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Granger causality between cardiovascular diseases and some macroeconomic indicators: Azerbaijan case

Madina Yuzbashova *

ABSTRACT

Objective: Statistical assessment of the interdependence of CVD indicators on macroeconomic indicators on the example of Azerbaijan. **Design:** Research design is to test statistical hypotheses about the presence of direct and inverse causal relationships between CDV-indicators and macroeconomic indicators. Baseline and estimated data cover the period from 1991 to 2018 and are based on data from the SSCRA (2019) report. We use paired linear regression in which macroeconomic indicators are independent and CDV indicators are dependent variables. The stationarity of the time series was checked using the ADF test. To investigate the causal relationship between time series, the Granger test was used. **Main Outcome Measures:** p-level < 0.05; time lags are 1, 2 and 3 years. **Results:** Absence of direct and inverse causal relationship between CVD indicators and macroeconomic indicators GDP per capita, average annual income households per capita and average annual income households per capita. **Conclusions:** In the period from 1991 to 2018, the number of CDV deaths in Azerbaijan increased by 1.54. There is a steady increase in CDV diseases by 2.23 times. Despite GDP growth, there is no direct and inverse causal relationship between CVD indicators and macroeconomic indicators in the sense of the Granger test.

KEYWORDS: cardiovascular diseases; CVD-mortality; macroeconomy; ADF-test; Granger causality.

* Republican Treatment and Diagnostic Centre (147, Tbilisi Ave., Baku, AZ1122, Azerbaijan). ORCID: https://orcid.org/0000-0002-8016-9548 E-mail: yuzbashova.madina@mail.ru

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Causalidad de Granger entre las enfermedades cardiovasculares y algunos indicadores macroeconómicos: el caso de Azerbaiyán

RESUMEN

Objetivo: Evaluación estadística de la interdependencia de los indicadores de ECV con los indicadores macroeconómicos en el caso de Azerbaiyán. Diseño: El diseño de la investigación tiene como objetivo probar hipótesis estadísticas sobre la presencia de relaciones causales directas e indirectas entre los indicadores CDV y los indicadores macroeconómicos. Los datos de referencia y estimados cubren el período de 1991 a 2018 y se basan en datos del informe SSCRA (2019). Usamos regresión lineal pareada en la que los indicadores macroeconómicos son independientes y los indicadores CDV son variables dependientes. La estacionariedad de la serie temporal se comprobó mediante la prueba ADF. Para investigar la relación causal entre series de tiempo, se utilizó la prueba de Granger. Principales medidas de resultado: nivel p ‹0,05; los retrasos son de 1, 2 y 3 años. Resultados: Ausencia de relación causal directa e indirecta entre los indicadores de ECV y los indicadores macroeconómicos PIB per cápita, hogares con ingresos anuales promedio per cápita y hogares con ingresos anuales promedio per cápita. Conclusiones: En el período de 1991 a 2018, el número de muertes por CDV en Azerbaiyán aumentó en 1,54. Hay un aumento constante de las enfermedades por CDV en 2,23 veces. A pesar del crecimiento del PIB, no existe una relación causal directa e indirecta entre los indicadores de ECV y los indicadores macroeconómicos en el sentido de la prueba de Granger.

PALABRAS CLAVE: enfermedades cardiovasculares; Mortalidad por ECV; macroeconomía; Prueba ADF; Causalidad de Granger.

Introduction

Cardiovascular Disease (CVD) is one of the leading causes of death worldwide. According to the World Health Organization (WHO), the number of deaths from CVD in 2016 was more than 17.9 million. 85% of these deaths are due to heart attack and stroke. CVD deaths in the world account for 31% of all deaths (WHO,2019). The main causes of CVD, as in other diseases, are: 1) living conditions; 2) ecological situation; 3) genetic; 4) health system status. Therefore, it is important to distinguish these causes from each other. Except for genetic reasons, the other three reasons are directly or indirectly related to the economic and socioeconomic status of the country. Studies show that 75% of CVD deaths are shared by middle and low-income countries. 82% of non-infectious deaths under the age of 70 account

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for low- and middle-income countries. Among these diseases, CVD account for more than 37%.

Economic studies show that there is a positive correlation between the level of economic development and the level of environmental sustainability of a country (Samimi et al., 2011), as well as the level of economic development and healthy habits (Van Heuvelen & Van Heuvelen, 2019).

The WHO and other relevant cardiovascular disease agencies are expanding efforts to reduce various risk factors for the prevention of cardiovascular disease. However, low-level countries are unable to provide quality CVD prevention due to low public health spending and low household incomes.

