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Health and income: analysis of impacts on life expectancy in Argentina, Brazil and Mexico

Saúde e renda: análise dos impactos na expectativa de vida na Argentina, Brasil e México

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A B S T R A C T

This article aims to discuss the correlation that the variables income inequality and health expenses presents in the life expectancy of the Brazil, Argentina and Mexico population in the period from 2000 to 2018, being these the countries chosen for the prominence of the Gross Domestic Product that they have in relation to the other Latin American countries. Pearson's correlation, multiple regression and ANOVA were used as quantitative analysis methods based on data collected from the World Bank and the World Health Organization. Among the main results found, there is a strong correlation between life expectancy and health expenditures *per capita*, as well as with the Gini coefficient that measures income inequality. Such behaviors are justifiable because, according to the literature, the lower the income inequality, the higher the life expectancy in the population. As well, the increase in health spending *per capita* also contributes to increasing life expectancy.

R E S U M O

O presente artigo pretende discutir qual a correlação que as variáveis desigualdade de renda e gastos com saúde apresentam na expectativa de vida da população do Brasil, da Argentina e do México no período de 2000 a 2018, sendo esses os países escolhidos pelo destaque do Produto Interno Bruto que possuem em relação aos demais países da América Latina. Para tanto, utilizou-se a correlação de Pearson, a regressão múltipla e a Anova como métodos de análise quantitativa a partir dos dados coletados do Banco Mundial e da Organização Mundial da Saúde. Dentre os principais resultados encontrados, observa-se uma forte correlação entre expectativa de vida e os gastos com saúde *per capita*, assim como, com o coeficiente de Gini que mensura a desigualdade de renda. Tais comportamentos são justificáveis, pois, de acordo com a literatura, quanto menor a desigualdade de renda maior a esperança de vida na população. Bem como, a elevação nos gastos com saúde *per capita* também contribui para aumentar a expectativa de vida.

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Introduction

This article aims to discuss the correlation that the variables income inequality and health expenditure presents in the life expectancy of the population of Brazil, Argentina and Mexico in the period of 19 years, specifically between 2000 and 2018. The criterion for choosing these was by Gross Domestic Product, since they are the first in Latin America, according to data from the World Bank Open Data (*Banco Mundial*).

According to the data contained in the report Macroeconomics and Health (*Macroeconomia e Saúde*) (2001), Executive Summary of the Report, of the World Health Organization, the countries with the lowest average annual income have lower life expectancy at birth in the five divisions presented in the document. The least developed countries have 643 million inhabitants, an average annual income of 296 dollars and life expectancy at birth of 51 years. In turn, middle-income people have more than 2 billion people with an average annual income of US$ 1,200 and an expectation of 70 years. The top of the pyramid is composed of countries whose combined population represents 891 million, with an average annual income of US$ 25,730 and the highest expectation of the group, 79 years.

However, the income indicator is not the only aspect to be considered to measure inequality, and education and health are relevant as observed below: “What matters is not just income. Public services such as education and health can be powerful instruments in reducing inequality” (Organization For Economic Co-Operation and Development [OECD], 2008, p. 03).

In Development as Freedom (*Desenvolvimento como Liberdade*) (2010), Sen argues that income is not and should not be the only way to measure well-being, mentioning Instrumental Freedoms as instruments of this perspective, among them, we highlight the Social Opportunities:

> It´s the dispositions that society establishes in the areas of education, health, et cetera, which influence the substantive freedom of the individual to live better. These facilities are important not only for the conduct of private life (such as leading a healthy life, getting rid of preventable morbidity and premature death), but also for a more effective participation in economic and political activities (Sen, 2010, pp. 42-43).

Thus, the issue of health is classified as important as income for the evaluation of development. And, for this reason, in addition to the income inequality indicator, health expenditures were used as the object of study in relation to life expectancy.

According to Bloom and Canning (2008) good health indicators should exist regardless of income or other factors, as they contribute to improving human well-being, in addition to the strong connection they have with life expectancy. However, if we assume that the increase in income is a consequence of better health indicators, health spending should be a priority even in developing countries and they add that “this argument for health as na investment good

is particularly relevant since ther and are cheap and easily implementable health policies that can improve health dramaticall y even in the poorest countries" (Bloom & Canning, 2008, p. 01).

