact on meteorologically sensitive segments of the population. In some cases, the dynamics of atmospheric parameters has an impact on people with chronic diseases. People suffering from rheumatism feel changes in atmospheric pressure or a sharp change in air humidity. Elderly people who belong to vulnerable segments of the population experience at least malaise from atmospheric parameters.

The impact of temperature on morbidity and mortality can be assessed at both the seasonal and daily level. The variability in occurrence of numerous illnesses is linked to somewhat predictable seasonal trends in temperature [3]. Kalkstein and Davis [4] report that daily fluctuations in temperature can increase mortality rates by up to 50% in certain cities. Morbidity attributed to pneumonia, influenza, bronchitis, and probably many other illnesses is also weather-related [5].

Hypothermia occurs when the core body temperature falls below 35^{o}C [6]. Certain sectors of the population appear more susceptible to hypothermia than others. Most victims fall in one or more of the following categories: the elderly, newborns, the unconscious, alcoholics, and people on medications [7, 8, 9, 10, 11]. In addition, malnourishment, inadequate hour sing, and high blood ethanol levels increase the incidence of hypothermia [12].

Humidity has an important impact on mortality since it influences the body's ability to cool itself by means of evaporation of perspiration. In addition, humidity affects human comfort, and the perceived temperature by humans is largely dependent upon atmospheric moisture content [13].

However, at present, there is no quantitative characteristic that can be used to assess the risk of an increase in morbidity for the general population under certain weather changes. For timely decision-making on adaptation to sudden weather changes, the assessment of the risk of an increase in morbidity based on the multiple regression method will allow taking scientifically based measures to adapt or reduce the effects of climate change in specific regions of the world.

Starting materials and methods.

Meteorological observations of the atmosphere are carried out on a regular basis using standard observation methods. As the initial data of meteorological observations, data on meteorological stations of the Tashkent region of Uzbekistan were taken. Data on the incidence of the population were taken based on the materials of medical statistics of the Ministry of Health for the administrative districts of rural areas of the Tashkent region.

Monitoring of the condition of patients is carried out on the basis of requests from the population to medical institutions. Often, a mildly ill person does not seek medical help, and in this case, the disease is not included in the statistics. With some types of diseases, the appeal to doctors occurs only in emergency cases, especially if this happens to a person for the first time. These circumstances make it difficult to carry out statistical analysis, since the initial data are not complete [14].

For the analysis of meteorological parameters, the materials of observations at meteorological stations were received. For the analysis of morbidity, the materials from collections of medical statistics published by the Ministry of Health of the Republic of Uzbekistan were taken.

To solve the problem of constructing homogeneous series, to which multivariate regression analysis can be applied, the following approach was used. To prepare the initial data in the form of

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homogeneous series in the multiple regression equation, we used the sum of calls per decade and the average ten-day values of weather parameters. For meteorological parameters the following equation was used:

$$\chi_j = \sum_{j=1}^{n} \frac{|\tau_j - \tau_{j-1}|}{n}, \quad (1)$$

where: χ_j is some factor from the set j; τ_j is the average value of the weather characteristic for a certain period; τ_{j-1} is the average value of the weather characteristic for the previous period; n is the number of observations; j - type of disease, n - list of diseases for a period of time.

Due to the fact that medical statistics in Uzbekistan uses data for a ten-day period, the meteorological parameters are also averaged over a decade. Thus, the dependence of the number of diseases on some weather characteristic is defined as a certain function:

$$\Psi_j = f(\chi_j), \quad (2)$$

It is known that the increase in the number of diseases is significantly influenced by several weather factors at the same time - a sharp change in air temperature and atmospheric pressure, air temperature, atmospheric pressure value, air humidity value. To solve this problem, we use a multivariate linear regression model [15] :

$$\Psi_j = \alpha_0 + \sum_{k=1}^{n} \alpha_k * \chi_k, \quad (3)$$

where α_o, α_k are linear multivariate regression coefficients, n is the number of variables.

The following were taken as weather and climatic factors: the values of the average, maximum and minimum air temperature, the values of atmospheric pressure and its change, air humidity and others.

As types of morbidity, a set of fixed diseases was taken - acute rheumatic fever, chronic rheumatic heart disease, rheumatic heart valve disease, high blood pressure, coronary heart disease, angina pectoris, acute myocardial infarction, chronic coronary heart disease, chronic diseases of the tonsils and adenoids, peritonsillar abscess , pneumonia.