Azerbaijan is an oil-rich country located in the west of the Caspian Sea. At the beginning of the 20th century, the country produced about half of the world's oil (Pomfret, 2011). During the Soviet era, Azerbaijan remained the main oil producer. After Azerbaijan gained independence in 1991, it was opened to foreign direct investment (Ciaretta and Nasirov 2012, p. 285). Over the past 20 years, oil revenues have had a significant impact on economic development as well as on the well-being of the population of Azerbaijan (Gurbanov et al., 2017). However, the expansion of oil production, especially the oil refining industry, had a negative impact on the environmental situation in the country (UNECE, 2011) and increased income inequality (Gulaliyev et al., 2018). Despite the growth in GDP, the number of CVD diseases and deaths from them continues to grow in the country.

Research examining the relationship between the economic situation of a country and the health status of the population provides the key to understanding and reducing the risks existing in this area. In each country, these risks have their own specifics, which became especially noticeable in the context of the global COVID-19 epidemic (Finol, 2021; Huacal Vásquez, 2020). At the same time, developed countries with high GDP per capita were among the leaders in mortality from this disease, despite the high level of health care costs compared to countries with less developed economies. On the other hand, countries with low economic indicators of population income cannot fully withstand the existing risks due to limited resources for the prevention and treatment of diseases, including CVD. In any case, the starting point for making decisions is objective statistics, on the basis of which one can judge the presence or absence of the influence of various indicators on each other.

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The purpose of our research is to statistically assess the dependence of CVD indicators on macroeconomic indicators using the example of Azerbaijan.

1. Materials and method

Research design is to test statistical hypotheses about the presence of direct and inverse causal relationships between CDV-indicators and macroeconomic indicators, such as:

- GDP per capita ($GDPPC_t$);
- average annual income households per capita ($HHRPC_t$);
- total health expenditure per capita ($HEXPPC_t$).

We use the following as CDV indicators:

- the number of cardiovascular patients (CVD_t);
- the number of mortality from CVD (CVM_t);
- the number of mortalities from CVD per 100,000 deaths ($CVMHTP_t$);
- the share of the number of mortalities from CVD in total disease deaths ($SCVM_t$).

We use linear regression in which macroeconomic indicators are independent and CDV indicators are dependent variables:

$$CVD_t = a_0 + a_1 * GDPPC_t + \varepsilon 1_t$$
$$CVD_t = a_2 + a_3 * HHRPC_t + \varepsilon 2_t$$
$$CVD_t = a_4 + a_5 * HEXPPC_t + \varepsilon 3_t$$
$$CVM_t = b_0 + b_1 * GDPPC_t + \nu 1_t$$
$$CVM_t = b_2 + b_3 * HHRPC_t + \nu 2_t$$
$$CVM_t = b_4 + b_5 * HEXPPC_t + \nu 3_t$$

To exclude spurious regression between random variables, it is necessary to check their time series for stationarity. The stationarity of the time series of independent and dependent variables was checked by using the Augmented Dickey-Fuller (ADF) test (Hill et al., 2011). The econometric software eViews was used to calculate the statistical data.

To investigate the causal relationship between the time series of independent and dependent variables, we used the Granger test (Hill et al., 2011). In order to establish how the consequences of changes in indicators in the past affect their current values in the Granger test, the values of time lags were chosen as Lag = 1, 2, 3. This means that we took into account the possible influence of some variables on the values of others with time lag=1, 2, 3 years old. To test statistical hypotheses, we use Fisher's F-test and p value with a significance level of 0.05.

Baseline and estimated data cover the period from 1991 to 2018 and are based on data from the SSCRA (2019) report.

The null hypotheses H_0 are formulated as follows:

- H_0: There is not any causal relation between CVD_t and $GDPPC_t$; CVD_t and $HHRPC_t$; CVD_t and $HEXPPC_t$;
- H_0: There is not any causal relation between CVM_t and $GDPPC_t$; CVM_t and $HHRPC_t$; CVM_t and $HEXPPC_t$;
- H_0: There is not any causal relation between $CVMHTP_t$ and $GDPPC_t$; $CVMHTP_t$ and $HHRPC_t$; $CVMHTP_t$ and $HEXPPC_t$;
- H_0: There is not any causal relation between $SCVM_t$ and $GDPPC_t$; $SCVM_t$ and $HHRPC_t$; $SCVM_t$ and $HEXPPC_t$.

