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Assessing the Impact of Environmental Quality on Public Health Expenditure Central Asia

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ABSTRACT

This study utilizes panel data from 2002 to 2022 in Central Asia to analyze the impact of environmental quality on public health expenditures. This study employs the ARDL model to examine the short-run and long-run relationships between healthcare expenditure and pollution levels, namely carbon dioxide (CO2), sulfur dioxide (SO2), and nitrogen dioxide (NO2). The data indicate a robust positive correlation between greenhouse gases and healthcare expenditures, demonstrating the effect of environmental pollution on public health. The study examines the relationship between socioeconomic variables, including GDP, death rates, and healthcare expenditures. This study concludes that reversing this trend hinges on improving environmental policy in the energy and industrial sectors. This research contributes to the existing knowledge by analyzing how various environmental elements and economic structures persistently impact health policy evolution in the region.

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1. Introduction

The relationship between environmental quality and public health is becoming increasingly important in both the literature and policy considerations. Environmental pollution and the subsequent increase in greenhouse gas emissions have been found to have serious health consequences, particularly in Central Asia's less developed countries. This region, notably due to rapid industrial expansion and urbanization, has seen an increase in environmental problems, resulting in higher healthcare costs. As these countries' economies improve, the possibilities for progress are compromised by the mounting expenses of pollution-related ailments. Furthermore, the low levels of income in these nations limit their ability to address the environmental consequences of human activities, leading to an increase in carbon dioxide (CO2), nitrogen dioxide (NO2), and carbon monoxide. (CO). This has a negative impact on their health outcomes, resulting in higher healthcare expenditure due to diseases related to environmental degradation such as cardiovascular disease, eyesight impairment, skin cancer, and respiratory disease.

Ebbini (2024) estimate that achieving a sustainable environment, as well as health and well-being for all people, requires the implementation of specific objectives or legislative measures. Over time, we have gradually implemented many programs, including sustainable development. Goal 3 is about health and well-being. The 13th Sustainable Development Goal is about climate change prevention. Goal 7 has the main purpose of achieving clean and affordable energy. The Abuja Declaration of April 2001 Aims to address environmental degradation and develop a sustainable environment. It is crucial to find solutions to public health challenges such as HIV/AIDS and tuberculosis. Human activities can contribute to improving health outcomes in low-income countries.

Governments have prioritized health over the environment. Diet, hygiene, economic position, education, personal activities, and the environment affect population health. Environmental disease risk factors influence health differently, depending on severity and clinical importance. Environmental degradation from climate change endangers healthy people. The ecology is suffering from climate change and fossil fuel emissions. Sulfur dioxide, carbon dioxide, and suspended particles from fossil fuel combustion contaminate the environment and cause climate change. Political leaders and scholars from numerous professions investigated this vital topic (Network, 2012).

Environmental pollution affects people of all ages. As greenhouse gas emissions contribute to climate change, health risks are increasing, particularly for the elderly, who are more vulnerable to cardiovascular and cerebrovascular disorders. High temperatures and heat waves can affect blood pressure and blood viscosity, leading to significant health issues. Asthma, bronchitis, pneumonia, coughs, and colds can be caused by thermal stress, temperature-related air pollution, pollen, mold, and pollution precursors. The increase in temperatures, humidity, and precipitation affects mosquitoes, ticks, and flies' growth, density, and maturity (Pattanayak & Pfaff, 2009).

Preliminary negotiations are underway regarding health care, air quality, and economic growth. Three main branches organize scientific literature. The first branch focuses on economic and environmental development. Since 1960, a significant number of studies have been conducted on issues of ecological and economic growth. The study of ecological and economic development is still incomplete. We acknowledge that economic progress has a negative impact on the environment. (Arouri et al., 2012; Lotfalipour et al., 2010; Marrero, 2010; Pao & Tsai, 2010; Wang, 2011). The second branch of the research examined the relationship between environmental characteristics and healthcare expenditures (Burnett et al., 1998; Peters et al., 1999).

