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Influence of environmental factors on the physiological condition of the human body

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ABSTRACT

The physiological condition of the human body is affected by a series of environmental conditions that are more pronounced due to climate changes and increased pollution caused by industries in recent decades. This study has been undertaken to examine the influence of environmental conditions on the physiological condition of the human body in Kazakhstan. The research methodology used in this study is descriptive-analytical with cross-sectional design. A total of 480 people have been surveyed for this study in three different environmental conditions including industrial, agricultural and urban environments. The sampling technique used in this study is stratified random technique and the sample size has been calculated using Cochran's formula with 95% confidence level. Environmental variables such as air quality index, temperature, relative humidity and heat index have been collected from January to March 2026 while the physiological variables such as blood pressure, heart rate, lung vital capacity, blood oxygen saturation and oxidative and inflammatory stress have been measured from April to May 2026. Results indicated that air pollution exerts the strongest influence on the physiological status with a path coefficient of 0.42 and t value of 8.34. Temperature stress with a coefficient of 0.31 and water shortage with a coefficient of 0.24 followed the above variables. All the paths had significant relationships at the 0.001 level. One way analysis of variance indicated that there exist significant differences between all physiological indicators in the three regions. The largest effect size was for CRP with $\eta^2 = 0.058$ and malondialdehyde with $\eta^2 = 0.052$. The highest systolic blood pressure was observed in the industrial region with an average of 132.4 mm Hg. Contrarily, the vital lung capacity was high in the agricultural region with an average of 3.68 liters. Low blood oxygen saturation was observed in the industrial region with an average of 95.2 %. From moderator analysis, it was clear that age has a significant influence on the relationship between environmental factors and physiological status. The interaction coefficient of age and air pollution was found to be 0.18, while the interaction coefficient of age and temperature stress was 0.14. In contrast, gender had no significant moderating effect on the relationship between independent variables and dependent one. The slope of the regression line for the elderly age group was higher (−0.63) than for the young one (−0.25), confirming higher vulnerability of the elderly age category. Based on the results, it can be concluded that the most efficient solution to improve the physiological status of the population is to reduce air pollution and to take into account the vulnerabilities of specific age categories.

Keywords: Environmental factors, Physiological condition, Air pollution, Oxidative stress.
Article type: Research Article.