Alternative hypotheses H_1 are accepted if there is a causal relationship between the above indicators.

2. Results

In Azerbaijan, CVD and the mortality rate from these diseases is higher than in other diseases. The disturbing fact is that the share of CVD in total diseases is steadily increasing. Compared to 1990, the number of patients diagnosed with CVD has increased from 60,000 to 144,000 in 2018 (Figure 1). The alarming point in the significant increase in the number of diagnosed CVD in the past 28 years is that there have been mortalities number in relation to the number of such diseases. In other words, a big number of the patients on CVD died from this disease. During the period covered by this study, mortality from CVD has steadily increased among both men and women, as well as in the urban and rural regions. It rose averagely from 22,000 in 1991 to 34,000 in 2018 (Figure 2).

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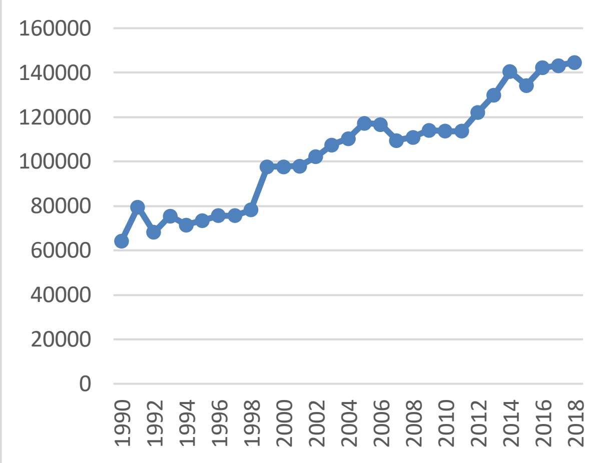