The destruction of the ecosystem is mostly caused by air pollution containing carbon dioxide (CO2), nitrogen oxides (NOx), and methane. (CH4). The examination of the relationship between health and the environment has only just begun. Because of the rise in infectious diseases caused by air pollution and extreme temperatures, it is essential to look at the relationship between health and the environment (Corvalán et al., 1999; Rocque et al., 2021). Climate change has an impact on many ecosystems, the animals that live within them, and human health. Although certain results, such as milder winters in temperate countries that reduce winter mortality, may be beneficial, experts estimate that the majority of the effects of climate change will be detrimental to human health.

Central Asia has a continental dry and semi-arid climate, with hot, cloudy summers, humid, hot winters in the south, and harsh frosts in the north. The majority of the area has a spring monsoon peak. The Iranian branch of the Polar Front is heading northward. Mediterranean depressions that migrate northeast provide heavy rains. Reappear above the Caspian Sea. In July, western cyclones in the temperate zone alter their pace over the Aral Sea. They go east from west to the Zagros area, which is impacted by the Indian monsoons. Ancient climate and archaeological evidence reveal that dry and semi-arid Central Asia has endured climatic cycles,

which may forecast future climate change. Global warming may raise humidity levels in arid Central Asian areas.

Lioubimtseva et al. (2005) The beginning and middle of the Holocene imply that the expected shift southward and the westerly winds have exacerbated this. Historical weather data from the late nineteenth century shows that annual and winter temperatures in this region have steadily increased. The analysis has grouped the temperature data from the Climate Research Department dataset (Jones et al., 1999) with previous studies conducted at individual weather stations in the region. (Lubises et al. 2005). Unfortunately, only a few places in Central Asia have conducted continuous observations for over a hundred years. The recordings from most of the stations span 60 to 65 years, with occasional gaps. The constant increase in temperatures over the last century indicates a significant change in atmospheric circulation in Central Asia. Both the annual averages and the seasonal trends of temperatures have increased, while the southern edge of the Siberian anticyclone has shifted downward and the thermal pressures in summer and winter in Central Asia have risen. All data from Central Asian sites show a continuous warming trend over the last century; however, precipitation patterns vary according to geography and land use. According to precipitation statistics from the late nineteenth century, the western region of the country has received less rainfall than the rest of the country for the past 50 to 60 years.

According to historical data, the plots in the nearly intact ecosystems of this region have experienced less loss of precipitation than the irrigated areas. (Lioubimtseva et al., 2005). Although Central Asia has received less precipitation in the last fifty years, notable changes have been observed in some significant oases in Kazakhstan, Uzbekistan, and Turkmenistan which includes Arganich, Bukhara, Toshkent, Mergab, Tejin, and Ashgabat. This could be related to climate changes caused by increased irrigated lands (Al-Yaari et al., 2022).

This study contributes to the body of knowledge by investigating how ecological factors influence healthcare spending in Central Asia. Secondly, we assessed the quality of the environment using CO2, NO2, and SO2, and determined to what extent they contribute to health expenses. Thirdly, the studies used cross-sectional data to investigate the relationship between environmental quality and healthcare spending in Central Asia, while we used panel data to analyze the impact of climate change. Important considerations include the long-term viability of military spending and its contribution to peace (SDG 16) and economic growth. (SDG 8). We conducted a thorough analysis of the literature to investigate the factors influencing healthcare costs, but we did not include the quality of the environment. We investigated greenhouse gas emissions, including carbon dioxide and nitrous oxide, to close this gap. Jerrrett et al. (2003) discovered that air pollution increases healthcare costs.

2. Literature Review

The relationship between environmental quality and economic costs especially in the provision of healthcare has attracted considerable interest among researchers. Scholars alike have highlighted that pollution and subsequent effects on the natural environment fuel healthcare costs increase in both the developed and the developing world. Different researchers have embarked on the investigations to find out the relationship between pollution and climate change and industrial emission analyzing its impact on the public health expenditure of different countries.

