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**Article**

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## Article

# The Impact of Macroeconomic Factors on Mortality from Non-Communicable Diseases: Evidence from Azerbaijan

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**Abstract:** The empirical findings of this study suggest a significant long-term relationship between the *probability of mortality due to non-communicable diseases (NCDs) among individuals aged 30–70 in Azerbaijan* and key economic and social indicators, including *Gross Domestic Product per Capita, Waged Employment, Human Development Index, and out-of-pocket health expenditures*. The *Error Correction Model coefficient* ( $-0.724701$ ) implies that the system adjusts back to equilibrium at a rate of 72.47% per period, highlighting a strong corrective mechanism. Additionally, in the short run, GDP, HDI, wage employment, and out-of-pocket health expenditures significantly influence mortality rates. The model's statistical diagnostics confirm its robustness, and the results align with economic theory, reinforcing their validity and policy relevance. According to the conclusion of this research, we suggest the enhancement of the HDI and Employment, control out-of-pocket expenditures, and increase Government Healthcare Spending to significantly reduce mortality rates. This study emphasizes that enhancing social determinants like the *HDI, Waged Employment, and accessible healthcare services* is crucial for reducing mortality rates of NCDs. While Azerbaijan's economic growth has improved living standards, further efforts are necessary to improve healthcare investments and reduce inequalities in health outcomes.



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**Keywords:** non-communicable diseases; GDP; human development index; out-of-pocket health expenditures; waged employment

## 1. Introduction

Non-communicable diseases (NCDs) are chronic conditions that are not transmitted from person to person. They are typically the result of a combination of genetic, physiological, environmental, and behavioral factors. The major NCDs include cardiovascular diseases, cancers, chronic respiratory diseases, and diabetes. The key causes can be grouped into the following categories: (a) unhealthy behaviors (e.g., tobacco use, unhealthy diet, physical inactivity, excessive alcohol consumption, etc.), which are the most significant contributors to NCD development; (b) biological risk factors (e.g., hypertension (high blood pressure), obesity and overweight, hyperglycemia, hyperlipidemia, etc.); (c) environmental and social determinants (e.g., air pollution, workplace hazards, urbanization and lifestyle shifts, social determinants, etc.); (d) genetic and physiological factors (e.g., family history,

age, gender, etc.); (e) psychological and emotional factors (e.g., chronic stress, depression, anxiety, etc.); (f) healthcare system-related factors (e.g., inadequate access to healthcare, lack of vaccination programs, etc.).

Cardiovascular diseases, cancer, diabetes, and chronic respiratory diseases are among the leading global causes of mortality. The probability of dying between the exact ages of 30 and 70 from any of these conditions (%), known as the “mortality” indicator, is a vital public health metric for assessing the burden of these diseases on populations. This indicator is a crucial health statistic and carries significant economic implications. Understanding the economic determinants of this probability is pivotal for policymakers aiming to reduce premature mortality and enhance public health outcomes.

Economic factors, such as income levels, healthcare expenditures, education, employment status, and lifestyle-related expenditures, play a substantial role in influencing these diseases’ prevalence and mortality rates. Countries with higher healthcare investments and robust public health policies generally exhibit lower probabilities of premature mortality from these conditions. On the other hand, economic disparities, poverty, and limited access to quality healthcare amplify the risks associated with chronic diseases. Furthermore, macroeconomic indicators like GDP per capita, inflation, and healthcare accessibility are integral in shaping individuals’ health-related decisions, including choices related to nutrition, physical activity, and preventive healthcare practices, which, in turn, affect disease outcomes and mortality rates.

This study examines the impact of key economic variables on the probability of dying between the ages of 30 and 70 from cardiovascular diseases, cancer, diabetes, or chronic respiratory diseases. By investigating the interplay between economic development and health outcomes, this study aims to provide policy recommendations that can help mitigate premature deaths while fostering sustainable economic growth.

The empirical investigation of the relationship between mortality from non-communicable diseases (NCDs) and economic indicators in Azerbaijan is essential for several important reasons. In Azerbaijan, NCDs such as cardiovascular diseases, diabetes, chronic respiratory diseases, and cancer are among the leading causes of overall mortality. According to the World Health Organization (WHO), NCDs account for more than 70% of deaths in low- and middle-income countries. This trend is also observed in Azerbaijan.

Empirical research indicates that the prevalence and mortality rates of NCDs are significantly influenced by economic indicators. Examining the relationship between mortality from NCDs and economic indicators in Azerbaijan is crucial for identifying the cause-and-effect relationships between NCDs and the economy, improving the state’s healthcare and social policies, and developing economic strategies to enhance public health.

The aim of this investigation is to identify the economic factors contributing to mortality from NCDs and to develop recommendations for eliminating these causes. Our hypotheses for the econometric analysis of the dependence of NCD mortality on economic indicators in Azerbaijan are as follows.

1. ***First Hypothesis:*** An increase in GDP leads to a decrease in mortality from NCDs.
2. ***Second Hypothesis:*** An increase in healthcare expenditures reduces mortality from NCDs.
3. ***Third Hypothesis:*** An increase in the unemployment rate leads to an increase in mortality from NCDs.
4. ***Fourth Hypothesis:*** An increase in out-of-pocket healthcare expenses increases mortality from NCDs.
5. ***Fifth Hypothesis:*** An increase in the Human Development Index (HDI) reduces mortality from NCDs.