Fig. 1. Dynamics of CVD in Azerbaijan

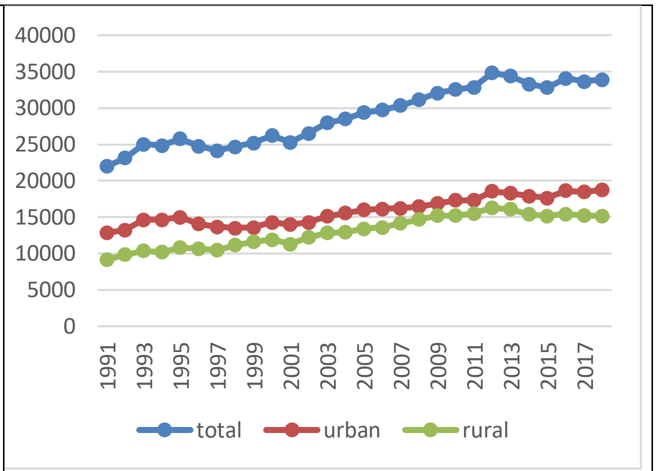

Fig. 2. Dynamics of deaths from CVD (CVM_t) in Azerbaijan

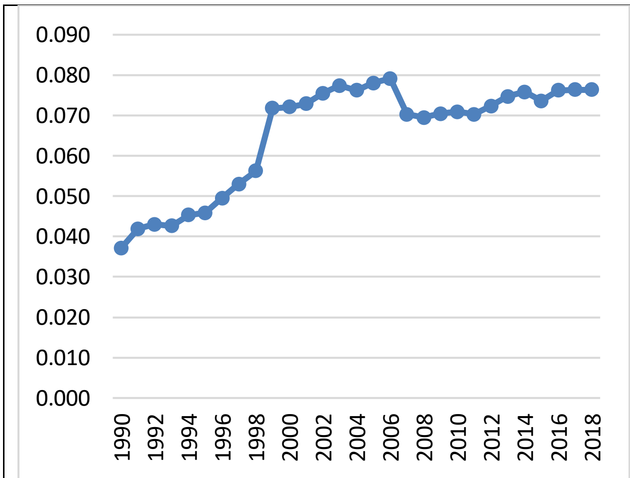

Fig. 3. Share of CVD in total diseases in Azerbaijan

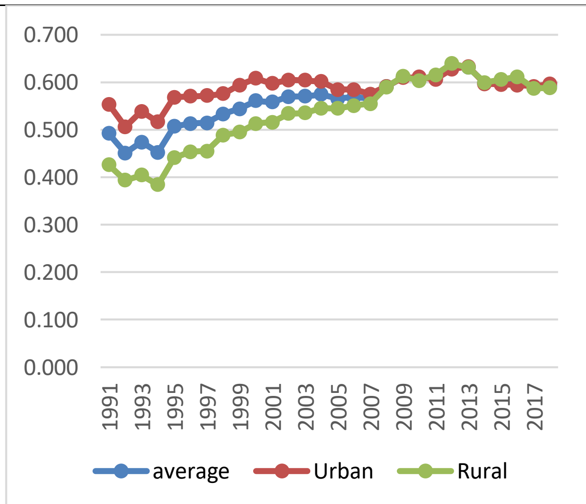

Fig. 4. Share of CVD mortality ($SCVM_t$) in total mortality in Azerbaijan

Even if we ignore the effects of population growth at that time period there is a significant increasing of CVD number in 100,000 populations. Thus, during the same period this number increased from 902 to 1462 (Figure 1). If we look at the dynamics of mortality rates on per 100,000 people, we will see a slight increase in the number of deaths during this period (Figure 2).

A significant increase is also apparent in the proportion of CVD in the total number of patients. Compared with 1990, this figure rose from 3.7% to 7.6% (Figure 3). However, there is a significant increase in the share of deaths number from CVD in total mortality number

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from all diseases. Thus, this figure rose steadily from 49% in 1991 to 59% in 2018 (Figure 4). This is 0.34% of the country's population. This indicator is higher than the world average (0.24%).

The initial data that reflect the dynamics of the analysed indicators are presented in Table 1. The results of the regression analysis (the value of the coefficient of determination R^2) show a strong correlation between the dependent and independent variables (Table 2).

Table 1. CVD dynamics in Azerbaijan (1991-2018)

	CVD_t	CVM_t	$CVMHTP_t$	$SCVM_t$	$GDPPC_t$	$HEXPPC_t$	$HHRPC_t$
1991	64306	21978	307.3	0.492	1209.2	-	-
1992	79572	23118	318.3	0.451	676.2	-	-
1993	68199	25016	339.2	0.474	529.8	-	-
1994	75501	24858	332.5	0.453	436.2	-	-
1995	71432	25767	340.6	0.507	397.2	4.37	-
1996	73448	24765	324.0	0.513	409.2	6.33	-
1997	75599	24163	313.1	0.515	505.6	6.22	-
1998	75720	24681	316.7	0.533	561.9	5.13	-
1999	78308	25181	320.3	0.544	573.9	5.38	-
2000	97765	26205	329.5	0.561	655.1	5.60	-
2001	97645	25267	314.5	0.558	703.7	5.45	367.4
2002	98056	26505	326.8	0.570	763.1	5.58	310.9
2003	102239	27960	341.4	0.571	883.6	6.76	503.5
2004	107440	28488	344.1	0.575	1045.0	8.98	788.6
2005	110346	29392	350.7	0.566	1578.4	14.83	962.9
2006	117345	29712	350.0	0.569	2473.1	21.77	1240.9
2007	116755	30355	352.8	0.566	3851.4	35.33	1515.8
2008	109487	31128	357.0	0.591	5574.6	49.29	1633.5
2009	110929	32072	363.3	0.611	4950.3	56.37	1875.1
2010	114130	32554	364.4	0.608	5842.8	59.63	2162.8
2011	113739	32835	362.7	0.611	7189.7	68.55	2521.0
2012	113702	34832	379.6	0.633	7496.3	84.60	2936.5
2013	121988	34379	369.8	0.632	7875.8	84.80	3302.7
2014	129970	33291	353.6	0.598	7891.3	90.00	3538.3
2015	140433	32825	344.5	0.600	5500.3	70.31	2748.3
2016	134225	34093	353.7	0.602	3880.7	46.40	1983.4
2017	142277	33663	345.8	0.589	4147.1	42.26	1894.4
2018	143182	33909	345.3	0.592	4721.2	42.19	1948.4

Source: calculated by the author based on the data of *SSCRA (2019), World Bank (2019).*

Table 2. Regression between CVD indicators and economic-indicators

	$GDPPC_t$				$HHRPC_t$				$HEXPPC_t$			
	F	R^2	t	SE	F	R^2	t	SE	F	R^2	t	SE
CVD_t	0.000	0.548	5.617	1.180	0.003	0.429	3.468	2.860	0.000	0.492	4.612	109.033
CVM_t	0.000	0.788	9.829	0.136	0.000	0.783	7.601	0.340	0.000	0.792	9.161	11.893
$CVMHTP_t$	0.000	0.666	7.207	0.001	0.001	0.514	4.112	0.003	0.000	0.654	6.449	0.076
$SCVM_t$	0.000	0.610	6.371	0.000	0.000	0.700	6.113	0.000	0.000	0.717	7.466	0.000

Source: calculated by the author, used eViews

However, in order to make sure that this is indeed the case, we need to examine their time series for stationarity. For these purposes we use ADF test. In this test, the no stationarity of the considered time series is assumed as the null hypothesis H_0. ADF statistics are used to test the significance of linear regression coefficients based on their comparison with critical values. An alternative hypothesis H_1 is considered to be the stationarity hypothesis.