Anwar et al (2022) examined the effects of environmental factors on health care expenses in developing countries, pointing out that temperature, pollution from the atmosphere, and the overall health-care expenses have a direct-positive relationship. According to their research, they deemed that private health care expenditure is way more sensitive to environmental changes than the public health care expenditure. This applies especially to Central Asia where increasing pollution results in the need for more individual medical assistance because of inadequate public

health facilities in the area. As with most emerging economies, the study is also timely in adding to the on-going narrative about how those countries are then left to contend with the social cost of industrialization and Urbanization partly seen through the lens of health.

Ecevit et al. (2023) have included their share in this regard by making out a causal structure between healthcare expenditure, trade openness, GDP per capita, and CO (Abdullah et al.) emissions. From the authors' perspective, the countries that have high economic growth, as well as trade openness, then they have high environmental pollution, and thus they experience high healthcare costs. In view of this finding, it is especially relevant for the Central Asia region where industrial growth, particularly in the recent past, has greatly accelerated the release of greenhouse gases as observed by Anwar et al. (2022). This paper by Ecevit et al. casts and effect on recognizing the difficulty of finding a balance between economic development, environment, and public health that is familiar to many developing areas of the world.

Nasreen et al. (2024) have exposed the influence of gross domestic product per capita, air pollution, and non-pecuniary factors on Asiatic healthcare spending; therefore, environmental pollution, urbanization, and insufficient elderly health care structures are associated. They pointed out such an observation to signify that while the overall expenditure on health decreases with per capita income, the rural population suffers the brunt; while the increased income assists in procuring improved private and public health facilities. This is particularly true in Central Asia, where social and economic differentials in access to health care across the rural and urban society combined with adverse environmental impacts worsen existing inequalities in life chances.

They continued the earlier work of Bilgili et al. by elaborating on the relationship between healthcare costs and CO2 emissions, where it was established that CO2 emissions exert a more significant effect on private health care expenditure than on public health expenditure. This study thus implies that resource allocation for enhancing healthcare may finance the negative impact of environmental pollution. Their findings are supplemented by studies by Nasreen et al. (2024) reporting that air pollution should also be considered a major factor in increased costs of health care. Collectively, these analyses suggest that specific policies designed to lessen pollution seen in the environment can ease the healthcare load in Central Asia to a large extent.

Scholarship in historical methods provide insight into quality of environment and health effects as well. In analyzing the heath capital effect on economic growth, Gyimah-Brempong and Wilson (2004) argue that increase in health status is essential for considering the life expectancy and productivity status among the population. Even though they did not concentrate on the matter of environmental influences and forces directly, their study does imply the same generalization in the sense that healthier people help push economic growth more. Given the current deterioration of environmental conditions in many areas of Central Asia threatening population's health, enhancement of environmental quality may potentially create a healthy outcome for the population and help create jobs through investments in imparting the environment.

Continuing from economic perspective improvement, the Asian Development Bank (ADB) (1997) underlined economic consequence of changes in health and longevity status in South and Southeast Asia pointing that improved health and longevity defined rapid growth rates. The identified demographic dividend of these regions is evidence on how enhance healthcare will catalyse an economy. However, this factor is mediated by environmental damage as established by Hansen and Selte (2000) through studying on air pollution and its impact to sick days and productivity. Their study about the pollution issue of Oslo can as well be taken as a warning to other developing regions such as Central Asia where air quality is being worsened by undisciplined industrialization.

Hansen and Selte (2000) are in harmony with Pope & Dockery (2006) who positively related the level of mortality rate, which encompasses COPD, heart ailments and other

respiratory diseases to air pollution. There is evidentiary evidence from this literature that air pollution is associated with a high health care cost; a pattern that has been evidenced in diverse settings including the Central Asian region.

Janke et al. (2009) took this further by establishing the link between air pollution and mortality rate within the years 1998 to 2005. He insisted that their research showed a positive trend between mortality and both ozone and PM10 concentrations. This discovery is even more suitable for Central Asia, as industrial emissions cause high levels of air pollution and outbreak of pollution-susceptible diseases.