## 2. Literature Review

The quantitative assessment of the economic and socioeconomic impacts on mortality rates from NCDs (non-communicable diseases) has been extensively studied in the context of various countries. A study by [Wang and Wang \(2020\)](#) evaluates the influence of socioeconomic factors on the probability of death due to NCDs, offering projections of NCD-related mortality rates up to 2030. A systematic literature review by [Lago-Peñas et al. \(2021\)](#) investigated the impact of socioeconomic status on the prevalence and outcomes of non-communicable diseases (NCDs). [Dhankhar et al. \(2021\)](#) argue that a significant portion of healthcare costs related to NCDs is borne by individuals themselves (out-of-pocket), imposing a considerable financial burden, especially on low-income families, which negatively affects the economic stability of households. [Malta et al. \(2020\)](#) present an analysis of historical trends, interregional disparities, and projections for NCD-related mortality rates in Brazil, offering insights into future health outcomes up to 2030. [Chai et al. \(2021\)](#) explore the efficiency and productivity of healthcare systems in China in the context of preventing and managing NCDs, examining how the healthcare system's effectiveness impacts overall NCD management. [Jakovljevic et al. \(2019a\)](#) demonstrate that increasing healthcare expenditures in BRICS nations has a notable effect on improving public health outcomes and fostering economic growth. [Hlafa et al. \(2019\)](#) evaluated the impact of public healthcare expenditures on health outcomes in South Africa, emphasizing that government investments in healthcare can significantly enhance health indicators in the country. [Fu et al. \(2021\)](#) conducted a study using data from Chinese family panel surveys, exploring the disparities in catastrophic healthcare expenditures between urban and rural regions in households affected by NCDs. Their findings indicate substantial differences in the financial burden of healthcare costs between these areas, further highlighting the impact of geographic disparities in healthcare access and expenditures on the population's health outcomes.

These studies collectively underscore the importance of socioeconomic factors, healthcare financing mechanisms, and the effectiveness of public health investments in shaping mortality rates due to non-communicable diseases. They also emphasize the need for targeted policy interventions that address both the financial and healthcare system-related challenges posed by NCDs, especially in regions with economic inequalities. [Jakovljevic et al. \(2019b\)](#) analyze key trends and challenges related to the financing and political economy of non-communicable diseases (NCDs). The researchers argue that NCD financing remains a critical issue for global health systems, particularly in light of the increasing burden these diseases place on healthcare infrastructure. [Al-Azri et al. \(2020\)](#) examined the relationship between healthcare spending and health outcomes in Oman. The study found that increases in healthcare expenditures had a significantly positive impact on key health indicators, including life expectancy and the reduction in mortality rates. [Arthur and Oaikhenan \(2017\)](#) investigated the effect of healthcare spending on health outcomes in sub-Saharan African (SSA) countries. Their research highlighted that healthcare spending in these countries has a substantially positive effect on health outcomes, especially in reducing child mortality rates and increasing life expectancy, demonstrating the potential benefits of investments in healthcare infrastructure. The relationship between healthcare spending and health outcomes in SSA countries has also been explored by [Chireshe and Ocran \(2020\)](#). Their findings emphasize the critical role of social determinants, such as education levels and economic inequality, in shaping health outcomes, pointing to the importance of addressing broader socioeconomic factors to improve public health.

Several studies have established a robust correlation between a country's GDP per capita and the burden of NCDs ([Aninditya et al., 2024](#); [Thomas-Lange & Urra-Miguieles, 2024](#)). Wealthier countries often face higher rates of NCDs due to lifestyle factors such

as high-calorie diets, physical inactivity, and stress. In contrast, lower-income countries experience significant NCD burdens as a result of limited healthcare access, inadequate preventive measures, and economic instability. Research suggests a U-shaped relationship, wherein both very high and very low GDP levels contribute to increased NCD prevalence, implying that both economic extremes are associated with poor health outcomes (Katzmarzyk et al., 2022).

Both public and private healthcare spending are directly linked to NCD outcomes. Countries that allocate higher expenditures to healthcare typically have lower mortality rates from NCDs, as these investments facilitate the provision of preventive care, early diagnosis, and treatment. However, inefficient allocation of healthcare resources, particularly in low- and middle-income countries (LMICs), can undermine the positive effects of increased spending. The literature suggests that even a 1% increase in healthcare spending as a share of GDP can substantially reduce NCD-related mortality rates, underscoring the importance of effective healthcare resource management (Torres et al., 2024).

Unemployment and income inequality are critical determinants of NCD prevalence. Long-term unemployment has been linked to higher stress levels, poor mental health, and reduced access to healthcare services. Additionally, income inequality exacerbates health disparities, as lower-income populations often lack access to quality healthcare, nutritious food, and healthy living environments. Studies indicate that countries with high Gini coefficients tend to experience higher rates of NCD-related deaths (Gavurová et al., 2017).

Unfortunately, this study on the macroeconomic factors of mortality from NCDs is the first of its kind in the context of Azerbaijan. Conducting further research in the field of health economics in the context of Azerbaijan is essential in the future.