First of all we will check stationarity of CVD_t time series. We will apply ADF test for stationary of CVD_t time series as following

$$\Delta CVD_t = \alpha + \gamma * CVD_{t-1} + \beta * \Delta CVD_{t-1} + \nu_t, \quad (1)$$

Where $\Delta CVD_t = CVD_t - CVD_{t-1}$ is the annual change in the number of cardiovascular patients; $CVD_{t-1}$is the change in the number of cardiovascular patients in (t-1) year; α, β, γ-coefficients; ν_t – error term.

Based on the initial data (Table 1) and by using econometric software eViews, we calculate the value of the regression coefficients:

$$\Delta CVD_t = 2284.515 + 0.009877 * CVD_{t-1} - 0.30913 * \Delta CVD_{t-1} \quad (2)$$

In this case, we obtain the value of the ADF statistic $\tau = 0.19$. Comparison of τ with critical values τ_c (see Table 3) shows that $\tau > \tau_c$. Consequently, the time series CVD_t is non-stationary. In this case, the null hypothesis H_0 is not rejected.

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Table 3. Stationary of time series *CVD*, *CVM*, *CVMHTP*, *SCVM*

	F	SE	τ *	I(0)	I(1)
CVD_t	0.250844	0.050758	0.19459	H_0	H_1
ΔCVD_t	0.000007	0.303883	−3.88807	H_1	-
CVM_t	0.628486	0.045484	−0.96978	H_0	H_1
ΔCVM_t	0.000387	0.312122	−3.62594	H_1	-
$CVMHTP_t$	0.23025	0.110329	−1.76829	H_0	H_1
$\Delta CVMHTP_t$	0.000054	0.277488	−4.21411	H_1	-
$SCVM_t$	0.035431	0.060196	−2.34476	H_0	H_1
$\Delta SCVM_t$	0.000008	0.325579	−3.50785	H_1	-

* Tabular values of τ_ (c) for stationarity of the time series: −3.43 (1%- critical value); −2.86 (5%- critical value); −2.57 (10%- critical value)

Source: calculated by the author, used eViews

That's why we need to check stationarity of the first differences CVD_t time series according to ADF test

$$\Delta(\Delta CVD)_t = \alpha + \gamma * \Delta CVD_{t-1} + \beta * \Delta(\Delta CVD)_{t-1} + \nu_t \qquad (3)$$

By calculation the regression equation (3) using the empirical data in Table 1 we find α, γ and β coefficients, as well ADF-statistics as follows

$$\Delta(\Delta CVD)_t = 3392.519 - 1.18152 * \Delta CVD_{t-1} + 0.009676 * \Delta(\Delta CVD)_{t-1} \qquad (4)$$

According to the equation (4) $\tau = -3.89 < \tau_c$. In this case, the value of the ADF statistic lies to the left of the critical value τ_c . Therefore, the first differences of the process, i.e. ΔCVD_t has stationarity $\Delta CVD_t \sim I(0)$ and the null hypothesis H_0 for this series is rejected.

Thus, checking the stationarity of the time series CVD_t using the ADF test shows that the time series of its first differences is stationary $\Delta CVD_t \sim I(0)$. Therefore, the original time series CVD_t has stationarity in first order $CVD_t \sim I(1)$.

Applying similar calculations for the rest of the indicators, we get the results that are presented in Table 3. From Table 3, it can be seen that other time series of CVD indicators have the same properties in the sense of the ADF test.

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According to the econometrics theory to find a causal-effect relationship between time series connected with *CVD*, *CVM* and some macroeconomic indicators as independent variables, we need to test stationarity of these variables also. So it is important to test by ADF tests stationarity of $GDPPC_t$, $HHRPC_t$, $HEXPPC_t$ (Table 4).

