DOI 10.65491/3106-5538-2026-2-53-62
УДК: 614.71:551.5:513.6

INFLUENCE OF METEOROLOGICAL FACTORS AND ATMOSPHERIC AIR POLLUTION ON MORBIDITY RATES OF THE POPULATION IN ZHITIKARA

Otarov Y.Zh.[1], Grebeneva O.V.[1], Shadetova A.Zh.[1], SabirovZh.B.[1], Russyayev M.V.[1], Orazbaeva S.K.[1], Vinnikova A.V.[1]

[1]NC JSC «National Centre Occupational Health and Diseases» (100017, Republic of Kazakhstan, Karaganda, Mustafina str. 15, e-mail: info@naoncgt.kz)

1. Otarov Y.Zh., Doctor of Medical Sciences, Chief Researcher NC JSC «National Centre Occupational Health and Diseases», e-mail: yertay.otarov@gmail.com
2. Grebeneva O.V., e-mail:ol_grebeneva@bk.ru
3. Shadetova A.Zh., e-mail: alma7722@mail.ru
4. Sabirov Zh.B., e-mail: zap.audacious@gmail.com
5. Russyayev M.V., e-mail: sotrnisgl@outlook.com
6. Orazbaeva S.K., e-mail: sholpankairatovna@mail.ru
7. Vinnikova A.V., e-mail: av821664@gmail.com

The relationship between atmospheric air pollution, meteorological factors, and morbidity rates in Zhitikara during 2021–2025 was assessed. A retrospective analysis of environmental monitoring and public health statistics was conducted. Strong positive correlations were identified between overall morbidity and concentrations of $PM_{2,5}$, PM_{10}, and SO_2. The findings suggest a possible influence of environmental factors on population health and emphasize the importance of air quality improvement measures.

Key words: atmospheric air pollution, morbidity, $PM_{2,5}$, PM_{10}, meteorological factors.

Introduction. The state of atmospheric air is one of the most important environmental factors capable of influencing population health indicators. In recent years, the problem of atmospheric air pollution has been considered one of the leading environmenttal risk factors associated with an increase in the prevalence of chronic non-communicable diseases, a decrease in quality of life, and premature mortality of the population [1,2]

Researchers pay special attention to the effects of suspended particles $PM_{2,5}$ and PM_{10}, nitrogen dioxide, sulfur dioxide, and ground-level ozone. According to modern studies, long-term exposure to these pollutants is associated with an increased risk of developping diseases of the respiratory, cardiovascular, nervous, and genitourinary systems [2,4,6]. The most dangerous are considered to be fine particles $PM_{2,5}$, which, due to their small aerodynamic diameter, are able to penetrate into the alveolar regions of the lungs and cause systemic inflammatory reactions [4,6].

Along with anthropogenic sources of pollution, meteorological factors that determine the processes of accumulation and dispersion of impurities in the atmospheric air are of significant importance. Air temperature, relative humidity, atmospheric pressure, and wind speed have a direct impact on the concentration of pollutants in the surface layer of the atmosphere and, as a result, on the level of exposure to the population [1,3]. The results of recent studies indicate that unfavorable meteorological conditions are capable of enhancing the negative impact of atmospheric pollutants on human health, forming a combined risk of developing various diseases [1,3].

Currently, the One Health concept is gaining wider acceptance, according to which human health is considered in close interconnection with the state of the environment. Within the framework of this approach, air quality is one of the key components determining the sanitary-epidemiological well-being of the population [5]. In this regard, the study of the influence of environmental factors on health indicators is of particular relevance for industrial regions.

Despite a significant number of international studies devoted to assessing the impact of atmospheric air pollution on population health, data on individual regions of the Republic of Kazakhstan remain limited. This is especially true for small industrial cities, where the combination of local emission sources and natural-climatic features can have a significant impact on the formation of health risks for the population.

Zhitikara is an industrial center of the Kostanay region, characterized by the presence of technogenic impact sources and continental climatic conditions. In this regard, assessing the relationship between meteorological parameters, the level of atmospheric air pollution, and population morbidity indicators is of scientific interest.

The aim of the study is to examine the relationship between meteorological factors, indicators of atmospheric air pollution, and the level of morbidity of the population of Zhitikara for the period 2021–2025.

Materials and methods. The study was conducted on the territory of Zhitikara, Kostanay region. A retrospective analysis of meteorological indicators, atmospheric air monitoring data, and population morbidity indicators for the period 2021–2025 was carried out.