### 3. Data and Methodology

Various indicators are used to assess the health level in cross-country comparisons. These indicators generally encompass different facets of health and enable the measurement of overall well-being. Widely used indicators include **“life expectancy”**, **“under-five mortality rate”**, **“maternal mortality rate”**, **“prevalence of chronic diseases”**, and others. For our study, we will employ the indicator **“probability of dying between exact ages 30 and 70 from any of cardiovascular disease, cancer, diabetes, or chronic respiratory diseases (%)”** (*Mortality<sub>t</sub>*).

Additionally, we will utilize macroeconomic indicators, including (a) **Gross Domestic Product per Capita** (*GDPPC<sub>t</sub>*), (b) **total healthcare expenditures** (*HEXP<sub>t</sub>*), (c) **Domestic Government Health Expenditures** (*GHEXP<sub>t</sub>*), (d) **household expenditures** (*HHEXP<sub>t</sub>*), (e) **waged and salaried employment in total employment** (*WEMP<sub>t</sub>*), (f) **out-of-pocket health expenditures** (*OPEXP<sub>t</sub>*), and (g) the **Human Development Index** (*HDI<sub>t</sub>*).

As previously noted, this study will compare the health levels of Azerbaijan. The relationship between health levels and macroeconomic indicators will be empirically evaluated and compared using a time series analysis. The advantage of applying a time series analysis is that it allows for the tracking of both economic characteristics and healthcare sector features over time in each country. This approach helps in capturing the dynamic nature of the relationship between health outcomes and macroeconomic factors, enabling a deeper understanding of the long-term trends and potential causalities.

When conducting a time series analysis, it is crucial to assess the stationarity of each indicator's time series. This can be performed through unit root tests, ensuring that the data are stable over time. If necessary, methods such as Vector Autoregression (VAR) or cointegration techniques will be employed to investigate the long-term relationships between the variables.

Based on the results from the stationarity tests, we will decide whether to use ARDL (Autoregressive Distributed Lag) model or VECM (Vector Error Correction Model). In our research, we plan to apply the VAR model and the ECM independently for each country, using the respective data of Azerbaijan and Austria. The VAR model is particularly suitable in this context because it allows for the examination of interrelationships not only between the NCD indicators and macroeconomic variables but also between the macroeconomic indicators themselves, capturing any potential feedback loops or mutual influences.

Additionally, we will consider employing the ECM, as it allows for the modeling of long-term equilibrium relationships between variables. Cointegration between the macroeconomic indicators and NCD-related variables could provide valuable insights into how these relationships evolve.

## 4. Results

### 4.1. Background

After Azerbaijan gained independence, the large-scale liberalization of the country's economy, particularly the liberalization of foreign economic relations (M. Gulaliyev et al., 2017), enabled its active integration into the global economic system. The rapid development of the oil sector not only had a positive impact on the welfare of the population but also facilitated the allocation of substantial investments into various sectors, including healthcare. The rapid digitalization of the country's economy (M. Gulaliyev et al., 2023) and the expansion of cultural and tourism relations with other countries (M. G. Gulaliyev et al., 2021) have allowed the population in Azerbaijan to benefit from new health-related technologies. Despite the increasing modernization of healthcare services in the country, the expansion of outbound medical tourism services indicates that people seek access to higher-quality healthcare services.

Azerbaijan's healthcare system operates as a hybrid model involving both the public and private sectors. Historically, the country has transitioned from a centralized Soviet-era healthcare model to a new system aligned with a market economy. Healthcare reforms and government programs have been aimed at improving public health. The healthcare system in Azerbaijan consists of both public and private institutions. The Ministry of Health of the Republic of Azerbaijan serves as the primary regulatory authority for the healthcare sector. Since 2020, the State Agency for Mandatory Health Insurance (SAMHI) has been responsible for managing the mandatory health insurance system.

Public hospitals and polyclinics are government-funded medical institutions operating across different regions of the country. Scientific Research Institutes function as state institutions, conducting research and providing specialized medical treatments in various fields. Private hospitals and clinics, primarily located in Baku and other major cities, serve as modern healthcare facilities offering a wide range of medical services.

Private health insurance services are also available in Azerbaijan, providing additional insurance packages offered by private insurance companies. The pharmaceutical sector, regulated by both public and private entities, oversees the sale of medicines and medical equipment.

Since 2020, Azerbaijan has adopted a mandatory health insurance system aimed at improving access to healthcare services, reducing the financial burden of medical expenses on citizens, and enhancing the quality of healthcare services. The country's healthcare system remains in transition from a post-Soviet model to a modern medical system. Despite ongoing reforms, including the implementation of mandatory health insurance, challenges related to the accessibility and quality of healthcare services persist, particularly in rural regions.

The healthcare systems and economic factors of Azerbaijan are important to consider in the context of the “ $Mortality_t$ ” indicator. While Azerbaijan’s healthcare system faces budgetary challenges, it has made gradual improvements in reducing mortality rates, albeit at a moderate pace. Azerbaijan’s efforts to address NCDs are still evolving, influenced by economic constraints and lifestyle factors, such as the prevalence of unhealthy dietary habits. This research will explore the relationship between economic development and health outcomes, emphasizing the importance of investments in healthcare systems, effective prevention programs, and the role of lifestyle changes in reducing the burden of NCDs.

The Azerbaijani economy is transitioning from the former Soviet model to a market economy, relying on energy resources while striving for diversification. Although the oil and gas industry remains the country’s primary economic sector, a series of reforms have been implemented in recent years to promote the development of the non-oil sector (Aliyev et al., 2023).