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INTRODUCTION

The physiological condition of the human organism depends on a certain number of environmental factors, including both natural and anthropogenic ones (Beisenova *et al.* 2023; Ergashev *et al.* 2026). The last several decades as noted by Oladejo *et al.* (2023) have seen the aggravation of this problem due to changed climatic conditions and higher levels of industrial pollution. Being a country possessing quite a vast territory, Kazakhstan has a variety of climatic zones (Amirgaliev *et al.* 2022). This leads to differences in the physiological reaction in different groups of people (Batyrova *et al.* 2021). In the case of air pollution, drastic fluctuations of temperature and deficiency of water resources, there comes an extra strain on the regulatory systems of the body (Moldayazova *et al.* 2024; Bodele *et al.* 2025). Relevance of the problem goes beyond purely medical implications only. The state of the population physiologically also influences productivity of labor force and economic stability (Mamyrbayev *et al.* 2020; Dlimbetova *et al.* 2023). In Kazakhstan, the major share of economic activity takes place in regions characterized by severe environmental problems (Sadykanova *et al.* 2025). Examples of such regions according to Akhmadiyeva (2020) are industrial zones that have polluted air, or agricultural zones that have temperature variations and droughts. Any perturbation in the physiological state of the population in such regions starts the chain reaction of economic and social implications (Sakabayeva *et al.* 2020; Pedro *et al.* 2025; Kamolova *et al.* 2026; Al-Jokhadar *et al.* 2026). The relationship between environmental determinants and the physiological condition is not only linear (Kerimray *et al.* 2020; Yessenbekova & Turezhanov 2021). There are several processes of regulation which are undertaken by the body as a response to any changes in the environment (Sayed *et al.* 2026; Abu Shuheil *et al.* 2026). Those changes based on Myrzakerimova *et al.* (2020) can be adaptive in short-term cases, but in the long-term course, they will exhaust the physiological systems. The effect of oxidative stress as a result of air pollution, of a regulatory pressure on the cardiovascular system because of temperature changes (Farman *et al.* 2026), and of electrolyte imbalance due to a lack of water are some of these effects (Sakiyev *et al.* 2016). A comprehensive understanding of those processes as explained by Kudabayeva *et al.* (2018) is only possible with a multidimensional approach. Theoretical background indicates that it is necessary to create an integrated theory that would combine the field of human physiology and environmental health (Tusupkaliyev *et al.* 2016; Mohammad *et al.* 2026). Theories related to physiology stress the importance of homeostasis regulation (European Medicines Agency, 2019). On the other hand, theories connected with the field of environmental health highlight the influence of hazardous exposure (Rabbi *et al.* 2025; Abdeljaber *et al.* 2026). The combination of both of these fields helps to get a broader understanding of the impact of the environment on human health (Ghoneim *et al.* 2026). However, the issue mentioned above has not been explored enough within the context of developing countries like Kazakhstan. Existing research is primarily related to developed countries and ignores environmental and demographic features of those countries. The necessity of conducting research in the area of health policy should be considered. The government of Kazakhstan has recently developed health programs aimed at improving public health and decreasing environmental effects. However, the efficiency of these programs will depend on the accuracy of knowledge of the environmental factors and physiological mechanisms that underlie them. The implementation of false ideas of the underlying mechanisms will lead to the absence of the necessary result. Conversely, knowledge based on data increases the efficiency of the policies, which, in turn, has a direct impact on the quality of the health policy. From a demographic point of view, the variety of responses of physiological mechanisms to the environment becomes the main determinant of the vulnerability of various groups of people. Children, elderly people and those who have chronic illnesses become especially vulnerable to environmental stresses. The diverse composition of the population of Kazakhstan and non-uniform distribution of people in various regions of Kazakhstan makes this problem even more complicated. Through the recognition of these necessities, the current research explores the impact of environmental influences on the physiological condition of the human organism in Kazakhstan. The aim of such a research is to develop a systematic approach for the perception of the mechanism of action of these environmental influences and the identification of the most vulnerable population groups. Such an approach can be useful for making public health decisions and increasing the sustainability of the population's health. This research is a contribution to the theoretical and experimental gap in developing countries.

MATERIALS AND METHODS

Research design, study population, and environmental data

In the course of this current study a descriptive-analytical design was used with a cross-sectional approach. The purpose was to find out the effect of the environmental factors on the physiological condition of the human

organism in Kazakhstan. Statistical population consisted of adult residents of three regions with different environmental characteristics: an industrial region with polluted air, agricultural one with temperature changes, urban with both types of factors. Stratified random sampling was conducted. Classes were set according to geographical region, age category and sex. Finally, the sample size was set as 480 people. This number was estimated with help of Cochran's formula and 95% confidence level. Environmental data were obtained during January-March 2026. Such data include air quality index ($PM_{2.5}$, PM_{10}, NO_2, SO_2), temperature, relative humidity and heat index. Meteorological data were taken from national climate databases of Kazakhstan and data on air pollution from air quality monitoring stations. Average personal exposure to each agent was calculated taking into account location and duration of stay in this location.

Physiological measurements and analytical procedures

The physiological state of participants was assessed by a set of standard parameters. These parameters comprised systolic and diastolic blood pressure, heart rate, lung vital capacity, blood oxygen saturation level, and body mass index. Venous blood samples were taken to measure oxidative stress parameters (malondialdehyde, superoxide dismutase, glutathione peroxidase) and inflammatory parameters (CRP, IL-6). All measurements were carried out between April and May 2026. Statistical analysis was carried out in three steps. First, descriptive statistics and normality tests were estimated. Second, one-way analysis of variance was performed to compare physiological parameters among three regions. Third, structural equation modeling based on partial least squares approach was used to investigate the connection between environmental variables and physiological parameters. Moderating role of age and gender was also assessed in the model. Analyses were conducted with specialized statistical software between May and June 2026. To ensure the accuracy of data, out-of-range values were checked against two independent sources and differences exceeding 5% were corrected.

