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ANALYSIS OF THE IMPACT OF AIR POLLUTION ON RESPIRATORY DISEASES (USING THE EXAMPLE OF THE RA)

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Abstract: Respiratory diseases take one of the leading places in the morbidity structure of the population of the Republic of Armenia, with the number of cases increasing annually. Among all the factors contributing to the development of respiratory diseases, a significant proportion is related to air pollution. Therefore, assessing the impact of pollutant emissions from industrial enterprises and transport on public health has become an urgent

research priority. The goal of this article is to study and evaluate the influence of harmful emissions on respiratory diseases based on monitoring data of different regions across the Republic of Armenia. The paper evaluates a multiple regression linear model that captures the relationship between the incidence of respiratory diseases, current health expenditure per capita, and current environmental protection expenditure.

Keywords: pollution, air emissions, industrial emissions, respiratory diseases, public health, environmental impact, methods of econometric modeling.

JEL codes: Q53, I18, C51

Research aims: To analyze the impact of harmful emissions into the atmosphere air on respiratory diseases using monitoring data collected across different regions of the Republic of Armenia.

Research novelty: The study provides an assessment of the impact of environmental pollution on human health, specifically respiratory health outcomes.

Introduction

Environmental pollution is one of the most significant factors, affecting human health. Human activities release various gases and particles into the atmosphere, harming human health, environment, and economy. Major sources of pollution include fuel combustion (electricity generation, transport, industry, and households), industrial emissions, solvents usage (for example, in the chemical and mining industries), agriculture, open waste burning, dust, and many others. Environmental pollution and the climate crisis represent interdependent challenges: the reduction

of emissions will not only help to control global temperatures but also improve the air quality and public health.

According to the World Health Organization (WHO), exposure to air pollution remains a global problem and a risk factor for non-communicable diseases. According to the WHO State of the World Air Report 2025, air pollution remains the second-leading risk factor for premature mortality, surpassed only to high blood pressure. Approximately 11% of the world's population lives in areas without national air quality standards [1].

In 2023, 7.9 million deaths were recorded due to air pollution, one in four deaths from cardiovascular disease was caused by air pollution. Mortality rates due to air pollution are highest in low and middle-income countries. In 2023, 90% of all air pollution-related deaths occurred in the following countries: India and China (more than 2 million deaths each), Bangladesh, Pakistan, and Nigeria (more than 200,000 deaths each), Indonesia, Myanmar, and Egypt (more than 100,000 deaths each).

These high mortality levels are primarily linked to exposure to fine particulate matter (PM2.5 and PM10), which leads to respiratory, gastrointestinal, and circulatory diseases, as well as the development of malignant tumors. WHO guidelines recommend [2] the following maximum annual average concentration of particulate matter: with a diameter 2.5 μm or less (PM2.5) - 5 μg/m3; with a diameter 10 μm or less (PM10) – 15 μg/m3; nitrogen dioxide (NO2) – 10 μg/m3; sulfur dioxide (SO2) – 40 μg/m3.

Currently, 36% of the world's population lives under the conditions of increased health risk due to consistently or frequently elevated air pollution levels that exceed sanitary and hygienic

standards. According to the World Air Quality Report provided by the Swiss monitoring company IQAir [3], in 2024 the most polluted countries, based on the Air Quality Index (AQI), were Chad, Bangladesh, and Pakistan. The AQI measures the concentration of pollutants in the air and the associated health risks: the higher the AQI, the more severe the pollution and the greater the potential threat to human health. One of the most widely used indicators for cross - country comparison is the annual average concentration of PM2.5 ($\mu g/m^3$). It measures the average annual concentration of fine particulate matter (PM2.5), which is the most harmful to health.

Within the Caucasus region, Armenia has the poorest air quality. In 2024, Armenia ranked 34th out 138 countries in terms of air pollution with an average annual PM2.5 concentration of 24.4 μg/m3, Azerbaijan ranked 49th, while Georgia ranked as 72nd.

Research methodology and data

The study employed statistical data on health and the environment obtained from the Statistical Committee of the Republic of Armenia, the Ministry of Environment of the Republic of Armenia, and the S. Avdalbekyan National Institute of Health under the Ministry of Health of the Republic of Armenia for the period of 1997-2024 [4, 5, 6, 7].

According to the international standards, the main air pollutants include sulfur dioxide, nitrogen oxides, carbon monoxide, carbon monoxide, dust, and ground-level ozone as a secondary pollutant. High level of concentration of these substances in atmosphere contribute to the development of respiratory and cardiovascular diseases and may also negatively affect brain function, particularly

among children and individuals with asthma. Air pollution also narrows the airways and impairs breathing capacity, and plays a significant role in the development of neurological disorders and a weakening immune system.