In 2000, healthcare spending in Azerbaijan was very low (USD 18.98 per capita) and increased to USD 249.08 per capita by 2021. Azerbaijan demonstrated significant growth during this period. In Azerbaijan, household expenditures in 1990 were USD 651.23. By 2023, these expenditures had increased to USD 3791.79.

The high share of “**out-of-pocket health expenditures**” ( $OPEXP_t$ ) in total healthcare expenditures differentiates Azerbaijan from developed countries. In Azerbaijan, in 2000, this indicator was 68.61%, and it peaked at 73.39% in 2018. Although there was a sharp decrease to 57.83% in 2020, it rose again to 66.03% in 2021. The share of out-of-pocket (OOP) health expenditures in Azerbaijan has consistently been high, indicating that a large portion of healthcare services is funded by private payments.

There are also significant differences between Azerbaijan and developed countries in terms of “**Domestic Government Health Expenditures**” ( $GHEXP_t$ ). In Azerbaijan, the government’s per capita health expenditures were USD 5.58 in 2000 and increased to USD 78.75 by 2021. The biggest jump in the GHEXP occurred between 2005 and 2007, reflecting efforts made by the government to increase the health budget.

The differences in the Human Development Index ( $HDI_t$ ) between Azerbaijan and developed countries involved in the study are also noticeable. Azerbaijan’s HDI showed steady growth until 2019, but in 2020, it sharply declined. However, in the subsequent years, its development has recovered.

#### 4.2. Descriptive Statistics

The provided descriptive statistics (Table 1) describe multiple variables in a time series dataset. Negative values of Skewness (e.g.,  $-0.1004$ ,  $-0.4982$ , etc.) indicate left-skewed distributions (longer tail on the left). Positive values (e.g.,  $0.2490$ ,  $0.0749$ ) suggest right-skewed distributions. Values near zero indicate symmetrical distributions. Kurtosis measures whether the data have heavy or light tails compared to a normal distribution. Values close to 3 (e.g.,  $WEMP_t$ ) indicate a normal distribution. Values below 3 (all other time series) suggest platykurtic distributions. Smaller values of the Jarque–Bera statistic combined with high  $p$ -values (above 0.05) indicate that the data are likely normally distributed. All variables show  $p$ -values  $> 0.05$ , suggesting no significant deviation from normality. Since all reported  $p$ -values are greater than 0.05, we fail to reject the null hypothesis of normality. This indicates that the data are consistent with a normal distribution.

**Table 1.** Descriptive statistics of time series.

	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	Jarque-Bera	Prob.
<i>Mortality<sub>t</sub></i>	30.0400	30.0500	32.5000	27.2000	1.7476	-0.1004	1.5958	1.6769	0.4324
<i>GHEXP<sub>t</sub></i>	41.2810	42.7400	87.2900	5.5000	27.97609	0.0982	1.7647	1.3038	0.5211
<i>WEMP<sub>t</sub></i>	32.0055	31.9003	33.4868	30.5640	0.7449	0.2490	2.8166	0.2347	0.8893
<i>GDPPC<sub>t</sub></i>	4092.372	4443.496	7890.840	655.0972	2532.320	-0.0238	1.7403	1.3243	0.5157
<i>HHEXP<sub>t</sub></i>	1861.735	2197.457	3585.410	421.9581	1090.500	-0.0996	1.5449	1.7974	0.4071
<i>OPEXP<sub>t</sub></i>	65.1580	66.9000	73.3900	52.6100	6.2039	-0.4982	1.9995	1.6615	0.4357
<i>HEXP<sub>t</sub></i>	127.3100	142.9400	277.0400	18.9800	88.0151	0.0749	1.6210	1.6035	0.4485
<i>HDI<sub>t</sub></i>	0.7054	0.7131	0.7620	0.6350	0.0453	-0.1841	1.4103	2.2190	0.3297

Note: calculated by authors.

#### 4.3. Stationarity of the Variables

There are some advantages of using time series analysis to determine which macroeconomic indicator the “mortality” indicator in Azerbaijan is more dependent on. For example, time series analysis allows for (a) the identification of country-specific trends; (b) the comparison of the effectiveness of healthcare policies implemented in different countries; (c) conducting more localized and in-depth research; (d) the verification of model suitability and stability across countries; (e) the development of appropriate recommendations for each country, among others.

Table 2 provides information regarding the stationarity of Azerbaijan’s indicators based on the ADF (Augmented Dickey–Fuller) test initially.