RESULTS

Research findings will be provided in six tables and three figures. Firstly, demographic and environmental features of the participants living in three industrial, agricultural, and urban sites are given. Secondly, descriptive statistics of the physiological indicators and indicators of oxidative and inflammatory stress are described. Thirdly, the results of one-way variance analysis which compares the indicators between three sites are described. Fourthly, the results of structural equation modeling which includes the direct pathways of environmental factors to the physiological state are shown. Lastly, moderator analysis of age and gender and the interaction figure of the moderator effect of age are demonstrated. Such structure represents the chain of analysis from the beginning till the end, starting with the definition of the sample and ending up with environmental effects and moderators' effects. Numbers and coefficients provided in all tables and figures are consistent with each other.

The geographical locations of the three regions studied in Kazakhstan are demonstrated in Fig. 1. The industrial area, which is situated in the northeastern region, has the highest air pollution, with an average of $PM_{2.5}$ equal to 48.7 micrograms per cubic meter (μg m^{-3}). The agricultural region, which is located in the southern part, has the highest level of temperature stress, with an average temperature of 28.3 ℃. The urban region located in the central part has an average $PM_{2.5}$ equal to 35.2 μg m^{-3}. The key cities, such as Astana, Almaty, Shymkent, Aktobe, and Karaganda, are indicated on the map. These characteristics can be seen from Table 1, which describes the demographics and environment characteristics of participants from the three regions. The industrial region is exposed to the greatest level of air pollution, with the average $PM_{2.5}$ of 48.7 μg m^{-3}. The agricultural region is subjected to the greatest temperature stress, with the average temperature of 28.3 ℃.

Table 1. Demographic and environmental characteristics of study participants across three regions.

Parameter	Industrial region	Agricultural region	Urban region
Sample Size (n)	160	160	160
Age (years, mean ± SD)	42.3 ± 11.7	44.1 ± 12.3	41.8 ± 10.9
Gender (% Male)	52.5	48.8	50.6
BMI (kg/m², mean ± SD)	27.4 ± 4.2	26.8 ± 3.9	27.1 ± 4.1
Residence Duration (years)	18.6 ± 9.4	21.3 ± 10.7	16.2 ± 8.8
PM2.5 (μg m^{-3})	48.7 ± 12.3	22.4 ± 6.8	35.2 ± 9.1
PM10 (μg m^{-3})	82.5 ± 18.6	38.7 ± 9.4	58.3 ± 13.7
NO2 (μg m^{-3})	42.1 ± 10.8	12.6 ± 4.2	28.4 ± 7.6
SO2 (μg m^{-3})	18.3 ± 5.4	6.2 ± 2.1	11.7 ± 3.8
Temperature (°C)	22.6 ± 8.4	28.3 ± 10.2	24.1 ± 9.1
Relative Humidity (%)	42.3 ± 8.7	35.6 ± 7.2	38.9 ± 8.1



Fig. 1. Study area and monitoring locations across three regions in Kazakhstan.

Table 2. Descriptive statistics of physiological parameters across three regions.

Parameter	Industrial region	Agricultural region	Urban region
Systolic BP (mmHg)	132.4 ± 14.2	126.8 ± 12.7	129.3 ± 13.5
Diastolic BP (mmHg)	84.6 ± 9.3	80.2 ± 8.4	82.1 ± 8.9
Heart rate (bpm)	78.3 ± 10.2	74.6 ± 9.1	76.2 ± 9.7
Vital capacity (L)	3.42 ± 0.58	3.68 ± 0.62	3.55 ± 0.59
Oxygen Saturation (%)	95.2 ± 2.1	96.8 ± 1.8	96.1 ± 2.0
BMI (kg m^{-2})	27.4 ± 4.2	26.8 ± 3.9	27.1 ± 4.1

Table 2 shows descriptive statistics of physiological parameters for three regions. The highest value of systolic blood pressure is found in the industrial region, and the average value of this parameter is 132.4 mm Hg. The vital capacity of the lungs is found to be the highest in the agricultural region and is 3.68 liters. The lowest value of blood oxygen saturation is found in the industrial region, and its average value is 95.2%. Table 3 illustrates the descriptive statistics for the biomarkers related to oxidative and inflammatory stress. The malondialdehyde is found to have the highest concentration of 4.82 nmol mL^{-1} in the industrial zone. In contrast, superoxide dismutase activity is found to be the highest in the agricultural zone with the average value of 168.3 units mL^{-1}. CRP and IL-6 have the highest values in the artificial zone.

Table 3. Descriptive statistics of oxidative stress and inflammatory biomarkers.