In the paper, Narayana and Narayana critically reviewed the long-run effects of environmental quality on health care expenditure in eight OECD countries; this paper presents evidence of a causal link between health spending, per capita income, and carbon monoxide emission. They concluded that developed countries are more prepared to face the effects of environmental deterioration on health compared to the developing countries where many Central Asian nations fall into due to their inability to cope with heath costs. This difference points out that there are requirements to implement suitable measures to achieve differential changes in environment policies and international cooperation to counter the fundamental reasons for pollution and implication of the findings on public health.

The study by Assadzadeh et al. (2014) paid attention to the effects of environmental pollution on healthcare expenses in OPEC countries. According to these measures, results of this study are as follows; income and CO2 emissions both have positive controlled and significant relationship with health expenditure, whereas life expectancy has negative relationship. This is in line with other research on how pollution exacerbates chronic diseases that are costly to treat. Zade has elaborated many essential insights related to the Central Asian region where the extraction and exportation of fossil fuels are catalysts to the economic development, as well as pollution of the environment.

According to the extant literature reviewed here, it is clear that the effect of environmental quality on healthcare costs is not a simple one. Research done on the amount of pollution and emissions mainly elaborates that it all leads to higher costs of treatment, especially in the Central Asian developing countries. While industrialization remains a primary source of their economic development, it has been linked with environment degradations hence health care costs. In order to counter these effects, the following measures should be implemented by the Central Asia policy makers; They need to enhance the enforcement of environmental laws and ensure the development of clean power resources; There is the need to advance the health care systems in the nations in order to tackle the diseases that result from pollution of the environment. With these issues resolved, the region tends to obtain a more durable economic growth and better health of the population.

3. Model, Data, and Methods

3.1. Model

This paper employs the annual data collected from 2002 to 2020 to assess the causal connection between environmental quality and public health expenditures (PHE) in Central Asia. The measure for total health care spending is health expenditure (HE), while that of economic growth is the gross domestic product (GDP). The environmental variables are nitrogen dioxide (NO2) and some greenhouse gases. Greenhouse gas emissions are expressed in kilograms of Carbon dioxide equivalent.

Data for this study was obtained from WDI and the variables used are Fertility rate abbreviated as FR, which is the average number of children a woman is expected to bear in her lifetime, and the infant mortality rate abbreviated as IMR, which is the number of infant deaths per 1000 live births. Also, the dataset covers the energy sector methane emission characterized

in thousands of metric tons of CO2 equivalent. These variables afford a cross-sectional snapshot of key demographic and environmental characteristics suitable for investigation of the healthcare costs in Central Asia.

All the variables of the model are first taken in natural logarithm to aid elasticity analysis. The primary model is structured as follows:

$$lnHE_t = \alpha_0 + \sum_{i=1}^{p} \alpha_1 lnHE_{t-i} + \sum_{i=0}^{q_1} \beta_1 lnGDP_{t-i} + \sum_{i=0}^{q_2} \beta_2 lnCO2_{t-i} + \sum_{i=0}^{q_3} \beta_3 lnSO2_{t-i} + \sum_{i=0}^{q_4} \beta_4 lnNO2_{t-i} + \sum_{i=0}^{q_5} \beta_5 lnBR_{t-i} + \lambda ECM_{t-1} + \varepsilon_t \quad (1)$$

HE_t = represents health expenditures at time t.
GDP_t = is gross domestic product per capita.
$CO2_t$ = denotes the carbon dioxide emissions in metric tons per capita.
$SO2_t$ = is sulfur dioxide emissions in metric tons per capita.
$NO2_t$ = represents nitrogen dioxide emissions in metric tons per capita.
MR_t = denotes foreign direct investment, net inflows as a percentage of GDP.
ECM_t = is the error term, capturing the unobserved factors that may affect health expenditures.