**Table 2.** Stationarity of Azerbaijan’s indicators’ time series (intercept, intercept, and trend).

	Intercept		Intercept and Trend		Intercept		Intercept and Trend		
	ADF Stat.	I(0)	ADF Stat.	I(0)	ADF-Stat. I(1)	I(1)	ADF-Stat. I(1)	I(1)	
1	<i>Mortality<sub>t</sub></i>	0.1450	—	-2.0296	—	-3.8047 ***	+	-3.1280	—
2	<i>GHEXP<sub>t</sub></i>	-1.8118	—	-2.2364	—	-2.0917	—	-2.1134	—
3	<i>WEMP<sub>t</sub></i>	-2.6408	—	-2.4209	—	-3.3413 **	+	-3.8134 **	+
4	<i>GDPPC<sub>t</sub></i>	-1.7524	—	-1.5132	—	-2.5926 *	+	-2.9106	—
5	<i>HHEXP<sub>t</sub></i>	-1.4282	—	-2.1194	—	-2.3979	—	-2.8981	—
6	<i>OPEXP<sub>t</sub></i>	-3.2088 **	+	-4.7089 ***	+	-2.3445	—	-2.5015	—
7	<i>HEXP<sub>t</sub></i>	-1.4385	—	-2.4085	—	-2.2517	—	-2.2350	—
8	<i>HDI<sub>t</sub></i>	-0.9832	—	-1.4181	—	-4.1159 ***	+	-4.1288 **	+
9	logGHEXP	-2.3257	—	-2.4160	—	-1.6083	—	-1.9818	—
10	logGDPPC	-2.1169	—	-0.3481	—	-2.0022	—	-2.9675	—
11	logHHEXP	-1.9056	—	-1.5853	—	-1.9930	—	-2.5467	—
12	logHEXP	-2.0661	—	-1.9576	—	-1.7097	—	-2.5793	—
13	logOPEXP	-3.0866 **	+	-4.3346 **	+	-2.4178	—	-2.5751	—

Note: calculated by authors. \*, \*\*, \*\*\* denote significance at 10%, 5%, and 1%, respectively. “—” and “+” denote “non-stationary” and “stationary”, respectively.

Since the indicators in Table 2 have different stationarity levels, the Johansen test will be applied only to “*Mortality<sub>t</sub>*”, “*WEMP<sub>t</sub>*”, “*GDPPC*”, and “*HDI<sub>t</sub>*”, which are stationary at the I(1) level. For these indicators, we will use “intercept (no trend) in CE and test VAR”

as the “cointegration test specification”. The VAR Lag Order has been used to determine the appropriate lag length.

#### 4.4. Lag Selection and Johansen Test

Based on the results of VAR Lag Order Selection Criteria LR (Sequential Modified LR Test): Lag 3 is chosen as it provides the lowest *p*-value satisfying the 5% level. FPE (Final Prediction Error): The lowest FPE value (0.002608) is observed at Lag 3. AIC (Akaike Information Criterion): AIC is minimized at Lag 3 with a value of 3.460318. SC (Schwarz Criterion): The smallest SC value (6.008971) occurs at Lag 3. HQ (Hannan–Quinn Criterion): HQ is minimized at Lag 3 (3.713659). Considering these results, we select Lag = 3 for the VAR model. Since the VAR model uses Lag = 3, we will set “Lag = 1 to 2” for the Johansen test.

After selecting the Lag, the results of the Johansen test show the long-term relationships between Azerbaijan’s mortality rate ( $Mortality_t$ ), GDP per capita ( $GDPPC_t$ ), Human Development Index (HDI), and employment level (WEMP). The test results indicate that both the Trace test and the Max-Eigen test confirm the existence of three cointegration relationships ( $p < 0.05$ ). These findings validate the presence of long-term associations among the variables. Based on the normalized cointegration coefficients, mortality (MORTALITY) is linked to the GDP per capita ( $GDPPC_t$ ), the Human Development Index ( $HDI_t$ ), and wage employment level ( $WEMP_t$ ).

$$MORTALITY_t = -0.002997 * GDPPC_t - 59.12949 * HDI_t + 5.196955 * WEMP_t \quad (1)$$

Based on Equation (1), as  $GDPPC_t$  and  $HDI_t$  increase, mortality levels decrease. However, an increase in wage employment (WEMP) may cause certain changes in mortality trends in an upward direction. The adjustment coefficients indicate that MORTALITY, GDPPC, and HDI significantly adjust to return to long-term equilibrium. For example, since the adjustment coefficient of GDPPC is  $-1637.046$ , short-term economic growth shocks have a strong impact on driving the economy back to long-term equilibrium.

Based on the results of the Johansen test, we can conclude that (a) there are long-term equilibrium relationships in Azerbaijan; (b) as the GDPPC increases, mortality rates decline, and as the HDI rises, a reduction in mortality is observed; (c) changes in economic growth and wage employment may influence these relationships; (d) although short-term shocks have an impact, the economy and social development adjust toward long-term equilibrium.

In the Johansen test for Azerbaijan, only three indicators that are stationary at the I(1) level were included. However, variables such as “GHEXP”, “HEXP”, “HHEXP”, and “OPEXP” may also have a significant impact on health outcomes, making their inclusion in the model essential. Among these variables, “OPEXP” is the only one found to be stationary at the I(0) level.

#### 4.5. ARDL Model

To analyze both the short-term and long-term effects of “OPEXP” alongside the I(1) variables on “mortality”, we will apply the ARDL model. A key advantage of the ARDL model in our study is its ability to handle small sample sizes, making it particularly suitable given that our analysis is based on only 20 observations covering the period 2000–2019. In the ARDL framework, long-term relationships are estimated through the cointegration equation, while short-term effects are captured using the Error Correction Model (ECM). The ARDL approach effectively differentiates between long-term relationships and short-term dynamics, improving the econometric accuracy and enhancing the overall quality of the analysis.

When constructing the ARDL model, the optimal lag length for each variable is selected. The calculations indicate that among all selection criteria, the optimal lag length is 2, as the AIC, HQ, and FPE criteria yield the lowest values at Lag = 2. Additionally, the LR test statistic (61.75643) confirms that Lag = 2 is statistically significant, indicating that this choice optimally balances the model stability and forecasting accuracy.