The source of information on meteorological conditions was data from the hydrometeorological service observations. To assess the climatic features of the territory, average monthly values of air temperature (°C), relative air humidity (%), atmospheric pressure (hPa), and wind speed (m/s) were analyzed.

Assessment of atmospheric air quality was carried out using data from state environmental monitoring. The analysis included indicators of the content of suspended particles $PM_{2.5}$ and PM_{10}, sulfur dioxide (SO_2), carbon monoxide (CO), nitrogen dioxide (NO_2), and ozone (O_3). For each pollutant, average annual concentrations and indicators characterizing the level of atmospheric air pollution were calculated.

Official statistical data on the morbidity of the population of Zhitikara were used to study the health status of the population. The analysis included indicators of overall population morbidity, child population morbidity, as well as indicators for individual classes of diseases: infectious and parasitic diseases, diseases of the nervous system, diseases of the genitourinary system, and diseases of the digestive organs.

At the first stage of the study, descriptive statistical processing of the data was performed with calculation of mean values (M), medians (Me), minimum and maximum values. To assess the nature of the relationships between meteorological parameters and indicators of atmospheric air pollution, non-parametric Spearman correlation analysis was used. Interpretation of the strength of the correlation was carried out according to generally accepted criteria: a coefficient of less than 0.30 was regarded as a weak relationship, from 0.30 to 0.69 as moderate, and 0.70 and higher as a strong relationship.

Statistical processing of the study results was carried out using the Statistica 10 software package. Differences were considered statistically significant at a significance level of $p < 0.05$.

Results. Dynamics of Morbidity of the Population of Zhitikara for 2021-2025.

Analysis of the morbidity indicators of the population of Zhitikara for the period 2021–2025 revealed a steady trend toward an increase in both overall morbidity and individual classes of diseases.

Overall population morbidity increased from 44,264.6 cases per 100,000 population in 2021 to 60,669.7 cases per 100,000 population in 2025, corresponding to a 37.1% increase. The most intensive growth was observed in the period from 2023 to 2025, when the indicator increased from 48,684.6 to 60,669.7 cases per 100,000 population (Figure 1).

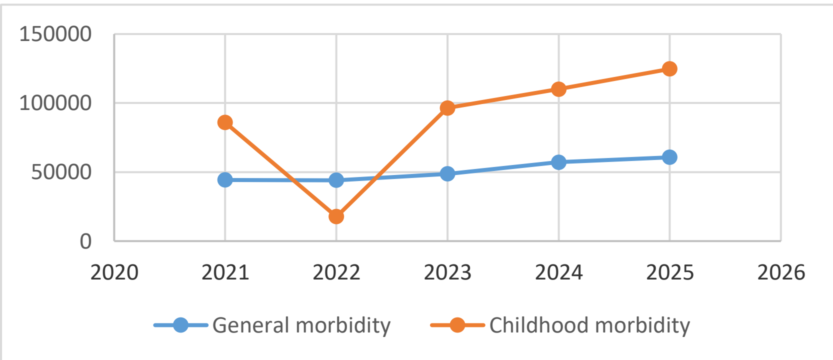

Figure 1. - Dynamics of overall morbidity and child population morbidity per 100,000 population in Zhitikara for 2021–2025

Among the child population, a pronounced trend toward an increase in morbidity was also noted. While in 2021 the indicator was 85,871.9 cases per 100,000 child population, by 2025 it reached 124,695.3 cases per 100,000, an increase of 45.2%. At the same time, in 2022 a significant decrease in the indicator to 17,683.4 cases per 100,000 child population was registered, after which a consistent increase was observed in subsequent years. The identified changes are probably related to the peculiarities of recording and registration of diseases, as well as organizational changes in the system of medical care for the population (Figure 1).

Morbidity from infectious and parasitic diseases over the study period increased from 693.0 to 1,085.0 cases per 100,000 population. The overall increase was 56.6%, which is the most pronounced increase among the analyzed classes of diseases (Figure 2).