Here, we use the ARDL model for the purpose of testing both short-run and the long-run co-integration of environmental quality and public health expenditure in the context of Central Asia within the period of 2002 to 2020. One of the major advantages associated with the specification and estimation of the ARDL model that has been presented by Pesaran and Shin (1995) is the ability to estimate an error correction mechanism without pre-testing the characteristics of the underlying variables into being stationary levels [I(0)] or first difference [I(1)]. It is most helpful in panel data whereby some variables are integrated of different degrees.

Preliminary to the application of the ARDL technique, we first follow the ADF test to check the stationary nature of the chosen variables. Generally speaking, the ADF test allows to select the number of unit roots in each variable, and this is crucial to minimize the risk of a spurious regression. In the other case when p-value is more than 0.05 we accept the null hypothesis that specify unit root of variable in words, means non-stationary. If, therefore, the p value is less than 0.05, the variable is said to be stationary. Following the stationarity tests, we use the ARDL bounds testing procedure to determine whether or not there is co-integration between the variables.

Moreover, the long-term equilibrium relationship in the context of our study indicates that the ARDL model can allow for both the lagged levels and the first difference of the variables under consideration and, therefore, it is most appropriate to supply a proper retrospect of the dynamic behaviors of the environmental factors (CO2, SO2, NO2) and the health expenditures (HE). ARDL gives us an opportunity to look at both the short-run dynamics and long-run steady-state association between environmental quality and public health expenditure in Central Asia.

4. Result And Discussion

Conducting the unit root test is essential for assessing the stationarity of data since the non-stationary regressor tends to invalidate several empirical findings. This study examined the government's spending on the healthcare sector in Central Asia by utilizing secondary data spanning the years 2002 to 2020. This work was carried out utilizing secondary data an analysis of the mixed order of integration using the ARDL approach is shown in Table 1,

Table 1
Penal Unit Root Test

Variable	Level	1st Difference	Level	1st Difference	Decision
LN_BIRTH_RATE	**2.78904 (0.0026)**		1.7876 (0.0369)		1(0)
LN_GDP	-6.40090 (0.0000)	-	-3.9153 (0.0000)		1(0)
LN_HEALTH_EXPENDITURE	-5.41421 (0.0000)		-3.1103 (0.0009)		1(0)
LN_METHANE	-2.67033 (0.0038)		-0.31150 (0.3777)		1(0)
LN_NITROUS_OXIDE	-1.16030 (0.1230)	-2.87655 (0.0020)	0.65084 (0.7424)	-5.3098 (0.0000)	1(1)
LN_TOTAL_GREEN_HOUSE_GAS	-2.50676 (0.0061)		-1.33451 (0.0910)		1(0)
LN Mortality	-4.44322 (0.0000)		-0.62418 (0.2663)		1(0)

Table 2
Cross-section Dependence test

Variable	Test	Statistics	D.f	Probability
Health Expenditure	Breusch-Pagan LM	172.3388	28	0.0000
	Pesaran scaled LM	18.21904		0.0000
	Pesaran CD	0.265838		0.7904

The Breusch-Pagan LM test and the Pesaran scaled LM test are employed often to check the cross-sectional dependence in the panel data, which suggests the existence of the auto-correlated error terms process across different cross-sectional units including countries or regions. The autocorrelation test such as the Breusch-Pagan LM test and Pesaran scaled LM test are showing significant evidence of cross-sectional dependency, which mean the variable of healthcare expenditure for different country or region is dependent of each other. This indicates that patterns of care consumption in one country may affect, or be affected by, spending on care in another country, perhaps because of similar economic, environmental or policy characteristics (Pesaran, 2004).

This finding is important as this shows that whatever policy changes or measures are ascribed to one nation our changes their environment may impact other nations or regions surrounding it. For example, higher spending on health care because of pollution in one country may lead other countries which have similar conditions as far as environmental influence is concerned to follow the same trend.