In the ARDL model, we set Lag = 3 for mortality and Lag = 2 for the independent variables to construct the model. The results of the ARDL model demonstrate that it explains 99.99% of the variance in the dependent variable, which is an exceptionally high explanatory power (adjusted R-squared = 0.999721). The high adjusted R<sup>2</sup> further confirms the model's robustness and reliability.

The Durbin–Watson statistic (2.824546) suggests that there is no serious issue of autocorrelation in the residuals. Additionally, the F-statistic (3824.100), with a corresponding probability of Prob(F-statistic) = 0.012689, indicates that the model is statistically significant ( $p < 0.05$ ). The nature of the long-term relationships among the variables included in the ARDL model is presented in Table 3.

**Table 3.** The results of the long-term effects of the independent variables on the “mortality” variable in the ARDL model are presented as follows.

Variables	Coefficient	t-Stat.	Variables	Coefficient	t-Stat.
Mortality(−1)	1.939628 **	19.71	HDI(−2)	171.9012 **	18.16
Mortality(−2)	−0.700086	−2.98	WEMP	−5.043491 **	−19.81
Mortality(−3)	0.964242 *	−7.71	WEMP(−1)	−0.407167 *	−10.78
GDPPC	0.001867 **	17.66	WEMP(−2)	−0.886005 **	−16.03
GDPPC(−1)	−0.000294	−5.63	OPEXP	−0.424178 **	−13.97
GDPPC(−2)	0.000869 **	20.07	OPEXP(−1)	0.136281 *	8.01
HDI	−159.8411 **	−23.25	OPEXP(−2)	0.057297 *	7.45
HDI(−1)	−80.46682 **	−18.29	Constant(C)	280.3995 **	22.65

Note: calculated by authors. \*, \*\*, denote significance at 10%, and 5%, respectively.

The findings from the ARDL model can be analyzed from an economic standpoint as follows: The relationship between GDP (GDPPC) and the mortality rate exhibits variability over both the short-term and long-term horizons. In the short term, an increase in GDP may contribute to an increase in the mortality rate, potentially driven by factors such as industrialization, environmental pollution, or stressful working conditions. However, in the long term, the effect of GDP becomes more heterogeneous and subject to dynamic economic factors. As the Human Development Index (HDI) rises, the mortality rate demonstrates a significant decline. A higher HDI reflects improvements in critical sectors such as healthcare, education, and social welfare, which collectively foster better health outcomes and enhance the overall quality of life. An increase in wage employment level (WEMP) is associated with a reduction in the mortality rate. Higher wage employment levels facilitate access to better healthcare services, thereby contributing to improved health and reduced mortality.

Furthermore, an increase in out-of-pocket expenditures (OPEXP) is correlated with a decrease in the mortality rate, suggesting that higher private healthcare spending may enhance health outcomes. Additionally, augmenting healthcare and social protection expenditures is found to have a mitigating effect on the mortality rate.

To verify the long-term cointegration relationships implied by the ARDL model, the Bounds test can be utilized. The Bounds test results for Azerbaijan are as follows: dependent

variable: D(MORTALITY), Selected Model: ARDL(3,2,2,2,2), Restricted Constant and No Trend, Number of Observations: 17 years (2003–2019).

The long-term relationships between the variables are outlined in Table 4. The results demonstrate that MORTALITY(−1) is negative and statistically significant, thereby providing strong evidence in support of the existence of long-term cointegration. In essence, when the system deviates from equilibrium, it tends to revert to its long-term relationship, indicating the stability of the underlying dynamics.

**Table 4.** Error Correction Model (ECM) and long-term relationships.

Variables	Coefficient	t-Stat	Variables	Coefficient	t-Stat
MORTALITY(−1)	−0.724701 *	−6.708142	WEMP(−1)	−6.336663 **	−21.65220
GDPPC(−1)	0.002442 **	22.42583	OPEXP(−1)	−0.230599 **	−17.60568
HDI(−1)	−68.40664 **	−16.51989			

Note: calculated by authors. \*, \*\*, denote significance at 10%, and 5%, respectively.

The F-statistic value of 292.4972 is significantly higher than the critical value from Pesaran et al. (2001) for the I(1) bound. This result unequivocally confirms the presence of a long-term relationship. The F-statistic surpasses the critical values at the 1% level, indicating a strong long-term relationship. The economic interpretation of these results suggests that in the long term, there is a relationship between GDP, HDI, wage employment (WEMP), out-of-pocket health expenditures (OPEXP), and the mortality rate (mortality) due to NCDs among individuals aged 30–70. Human Development Index (HDI) and wage employment levels (WEMP) significantly reduce the mortality rate. The long-term effect of GDP is positive, which may be explained by economic growth increasing the risk of mortality in certain cases. For instance, if GDP growth is driven by industrialization, pollution and health risks may also rise. When OPEXP increases, a reduction in mortality probability is observed. These results indicate that reforms in the healthcare and employment sectors in Azerbaijan have an impact on mortality rates, underscoring the importance of directing social policies towards these areas.

#### 4.6. ECM

After establishing the ARDL model and performing the Bounds test (long-term relationship test), it is necessary to assess the long-term relationships. The coefficients of the independent variables and their significance in both the long-term and short-term relationships are provided in Tables 5 and 6.