Table 4. Stationary of time series *GDPPC, HHRPC, HEXPPC*

	F	SE	τ *	I(0)	I(1)
$GDPPC_t$	0.04249	0.055729	−1.30732	H_0	H_1
$\Delta GDPPC_t$	0.01529	0.223092	−3.09492	H_1	-
$HEXPPC_t$	0.00721	0.053618	−1.52293	H_0	H_0
$\Delta HEXPPC_t$	0.09701	0.215486	−2.25642	H_0	-
$HHRPC_t$	0.00874	0.072448	−2.21679	H_0	H_0
$\Delta HHRPC_t$	0.07246	0.236128	−2.50093	H_0	-

* Tabular values of τ_ (c) for time series stationarity:−3.43 (1%- critical value); −2.86 (5%- critical value); −2.57 (10%- critical value)

Source: calculated by the author, used eViews

Table 4 shows that only $GDPPC_t$ has stationarity in first-order, i.e. $CDPPC_t \sim I(1)$ Since the time series of CVD indicators and the indicator $GDPPC_t$are non-stationary and there is a strong relationship between them (Table 2), we need to further investigate the relationship between the differences of these time series. These results are presented in Table 5.

Table 5. Regression between $\Delta GDPPC_t$ and Δ*CVD* indicators

	F	R^2	t	SE
ΔCVD_t	0.33453	0.037288	−0.98403	1.546872
ΔCVM_t	0.87215	0.001056	0.16259	0.205113
$\Delta CVMHTP_t$	0.94947	0.000164	0.06402	0.002461
$\Delta SCVM_t$	0.70093	0.006001	0.38850	0.000004

Source: calculated by the author, used eViews

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From Table 5 it follows that there is no regression relationship between the differences of the considered time series, Therefore, the relationship between CVD indicators and the macroeconomic indicator $GDPPC_t$ is considered a spurious regression.

Next, we will test the causality between these indicators using Granger tests (Hill et al., 2011). Wee will use time lags 1, 2 and 3 years (Lag = 1,2,3). Tables 6-7 show the likelihood of a causal relationship between the Granger tests.

Table 6. Granger causality tests between *ΔCVD* indicators and *ΔGDPPC*

	Lag = 1		Lag = 2		Lag = 3	
	F*	p value**	F	p value	F	p value
$\Delta CVD_t \rightarrow \Delta GDPPC_t$	0.12917	0.7226	0.45335	0.6419	0.32754	0.8055
$\Delta GDPPC_t \rightarrow \Delta CVD_t$	0.08094	0.7786	0.14661	0.8646	0.19087	0.9012
$\Delta CVM_t \rightarrow \Delta GDPPC_t$	3.31439	0.0817	2.56060	0.1023	2.04588	0.1456
$\Delta GDPPC_t \rightarrow \Delta CVM_t$	0.13463	0.7170	0.77416	0.4744	1.22226	0.3321
$\Delta CVMHTP_t \rightarrow \Delta GDPPC_t$	2.70883	0.1134	2.05967	0.1537	1.78448	0.1883
$\Delta GDPPC_t \rightarrow \Delta CVMHTP_t$	0.04620	0.8317	0.47749	0.6272	1.02374	0.4068
$\Delta SCVM_t \rightarrow \Delta GDPPC_t$	0.50317	0.4852	1.54078	0.2386	1.07047	0.3878
$\Delta GDPPC_t \rightarrow \Delta SCVM_t$	1.55198	0.2254	0.92947	0.4112	1.95456	0.1592

* $F_c = 4.24$
**$p < 0.05$

Source: calculation of the author, used eViews

Table 7. Granger causality tests between *ΔCVD* indicators and $\Delta HHRPC$

	Lag = 1		Lag = 2		Lag = 3	
	F*	p value**	F	p value	F	p value
$\Delta CVD_t \rightarrow \Delta HHRPC_t$	5.25322	0.0392	2.78053	0.1096	1.33068	0.3389
$\Delta HHRPC_t \rightarrow \Delta CVD_t$	0.39197	0.5421	0.51274	0.6138	1.05239	0.4275
$\Delta CVM_t \rightarrow \Delta HHRPC_t$	12.1757	0.0040	10.9711	0.0030	7.98132	0.0116
$\Delta HHRPC_t \rightarrow \Delta CVM_t$	0.10156	0.7550	0.12974	0.8798	0.60977	0.6297
$\Delta CVMHTP_t \rightarrow \Delta HHRPC_t$	11.6609	0.0046	7.68146	0.0095	7.79516	0.0124
$\Delta HHRPC_t \rightarrow \Delta CVMHTP_t$	0.18512	0.6741	0.13259	0.8773	0.59304	0.6391
$\Delta SCVM_t \rightarrow \Delta HHRPC_t$	8.90436	0.0106	6.81747	0.0136	3.12851	0.0968
$\Delta HHRPC_t \rightarrow \Delta SCVM_t$	0.15956	0.6960	0.93415	0.4247	0.23920	0.8664