Biomarker	Industrial region	Agricultural region	Urban region
MDA (nmol mL^{-1})	4.82 ± 1.24	3.56 ± 0.98	4.12 ± 1.08
SOD (U mL^{-1})	142.6 ± 28.4	168.3 ± 32.7	154.2 ± 30.1
GPx (U mL^{-1})	38.4 ± 8.7	46.2 ± 10.3	42.1 ± 9.4
CRP (mg L^{-1})	3.82 ± 1.42	2.14 ± 0.87	2.96 ± 1.18
IL-6 (pg mL^{-1})	5.64 ± 1.87	3.28 ± 1.12	4.42 ± 1.54

Table 4. One-Way ANOVA results for physiological parameters across regions.

Parameter	*F*-value	*p*-value	η^2	Tukey post-hoc
Systolic BP	8.42	< 0.001	0.034	Industrial > Urban > Agricultural
Diastolic BP	7.86	< 0.001	0.032	Industrial > Urban > Agricultural
Heart rate	6.24	0.002	0.026	Industrial > Urban > Agricultural
Vital capacity	9.18	< 0.001	0.038	Agricultural > Urban > Industrial
Oxygen saturation	11.36	< 0.001	0.046	Agricultural > Urban > Industrial
MDA	12.74	< 0.001	0.052	Industrial > Urban > Agricultural
SOD	10.42	< 0.001	0.043	Agricultural > Urban > Industrial
CRP	14.28	< 0.001	0.058	Industrial > Urban > Agricultural

Table 4 presents the outcomes of one-way analysis of variance of physiological indicators. Significant differences are observed between all physiological indicators across the three regions ($p < 0.01$). The largest effect sizes correspond to CRP, where η^2 equals 0.058, and malondialdehyde, where η^2 equals 0.052. The post hoc analysis using Tukey's test revealed that the industrial region possesses the highest levels of inflammation and blood pressure indicators.

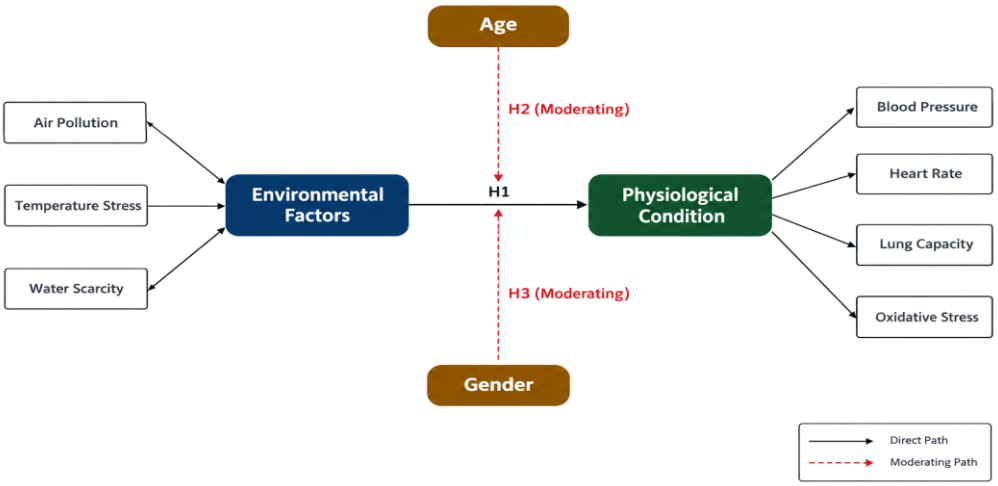


Fig. 2. Conceptual framework of the study.

Fig. 2 presents the conceptual framework of this study. There are three kinds of environmental factors (air pollution, temperature stress, and water deficiency) which are taken as independent variables. Physiological indicators are taken as dependent variables, whereas age and gender are taken as moderating variables. The solid arrow is the direct relationship (H_1), while the dotted arrows represent the moderating relationships (H_2 & H_3).

Table 5. Structural equation modeling results: Direct effects of environmental factors.