In the ECM Regression (Case 2: Restricted Constant and No Trend) mode, R-squared = 0.999452. This indicates that the model has a very high explanatory power. The Durbin–Watson stat = 2.824546 suggests that there is no significant autocorrelation issue in the residuals. The Akaike Information Criterion = −5.891490 implies that the optimal lag length has been properly selected. The Schwarz Criterion = −5.352352 also aligns with the selection of the model, confirming that it is consistent with other criteria.

Based on the obtained results, we can assert that in Azerbaijan, there is a long-term relationship between the “probability of mortality due to NCDs in individuals aged 30–70” (Mortality) and indicators such as “GDP per capita” (GDPPC), “wage employment level” (WEMP), “Human Development Index” (HDI), and “out-of-pocket health expenditures” (OPEXP). The ECM (−0.724701) shows that the system returns to equilibrium at a rate of 72.47% in each period. In the short term, GDP, HDI, wage employment, and out-of-pocket health expenditures also affect the mortality rate. The statistical indicators of the model are reliable, and the results are economically logical.

**Table 5.** Conditional error correction regression.

Variables	Coefficients (Std.Err.)	Variables	Coefficients (Std.Err.)	Variables	Coefficients (Std.Err.)
C	280.3995 ** (12.38084)	D(MORTALITY(−1))	1.664329 * (0.155479)	D(HDI(−1))	−171.9012 ** (9.464683)
MORTALITY(−1)	−0.724701 * (0.108033)	D(MORTALITY(−2))	0.964242 * (0.125052)	D(WEMP)	−5.043491 ** (0.254490)
GDPPC(−1)	0.002442 ** (0.000109)	D(GDPPC)	0.001867 ** (0.000106)	D(WEMP(−1))	0.886005 ** (0.055261)
HDI(−1)	−68.40664 ** (4.140864)	D(GDPPC(−1))	−0.000869 ** (4.33E−05)	D(OPEXP)	−0.424178 ** (0.030356)
WEMP(−1)	−6.336663 ** (0.292657)	D(HDI)	−159.8411 ** (6.874505)	D(OPEXP(−1))	−0.057297 * (0.007694)
OPEXP(−1)	−0.230599 ** (0.013098)				

Note: calculated by authors. \*, \*\*, denote significance at 10%, and 5%, respectively.

**Table 6.** ECM Regression. Case 2: Restricted Constant and No Trend.

Variables	Coefficients (Std.Err.)	Variables	Coefficients (Std.Err.)
D(MORTALITY(−1))	1.664329 *** (0.017185)	D(WEMP)	−5.043491 *** (0.048618)
D(MORTALITY(−2))	0.964242 ** (0.018559)	D(WEMP(−1))	0.886005 *** (0.012578)
D(GDPPC)	0.001867 *** ( $1.87 \times 10^{-5}$ )	D(OPEXP)	−0.424178 *** (0.004201)
D(GDPPC(−1))	−0.000869 *** ( $9.29 \times 10^{-6}$ )	D(OPEXP(−1))	−0.057297 ** (0.001431)
D(HDI)	−159.8411 *** (1.484008)	CointEq(−1)	−0.724701 *** (0.007062)
D(HDI(−1))	−171.9012 *** (1.622375)		

Note: calculated by authors. \*\*, \*\*\*, denote significance at 5%, and 1%, respectively.

## 5. Discussion

The empirical findings of this study highlight the significant influence of macroeconomic indicators on mortality from non-communicable diseases (NCDs) in Azerbaijan, particularly for individuals aged 30–70. These results reinforce the relevance of income, employment, human development, and healthcare financing as key determinants of health outcomes in emerging economies.

The long-term relationships identified through the Johansen and ARDL-ECM frameworks indicate that the GDP per capita, the Human Development Index (HDI), wage employment (WEMP), and out-of-pocket health expenditures (OPEXP) are all statistically and economically significant factors in explaining mortality trends due to NCDs. These findings are consistent with previous literature emphasizing the multidimensional nature of public health outcomes (e.g., [Lago-Peñas et al., 2021](#); [Dhankhar et al., 2021](#)).

A particularly noteworthy result is the dual nature of GDP's impact on mortality. In the short term, a rising GDP per capita may coincide with increased mortality—potentially reflecting urbanization, environmental degradation, or stress-related work conditions.

However, in the long term, economic growth tends to support improved healthcare infrastructure and living standards, thereby reducing NCD mortality. This nuanced outcome underscores the importance of understanding the direction and nature of causality in such macro-health relationships.

The Human Development Index (HDI) was shown to have a robust and consistently negative relationship with NCD mortality. This result aligns with global evidence that improvements in education, life expectancy, and income contribute meaningfully to better health outcomes. For Azerbaijan, this suggests that policies aimed at enhancing human capital are central to long-term public health strategies.

Wage employment also emerged as a protective factor, with higher levels correlating with reduced mortality. This is likely because formal employment provides both income stability and often greater access to healthcare benefits, thereby reducing vulnerability to catastrophic health expenditures. However, it is important to acknowledge that a significant share of Azerbaijan's population—especially in rural regions—lacks access to stable wage-based income, highlighting an area of policy concern.

