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Assessment of Factors Contributing to Environmental Pollution in the Context of Public Health Using the Example of the Republic of Armenia

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Abstract. Frequent changes in environmental pollution factors have a negative impact on human health and, as a result, dramatically change the quality of his life, perhaps it is precisely this circumstance that determines the relevance of the topic. The purpose of the article is to assess the connection between the factors contributing to environmental pollution and human health. It is obvious that in a given country, the healthier people are, the more effectively the mechanisms of state environmental management function, as a result of which the life expectancy of the population increases especially. The genetic, environmental, and healthcare factors affecting human health can be presented from two perspectives. These factors have the opposite effect, and it is in this context that the article distinguishes 8 factors of environmental pollution and 7 factors threatening human health, and proposes 7 hypotheses (The statistics were selected between 2000 and 2022). To reveal the interconnection between these factors, empirical, statistical, and mathematical tools and methods have been applied. The results of the evaluation of the hypotheses have shown that the selected environmental pollution-promoting factors have an impact on the deterioration or improvement of human health. The article also evaluates the risk of human life loss in the context of the environment. Accordingly, the healthcare sector reforms in Armenia are divided into 3 phases (2000-2007 up to emergence of financial crisis, 2008-2019 overcoming of financial crisis and nowadays reforms, 2020-2022) and for each phase, the standard mortality rate in Armenia, as well as the risk of human health deterioration and life loss, have been calculated. The results show that there has been an increase in both indicators, and their growth points to the deterioration of human health. Therefore, the current indicators characterizing the state of the healthcare sector in Armenia are concerning, while the upcoming trends are alarming. We believe that the implementation of the mechanism proposed in the article could later create guarantees for the restoration of human health.

1. INTRODUCTION

In studies and analyses conducted by various international organizations, factors affecting the maintenance and improvement of human health have been identified. The World Health Organization identified factors affecting human health.

1. biological and genetic factors (heredity, vital activity of the nervous system, national mentality, behavioral and psychological behavioral manifestations),
2. chemical pollution, emissions in the form of negative external influences,
3. Socio-economic factors.

A person's lifestyle and living conditions affect their health, while there are specific standards that justify the rational use of the environment in a given country and the improvement of human health. Accordingly, the lifestyle of a person is 50 percent, of which the state of the environment is 15-20%, heredity is 15-20%, and the health care system is 10%. Genetic factors, environmental factors and medical support factors affecting human health can be presented from two points of view: these factors contribute to the restoration, or have the opposite effect, and it is in this context that we have identified the existing link between environmental pollution factors in Armenia and health-threatening risks population. Empirical, statistical and mathematical tools have been used to solve this problem.

The article is structured in the following logical sequence: first, the literature sources are examined, followed then the factors that we have considered, and then the main methods used for the analysis are described. In the discussion section, the standard mortality rate and the general risk of human life loss in Armenia have been calculated, and using a regression model, the interconnection between environmental factors and human health has been assessed. Additionally, 7 hypotheses have been proposed.

2. LITERATURE REVIEW

A person affects the environment in one way or another throughout his life. Consequently, anthropogenic impact on the environment can be devastating. Anthropogenic factors cause the depletion of natural resources, environmental pollution. Man is closely connected with the environment due to the need to satisfy his origin, material and spiritual needs. The existence of this connection became essential in modern industrial society when man began to use irrational and natural resources (Vereshchagin N.N., et al., 2003).

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The environment also contributes to the creation and strengthening of social norms (Khrushchka et al., 2011), which affect health indicators and have a spatial structure. In addition, factors related to space and location can, in turn, contribute to and reinforce socio-economic, racial, or ethnic differences in health status (Bleich et al., 2012; Laveist et al., 2011). The environment can affect health through physical exposures, such as air pollution (OECD, 2012b). A large body of work has documented the effects of exposure to particulate matter (solid particles and liquid droplets found in the air) on cardiovascular and respiratory mortality and morbidity (Brook et al., 2010; Laumbach and Kipen, 2012; Mustafić et al., 2012; Tzivian, 2011).