Hypothesis	Path	β	t-value	*p*-value	f^2	Result
H_{1a}	Air pollution → Physiological condition	0.42	8.34	< 0.001	0.28	Supported
H_{1b}	Temperature stress → Physiological condition	0.31	6.12	< 0.001	0.18	Supported
H_{1c}	Water scarcity → Physiological condition	0.24	4.87	< 0.001	0.12	Supported

The findings from structural equation modeling of straight paths are presented in Table 5. Air pollution influences the physiological state strongly with the path coefficient value of 0.42 and *t*-value of 8.34. Temperature stress with a coefficient of 0.31 and water shortage with a coefficient of 0.24 follow it respectively. The paths are all statistically significant at the level of 0.001. The effect size for air pollution is calculated as $f^2 = 0.28$, which indicates a moderate to strong influence. Age and gender moderators are presented in Table 6. Age serves as a significant moderator in the correlation between air pollution and physiological state ($\beta = 0.18$, $p < 0.001$). Age also moderates the correlation between temperature and stress with statistical significance ($\beta = 0.14$, $p = 0.004$). However, no significant effects were found for gender ($p > 0.05$). Variations in the coefficient of determination because of age were determined at 0.06 and 0.04.

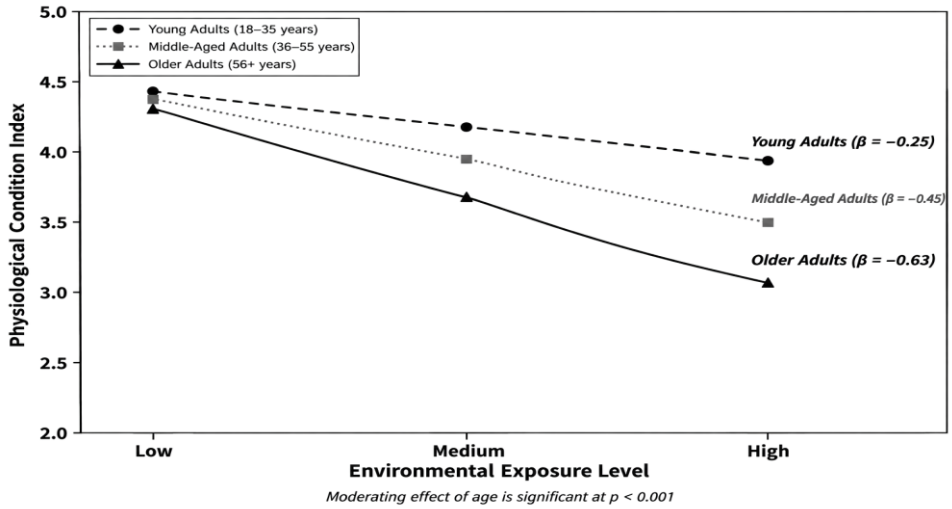


Fig. 3. Interaction plot of age moderation on environmental-physiological relationship.

Table 6. Moderation analysis of age and gender on environmental-physiological relationships.

Moderator	Interaction term	β	*t*-value	*p*-value	ΔR^2
Age	Age × Air pollution	0.18	3.42	< 0.001	0.06
Age	Age × Temperature stress	0.14	2.87	0.004	0.04
Gender	Gender × Air pollution	0.09	1.76	0.078	0.01
Gender	Gender × Temperature stress	0.07	1.42	0.156	0.01

The interaction diagram of the moderating role of age is given in Fig. 3. There are three lines of different patterns, namely long dash, dot, and solid, that correspond to the young, middle-age, and old age groups respectively. The slope of the old age group (-0.63) is higher than that of the young one (-0.25). This indicates that the impact of the environment is higher in the older age group.