In addition to this introduction, the article has the sections of methodological procedures; results and discussions with the research findings; and, finally, the final considerations are presented.

Methodological procedures

The research used two databases in data collection. For the Gini coefficient, data were taken from the World Bank (*Banco Mundial*)[1], and the other data are taken from the World Health Organization (*Global Health Expenditure Database*)[2] in the period from 2000 to 2018, that is, nineteen years to be observed for the countries: Argentina, Brazil and Mexico. In the period from 2000 to 2018, not all information was present in the 19 years of studies, and therefore the available data are considered. The data used in this research were cross-section.

Pearson's correlation, multiple regression and ANOVA, through the SPSS (Statistical Package for the Social Sciences) program, with quantitative analysis method, were used in order to verify the hypothesis of life expectancy being prolonged by health expenditure and the reduction of income inequality. Therefore, life expectancy is the dependent variable and health expenditures and Gini are the independent ones.

The coefficient, Gini index or only Gini measures the deviation of the income distribution in an egalitarian distribution (Medeiros, 2012). Result 0 equals the absence of existing inequality between people and, in turn, 100[3] it´s the opposite, that is, the opposite of perfect equality[4].

Regarding health and life expectancy, the concepts described in table 1 were used, based on Figueiredo et al. (2018), *European Health Information Gateway*[5] and Barreto (2020), a saber:

Table 1.

Indicators spent on health and life expectancy.

Total Health Expenditure Per Capita (GSaupc).	*Public and private spending on health per inhabitant.*
Public Spending on Health (Gastpub).	*Public sector expenditure on health as a proportion of total health expenditure (WHO - World Health Organization - Organização Mundial da Saúde -*

[1]Available in: https://data.worldbank.org/indicator/SI.POV.GINI?locations=BR-AR-MX
[2]Available in: https://apps.who.int/nha/database/Select/Indicators/en
[3]Some authors use results 0 and 1 for Gini, however the World Bank (*Banco Mundial*) uses 0 and 100.
[4]Available in: https://data.worldbank.org/indicator/SI.POV.GINI?locations=BR-AR-MX
[5]Available in: https://gateway.euro.who.int/en/search/

	estimates).
Private Health Expenditure (Gastpriv),	*Private sector spending on health as a proportion of total health expenditures (WHO estimates).*
Total Health Expenditure GDP (Gasttpib).	*Percentage of Gross Domestic Product (GDP) national which corresponds to the total expenditure on health in the year considered.*
Life Expectancy (Expecvida).	*Average number of years of life expected for a newborn, maintaining the mortality pattern existing in the resident population, in a given geographic space, in the year considered.*

Source: Prepared by the authors based on Figueiredo et al. (2018), European Health Information Gateway and Barreto (2020).

The first step was to perform the Pearson Correlation for each country in relation to life expectancy and Gini with all indicators of health expenditures. According to Dancey (2006), a correlation is strong from 0.7 (positive or negative). Therefore, there is a strong correlation between life expectancy and Gini coefficient, as well as between life expectancy and total health expenditure *per capita* in the three countries.

From the results presented in Table 1, the estimate was performed using the Least Squares Method (MMQ) and the linear model, with multiple regression analysis, analysis of variance - ANOVA, with a significance level established at 5%. For each country the dependent variable Life Expectancy and the independent variables those that presented strong correlation and present simultaneously in Argentina, Brazil and Mexico.

Thus, the proposed model, after the study of the correlation that relates life expectancy (EXPECVIDA) with the two explanatory variables: Health expenditure *per capita* (GSaupc) and Gini coefficient (CGINI) represented in the following equation:

$$\mathbf{Expecvida = ß0 + ß1\ CGini + ß2\ GSaupc + \mu}$$

Where:

Expecvida: See table 1.

CGini: Previously described.

GSaupc: See table 1.

ß0: It´s the linear coefficient to be estimated, measured in years of life.

ß1: Indicates the effect of the CGini variable on life expectancy.