When analyzing the impact of humans on the environment, it is necessary to discuss the main laws, rules, and regulations existing in the "human-nature" system. Thus, Globally (Global Environmental Problem. 1988) demonstrated that a number of laws and regulations objectively characterize the modern relationship between humans and nature. According to P. Danseru (Young OR, King L,at al., 2008), the 'boomerang law' operates in the 'human-biosphere' interactions, specifically stating that the pressure of anthropogenic impact affects the biosphere, even to the point of putting the future existence of humanity at risk. B. Kommoni proposed a number of laws that reflect the universal connection of natural processes and phenomena of nature. The underlying idea is as follows: 'In nature, every phenomenon is interconnected with another, or everything in nature is connected to everything else. Although many countries have adopted laws that regulate and strictly limit the dumping of toxic waste harmful to living beings' lives and health, chemical substances continue to be released into rivers and lakes (Nikitin A.I.,2005). Furthermore, Avaliani S.L. and others (Avaliani S.L.,at al 2001) in their work discuss the so-called acid rains that fall on the Earth's surface, which poison freshwater reservoirs and destroy forests in Europe and North America.

The gases emitted into the atmosphere by power plants and automobiles, when mixed with fine water droplets in the air, create weak acids that later fall to the Earth in the form of acid precipitation, destroying and damaging plants, polluting rivers and lakes, and eroding human-made structures (Gichev Yu.P, 2002). It must be said that a person, guided by their principles, has the ability to achieve the desired result with minimal energy expenditure. However, K.A. Bushueva demonstrated in her work that this leads to irreparable consequences of the disruption of the natural environment shaped by humans.

Young et al have discussed the human aspects of global environmental changes in their works (Young OR et al, 2008). Human activity aimed at transforming nature led to the emergence of relatively new conditions for its existence. Therefore, it should be considered that environmental disruptions have an almost global nature for the Earth, being influenced by air currents, the water cycle in nature, ocean currents, transportation transfers, animal migration, and so on. For example, currently only one-third of the Earth's land does not bear visible traces of human activity (in Russia - 33.6%, North America - 37.5%, Africa - 27.5%, Europe - 2.8%) (Gichev Yu.P.,2002). In the second half of the 20th century, the rapid increase in the pace of mineral resource utilization led to a sharp rise in the mining industry, which in turn expanded the extraction of natural resources. For example, the work of Smith et al. (Smith, K. R.,et al, 2000) shows that in 1913, the amount of mineral raw materials per capita was 5 tons, in 1940 it was 7.4, in 1960 it was 14.3, and by the late 1970s it had reached 25 tons.

According to Golderova the increase in environmental pollution contributes to the spread of diseases There are diseases whose spread is directly related to environmental pollution, such as bronchial asthma, various types of allergies (Golderova A.S, 2002). According to various authors, there are other environmental pollution factors that threaten human health and malignant tumors, therefore the purpose of the article is to assess the connection between the factors contributing to environmental pollution and human health.

3. DATA AND RESEARCH METHOD

Of course, there are other environmental pollution factors that threaten human health, which we simply did not consider. We believe that the application of our proposed mechanism can further create guarantees as a result of simultaneous solutions to the problems of restoring human health and environmental pollution.

To this end, it was proposed to apply the following mechanism in practice, taking official statistical data as a basis and making the following designations

Since the values of medical and demographic factors and environmental pollution factors are not comparable, the observed indicators were smoothed out, and 8 environmental pollution factors and 7 factors threatening human health were identified from them: They were assigned Y values, which are dependent variables (Table 1).

Table 1. Determining environmental pollution, and their mathematical designations (Nikitin A.I.,2005, Vereshchagin N.N et al., 2003).