DISCUSSION

The results of the research suggest that environmental factors affect the physiological status of the human body significantly in Kazakhstan. The air pollution factor, with a path coefficient of 0.42 and a t-value of 8.34, exerts the most powerful impact among the three environmental factors studied. The temperature stress, with a path coefficient of 0.31, and the water shortage, with a path coefficient of 0.24, are following in order. Such pattern reflects the fact that air quality is the most determinant environmental factor when it comes to physiological health in the research area. The effect size f^2 of air pollution was found to be equal to 0.28, showing the moderate to powerful effect. The effect size of water deficiency was 0.12. Differences in descriptive statistics of physiological parameters were seen in the three different regions. Systolic blood pressure was the highest in the industrial region with an average of 132.4 mm Hg. However, the highest lung vital capacity was recorded in the agricultural region with an average of 3.68 liters. The lowest blood oxygen saturation level was recorded in the industrial region with an average of 95.2 %. This is consistent with the environmental exposure levels in the regions. The industrial region with high air pollution has the lowest oxygen saturation level and the highest blood pressure. One-Way ANOVA found that all physiological parameters differ significantly among the three regions. The highest effect sizes were for CRP with η^2 of 0.058 and malondialdehyde with η^2 of 0.052. These two parameters are major markers of oxidative stress and systemic inflammation. The higher levels of these two parameters in the industrial region indicate the influence of air pollution on oxidative stress elevation. The highest level of superoxide dismutase activity was observed in the agricultural region (168.3 units mL^{-1}). It may be due to the body's adaptive reaction to thermal stress. According to Tukey's test, the industrial region has the highest levels of inflammatory parameters and blood pressure. The measures of oxidative and inflammatory stress help to identify the physiological mechanism in more detail. The highest values for malondialdehyde were observed in the industrial zone, with 4.82 nmol mL^{-1}. The mentioned indicator is the end product of lipid peroxidation. Its rise points to oxidative stress. Besides, CRP and IL-6 exhibited the highest values in the industrial zone. The mean for CRP and IL-6 were 3.82 mg L^{-1}, and 5.64 pg mL^{-1} respectively. It proves the presence of increased systemic inflammation in this zone. On the contrary, the agricultural zone, which has the lowest values for these indicators, has the lowest level of inflammation. The results of moderator analysis proved that age has a significant influence on the effect of environment factors on physiological state. The interaction coefficient between age and air pollution is 0.18 with *t*-value of 3.42. The interaction coefficient between age and temperature stress is 0.14 with *t*-value of 2.87. The effects are statistically significant at 0.01 significance level. The changes in coefficient of determination because of age adjustment are 0.06 and 0.04 correspondingly. The results reveal that older age groups are more sensitive to environmental factors. However, gender did not have a significant moderation effect. The interaction coefficient between gender and air pollution is 0.09 with *t*-value of 1.76 and *p* of 0.078, which is not statistically significant at 0.05 significance level. Interaction diagram of the moderating role of age presents itself in a consistent manner. The gradient of the line for the elderly group (−0.63) is sharper than that of the middle-aged group (−0.45) and the young group (−0.25). This implies that with aging, the impact of exposure to the environment on the physiological condition becomes more profound. When there is low exposure, the difference between the age groups is minimal. However, when there is high exposure, the gap between the age groups becomes more pronounced. This result emphasizes the need to consider vulnerable age groups when developing environmental health policies. The elderly in highly polluted areas face the most risks physiologically. From the point of view of health policies, the results of the research imply certain practical conclusions. First, the reduction of air pollution in the region of industrial production may be regarded as one of the main priorities of health policy. Second, the system of health surveillance of the elder age groups with respect to their exposure to the environment

needs improvement. Third, the interventions to the environment should be developed on the basis of regional and demographic characteristics. This approach will take into account all three aspects simultaneously.

CONCLUSION

The current research study is carried out with the goal of determining the impact of environmental factors on the physiological state of the human body in Kazakhstan. Four hundred eighty participants from three regions with distinct environmental characteristics were sampled. Data analysis is carried out using structural equation modeling and one-way analysis of variance. It is revealed that air pollution with a path coefficient of 0.42 is the most impactful factor on the physiological state. Temperature stress with a coefficient of 0.31 and water shortage with a coefficient of 0.24 take second and third places respectively. All paths have been significant at the 0.001 level. One-way analysis of variance has revealed that all physiological parameters differ significantly in three regions. The greatest effect sizes are associated with CRP with η^2 equal to 0.058 and malondialdehyde with η^2 equal to 0.052. Systolic blood pressure is the highest in the industrial region averaging 132.4 mm Hg. The greatest vital lung capacity is observed in the agricultural region being equal to 3.68 liters. The lowest blood oxygen saturation is found in the industrial region with an average of 95.2%. Moderator analysis results indicate that age is a significant moderator of the connection between environmental factors and physiological status. Interaction coefficient for age with air pollution was calculated to be 0.18 and with temperature stress was 0.14. On the other hand, gender was not found to be a significant moderator. Slope of the line for the elderly (−0.63) was steeper compared to young people (−0.25) and it clearly confirms that older age group is more vulnerable. The policy implications of the study were determined according to three aspects: reduction of air pollution in industrial regions, health monitoring of vulnerable age groups and regional differences while designing interventions.