In Armenia, respiratory diseases rank among the leading causes of mortality after diseases of the circulatory system, ischemic heart disease and malignant neoplasms. According to the [4], in 2023, mortality from these diseases in total mortality was 53.3%, 26.3%, 20.8%, and 8.6%, respectively. Compared with 2000, mortality from respiratory diseases in total mortality increased by 2.7 percentage points and decreased by 0.3 percentage points compared with the previous year (Fig. 1).

In 2023, 2,083 people died from respiratory diseases, of which 50.07% were women and 49.93% were men. 37.1% of deaths were recorded in Yerevan, 11.2% in Gegharkunik, 9.9% in Ararat, and 9.5% in Syunik.

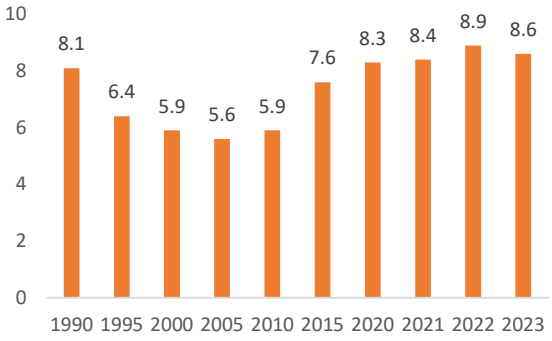


Figure 1. Mortality of the population of the Republic of Armenia from respiratory diseases in the structure of total mortality (%) (1990-2023).
Source: *[4]*

Figure 2 shows a graph of the dynamics of emissions of harmful substances from stationary sources of air pollution (thousand tons/year) by regions of the Republic of Armenia for 2019-2023. The most polluted regions are Kotayk, Gegharkunik, Yerevan, Lori and Syunik.

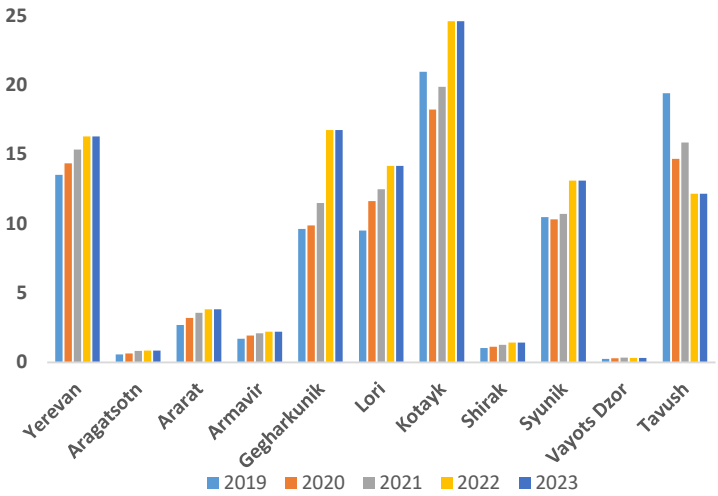


Figure 2. Dynamics of emissions of harmful substances from stationary sources of air pollution by regions (thousand tons/year), 2019-2023.
Source: *[7]*

In 2023, the volume of harmful emissions into the atmosphere from mobile sources amounted to 199.35 thousand tons. Among these, the largest share was accounted for by carbon monoxide – 144.8 thousand tons or 72.6% of the total emissions, volatile organic compounds – 34.9 thousand tons or 17.5%, nitrogen oxides – 19.0 thousand tons or 9.5%, and other – 0.4%.

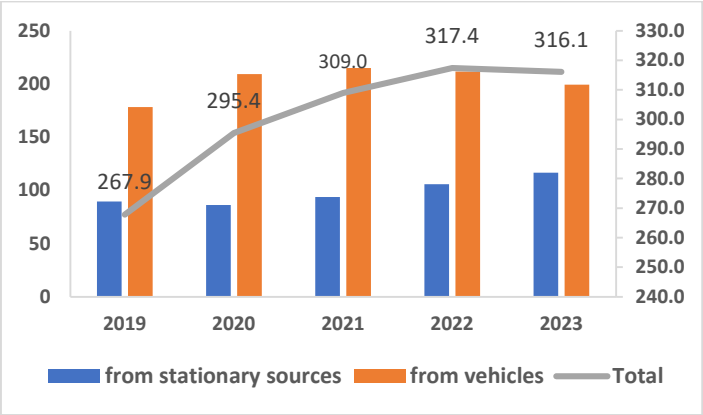


Figure 3. Emissions of harmful substances into the atmosphere, 1,000 tons (2019-2023)
Source: *[6]*

According to monitoring results conducted in Yerevan, Gyumri, Vanadzor, Alaverdi, Hrazdan, Ararat, Tsaghkadzor, Kapan, Kajaran and Charentsavan, atmospheric nitrogen dioxide levels increased in 2023 compared to the previous year. Concentrations of dust, nitrogen dioxide, and sulfur dioxide in the atmospheric air of Yerevan exceeded the permissible limits at various times of the year and on different days. The primary sources of atmospheric air pollution include transport, industry, energy and urban construction.