ß2: It´s the angular coefficient, indicating the effect of the variable GSaupc and life expectancy.

μ: Term of error that includes unmeasured causes in life expectancy.

The expected behavior for the coefficients of the variables of the above is described as follows:

ß1: It´s to be expected that the parameter of this relationship presents a negative value, since the lower the CGini, the higher the life expectancy, that is, when the CGini is low the income is better distributed and life expectancy increases.

ß2: It has positive expected behavior, demonstrating that the increase in GSaupc, implies an increase in life expectancy.

μ: Error term that includes causes not measured in the Gini coefficient.

Finally, in the third stage, the study was developed through simple regression analysis and ANOVA, with a significance level set at 5%, having as a dependent variable the Gini coefficient (CGini) and as an explanatory variable the *per capita* health expenditure (GSaupc) in Argentina and Brazil. In Mexico, the related independent variable was private health expenditure (Gastpriv). The choice of the different variable in Mexico was due to the greater explanatory power, when applying the t test in a simple linear regression model.

The model proposed for Argentina and Brazil used the independent variable: Health Expenditure *per capita* (GSaupc), due to its greater explanatory power in the simple regression model. Thus, the model to be estimated by the Least Squares (MMQ) technique is as follows:

$CGini = ß0 + ß1\ GSaupc + \mu$

Where:

CGini: Previously described.

GSaupc: See table 1.

In Mexico, the model used by MMQ is:

$CGini = ß0 + ß1\ Gastpriv + \mu$

Where:

CGini: Previously described.

Gastpriv: See table 1.

The expected behavior for the coefficient of the variable GSaupc is described as follows, in Argentina and Brazil:

ß1: It´s to be expected that the parameter of this relationship presents a negative value, since the higher the GSaupc, the lower the Gini coefficient, that is, the lower the inequality provided by health expenditures *per capita*.

In the case of Mexico, it´s expected that ß1: Present a negative sign, since the higher the Gastpriv, the lower the Gini coefficient, that is, the lower the inequality.

From this, through this methodology, we will identify the variables related to health expenditures, correlated with life expectancy and the Gini coefficient, and then construct two regression models. The first is capable of estimating life expectancy as a function of the variables: Gini coefficient and health expenditures. And the second model, the Gini coefficient as a function of the variable related to health expenditures with greater explanatory power. In Argentina and Brazil the variable was GSaupc and in Mexico Gastpriv.

Results and discussions

The present study makes clear the strong negative correlation between Expecvida and CGini in the three countries, evidencing the importance of a better income distribution to increase life expectancy at birth. The fact that the correlation is negative is explained by the behavior of the CGini, that the lower the value, on a scale from 0 to 100, the better the distribution of income, that is, a more equitable distribution of income. It´s also possible to observe that Expecvida presents a strong and positive correlation with GSaupc, highlighting that increases in health expenditures per individual contribute to a higher life expectancy.

Table 2.

Correlation of indicators.

Argentina		*Expecvida*	*CGini*	*GSaupc*	*Gasttpib*	*Gastpub*	*Gastpriv*
Expecvida	*Pearson correlation*	*1*	*-,934***	*,824***	*,756***	*,810***	*-,009*
	Sig. (2-failed)		*,000*	*,000*	*,000*	*,000*	*,972*
	N	*18*	*18*	*18*	*18*	*18*	*18*
CGini	*Pearson correlation*	*-,934***	*1*	*-,835***	*-,756***	*-,791***	*-,085*
	Sig. (2-failed)	*,000*		*,000*	*,000*	*,000*	*,747*
	N	*18*	*18*	*18*	*18*	*18*	*18*
Brazil		*Expecvida*	*CGini*	*GSaupc*	*Gasttpib*	*Gastpub*	*Gastpriv*
Expecvida	*Pearson correlation*	*1*	*-,901***	*,704**	*,400*	*,820***	*-,310*
	Sig. (2-failed)		*,000*	*,016*	*,223*	*,002*	*,354*
	N	*11*	*11*	*11*	*11*	*11*	*11*
CGini	*Pearson correlation*	*-,901*	*1*	*-,551*	*-,447*	*-,700*	*,113*
	Sig. (2-failed)	*,000*		*,079*	*,168*	*0,17*	*,741*
	N	*11*	*11*	*11*	*11*	*11*	*11*
Mexico		*Expecvida*	*CGini*	*GSaupc*	*Gasttpib*	*Gastpub*	*Gastpriv*
	Pearson correlation	*1*	*-,916***	*,905***	*,418*	*,608***	*,287*
	Sig. (2-failed)		*,000*	*,000*	*,095*	*,010*	*,263*
	N	*17*	*17*	*17*	*17*	*17*	*17*
	Pearson correlation	*-,916***	*1*	*-,937***	*-,113*	*-,375*	*,039*
	Sig. (2-failed)	*,000*		*,000*	*,666*	*,138*	*,882*
	N	*17*	*17*	*17*	*17*	*17*	*17*