REFERENCES

Abdeljaber, O, Al-Masaeed, S, Al-Muʹani, L, Yaseen, H & Alhnaity, B 2025, Strategic intelligence: The power of AI in planning efficiency. *Human Behavior and Emerging Technologies*, 2025(1): Article 5383054. https://doi.org/10.1155/hbe2/5383054.

Abu Shuheil, M, Hussein Ismael, S, Ganesan, S, Ray, S, Basheer, NM, Jayabalan, K, Pramanik, A, Gautam, A & Sarhan, N 2026, Engineering MXene quantum dots: From quantum confinement and interfacial charge transfer to multifunctional environmental technologies. *International Journal of Environmental Analytical Chemistry*: 1–43. https://doi.org/10.1080/03067319.2026.2645938.

Akhmadiyeva, ZK 2020, To the problems of desertification/land degradation in the Aktobe region. *Hydrometeorology and Ecology*, 2: 37–46.

Al-Jokhadar, A, Soudi, Y & Alnusairat, S 2026, Beyond green buildings: How green certification systems contribute to the dual imperative of environmental/well-being outcomes through the lens of SDGs. *Archnet-IJAR: International Journal of Architectural Research*: 1–20. https://doi.org/10.1108/ARCH-08-2025-0334.

Amirgaliev, NA, Askarova, M, Opp, C, Medeu, A, Kulbekova, R & Medeu, AR 2022, Water quality problems analysis and assessment of the ecological security level of the transboundary Ural-Caspian Basin of the Republic of Kazakhstan. *Applied Sciences*, 12(4): 2059. https://doi.org/10.3390/app12042059.

Batyrova, GA, Tlegenova, Z, Umarova, GA, Kononec, VI, Umarov, EA, Kudabayeva, HI, Ajtmaganbet, PZ & Amanzholkyzy, AA 2021, Microelemental status of the adult population of western Kazakhstan. *Human Ecology*, 11: 42–49.

Beisenova, R, Kuanyshevich, BZ, Turlybekova, G, Yelikbayev, B, Kakabayev, AA, Shamshedenova, S & Nugmanov, A 2023, Assessment of atmospheric air quality in the region of Central Kazakhstan and Astana. *Atmosphere*, 14: 1601. https://doi.org/10.3390/atmos14111601.

Bodele, HM, Asutkar, GM & Asutkar, KG 2025, DGCA3QM: Design of a dual genetic algorithm based autoregression model for correlative prediction of air quality metrics. *Proceedings on Engineering Sciences*, 7(1): 689–700. https://doi.org/10.24874/PES07.01D.024.

Dlimbetova, G, Kurmanbayev, R, Akimish, D, Toktaganova, G & Zharmenova, B 2023, Socio-economic mechanisms of environmental education for young people in Kazakhstan. *Economic Annals-XXI*, 203(5–6): 59–69.

Ergashev, N, Khaitova, D, Kabilova, Z, Mamedov, S, Rikhsikhodjaeva, G, Mirzajonova, S, Alieva, N & Gati, MA 2026, A novel framework for human health risk assessment in urban watersheds. *Procedia Environmental Science, Engineering and Management*, 13(1): 249–256.

European Medicines Agency 2019, ICH guideline Q3D (R1) on elemental impurities. Retrieved 17 October 2023. https://www.ema.europa.eu/en/documents/scientific-guideline/internationa.

Farman, M, Jamil, K, Jamil, S, Nisar, KS, Smerat, A & Hafez, M 2026, Mathematical analysis of air pollution dynamics system for emission controls and air filtration technologies with Caputo derivative. *Modeling Earth Systems and Environment*, 12(2): Article 105. https://doi.org/10.1007/s40808-026-02750-7.

Ghoneim, RS, Arabasy, M & Abdulhadi, AN 2026, AI-driven optimization of indoor environmental quality and energy consumption in smart buildings: A bio-inspired algorithmic approach. *Journal of Asian Architecture and Building Engineering*, 25(2): 1089–1113. https://doi.org/10.1080/13467581.2025.2472742.