The Nubarashen landfill, located just a few kilometers from the center of Yerevan, is particularly dangerous. Carbon monoxide and fine particles recorded in the surrounding atmospheric air pose significant health risks for residents of Yerevan. Despite the existence of professional international standards for the collecting, sorting, and recycling of household waste, these practices are not adequately implemented in Armenia. Under such conditions, those

residents who already have health problems - pulmonary diseases, heart failure, allergic reactions – are especially vulnerable.

Thus, in recent years, the unprecedented expansion of construction, the sharp increase in the number of cars, and large-scale deforestation have had an extremely negative impact on Yerevan's air pollution. Therefore, it is necessary to take immediate measures to reduce the intensity of emissions into the atmosphere and eliminate their harmful effects.

The number of people with respiratory diseases continues to increase due to air pollution. Figure 4 shows a graph of the dynamics of the number of registered cases with a newly diagnosed respiratory disease for 1997–2023 (per 100,000 population).

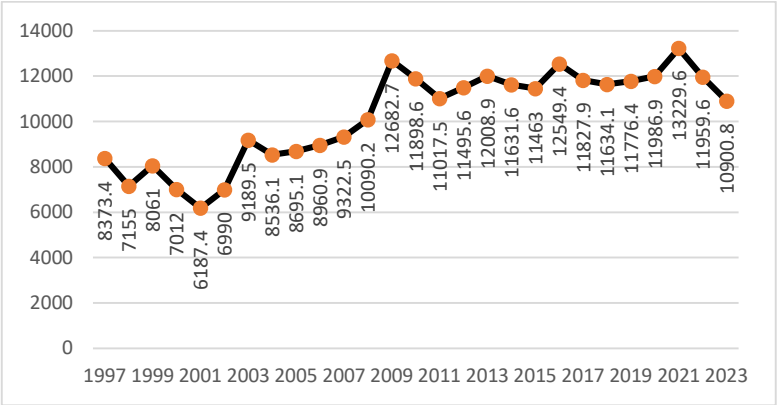


Figure 4. Dynamics of the number of registered cases with a newly established diagnosis of respiratory disease (1997–2023 per 100,000 population).
Source: *[4, 5]*

To determine the strength of the relationship between the number of respiratory diseases and air pollutants, the following correlation matrix was constructed, where SO2 - the amount of

sulfur dioxide (thousand tons/year), NOX - the amount of nitrogen oxides (thousand tons/year), CO - Carbon Monoxide (thousand tons/year), CH - hydrocarbons (thousand tons/year), Respiratory - the number of registered cases with a newly diagnosed respiratory disease. The matrix shows that the number of respiratory diseases is most closely is correlated to the amount of hydrocarbons, nitrogen oxides, carbon monoxide, and dust emitted into the atmosphere.

Table 1. Correlation matrix of variables
Source: *Authors' own work.*

	Respiratory	CO	CH	NOX	SO2	DUST
Respiratory	1	0.338	0.918	0.698	0.195	0.599
CO	0.338	1	0.197	0.777	-0.679	0.725
CH	0.918	0.197	1	0.669	0.176	0.582
NOX	0.698	0.777	0.669	1	-0.368	0.848
SO2	0.195	-0.679	0.176	-0.368	1	-0.496
DUST	0.599	0.725	0.582	0.848	-0.496	1

Using annual statistical data for the period 2000–2023, a multiple linear regression model was estimated, which represents the dependence of the number of registered respiratory diseases on current healthcare expenditures (per capita) and current environmental protection expenditures.

D(LOG(RESPIRATORY)) = 0.15*D(LOG_ECOLOGY_COSTS) - 0.25*D(LOG_HEALTH_EXP) + 0.034,

where HEALTH_EXP – current health expenditure per capita (current US$), ECOLOGY_COSTS – current environmental protection expenditures, million drams.

According to Student's t-test, all coefficients are statistically significant. The model is statistically significant, as Prob (F-statistic)=0.004 [8].

$R^2_{adj} = 0.194$, which means that approximately 19.4% of the variation in the dependent variable is explained by regression model.