*Note: **significant correlation in p<0.01; *significant correlation in p<0.05. Source: Elaboration of the authors from the SPSS software.*

When analyzing Table 2, it´s observed that Argentina and Mexico presented a strong negative correlation between CGini and GSaupc, evidencing that higher health expenditures per individual contribute to reduce income inequality. Brazil, on the other hand, presented a mean correlation, but when it came to correlating Gastpub and CGini, both Brazil and

Argentina presented a strong negative correlation. It´s believed that this fact is related to the high percentage of private spending in relation to total health spending and, therefore, contributes to the increase in inequality. For example, in 2018, Brazil, the country with the highest percentage among the three analyzed, of the total health expenditure more than 58% was spent privately. This argument is consistent with the following:

> The negative effect that the variables medical deductions and tax expenses of these deductions on total health expenditures suggests that indirect spending is increasing more than expected, thus reducing direct health spending, which may generate an effect of inequality (Barreto, 2020, p. 42).

Thus, it´s noticed that with the use of Pearson's correlation, CGini is negatively correlated with some variable that indicates health expenditures. Expecvida, on the other hand, presents a strong correlation in the three countries with the same variables: CGini and GSaupc.

The analysis proceeds with the multiple regression model to obtain an explanatory equation between Expecvida (dependent variable) and the independent variables: CGini and GSaupc. These variables were selected because they present a strong correlation with Expecvida.

The result presented in Table 3 shows the coefficient of determination R Square (or R^2). The multiple regression model with the dependent variable Expecvida, as a function of C.Gini and GSaupc, presented an $R^2 = 0.879$ for Argentina; $R^2 = 0.856$ for Brazil and $R^2 = 0.873$ for Mexico, showing that Expecvida is explained in more than 85% of cases by independent variables.

Table 3.

Coefficient of determination R Square

	R	*R Square*	*Adjusted R Square*	*Std. Error of the Estimate*
Argentina	*,938[a]*	*,879*	*,863*	*,35227*
Brazil	*,952[a]*	*,856*	*,836*	*,72493*
Mexico	*,934[a]*	*,873*	*,841*	*,38991*

Note: [a]Predictors: (constant), GSaupc, CGini. Source: Elaboration of the authors from the SPSS software.

After the identification of the coefficient of determination - R^2, we proceeded to the study of analysis of variance - ANOVA. The objective is to describe whether the set of explanatory variables has an influence on the dependent variable. This differs from the use of the t test, which individually tests the significance of the regression estimating coefficients.

For the application of the Fisher test (F test), the Anova table was analyzed. This test shows whether the variables together explain the behavior of the dependent variable - Expecvida, as shown in Table 4.

Table 4.

Anova[b]

		Sum of squares	*df*	*Mean Square*	*F*	*Sig.*
Argentina	*Regression*	*13,543*	*2*	*6,772*	*54,567*	*,000*[a]
	Residual	*1,861*	*15*	*,124*		
	Total	*15,404*	*17*			
Brazil	*Regression*	*43,853*	*2*	*21,927*	*41,723*	*,000*[a]
	Residual	*7,357*	*14*	*,526*		
	Total	*51,211*	*16*			
Mexico	*Regression*	*8,364*	*2*	*4,182*	*27,506*	*,000*[a]
	Residual	*1,216*	*8*	*,152*		
	Total	*9,580*	*10*			

Note: [a]Predictors: (constant), GSaupc, CGini; [b]Dependent variable: Expecvida. Source: Elaboration of the authors from the SPSS software.