Factors	Meetings
Population density, people/m^2	Y_1
Life expectancy, year	Y_2
Mortality rate of children under the age of 1 year per 1000 live births	Y_3
Mortality rate of children under 5 years of age per 1,000 live births	Y_4
Mortality rate from infectious and parasitic diseases per 100,000 inhabitants	Y_5
The mortality rate from neoplasms per 100,000 inhabitants	Y_6
Mortality rate from diseases of the circulatory system per 100,000 inhabitants	Y_7
Mortality rate from respiratory diseases per 100,000 inhabitants	Y_8
The mortality rate from diseases of the digestive system Per 100,000 inhabitants	Y_9
Mortality rate from other external causes per 100,000 inhabitants	Y_{10}
The mortality rate of the population per 1000 inhabitants	Y_{11}
Natural growth rate, million people	Y_{12}
Diseases by main groups	
Morbidity: infectious and parasitic, million	Y_{13}
Diseases: neoplasms, million	Y_{14}
Diseases-Diseases of the circulatory system	Y_{15}
Morbidity: poisoning and injuries, million	Y_{16}
Morbidity: respiratory diseases, million	Y_{17}
Diseases registered with a newly diagnosed diagnosis, million	Y_{18}
Emissions of harmful substances from stationary (stationary) sources per inhabitant	X_1
Emissions of harmful substances by motor transport per inhabitant,	X_2
Wastewater discharge to external sources per inhabitant	X_3
Wastewater discharge to external sources per inhabitant	X_4

Water consumption per inhabitant,	X_5
The amount of waste generated in production per inhabitant,	X_6
Part of landscaping (afforestation)on a common plot of land	X_7
The area of specially protected areas per inhabitant	X_8

7 hypotheses have been put forward. The relationship between the factor indicators was evaluated using the Eviews 9 program using the least squares method.

The article also assessed the risk of death in the context of the environment, using Formulas (1)-(2) for this purpose, the overall indicator of human health deterioration and death in Armenia was calculated:

Accordingly, as a generalizing indicator of losses in the I-th object with the j-th feature over a period of time t, is calculated as follows.

$$I_i^{mt} = \sqrt[m]{\sum_{j=1}^{m} V_{ji}^t} \qquad (1)$$

$$V_{ji}^t = \frac{x_{ji}^t - 0.95x_{min}}{1.05x_{max} - 0.95x_{min}} \qquad (2)$$

where:

- x_{ji}^t –mortality rate
- V_{ji-}^t standard mortality rate
- x_{min} – minimum mortality rate
- x_{max} – maximum mortality rate
- m- is the number of indicators, in the given case these are 3, since 3 variables
- are included.
- I_i^{mt}- the risk of deterioration of human health and loss of life

4. HYPOTHESES, RESULTS AND DISCUSSION

4.1. Regression Analysis Results

As a result of regression analysis, statistically significant equations were obtained and the influence of independent variables (environmental factors) on dependent variables (factors threatening human health) was calculated, as well as their statistical properties were given: t-states, samples. Prob. In addition, to understand the qualitative characteristics of the model, the following indicators are given: R^2, adjusted R^2.

Table 2. Hypotheses verification results

Hypothesis	R^2	Adjusted R^2	F-statistic	Prob(F-statistic)
(1)	0.929432	0.903771	36.21955	0.000003
(2)	0.464906	0.426685	12.16364	0.003623
(3)	0.844987	0.782982	13.62772	0.000468
(4)	0.717458	0.646822	10.15717	0.001298
(5)	0.501489	0.465881	14.08362	0.002141
(6)	0.484987	0.782982	13.62772	0.000468
(7)	0.196484	0.139090	34.23427	0.085494

Hypothesis 1.

$$Y_2 = a_0 + a_1 x * X_3, + a_2 * X_4 + a_3 * X_7 + a_4 * X_8 + \beta \qquad (3)$$

Table 3. Results of hypothesis 1.

Coefficient			Prob.
a_0		72.97264	0.0000
	a_1	0.006069	0.0023
	a_2	-0.007432	0.0095
	a_3	-0.016116	0.0065
	a_4	5.459958	0.0063

According to formula (3) It turns out that the more green spaces or specially protected areas in Armenia increase, the longer the life expectancy of people. Therefore, the government should take this fact into account and carry out landscaping work to increase the oxygen layer.

Hypothesis 2.

$$Y_4 = b_0 + b_1 * X_1 + \beta \qquad (4)$$

Table 4. Results of hypothesis 2.

Coefficient			Prob.
b_0		16.63077	0.0000
	b_1	-130.5495	0.0036

The results of equation 4 show that X_1 per unit led to a decrease in the mortality rate of children under the age of 5 by

130.6 points. This means that the lower the child mortality rates, the higher the efficiency of the healthcare sector.
Hypothesis 3.

$$Y_6 = c_0 + c_1 * X_3 + c_2 * X_4 + c_3 * X_5 + c_4 * X_8 + \beta \quad (5)$$

Table 5. Results of hypothesis 3.