* $F_c = 4.28$
**$p < 0.05$

Source: calculation of the author, used eViews

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Table 8. Granger causality tests between ΔCVD indicators and $\Delta HEXPPC$

	Lag = 1		Lag = 2		Lag = 3	
	F*	p value**	F	p value	F	p value
$\Delta CVD_t \rightarrow \Delta HEXPPC_t$	1.44088	0.2448	0.73965	0.4929	1.01610	0.4172
$\Delta HEXPPC_t \rightarrow \Delta CVD_t$	0.01092	0.9179	0.19644	0.8236	0.43900	0.7289
$\Delta CVM_t \rightarrow \Delta HEXPPC_t$	1.79643	0.1960	3.31034	0.0626	2.32988	0.1221
$\Delta HEXPPC_t \rightarrow \Delta CVM_t$	0.09418	0.7623	0.25973	0.7745	0.63030	0.6083
$\Delta CVMHTP_t \rightarrow \Delta HEXPPC_t$	1.60944	0.2199	2.93841	0.0819	2.07728	0.1528
$\Delta HEXPPC_t \rightarrow \Delta CVMHTP_t$	0.01840	0.8935	0.13961	0.8707	0.53301	0.6676
$\Delta SCVM_t \rightarrow \Delta HEXPPC_t$	1.01573	0.3262	1.49013	0.2550	0.89117	0.4716
$\Delta HEXPPC_t \rightarrow \Delta SCVM_t$	2.47731	0.1320	2.72388	0.0959	1.72272	0.2115

* F_c = 4.45
**p < 0.05

Source: calculation of the author, used eViews

Note that in our studies we use paired regression and the number of observations for different indicators (Table 1.) varies, i.e. we have 28 observations for *CVD*, *CVM*, *CVMHTP*, *SCVM*, *GDPPC*; 24 observations for HEXPPC and 18 observations for HHRPC. Accordingly, the critical values of the F-test with a significance level, i.e. $\alpha = 0.05$ for these three groups of indicators will be different, i.e. for the first group F_c = 4.24, for the second F_c = 4.28 and for the third F_c = 4.45.

Analysis of the data in Table 6 show that in Azerbaijan in the considered time period there is no causal relationship between changes in the number of cardiovascular diseases and changes in GDP per capita. As well as there is no inverse relationship. All values of the F-test are less than the critical F < Fc = 4.24 and p value > 0.05. Consequently, the null hypothesis H_0 about the absence of direct and reverse causal relationships is confirmed.

The study of the mutual influence of changes in CVD indicators and changes in household incomes is presented in Table 7. Since the standard of living of the population is strongly related to household income, one could assume that their change will somehow affect the health of the population in terms of CVD. At first glance, the health of family members of households contributes to an increase in their income and vice versa. However, the data in Table 7 show that changes in household income in Azerbaijan do not affect CVD

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indicators. On the other hand, there is an inverse relationship between these indicators. The impact of changes $\Delta CVD_t \rightarrow \Delta HHRPC_t$ manifests itself during the year, $\Delta SCVM_t \rightarrow \Delta HHRPC_t$ within two years, and changes in mortality rates ΔCVM_t *and* $\Delta CVMHTP_t$ are felt for lag=3, i.e. three years old.

Our studies show (Table 8) that in Azerbaijan there is no causal relationship between government spending on health care and changes in the number of CVD diseases, including a decrease in mortality from these diseases. General health care costs include government spending, out-of-pocket spending and insurance. According to the World Bank[1], in Azerbaijan in 2017, public health spending accounted for about 15% of total spending. These funds are insufficient to improve the quality of medical care to the level of tangible results in reducing CVD. The majority of the country's population currently does not have health insurance. According to the WHO's statistics on 2019, in Azerbaijan about 1% of health care costs are covered by health insurance and about 84% of health care costs are covered by the patients themselves[2].