The calculated results: F = 54.567, F = 41.723 and F = 27.506 for Argentina, Brazil and Mexico respectively, with a significance level Sig = 0.000, indicate that the calculated values were higher than those tabulated in all equations, implying the acceptance that the variables together exert influence on the dependent variable.

Thus, being Fcal > Ftab, the hypothesis that there is no relationship between the variables Expecvida, CGini and GSaupc was rejected. This result demonstrates that there is an infinitesimally small probability that such a high F occurred only at random.

After the finding that the independent variables CGINI and GSaupc affect Expecvida, we move on to the hypothesis test, student's t. The t test measures the individual effect of the parameters. For the respective coefficients of the t test, it was observed in Table 5 that in Argentina and Mexico the associated probabilities of 0.000 and 0.001 respectively indicate that the chances of such a result having occurred due to sampling error, and the null hypothesis is true, is very close to 0%. In Brazil the t-value is - 1.920 with an associated probability of 0.075, so the chance of such a result having occurred by sampling error, and the null hypothesis is true is 7.5%.

Regarding the t test applied in the analysis for the GSaupc parameter, it´s noticed, according to Table 4, that the t values with an associated probability of: Argentina = 0.397, Brazil = 0.210 and Mexico = 0.084 indicate that the chances of sampling errors having occurred, and the null hypothesis is true is 39.7%, 21.0% and 8.4% respectively. Although, for the three countries, the t test indicates that the GSaupc variable is not statistically significant, there are reasons to believe that it´s a determinant of life expectancy, since the correlation

between them was strong and it´s expected that higher health expenditure *per capita* will improve people's quality of life, resulting in increased life expectancy. For these reasons, we keep in the equation from the following explanation:

> (...) If we have strong a priori reasons to believe that X3 and X4 are positively related to Y, they should not be eliminated from the estimating equations; on the contrary, they should be kept with all the information pertinent to their values (Wonnacott & Wonnacott, 1976, p. 62).

In Table 5 in an analysis of the standardized coefficients, the CGini has a greater contribution to Expecvida in the tests than the GSaupc for the countries under analysis..

Table 5.

T Test.

		Unstandard Coefficients		*Standard Coefficients*	*t*	*Sig*
		B	*Std. error*	*Beta*		
Argentina	*(Constant)*	*83,203*	*1,892*		*43,975*	*,000*
	CGini	*-,178*	*,036*	*-,815*	*-4,993*	*,000*
	GSaupc	*,000*	*,000*	*,142*	*,871*	*,397*
Brazil	*(Constant)*	*98,125*	*14,785*		*6,637*	*,000*
	CGini	*-,480*	*,250*	*-,558*	*-1,920*	*,075*
	GSaupc	*,002*	*,002*	*,382*	*1,315*	*,210*
Mexico	*(Constant)*	*91,752*	*4,090*		*22,432*	*,000*
	CGini	*-,357*	*,073*	*-,737*	*-4,881*	*,001*
	GSaupc	*,003*	*,002*	*,298*	*1,972*	*,084*

Note: Dependent variable: Expecvida. Source: Elaboration of the authors from the SPSS software.

In the 3rd stage, we selected the variable related to health expenditures (independent variable), which would best explain the behavior of CGini (dependent variable). The result of the simple regression model between CGini and GSaupc for Argentina and Brazil. In Mexico, the variable used was Private Health Expenditure (*Gasto Privado com Saúde*). The observations in Table 6 shows strong R^2 in Argentina (R^2 = 0.688) and Brazil (R^2 = 0.870). Mexico, on the other hand, presented an R^2 = 0.483, considered moderate.

Table 6.

Coefficient of determination R Square.