Building a multiple regression model in a standardized or normalized form shows the contribution of each of the components of the equation. The regression equation on a standardized scale is:

$$\Psi_j = \beta_1\chi_1 + \beta_2\chi_2 + \cdots + \beta_n\chi_n, \quad (4)$$

where: $\Psi_j = \frac{\Psi - \bar{\Psi}}{\sigma_j}$, , $\chi_j = \frac{\chi - \bar{\chi}}{\sigma_j}$, β_j - standardized regression coefficients.

Through the process of standardization, the reference point for each normalized variable is set to its mean value over the sample population. In this case, its standard deviation σ is taken as the unit of measurement of the standardized variable. β-coefficients show how the standard deviations will change on average the result due to a change in the corresponding factor χ_j by one-unit σ with the average level of other factors unchanged. The standardized regression coefficients β_j are comparable to each other, which makes it possible to rank the factors according to the strength of their impact on the result. A greater relative influence on the change in the resultant variable is exerted by the factor that corresponds to the greater modulo value of the coefficient β_j. Thus, a certain summary analytical table of the risk of an increase in the number and spread of the type of morbidity of the population depending on weather and climatic factors is obtained in the form of a certain dependence of the incidence on

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weather and climatic factors, with the corresponding linear regression coefficient (R^2) and the approximation reliability value.

The value of the regression coefficient serves as a probabilistic characteristic of the dependence of the type of morbidity on a set of weather and climatic factors and serves as a measure of risk assessment, in terms of its probabilistic excess over the norm, and varies from 0 to 1. Having a weather forecast from the hydrometeorological service, we can make a forecast of the risk of an increase in the number or spread of morbidity with a predetermined degree of probability corresponding to the value of the approximation reliability. It should be noted that in this case, only the weather factor is taken into account, which is secondary, if others are taken as primary factors, for example, an unhealthy lifestyle, an unbalanced diet, stressful situations, constant psycho-emotional stress, physical inactivity, high cholesterol levels in the blood, arterial hypertension, etc.

In accordance with the statistical processing method [16], standardized multiple regression coefficients and determination coefficient were obtained (Table 1).

Table 1
Summary table of standardized regression coefficients, multiple determination coefficient and multiple correlation coefficient for some types of diseases and weather characteristics

Diseases	Atmosphere pressure	Drop atmospheric pressure, per day	Air temperature, average per day	Drop air temperature	Determination coefficient (R^2)	Coefficient Correlation
Acute rheumatic fever	0.0001	0.0668	0.0238	0.0016	0.18	0.42
Chronic rheumatic heart disease	0.0055	0.0282	0.0088	0.0635	0.17	0.41
Rheumatic valvular heart disease	0.0570	0.0019	0.0312	0.0790	0.19	0.44
Diseases characterized by high blood pressure	0.0141	0.2163	0.0027	0.0040	0.23	0.48
Cardiac ischemia	0.0146	0.0230	0.0094	0.0221	0.16	0.4
angina pectoris	0.1720	0.2463	0.3288	0.4280	0.32	0.57
Acute myocardial infarction	0.0661	0.4262	0.2520	0.3488	0.33	0.57
Chronic ischemic heart disease	0.0395	0.2290	0.2024	0.2108	0.29	0.54
Chronic diseases of the tonsils and adenoids, peritonsillar abscess	0.0979	0.1972	0.1469	0.2212	0.27	0.52
Pneumonia	0.0300	0.0957	0.1149	0.0864	0.23	0.48

Only for rheumatic heart valve disease is the value of atmospheric pressure more significant. At the risk of increasing the incidence of acute myocardial infarction, the change in high blood pressure and the change in atmospheric pressure during one day exceeds more than 10 times. Probably for this

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reason, many weather-sensitive people feel the approach of cyclones in the form of a change in atmospheric air pressure.