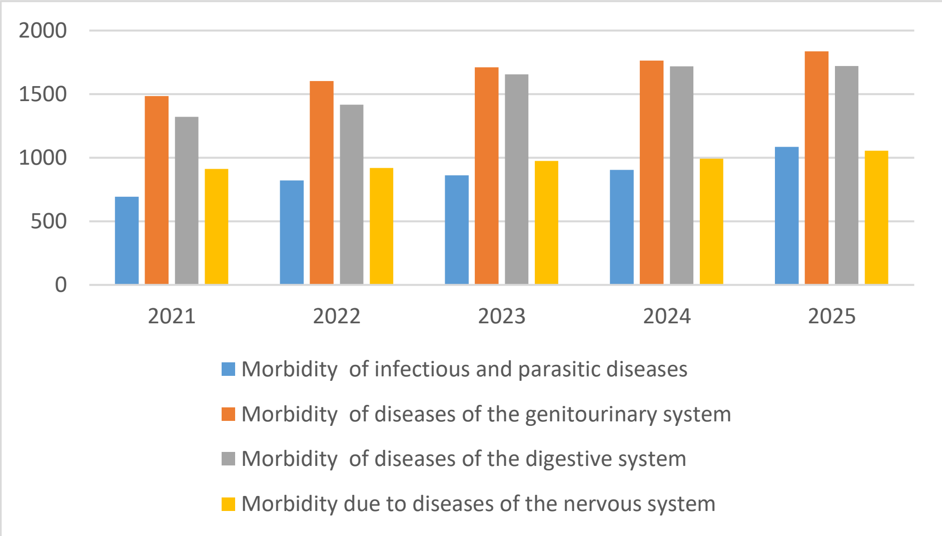

Figure 2. - Dynamics of morbidity by individual classes of diseases among the population of Zhitikara for 2021–2025 (per 100,000 population)

Indicators of diseases of the genitourinary system were also characterized by gradual growth. In 2021, the level of morbidity was 1,483.2 cases per 100,000 population, and by 2025 it reached 1,836.5 cases per 100,000, corresponding to an increase of 23.8% (Figure 2).

A similar dynamic was observed for diseases of the digestive organs. Over the five-year period, the indicator increased from 1,320.5 to 1,720.5 cases per 100,000 population, with a 30.3% increase (Figure 2).

Morbidity from diseases of the nervous system changed less markedly but also demonstrated a trend toward an increase. In 2021, the indicator was 912.7 cases per

100,000 population, and in 2025 it was 1,053.6 cases per 100,000 population, which is 15.4% higher than the initial level (Figure 2).

During the study period in Zhitikara, an increase in most of the analyzed morbidity indicators of the population was noted. The highest growth rates were registered for infectious and parasitic diseases, as well as among the child population. The identified changes may be due to the combined influence of socio-economic, demographic, climatic, and environmental factors, which requires further study of their relationship with the characteristics of atmospheric air and meteorological conditions.

Characteristics of Meteorological Conditions and Atmospheric Air Quality.

Analysis of meteorological indicators in Zhitikara for 2021–2025 showed relative stability of climatic conditions during the study period. Average annual relative air humidity varied from 67.1% to 69.1%, averaging about 68%. Average air temperature varied within 4.6 to 6.2°C, which corresponds to the climatic features of the region. Atmospheric pressure was characterized by minor interannual fluctuations and ranged from 984.0 to 985.4 hPa. Average wind speed varied from 2.8 to 3.1 m/s.

The analysis of atmospheric air quality revealed differences in the concentrations of the studied pollutants. Among gaseous impurities, the highest concentrations were characteristic of nitrogen dioxide. The average annual content of NO_2 varied from 0.102 to 0.149 mg/m³. Sulfur dioxide concentration varied from 0.033 to 0.041 mg/m³.

Carbon monoxide content in the atmospheric air was characterized by significant interannual fluctuations. Average values varied from 0.002 to 0.071 mg/m³. For ozone, the lowest content levels among the analyzed pollutants were noted, with concentrations ranging from 0.005 to 0.014 mg/m³.

The obtained results indicate the presence of interannual variability in both meteorological indicators and concentrations of individual pollutants in the atmospheric air of Zhitikara. The identified differences may influence the formation of the sanitary-hygienic situation and the health status of the population, which served as the basis for conducting correlation analysis.

Correlation Analysis of the Relationship Between Environmental Indicators and Population Morbidity.

The conducted correlation analysis revealed the presence of relationships between indicators of atmospheric air pollution, meteorological factors, and morbidity of the population of Zhitikara.

The strongest positive correlations of overall morbidity were established with concentrations of suspended particles $PM_{2.5}$ ($\rho=0.90$; $p<0.05$), PM_{10} ($\rho=0.90$; $p<0.05$), and sulfur dioxide ($\rho=0.90$; $p<0.05$). For nitrogen dioxide, a moderate positive relationship was revealed ($\rho=0.60$; $p<0.05$). Similar dependencies were observed for child population morbidity.