The findings on out-of-pocket health expenditures (OPEXP) are particularly important for Azerbaijan's healthcare system. While higher private spending may reduce mortality in the short term by facilitating better or quicker access to services, it imposes a substantial financial burden on households. This reflects a broader challenge for health equity. In line with global studies (e.g., [Falkingham, 2004](#); [Pallegedara, 2018](#)), excessive reliance on private payments can undermine the sustainability of healthcare financing and worsen health disparities. Thus, Azerbaijan's high share of OPEXP points to the need for stronger public financing and more inclusive health insurance mechanisms.

Furthermore, although total and government healthcare expenditures (HEXP, GHEXP) did not show a strong direct correlation with mortality in this study, their indirect impact through infrastructure and system-wide improvements should not be overlooked. This suggests inefficiencies or insufficient allocation of health budgets that warrant further institutional and policy analysis.

The results affirm that improvements in the HDI and employment, along with equitable healthcare financing, are central to reducing premature mortality from NCDs in Azerbaijan. The study demonstrates that macroeconomic policies cannot be isolated from health outcomes, and that effective cross-sectoral coordination is essential. These insights provide strong justification for broader social policy interventions in addition to traditional health sector reforms.

## 6. Limitation of the Research

Although significant results have been achieved in the study, as with any research, this study also has certain limitations. The first limitation is related to data availability. This study uses data from the World Health Organization (WHO) database. This organization relies on local statistical databases. Local statistics record deaths from NCDs as deaths from various diseases. Moreover, such mortality data are not classified by age. The second limitation of the study is the lack of differentiation of NCD-related mortality rates by the country's regions. Due to the absence of such statistics, conducting a panel analysis across the country's regions was not possible. The third limitation concerns the use of ARDL and ECMs. While these models are reliable in identifying both short- and long-term relationships, they assume linearity in relationships. However, non-linear effects, which are frequently observed in real economic and healthcare systems, may not be fully captured. The fourth limitation of the study is the omission of other potential determinants of mortality, such as environmental factors, healthcare quality, and cultural aspects. These indicators were not included in the model. The fifth limitation is that the study covers the

period from 2000 to 2019. Considering that 2020–2021 were shock years both economically and in terms of public health, the model built with the ARDL framework was not tested for its performance during this period, resulting in certain limitations. While the ECM can identify some cause-and-effect relationships, additional methodologies may be required to fully uncover the precise causal mechanisms between economic indicators and mortality rates. Consequently, applying multiple methods within a single study may pose certain challenges in terms of scope and complexity.

Considering the aforementioned and other possible limitations in future research would not only enhance the reliability of the obtained results but also improve the effectiveness of the decisions made based on those results.

## 7. Conclusions

By analyzing of the findings for Azerbaijan, we can derive a series of targeted economic recommendations for both short-term and long-term policy formulation: Enhance HDI and Wage Employment: Since indicators such as the Human Development Index (HDI) and wage employment have been shown to reduce mortality risks, policies focused on boosting these indicators should be prioritized. This would improve the overall living standards and health outcomes, contributing to lower mortality rates.

While out-of-pocket expenditures might have a marginally positive effect on mortality by encouraging self-care, they also burden households, particularly low-income families. This can lead to exacerbated health disparities and higher mortality rates. A better approach would be for the government to shoulder a greater proportion of healthcare costs or implement an effective insurance system to mitigate the financial strain on citizens. According to the results, the relationship between “out-of-pocket” expenses and “Mortality” is interesting. The costs required for the treatment of NCDs are often so substantial that “out-of-pocket” expenses (“OPEXP”) do not fully cover them, and in most cases, such expenses are insufficient to ensure complete treatment. Nevertheless, the increase in expenses contributing to higher “Mortality” rates is linked to the fact that, in Azerbaijan, mortality cases are predominantly attributed to NCDs covered by “out-of-pocket” expenses. In other words, “out-of-pocket” expenses do not increase mortality; rather, they reveal the registration of mortality cases.

While economic growth is generally beneficial, it can sometimes lead to higher mortality rates if social determinants such as healthcare access, income inequality, and social protection are not adequately addressed. Thus, it is critical to design policies that ensure that the social benefits of economic growth are broadly distributed, preventing negative health outcomes despite GDP increases.

The absence of a strong relationship between “mortality” and healthcare expenditure indicators (*HEXP* and *GHEXP*) in Azerbaijan suggests that the level of healthcare spending is insufficient to effectively reduce mortality. Azerbaijan should prioritize increasing government spending on healthcare. This will help achieve better long-term health outcomes by directly impacting the quality and accessibility of healthcare services.

Economic growth should translate into greater investment in healthcare, ensuring that rising GDP is directed toward improving public health systems. A robust strategy should be developed to allocate a larger portion of GDP to healthcare, fostering better infrastructure, technological advancements, and access to care, which will ultimately lead to improved public health and reduced mortality rates.

Policymakers must ensure that healthcare expenditures are used efficiently and sustainably. This requires the transparent allocation of resources, regular assessments of spending effectiveness, and the implementation of targeted reforms in the healthcare sector. Short-

term reforms should aim to make immediate improvements in healthcare delivery, while long-term strategies should focus on building a resilient and effective healthcare system.

By implementing these recommendations, countries like Azerbaijan can strengthen their healthcare systems, reduce mortality rates, and ensure that economic growth benefits public health. Optimizing both healthcare investments and policies will play a crucial role in achieving sustainable health improvements for the population.

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