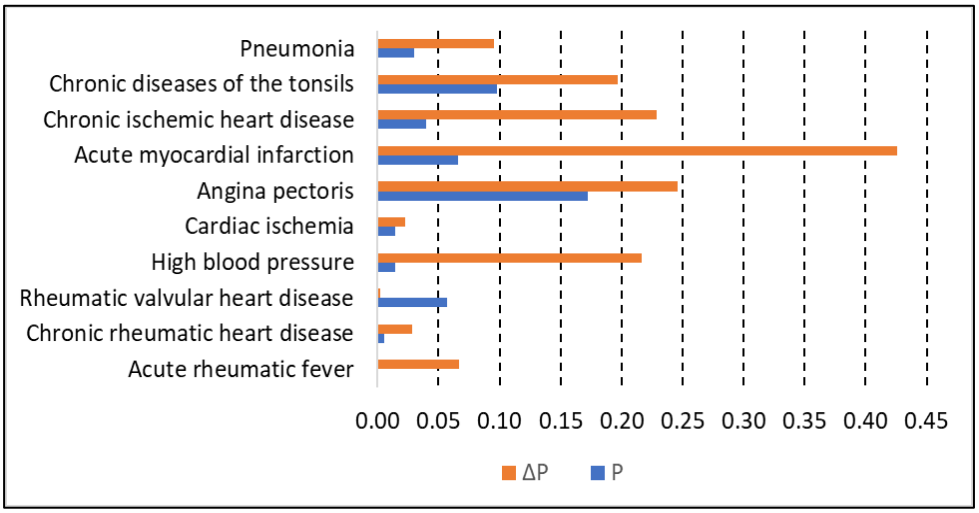

Fig.1 Graphical analysis of the dependence of the risk of morbidity on changes in atmospheric pressure (ΔP) for one day and values of atmospheric pressure (P).

Figure 2 shows a graph of the dependence of the risk of morbidity on changes in air temperature (Δt) for one day and air temperature values (t). The figure shows the influence of a greater influence of air temperature changes on the risk of morbidity than the temperature value itself.

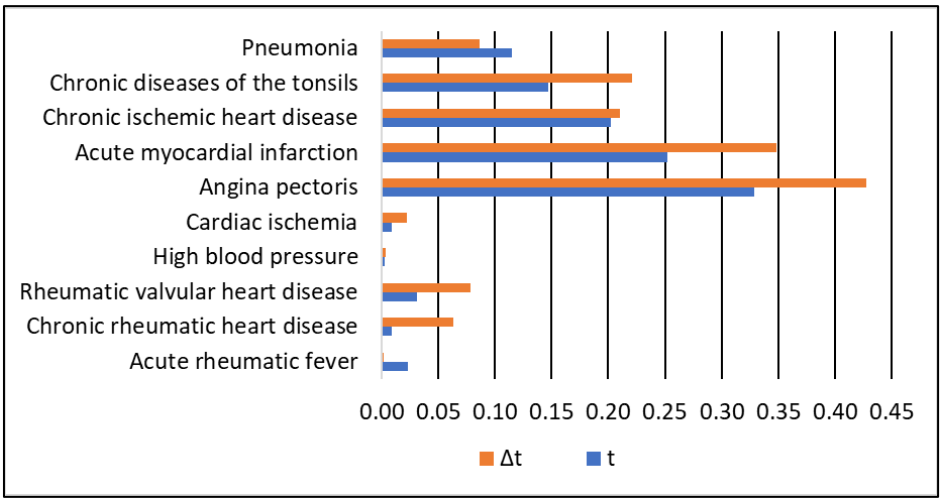

Fig.2. Graphical analysis of the dependence of the risk of morbidity on changes in air temperature (Δt) for one day and air temperature values (t).

Apparently, this circumstance shows that heat waves occurring in countries with a cool climate have a greater impact on health than in countries with a warm and hot climate, where air temperature drops are not so significant. Probably, during air flights, due to a sharp change in atmospheric characteristics, a certain period of acclimatization is necessary. This factor also explains the need for an acclimatization period in cases of high-altitude ascents of climbers.

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Results

As a result of the study, it shown that diseases associated with high blood pressure, angina pectoris and heart disease are more susceptible to changes in atmospheric characteristics than the values of atmospheric air pressure and air temperature are more important for the condition of patients.

Conclusions

As a result of the processing of initial data on the compilation of homogeneous series of meteorological observations and observational materials on morbidity it became possible to conduct a multivariate regression analysis. Multivariate regression analysis showed that, in terms of the combination of atmospheric characteristics, changes in atmospheric pressure and changes in air temperature have a significant impact on the risk of an increase in morbidity. The value of the multifactorial regression coefficient $R^2 = 0.3$ indicates a sufficient level of reliability of the calculation equations for assessing the risk of an increase in certain types of morbidity in the population with the dynamics of atmospheric processes. With climate change it is expected that the number of extreme weather changes will increase, as a result of which an increase in the risk of morbidity is expected.

Acknowledgments: The authors acknowledge the Department of Medical Statistic Ministry of Health of Uzbekistan and Department of Hydrometeorological Services of Uzhydromet.

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https://www.jisem-journal.com/

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