3. Discussion

The studies on the economic and socioeconomic nature of the major risks of CVD and death from these diseases are found in the economic and medical literature. Most of these studies confirm that there is social inequality in CVD. When examining the economic aspect of the problem, much attention is paid to the assessment of the economic and socioeconomic costs created by CVD, as well as the role of socioeconomic (Mosquera et al.,2016), environmental (e.g. *Diez Roux, 2001*), educational attainment (Woodward et al., 2015) factors in the emerging of these diseases. Therefore, we will review the results obtained separately in both studies.

For example, *Kaplan & Keil (1993)* argue that there is an uneven distribution of different types of CVD and the prevalence of mortality from these diseases across geographical and socioeconomic conditions. This distribution indicates that some regions and some social groups are most vulnerable to these diseases. *Galobardes et al. (2006)* argue that the main risks of developing CVD in older people are due to the socioeconomic environment in which they

[1] https://data.worldbank.org/indicator/SH.XPD.GHED.CH.ZS?locations=AZ
[2] WHO, 2019. https://apps.who.int/nha/database/ViewData/Indicators/en

are at an early age. Studies by some researchers, such as Manrique-Garcia et al. (2011), Krieger et al. (2008), Avedeno et al. (2009) show that CVD inequality in social groups and in periods is inherent in all countries, however, in-country inequality has been declining in recent years.

One important consequence is that some habits or behaviors of people, such as smoking and low physical activity, do not play a major role in this disease. For example, research by Nandi et al. (2014) and Stringhini et al. *(2010)* shows that risks of people with low and high social status but do not have these habits are different.

Akimova et al. (2014) conducted a 12-year study in the Tyumen region of the Russian Federation and found that 10.7% of men's deaths and 4.1% of women are caused by CVD. Men with lower levels of education are more likely to have CVD. The same holds for women. On the other hand, men and women who are engaged in heavy physical activity are more likely to have higher CVD and, therefore, mortality rates than those who have easier work. Men who are not married or divorced have a higher risk of CVD than married men. In contrast, married women have a higher risk of CVD and mortality rates than single women.

Glymour et al. (2014) show in their research that the risk of CVD is highly dependent on the socioeconomic status of people (SES). And SES is changing across regions and social groups, so the risk of CVD is also changing. Therefore, mitigation of socioeconomic inequality should be taken into account in the risk mitigation measures of CVD.

This problem was also explored in Kyrgyzstan by Djorupbekova et al (2016). The main result of the study is that in the 95% confidence interval CVD's risk is increased by education level increases. CVD's risks of urban population greater than of rural populations. Researchers show that social isolation after a certain age, especially retirement and loss of employment, can also lead to an increase of CVD or increasing mortality from these diseases.

Thus, a comparative analysis of numerous studies on the factors of CVD suggests that non-social factors, such as age, sex, smoking, hypertension, etc. are the main causes of morbidity and mortality. Our research indirectly confirms these findings. Analysis of the causal relationship between CVD indicators and a group of main economic indicators by using the case of Azerbaijan show that there is no direct or inverse relationship between them. Therefore, the rate of GDP growth in Azerbaijan does not yet allow reducing the risk of CVD and achieving a decrease in mortality from CVD. The research methodology proposed by us can become a platform for finding the reasons influencing CVD changes in other countries. Based on this information, strategies to reduce the risk of CVD in a specific country can be optimized.

Conclusion

The conducted studies of the direct and inverse causal relationship between CVD indicators and macroeconomic indicators allow us to draw the following conclusions.

In the period under review, 1991-2018 in Azerbaijan there is a steady increase in CDV diseases by 2.23 times and mortality from these diseases by 1.54 times. GDP per capita between 1995 and 2014 (excluding 2009) also tended to grow from $ 397.2 (1995) to $ 7891.3 (2014). In other periods, this indicator decreased, especially in 2015 ($ 5500.31) and in 2016 ($ 3880.74). Recently, there has been a gradual increase in this indicator to the value of $ 4793.59 (2019). However, there is no direct and inverse causal relationship between these indicators. Thus, the reasons for the increase in CVD diseases are not related to the growth of GDP per capita and vice versa.

Since the standard of living of the population is strongly related to household income, it could be assumed that their change will somehow affect the health of the population in terms of CVD. However, our research shows that changes in household income in Azerbaijan do not affect CVD indicators. On the other hand, an inverse relationship between these indicators is observed and manifests itself over the course of three years.

Our research also shows that there is no causal relationship between government spending on health care and changes in the number of CVD diseases in Azerbaijan, including a decrease in mortality from these diseases. It is possible that these funds are not yet sufficient to improve the quality of medical care to the level of tangible results in reducing the risks of CVD.

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