The hypothesis of a normal distribution of random residuals was tested using the Jarque-Bera statistic (Jarque-Bera = 0.869186, Probability = 0.647528). The null hypothesis of a normal distribution of residuals is not rejected, as Probability > 0.05.

The absence of autocorrelation was verified using the Serial Correlation LM Test (Obs*R-squared=0.3939, Prob Chi-Square(2)=0.8212). Since Prob Chi-Square(2)>0.05, the null hypothesis of the absence of autocorrelation of the random residuals is accepted. The White test revealed homoscedasticity of the random residuals (Obs*R-squared=9.3810, Prob Chi-Square(2)=0.11). Since Prob Chi-Square(2)>0.05, the null hypothesis of homoscedasticity of the random residuals is accepted.

Thus, the constructed model is adequate, meaning it can be used to predict the incidence of respiratory diseases in the Republic of Armenia. According to the model's results, the 1% increase in the growth rate of current per capita healthcare expenditures reduces the growth rate of new cases of respiratory diseases by an average of 0.25% at 10% significance level.

The coefficient for current environmental protection expenditures is positive (a positive relationship between environmental protection expenditures and the number of respiratory diseases),

which most likely indicates the non-targeted nature of these expenditures.

Conclusion

The article analyzes the impact of environmental pollution on human health (respiratory diseases). In recent years, the unprecedented growth of construction, a sharp increase in the number of cars, and large-scale deforestation have had a very negative impact on the quality of atmospheric air in Yerevan and the regions of RA. The problem of reducing the intensity of harmful emissions and eliminating their harmful effects has become extremely urgent.

In the article, based on annual statistical data for 2000-2023, a multiple linear regression model was estimated, which represents the dependence of the number of registered respiratory diseases on current healthcare expenditures (per capita) and current environmental protection expenditures. The model demonstrates the effectiveness of healthcare spending: a 1% increase in the growth rate of current health expenditure per capita reduces the growth rate of new cases of respiratory diseases by an average of 0.25% at 10% significance level.

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ՇՆՉԱՌԱԿԱՆ ՀԻՎԱՆԴՈՒԹՅՈՒՆՆԵՐԻ ՎՐԱ ՄԹՆՈԼՈՐՏԱՅԻՆ ՕԴԻ ԱՂՏՈՏՎԱԾՈՒԹՅԱՆ ԱԶԴԵՑՈՒԹՅԱՆ ՎԵՐԼՈՒԾՈՒԹՅՈՒՆ (ՀՀ ՕՐԻՆԱԿՈՎ)

Գայանե Ղուկասյան
Երևանի պետական համալսարան, ֆիզ.-մաթ. գ. թ., դոցենտ

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Մարգարիտա Եղիազարյան
Հայաստանի պետական տնտեսագիտական համալսարան
տ.գ.թ., դոցենտ

Բանալի բառեր – աղտոտվածություն, օդի աղտոտում, արդյունաբերական արտանետումներ, շնչառական հիվանդություններ, հանրային առողջություն, շրջակա միջավայրի ազդեցություն, Էկոնոմետրիկ մոդելավորում:

Հոդվածում վերլուծվում է շրջակա միջավայրի աղտոտվածության ազդեցությունը մարդու առողջության վրա (շնչառական օրգանների հիվանդություններ):

Վերջին տարիներին շինարարության աննախադեպ աճը, մեքենաների թվի կտրուկ ավելացումը և լայնածավալ անտառահատումները խիստ բացասական ազդեցություն են ունեցել Երևանի և ՀՀ մարզերի մթնոլորտային օդի որակի վրա: Վնասակարար արտանետումների ինտենսիվությունը նվազեց-

նելու և դրանց վնասակար հետևանքները վերացնելու խնդիրը դարձել է խիստ հրատապ:

Հոդվածում 2000-2023 թվականների տարեկան վիճակագրական տվյալների հիման վրա գնահատվել է բազմակի գծային ռեգրեսիայի մոդել, որը ներկայացնում է գրանցված շնչառական հիվանդությունների թվի կախվածությունը առողջապահության ընթացիկ ծախսերից (մեկ շնչի հաշվով) և բնապահպանության ընթացիկ ծախսերից:

Հոդվածում ցույց է տրված առողջապահական ծախսերի արդյունավետությունը, այն է՝ մեկ շնչի հաշվով առողջապահական ընթացիկ ծախսերի հավելաճի տեմպի 1% ավելացումը միջինում կրճատում է շնչառական հիվանդությունների հավելաճի տեմպը 0.25%-ով 10% արժեքականության մակարդակում:

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