Among meteorological factors, the most pronounced inverse relationship was noted for air temperature. The correlation coefficient with overall and child morbidity was $\rho=-0.80$ ($p<0.05$). A negative correlation with wind speed was also revealed (ρ=-

0.70; p<0.05), while relative humidity demonstrated a moderate positive relationship with overall morbidity (ρ=0.60; p<0.05) and infectious diseases (ρ=0.70; p<0.05).

The obtained results indicate that the closest relationships with population morbidity indicators were observed for concentrations of suspended particles $PM_{2,5}$, PM_{10}, and sulfur dioxide, as well as individual meteorological factors, primarily air temperature and wind speed (Table 1).

Table 1. - Spearman rank correlation coefficients between population morbidity indicators, meteorological factors, and atmospheric air pollutants.

	Rel. Humidity	Air Temperature	Atmospheric Pressure	Wind Speed	$M_{2,5}$	M_{10}	O2	O	O_2	O_3
Overall morbidity	0,600	-0,800**	-0,600	-0,700	0,900**	0,900	0,900**	-0,600	0,600	-0,200
Child morbidity	0,600	-0,800**	-0,600	-0,700	0,900**	0,900	0,900**	-0,600	0,600	-0,200
Infectious & parasitic morbidity	0,700	-0,700	-0,700	-0,600	0,900	0,900**	0,800	-0,700	0,700	-0,500
Genitourinary diseases	0,700	-0,700	-0,700	-0,600	0,700	0,700**	0,800	-0,700	0,700	-0,500
Digestive diseases	0,700	-0,700	-0,700	-0,600	0,700	0,800**	0,800	-0,700	0,700	-0,500
Nervous system diseases	0,700	-0,700	-0,700	-0,600	0,700	0,800**	0,800	-0,700	0,700	-0,500

Note: ** - Spearman correlation coefficients statistically significant at p<0.05.

It should be taken into account that the analysis was carried out on the basis of five annual observations for the period 2021–2025. In this regard, the obtained correlation coefficient values reflect the general direction of the relationships and require further confirmation over a longer observation period.

Discussion. The conducted study showed the presence of relationships between indicators of atmospheric air quality, meteorological factors, and the level of morbidity of the population of Zhitikara. The most pronounced correlation relationships were identified between overall and child morbidity and concentrations of suspended particles $PM_{2,5}$, PM_{10}, as well as sulfur dioxide.

The obtained results are consistent with data from modern studies, according to which long-term exposure to fine particles and gaseous pollutants contributes to an increased risk of developing various diseases and deterioration of public health indicators [1, 2, 6]. Of particular importance are $PM_{2.5}$ and PM_{10} particles, which are able to penetrate the respiratory tract and cause the development of inflammatory reactions, oxidative stress, and dysfunction of various organs and systems [4, 6].

The identified positive relationship between sulfur dioxide concentrations and morbidity indicators also corresponds to the results of studies indicating the adverse effects of sulfur compounds on population health, especially in industrial regions [1, 2].

Among meteorological factors, air temperature, relative humidity, and wind speed were the most significant. The negative correlation between air temperature and morbidity indicators may be associated with seasonal features of the spread of infectious diseases and changes in the conditions of exposure to environmental factors. At the same time, higher wind speed contributes to the dispersion of pollutants in the atmospheric air, which potentially reduces the level of exposure to the population.

The data indicate that suspended particles $PM_{2,5}$ and PM_{10} may make the greatest contribution to the formation of population morbidity indicators. This is consistent with the results of international studies in which these pollutants are considered one of the main risk factors for the development of chronic diseases and deterioration of populartion health. Exposure to fine particles is accompanied by the development of inflammatory processes, disruption of the respiratory system, and an increase in the overall susceptibility of the body to adverse environmental factors [4, 6].

The obtained findings are in agreement with recent international studies demonstrating that long-term exposure to particulate matter and gaseous pollutants is associated with increased morbidity and adverse health outcomes. According to recent systematic reviews and epidemiological investigations, $PM_{2.5}$ and PM_{10} remain among the most significant environmental risk factors contributing to chronic diseases and increased healthcare burden [7 - 10]. These observations support the results obtained in the present study and emphasize the importance of continuous environmental monitoring in industrial regions.