Coefficient		Prob.
c_0	186.6391	0.0000
c_1	0.690594	0.9985
c_2	-0.022567	0.8466
c_3	1.055539	0.0017
c_4	-582.7449	0.0563

(5) In the Formula, only X_3 and X_8 had a statistically significant effect on Y_6, that is, a change in X_3 led to an increase in mortality from neoplasms by 0.288 points per unit of measurement, and X8 change results in 664.04 descending.

Hypothesis 4.

$$Y_8 = d_0 + d_1 * X_3 + d_2 X_4 + d_3 * X_8 + \beta \quad (6)$$

Table 6. Results of hypothesis 4.

Coefficient		Prob.
d_0	-329.6971	0.0863
d_1	-2.114203	0.0002
d_2	-0.141720	0.9140
d_3	9089.183	0.0015

The change in X_3 led to a decrease in the mortality rate from respiratory diseases by 2.11 points, and the change in X_8 led to an increase in the latter by 9089.2 points.

Hypothesis 5.

$$Y_{11} = e_0 + e_1 * X_2 + \beta \quad (7)$$

Table 7. Results of hypothesis 5.

Coefficient		Prob.
e_0	15.92390	0.0001
e_1	229.8763	0.0021

The results of equation 7 show that that is, the more cars there are, the more harmful substances are released into the atmosphere, which contributes to an increase in the mortality rate. Therefore, we propose to tighten the environmental charges levied by the state for emissions of harmful substances by motor vehicles and apply stricter administrative tools to regulate them, as is used, for example, in the EU and OECD countries, where fewer taxes have been introduced for vehicles with the least damage, in particular those powered by an electric motor.

Hypothesis 6.

$$Y_{13} = f_0 + f_1 * X_1 + f_2 * X_4 + f_3 * X_7 + f_4 * X8 + \beta \quad (8)$$

Table 8. Results of hypothesis 6.

Coefficient		Prob.
f_0	186.6391	0.0000
f_1	0.690594	0.9985
f_2	-0.022567	0.8466
f_3	1.055539	0.0017
f_4	-582.7449	0.0563

(8) in the Formula, only the variable X_7 had a statistically significant effect on Y_{13}, since the Prob (F-Statistics) <5%, X_4 leads to an increase in the number of infectious and parasitic diseases per 10,000 inhabitants by 1,055 units. this means that an increase in the share of landscaping on the total land area without observing sanitary and hygienic requirements can contribute to the emergence of parasitic and infectious diseases.

Hypothesis 7.

$$Y_{16} = g_0 + g_1 * X_6 + \beta \quad (9)$$

Table 9. Results of hypothesis 7.

Coefficient		Prob.
g_0	166.6249	0.0000
g_1	1.444992	0.0855

$$Y_{16} = 166.6248955 + 1.444992118 * X_6 \quad (10)$$

(16) in the Formula Prob (F-Statistics)>5% (about 8.5%), which means that hypothesis 7 is rejected, X_6 depends on diseases acquired as a result of poisoning and injuries, does not exist.

4.2. Assessment of the Risk of Loss of Human Life in Armenia in the Context of the Environment

Health care can be considered as a product or service that has a production function - supply, as well as existing health standards. (Kyuregyan A.,Q.Baghdasaryan, 2021., Kyuregyan A.,Q.Baghdasaryan., 2023), therefore (1)-(2) formulas were applied and the overall indicator of human health deterioration and death in Armenia was calculated, for which the period from 2000 to 2022 was considered the total mortality rate per 1000 people.