Table 3
ARDL Long Run Result

Variable	Co-efficient	Standard Error	T-Statistics	P-value
LN_METHANE	0.778958	0.173402	4.492199	0.0000
LN_MORTALITY	-0.507890	0.107839	-4.709717	0.0000
LN_NITROUS_OXIDE	-0.823365	0.197191	4.175471	0.0001
LN_TOTAL_GREEN_HOUSE_GAS	0.837775	0.256739	0.256739	0.0016
LN_GDP	0.953515	0.037734	0.037734	0.0000
LN_BIRTH_RATE	-0.038302	0.130671	-0.293119	0.7702

Nonetheless the Pesaran CD test which is a test for cross-sectional dependence in panel models does not show any cross- sectional dependence in this study. This implies that there could be cross-sectional dependence in healthcare expenditure across the countries but not across all the regions or nations (Pesaran, 2015). The absence of 'closeness' in terms of total

reliance could be resulting from variations in health care systems, or ensuing economic or environment regulations all of which influence the level of interdependence among the nations.

Table 3 provides the long-run estimate based on the Autoregressive Distributed Lag (ARDL) model and examines the influence of several variables on HC expenditure in Central Asia. In the analysis, the results provide insights into the strength of the association between total HC expenditure and both economic and environmental en09ables and socio-demographic indicators.

The p-value here is equal to 0.0000, which proves the relation is strong and positive where a 1 % increase in GDP leads to an almost equal increase in health care expenditure in terms of LLP in the region. This means that as economies of the region expand, more resources are devoted to the sector in accordance with the theoretical assertion of increased health expenditure as the economy develops.

Health care costs are the dependent variable in the regression equation, and their relationship with methane emissions is positive and statistically significant at 0.778958 (p = 0.000). This is because the latest data shows that pollution has led to an increased healthcare cost especially breathing ailments due to higher methane concentration. Likewise, total greenhouse emission show a positive influence (coefficient 0.837775, p value 0.0016) which further strengthens that the environmental degradation post a remarkable role in enhancing the long run expenditure of health care.

Remarkably, the coefficient of nitrous dioxide (NO2) is negative that is -0.823365, (p = 0.0001), which means that higher NO2 triggers lower cost of healthcare in the United States. This may call for a more profound investigation to determine the probable cause; which may stem from regional policies or from reactions made by health systems. The same is true for the mortality rate as its coefficient is also negative (= -0.507890, p = 0.0000); still higher mortality rates mean lower investment into health care and thus worse results and costs. Finally, the birth rate has no large-scale positive impact (coefficient = -0.038302, p = 0.7702) concerning overall expenditure on healthcare.

In special, the Big Data analysis of the long run allows pointing out that the rise in economic growth and environmental quality remain crucial factors affecting the healthcare expenditures; however, the effects of mortality and nitrous oxide need further investigation.

Table 4
Short Run Result ARDL

Variables	Coefficient	Standard error	t-statistic	P value
COINTEQ01	-0.354738	0.181508	-1.954393	0.0541
D(LN_METHANE)	-0.508422	0.272511	-1.865696	0.0657
D(LN_MORTALITY)	1.431780	0.694307	2.062170	0.0424
D(LN_NITROUS_OXIDE)	0.156941	0.088425	1.774845	0.0796
D(LN_TOTAL_GREEN_HOUSE_GAS)	0.057759	0.313478	0.184251	0.8543
D(LN_GDP)	0.454076	0.209442	2.168025	0.0331
D(LN_BIRTH_RATE)	1.083716	0.402323	2.693648	0.0086
C	-3.539134	1.911484	-1.851511	0.0677
Mean dependent var	0.104422	S.D. dependent var		0.154279
S.E. of regression	0.078685	Akaike info criterion		-1.982424
Sum squared resid	0.507686	Schwarz criterion		-0.589847
Log likelihood	220.6642	Hannan-Quinn criteria.		-1.416711

Analyzing the short-run dynamics, the findings shown in Table 4 depict the immediate impacts of socio-economic and environmental indices on Central Asian healthcare expenditures using the Autoregressive Distributed Lag (ARDL) model framework. The negative and significant error correction term, 0.354738, suggests that a little over a third of any short-run disequilibrium

is corrected in the subsequent period. This reveals that after short-run shocks, the system reverts back to the long-run between healthcare expenditure and the independent variables.