	R	*R Square*	*Adjusted R Square*	*Std. Error of the Estimate*
Argentina	*,830[a]*	*,688*	*,670*	*2,47573*
Brazil	*,937[a]*	*,878*	*,870*	*,74879*
Mexico	*,695[b]*	*,483*	*,409*	*1,32401*

Note: [a]Predictors: (constant), GSaupc. [b]Predictors: (constant), Gastpriv. Source: Elaboration of the authors from the SPSS software.

Table 6, Anova, shows that the results of the F test were satisfactory for the three countries. The t test was also used, finding that the independent variables are statistically significant, and that the null hypothesis is rejected, understanding that the coefficients are different from zero, as detailed in table 7.

Table 7.

Anova [c]

		Sum of squares	*df*	*Mean Square*	*F*	*Sig.*
Argentina	*Regression*	*230,069*	*1*	*230,069*	*37,536*	*,000[a]*
	Residual	*104,197*	*17*	*6,129*		
	Total	*334,266*	*18*			
Brazil	*Regression*	*60,768*	*1*	*60,768*	*108,381*	*,000[a]*
	Residual	*8,410*	*15*	*,561*		
	Total	*69,179*	*16*			
Mexico	*Regression*	*11,464*	*1*	*11,464*	*6,540*	*,038[b]*
	Residual	*12,271*	*7*	*1,753*		
	Total	*23,736*	*8*			

Note: [a]Predictors: (constant), GSaupc; [b]Predictors: (constant), Gastpriv; Dependent [c]variable: Expecvida. Source: Elaboration of the authors from the SPSS software.

In the development of the analysis, table 8 shows the values of the t test, linear coefficient (ß0) and the angular coefficient (ß1). For the respective coefficients of the t test, a significance level below 0.05 is observed, so the hypothesis of ß1 = 0 is rejected, confirming that the variable GSaupc for Argentina and Brazil is related to CGini. And in Mexico it´s Gastpriv that relates to CGini.

Table 8.

Test t, linear coefficient (β0) and angular coefficient (β1).

		Unstandard Coefficients		Standard Coefficients	t	Sig
		B	Std. error	Beta		
Argentina	(Constant)	52,461	1,291		40,636	,000
	GSaupc	-,008	,001	-,830	-6,127	,000
Brazil	(Constant)	59,120	,467		126,467	,000
	GSaupc	-,007	,001	-,937	-10,411	,000
Mexico	(Constant)	36,746	4,687		7,840	,000
	GSaupc	4,012	1,569	,695	2,557	,038

Note: Dependent variable: CGini. Source: Elaboration of the authors from the SPSS software.

Final considerations

With the main objective of understanding how life expectancy, income distribution and health expenditures among Argentines, Brazilians and Mexicans is related, the article adopted Pearson's correlation analysis, a simple and multiple regression analysis to measure the behavior of these variables. With data from the World Bank (*Banco Mundial*) and World Health Organization (*Organização Mundial da Saúde*) corresponding to the period from 2000 to 2018, it was possible to understand the behavior of inequalities related to health spending and the Gini coefficient, as well as the last two between them.

Among the main results found, there is a strong correlation between life expectancy and health expenditures *per capita*, as well as with the Gini coefficient. Such behaviors are justifiable, because the lower the inequality, the higher the life expectancy in the population. And the increase in *per capita* spending also contributes to raising life expectancy.

Also among the findings, factors related to health spending contribute to reducing income inequality. In Argentina and Brazil, *per capita* health expenditures impacted the Gini coefficient. In Mexico, the variable private spending on health presented greater explanatory power for inequalities.

Considering the results found here, it´s observed based on the literature that income should not be the only point to be considered for the well-being of the population, that health contributes directly to the increase of income, including, and therefore, should be a priority for the governments of the countries, and that both the decrease in inequality and the increase in health expenditures have a correlation in different intensities with the increase in life expectancy.

In addition, among the limitations of the present study, we can mention some variables omitted because they were not available throughout the analysis period for the three countries.

We can also mention the analysis in only three countries, and the lack of the test to detect heteroscedasticity, and the test for autocorrelation, which were not applied.

Future studies can verify whether this fact is repeated with a larger sample, both in a larger time frame and in a larger number of countries. In addition, perform the analysis with panel data for comparisons of convergences and divergences of a survey with cross-section and panel data.

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