The obtained results confirm the importance of comprehensive consideration of both environmental and climatic factors when assessing health risks to the population. At the same time, the study has a number of limitations associated with the use of average annual indicators and a limited observation period. In this regard, the identified relationships should be considered preliminary and requiring further confirmation on longer time series.

Conclusions:

1. During the period 2021–2025 in Zhitikara, a trend toward an increase in overall and child morbidity was noted, as well as morbidity from infectious and parasitic diseases, diseases of the genitourinary system, digestive organs, and nervous system.

2. Analysis of atmospheric air quality showed the presence of interannual variability in pollutant concentrations, among which suspended particles $PM_{2,5}$ и PM_{10}, and sulfur dioxide were the most significant for population health indicators.

3. Based on the results of the correlation analysis, strong positive relationships were established between overall population morbidity and concentrations of $PM_{2,5}$ (ρ=0.90), PM_{10} (ρ=0.90), and SO_2 (ρ=0.90), as well as a moderate positive relationship with NO_2 concentration (ρ=0.60).

4. Among meteorological factors, the most pronounced relationships with morbidity indicators were identified for air temperature, relative humidity, and wind speed.

5. The obtained results indicate a possible influence of atmospheric air quality and meteorological conditions on the formation of morbidity indicators of the popularion of Zhitikara and can be used in the development of measures to protect atmospheric air and reduce environmental risks to population health.

Reference

1. Rackow B., König H.H., Wall M., Konnopka C. The interaction between air pollution, weather conditions, and health risks: a systematic review // Science of the Total Environment. 2025. Vol. 996. Art. 180080. DOI: 10.1016/j.scitotenv.2025.180080.

2. Vongelis P., Koulouris N.G., Bakakos P., Rovina N. Air Pollution and Effects of Tropospheric Ozone (O3) on Public Health // International Journal of Environmental Research and Public Health. 2025. Vol. 22, No. 5. Art. 709. DOI: 10.3390/ijerph22050709.

3. Rida J., Bouchriti Y., Ait Haddou M., Achbani A., Sine H., Serhane H. Meteorological factors and climate change impact on asthma: a systematic review of epidemiological evidence // Journal of Asthma. 2024. Vol. 61, No. 12. P. 1601–1610. DOI: 10.1080/02770903.2024.2375272.

4. Roostaei V., Gharibzadeh F., Shamsipour M., Faridi S., Hassanvand M.S. Vertical distribution of ambient air pollutants (PM2.5, PM10, NOx and NO2): a systematic review // Heliyon. 2024. Vol. 10, No. 21. Art. e39726. DOI: 10.1016/j.heliyon.2024.e39726.

5. Contini D., Costabile F. Air Pollution, Health Effects Indicators, the Exposome, and One Health // Atmosphere. 2024. Vol. 15, No. 5. Art. 618. DOI: 10.3390/atmos15050618.

6. Josa-Culleré A., Cakmak-Onal A., Gimeno-Santos E., Alcaraz-Serrano V., Buekers J., Delgado-Ortiz L., et al. Effects of the inhaled dose of air pollution on health: a systematic review // European Respiratory Review. 2025. Vol. 34, No. 177. Art. 250042. DOI: 10.1183/16000617.0042-2025.

7. Liu X., Zhang Y., Chen R., Wang C., Li T. Association between long-term exposure to PM2.5 and population morbidity: a systematic review and meta-analysis // Environmental Research. 2025. Vol. 268. Art. 120845. DOI: 10.1016/j.envres.2025.120845.

8. Wang Q., Guo Y., Niu Y., Liu H. Ambient air pollution and burden of chronic diseases: recent epidemiological evidence and public health implications // Science

of the Total Environment. 2024. Vol. 947. Art. 174352. DOI: 10.1016/j.scitotenv.2024. 174352.

9. Manisalidis I., Stavropoulou E., Stavropoulos A., Bezirtzoglou E. Environmental and health impacts of air pollution: current evidence and future perspectives // International Journal of Environmental Research and Public Health. 2024. Vol. 21, No. 11. Art. 1487. DOI: 10.3390/ijerph21111487.

10. Buteau S., Goldberg M.S., Burnett R.T., Jerrett M. Long-term exposure to ambient air pollution and population health outcomes: recent advances in environmental epidemiology // Environmental Health. 2024. Vol. 23, No. 1. Art. 76. DOI: 10.1186/s12 940-024-01076-4.