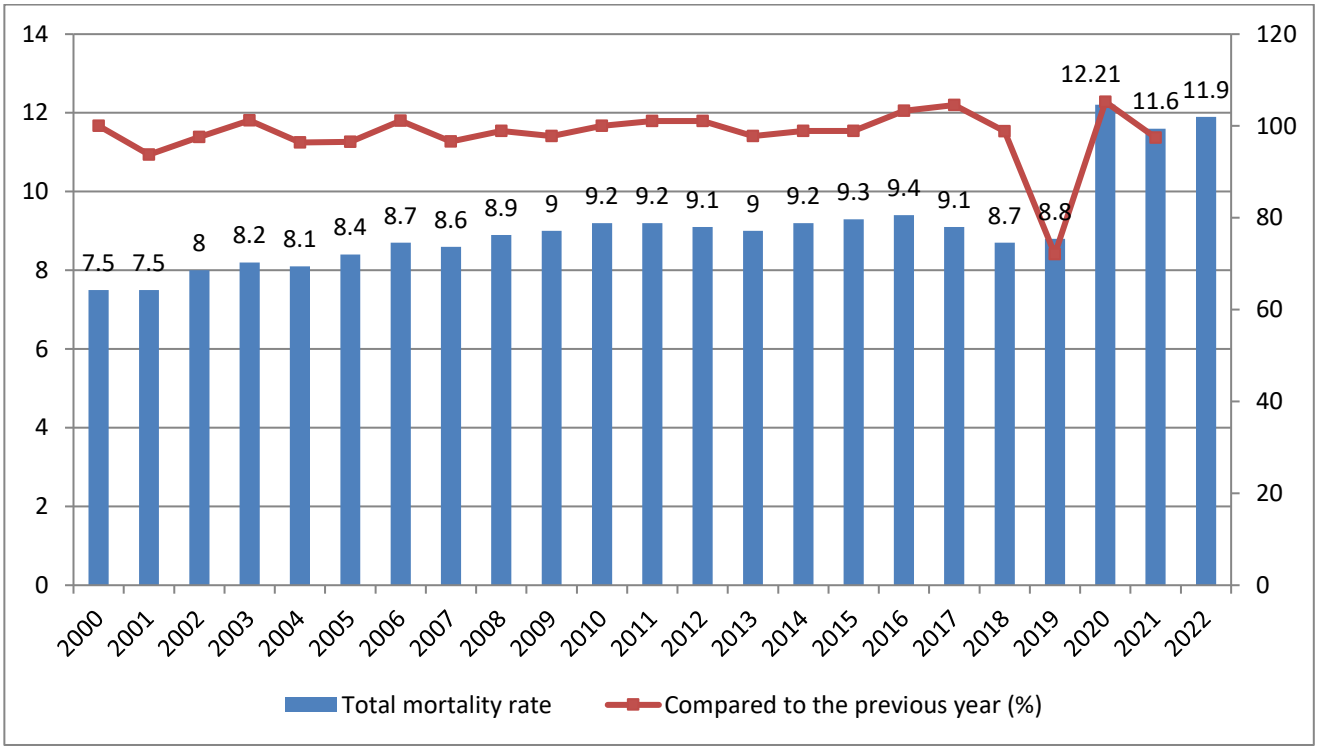

Figure 1. 2000-2022 total mortality rate, per 1000 inhabitants.

As the data in Figure 1 show, the total mortality rate in the Republic of Armenia in 2000 was 7.5/1000, which began to grow in 2002 (increasing by 25.33% in 2016). In 2019, the dynamics of this indicator decreased by 6.38%, amounting to 8.8/1000, but the mortality rate caused by the coronavirus pandemic (COVID-19) has increased, in particular, in 2020 this figure increased by 38.57% compared to 2019, in 2022 an increase of 2.5% was recorded compared to the previous year.

Analyzing the data in Figure 1 and combining them with formula 1, the standard mortality rate in the Republic of Armenia was calculated (V_{ji}^{t}) , standard mortality rate in the Republic of Armenia, for which average, maximum and minimum values are derived from Table 10.

Table 10. Average indicator of standard mortality rate in the RA (Statistical Committee Republic of Armenia).

Indicators	Values
Average	9.1
Maximum	12.2
Minimum	7.5
V_{ji-}^{t}	0.35

As a result, the average standard death rate of people in Armenia and the risk of deterioration of health and death of people were estimated (I_i^{mt}) and since 3 indicators were included, therefore m=3

$$I_i^{mt} = \sqrt[3]{0.35 = 0.70}$$

Armenia's health care reforms were divided into 3 stages

1. 2000-2007 up to emergence of financial crisis (T_1),
2. 2008-2019 overcoming of financial crisis and nowadays reforms(T_2),
3. 2020-2022 coronavirus pandemic (COVID-19) and ongoing reforms (which was designated as T_3)

Table 11. Average of the standard mortality rate in Armenia in 2000-2007, 2008-2019 and 2020-2022.