Kamolova, L, Ramazanova, N, Furaijl, HB, Ibragimova, Y, Bakirov, F, Nizomov, O, Yunuskhodjaeva, K & Ali, DA 2026, Efficacy of public health education campaigns in mitigating air pollution risks. *Procedia Environmental Science, Engineering and Management*, 13(1): 145–156.

Kerimray, A, Assanov, D, Kenessov, B & Karaca, F 2020, Trends and health impacts of major urban air pollutants in Kazakhstan. *Journal of the Air & Waste Management Association*, 70(11): 1148–1164.

Kudabayeva, KI, Koshmaganbetova, GK, Bazargaliyev, YS & Baspakova, AM 2018, Assessment of iodine supply of the population of Western Kazakhstan according to ioduria. *Hygiene and Sanitation*, 95(3): 251–254.

Mamyrbayev, AA, Yegizbayeva, DK, Aytmaganbet, PZ, Sabyrakhmetova, VM, Umarova, GA, Sakabayeva, LD & Karashova, GI 2020, The main trends in the primary incidence of malignant neoplasms in the adult population of the oil and gas producing region. *Public Health*, 3(99): 303–308. https://doi.org/10.47470/0016-9900-2020-99-3-303-308.

Mohammad, SI, Vasudevan, A, Oriquat, G & Qian, C 2026, Polymeric nanoparticles for modulating reactive oxygen species in the periodontitis microenvironment. *Journal of Biochemical and Molecular Toxicology*, 40(5): Article e70900. https://doi.org/10.1002/jbt.70900.

Moldayazova, L, Zhapalakov, B, Shagatayeva, B, Kuatbaeva, A & Baspakova, A 2024, The influence of environmental factors on the health of the population of the Aktobe region. *Integrated Environmental Assessment and Management*, 20(4): 1156–1165. https://doi.org/10.1002/ieam.4862.

Myrzakerimova, AB, Shayzat, M, Duisebekova, KS & Nurmaganbetova, MO 2020, Forecasting risk of diseases in Kazakhstan with using mapping technique based on 9 years statistics. *Procedia Computer Science*, 170: 75–81. https://doi.org/10.1016/j.procs.2020.03.010.

Oladejo, TO, Balogun, FO, Haruna, UA, Alaka, HO, Almazan, J, Shuaibu, MS & Eliseo III, DLP 2023, Climate change in Kazakhstan: Implications to population health. *Bulletin of the National Research Centre*, 47: 144. https://doi.org/10.1186/s42269-023-01122-w.

Pedro, E, Capucho, J & [coauthors] 2025, Study of higher-education institutions' impacts on residents' quality of life. *International Journal for Quality Research*, 19(1): 13–32. https://doi.org/10.24874/IJQR19.01-02

Sadykanova, G, Kumarbekuly, S & Yessimbekova, A 2025, The impact of air pollution on morbidity in the industrial areas of the East Kazakhstan Region. *Atmosphere*, 16(6): 736. https://doi.org/10.3390/atmos16060736.

Sakabayeva, L, Sabyrakhmetova, V, Karashova, G, Aitmaganbet, P & Shayakhmetova, K 2020, Public health risk assessment due to air pollution in the Temir district of the Aktobe region. *Public Health Disease Control*, 8: 481–487.

Sakiyev, KZ, Ibrayeva, LK, Dyusembayeva, NK, Rybalkina, DK & Drobchenko, YA 2016, Qualitative indicator of the loss of health of the population of the Aral Sea region. *Hygiene and Sanitation*, 95(10): 950–954.

Sayed, U, Naser, ST, Ganesan, S, Ray, S, Basheer, NM, Jayabalan, K, Pramanik, A, Gautam, A & Nooriadeh, H 2026, MXene quantum dots as multifunctional nanostructures for enhanced mass spectrometry: Mechanistic profiling and real-time monitoring of environmental pollutants. *Chemical Papers*. https://doi.org/10.1007/s11696-026-04850-1.

Tusupkaliyev, BT, Bermagambetova, SK & Tusupkaliyev, AB 2016, Morbidity and microelement levels in the blood of schoolchildren living near chromium enterprises. *Hygiene and Sanitation*, 95(7): 655–658.

Yessenbekova, Z & Turezhanov, S 2021, Circular bioeconomy and sustainable development in Kazakhstan. *Economic Annals-XXI*, 193(9–10): 45–53.

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