ЖІТІҚАРА ҚАЛАСЫ ТҰРҒЫНДАРЫНЫҢ АУРУШАҢДЫҒЫНА МЕТЕОРОЛОГИЯЛЫҚ ФАКТОРЛАР МЕН АТМОСФЕРАЛЫҚ АУАНЫҢ ЛАСТАНУЫНЫҢ ЫҚПАЛЫН БАҒАЛАУ

Отаров Е.Ж.[1], Гребенева О.В.[1], Шадетова А.Ж.[1], Сабиров Ж.Б.[1], Руссяев М.В.[1], Оразбаева Ш.К.[1], Винникова А.В.[1]

[1]«Еңбек гигиенасы және кәсіптік аурулар ұлттық орталығы» КеАҚ (100017, Қазақстан Республикасы, Қарағанды қ., Мұстафин к. 15, e-mail: info@naoncgt.kz)

1. Отаров Е.Ж., м.ғ.д., «Еңбек гигиенасы және кәсіптік аурулар ұлттық орталығы» КеАҚ қауымдастырылған профессоры, e-mail: yertay.otarov@gmail.com
2. Гребенева О.В., e-mail: ol_grebeneva@bk.ru
3. Шадетова А.Ж., e-mail: alma7722@mail.ru
4. Сабиров Ж.Б., e-mail: zap.audacious@gmail.com
5. Русяев М.В., e-mail: sotrnisgl@outlook.com
6. Оразбаева Ш.К., e-mail: sholpankairatovna@mail.ru
7. Винникова А.В., e-mail: av821664@gmail.com

Тұжырым

2021-2025 жылдар аралығында Жітіқара қаласы тұрғындарының аурушаңдығы мен атмосфералық ауаның ластану көрсеткіштері, сондай-ақ метеорологиялық факторлар арасындағы байланыс зерттелді. Қоршаған орта мониторингі және медициналық статистика деректеріне ретроспективті талдау жүргізілді. Жалпы аурушаңдық пен $PM_{2,5}$, PM_{10} және SO_2 концентрациялары арасында күшті корреляциялық байланыстар анықталды. Нәтижелер қоршаған орта факторларының халық денсаулығына ықтимал әсерін көрсетті.

Түйін сөздер: атмосфералық ауаның ластануы, аурушаңдық, $PM_{2,5}$, PM_{10}, метеорологиялық факторлар.

ВЛИЯНИЕ МЕТЕОРОЛОГИЧЕСКИХ ФАКТОРОВ И ЗАГРЯЗНЕНИЯ АТМОСФЕРНОГО ВОЗДУХА НА ПОКАЗАТЕЛИ ЗАБОЛЕВАЕМОСТИ НАСЕЛЕНИЯ Г. ЖИТИКАРА

Отаров Е.Ж.[1], Гребенева О.В.[1], Шадетова А.Ж.[1], Сабиров Ж.Б.[1], Руссяев М.В.[1], Оразбаева Ш.К.[1], Винникова А.В.[1]

[1]НАО «Национальный центр гигиены труда и профессиональных заболеваний» (100017, Республика Казахстан, г.Караганда, ул.Мустафина 15, e-mail: info@nao ncgt.kz)

1. Отаров Е.Ж., д.м.н., ассоциированный профессор НАО «Национальный центр гигиены труда и профессиональных заболеваний», e-mail: yertay.otarov@gmail. com
2. Гребенева О.В., e-mail: ol_grebeneva@bk.ru
3. Шадетова А.Ж., e-mail: alma7722@mail.ru
4. Сабиров Ж.Б., e-mail: zap.audacious@gmail.com
5. Русяев М.В., e-mail: sotrnisgl@outlook.com
6. Оразбаева Ш.К., e-mail: sholpankairatovna@mail.ru
7. Винникова А.В., e-mail: av821664@gmail.com

Резюме

Изучена взаимосвязь между показателями загрязнения атмосферного воздуха, метеорологическими факторами и заболеваемостью населения г. Житикара за 2021–2025 гг. Проведен ретроспективный анализ данных мониторинга окружающей среды и медицинской статистики. Установлены сильные корреляционные связи общей заболеваемости с концентрациями $PM_{2,5}$, PM_{10} и SO_2. Полученные результаты свидетельствуют о возможном влиянии факторов окружающей среды на здоровье населения.

Ключевые слова: загрязнение атмосферного воздуха, заболеваемость, $PM_{2,5}$, PM_{10}, метеорологические факторы.