Year	Value	Year	Value	Year	Value
2000	7.5	2008	8.9	2020	12.2
2001	7.5	2009	9	2021	11.6
2002	8	2010	9.2	2022	11.9
2003	8.2	2011	9.2		
2004	8.1	2012	9.1		
2005	8.4	2013	9		
2006	8.7	2014	9.2		
2007	8.6	2015	9.3		
		2016	9.4		
		2017	9.1		
		2018	8.7		
		2019	8.8		
Minimum	7.5	Minimum	8.7	Minimum	11.6
Average	8.1	Average	9.0	Average	11.9
Maximum	8.7	Maximum	9.4	Maximum	12.2
V_{ji-}^{t} 2000-2007	0.53	V_{ji-}^{t} 2008-2019	0.45	V_{ji-}^{t} 2020-2022	0.49

The average indicator of the standard human mortality rate in Armenia was calculated in the period from 2000 to 2007 for the periods 2008-2019 and 2020-2022. and based on resolutions 2-3, it was evaluated in the pre-crisis and crisis years (2000-2007), after the crisis (2008-2019), as well as in 2009-2019, as well as the coronavirus pandemic and until recently (2020-2022).) the standard human mortality rate (V_{ji-}^{t}), that in 2000-2007 averaged 0.53, which decreased by about 15.09% after the crisis. However, in 2020-2022, the standard human mortality rate averaged 0.49, that is, an increase of 8.8 was recorded.%, the latter was caused by the coronavirus pandemic (Table 11).

According to the same logic, the general indicator of human losses in Armenia for the periods 2000-2007, 2008-2019 and 2020-2022 was calculated based on formulas 1.

$$\begin{cases} I_i^{T_1} = \frac{1}{T_1}\sum_{t=1}^{T_1} I_i^{mt} \\ I_i^{T_2} = \frac{1}{T_2}\sum_{t=1}^{T_2} I_i^{mt} \\ I_i^{T_3} = \frac{1}{T_1}\sum_{t=1}^{T_1} I_i^{mt} \end{cases} \qquad (11)$$

where`
T_1: 2000-2007 ,
T_2: 2008-2019
T_3: 2020-2022

$$\begin{cases} I_i^{T_1} = \mathbf{\frac{1}{8}\sqrt[3]{0.53} = 0.10} \\ I_i^{T_2} = \mathbf{\frac{1}{12}\sqrt[3]{0.45} = 0.06} \\ I_i^{T_3} = \mathbf{\frac{1}{3}\sqrt[3]{0.49} = 0.26} \end{cases} \qquad (12)$$

As a result of calculations, the following results were obtained: 2000-2007. (which covers 8 years: 1/8) it was 0.10 between 2008 and 2019.(which covers 12 years: 1/12): 0.06, and in 2020-2022 (which covers 3 years: 1/3) it was 0.26. The economic meaning of the general human mortality indicator lies in the fact that the latter shows the so-called "accumulated losses" of maternal and child mortality rates. At the same time, the minimum value of the total loss index indicates the best medical and demographic condition for this period, and, at best, the worst condition. The minimum value of the total human losses calculated by us was obtained in 2008-2019. for, which amounted to 0.06, but in 2020-2022, an increase in this indicator was recorded to 0.26.

5. CONCLUSION

The purpose of the article is to assess the connection between the factors contributing to environmental pollution and human health. The findings confirm that the frequent changes in environmental pollution factors have a negative impact on human health, thereby drastically altering the quality of life. Additionally, the standard mortality rate and the risk of health deterioration and life loss in Armenia, calculated by us, were 0.45 and 0.06 for the years 2008-2019, and 0.49 and 0.26 for the years 2020-2022. The analysis results show that both indicators have increased, and their growth indicates the deterioration of human health. Therefore, the state must do everything possible to have an effective healthcare system, which is also one of the guarantees for improving the level of economic development and well-being. In a country, the healthier the people are, the more effectively the mechanisms of environmental governance function, and as a result, the life expectancy of the population, in particular, increases.

Of course, there are other environmental pollution factors that contribute to the deterioration of human health, which we have not assessed; however, it is planned to address other factors in future studies.

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