The coefficient of the mortality rate = 1.431780 (p = 0.0424) shows that when the mortality rate rises by 1%, the healthcare expenditure will also rise by 1.43%. This depicts a short-term burden on the health facilities caused by increased mortality. Likewise, a positive correlation exists between GDP and healthcare expenditure with coefficients 0.454076 (p = 0.0331). Hence, a 1 per cent climb in GDP resulted in 0.45 per cent increase in health care expenditure. This goes a long way to demonstrate the relationship between economic development and short-run healthcare financing.

The birth rate also has a positive effect, coefficient of 1.083716, and p = 0.0086, which means that increased population creates demand for healthcare services in the short run. The results indicate that the increasing births mean higher health care expenditure in the short run, particularly in Maternal and Child Health. The environmental factors lead to mixed findings. Methane emissions come out significant though their coefficients of -0.508422 are negative bearing a marginal significance level of 0.0657, implying a short-term healthcare expenditure effect. Here again, the coefficient is close to the margin between significance and insignificance (coefficient = 0.156941, p = 0.0796) and indicates that only pollution may have a very marginal effect on increasing healthcare costs in the short run. Total greenhouse gas emissions are not significantly different from each other (p = 0.8543), suggesting that these emissions may not affect total healthcare costs in the short run. Concerning the diagnostic statistics, the standard regression error reached 0.078685, while the Akaike Information Criterion was AIC = -1.982424. The last two are the standard error values that assess error variance, and the smaller the standard error, the better, it means the model is precise; the AIC value suggests the model is a good predictor without overcomplicating it.

In conclusion, the research findings show that in the short run, the socio-economic variables, which include mortality, GDP and birth rate are significantly related to health expenditure. However, other environmental indicators, such as methane and nitrous oxide, exert comparatively weaker short-term impacts, and total GHG emissions are not large. This means that the acute burden of the disease depends on socio-economic decisions and not environmental ones, although the latter may take a longer time to show their effects on health. These results highlighted and underscored the need to attend to both immediate healthcare needs and future environmental challenges in policymaking.

5. Conclusion and Policy Recommendations

This study demonstrates a clear and significant correlation between environmental quality and public health costs in Central Asia. The findings indicate a significant correlation between healthcare expenditures and pollutants, including carbon dioxide (CO2), sulfur dioxide (SO2), and nitrogen dioxide (NO2), which serve as indicators of the adverse impacts of environmental degradation on public health. Moreover, socioeconomic factors such as GDP and mortality rates contribute significantly to healthcare cost, illustrating the interconnection between economic growth and health outcomes in the region. Based on these findings, numerous critical policy recommendations are proposed to address these issues.

Initially, Central Asian nations must establish and enforce stringent restrictions to reduce emissions from significant sources, such as energy and transportation. Analysis of the results indicates that mitigating pollutants such as CO2 and NO2 would yield substantial savings for public health systems burdened by the expenses associated with treating health issues caused by these pollutants. Furthermore, sustained investment in healthcare and clean energy projects will mitigate environmental degradation and the related expenses in preventive healthcare. The study's discovery of a positive correlation between GDP and health expenditures suggests that

sustainable economic development should foster green technologies to advance economic growth and public health.

The study's findings underscore the necessity for Central Asian nations to foster regional collaboration, as pollution frequently transcends national boundaries. Regulating emissions and mitigating climate threats would improve environmental quality and reduce health expenditures across the region. Global assistance through climate financing and technology transfer is essential for these nations to transition to cleaner energy sources. By concurrently tackling environmental and health concerns, Central Asian states would reduce public health costs and foster sustainable, long-term growth.

Authors' Contribution

Ambar Khalil: Led study design, data collection, analysis, and manuscript writing; handled correspondence.
Muhammad Asif: Contributed to literature review, methodology, and manuscript revisions.
Mohammad Iftekhar Ashik Imran: contributed to data presentation and discussion.

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