Inequalities in Health Status of World Population

Elisabeta JABA[1], Christiana Brigitte BĂLAN[2], Ioan-Bogdan ROBU[3]

Abstract: Objectives The paper aims to study the regional variation in population health at world level. It focuses on the analysis of the influence of determinant factors, such as geographic region and income, on health. **Prior Work** If previous studies on health refer to a specific group of countries, the paper expands the analysis of health status to world countries. Based on prior findings from the literature regarding the factors that affect health, the paper considers two main determinants, income and geographic region. **Approach** The health status of the population is assessed through a widely used indicator, namely life expectancy at birth, observed for a sample of 193 countries, in 2009. For the analysis of variation of life expectancy among world regions we apply the ANOVA and contrasts methods. We test the differences in life expectancy for different groups of countries. **Results** The results show that high income countries have the highest average life expectancy. Moreover, life expectancy in European countries is higher than American countries, while African countries have the lowest life expectancy compared to the rest of the world. **Implications** The existence of differences in life expectancy among world countries reveal the need for differentiated health policies in order to eradicate factors that have negative effects on population health. **Value** The paper allows to identify the regions that are best performers in health and to explain the differences in health between countries grouped by income level and geographic position.

Keywords: life expectancy; income; ANOVA; contrasts; GLM.

JEL Classification: I14, I15, C12, O15

1 Introduction

Health status of a population is affected by various factors such as health care resources, lifestyle, income per capita, education level, environment, etc. (Joumard et al., 2008, Or, 2000).

The relationship between income and the health status of the population is strong and positive (Cutler, 2006). It is obvious that increased income allows for better nutrition, but also improves the access to preventive technologies (Casabonne and Kenny, 2012). The relationship is found to be bidirectional as income affects health and, in the same time, health improves income (French, 2012). Though there is a significant relationship between income and health at cross-country level and within countries, however the improvements in income and the improvements in health are weakly correlated over time (Kenny, 2009). Previous studies analysed the relationship between health and income considering as dependent variable life expectancy (or infant mortality or mortality rate) and as explanatory variables GNP per capita (Hertz et al., 1994) or GDP per capita (Or, 2000).

[1] Professor Emeritus, Alexandru Ioan Cuza University of Iasi, 22, Blv. Carol I, code 700505, Iasi, Romania, Corresponding author: ejaba@uaic.ro
[2] Lecturer, Alexandru Ioan Cuza University of Iasi, Romania, 22, Blv. Carol I, code 700505, Iasi, Romania, christiana.balan@uaic.ro
[3] PhD Student, Alexandru Ioan Cuza University of Iasi, 22, Blv. Carol I, code 700505, Iasi, Romania, bogdan.robu@feaa.uaic.ro

In the paper we aim to analyse the influence of income level on the health status of the population by studying the variation of life expectancy under the influence of income and geographic position for a sample of countries. The health status is measured using life expectancy at birth.

2. Data and Method

2.1. Data

In the paper we analyse life expectancy at birth for the world countries. Life expectancy is observed in 2009 for a sample of 193 countries.

The world countries are grouped according to geographical region, considering the World Health Organisation classification. The six regions are: African Region, Region of the Americas, South-East Asia Region, European Regions, Eastern Mediterranean Region, and Western Pacific Region.

Another classification factor is the income. The classification follows the World Bank's classification of countries by income group according to 2008 Gross National Income (GNI) per capita, calculated using the World Bank Atlas method. The World Bank's classification proposes four income groups (low income: 975 or less, lower middle income: \$976–3,855, upper middle income: \$3,856–11,905, high income: \$11,906 or more).

2.2. Method

The statistical method that implies the analysis of the variance of a quantitative variable, *Y*, in relation to one or more explanatory categorical variables, *X*, is the ANalysis Of VAriance or ANOVA method (Jaba, 2002). In order to test for significant differences in *Y* between the groups defined by *X*, we test for equality of means of the groups. ANOVA method consists in the decomposition of the variation of Y variable into two components: the variation explained by the essential factor considered in the analysis and the residual variation due to residual factors. The test statistics used for testing the equality of means is the F test. However, this test does not indicate the populations for which the means are different. To avoid this inconvenience, it is necessary to conduct additional analysis to identify groups that differ.

When we know a priori what comparisons to make, pairwise or complex, we analyse the contrasts of the means. We decompose the variance explained by the considered factors into components using the contrasts.

Contrasts are linear combinations of weighted means (Karpinski, 2006). A contrast is defined as:

$$\psi = \sum_{j=1}^{k} w_j \mu_j = w_1\mu_1 + w_2\mu_2 + w_3\mu_3 + ... + w_k\mu_k \qquad (1)$$

and

$$\hat{\psi} = \sum_{j=1}^{k} w_j \bar{y}_j = w_1\bar{y}_1 + w_2\bar{y}_2 + w_3\bar{y}_3 + ... + w_k\bar{y}_k \qquad (2)$$

where:

ψ is the contrast;

$\hat{\psi}$ is the estimate of the contrast,

$(\mu_1, \mu_2, \mu_3, ..., \mu_k)$ are the means of the populations,

$(\bar{y}_1, \bar{y}_2, \bar{y}_3, ..., \bar{y}_k)$ are the means of the samples,

$(w_1, w_2, w_3, ..., w_k)$ are the weights or the contrast coefficients, with $\sum_{j=1}^{k} w_j = 0$.

In the study we consider both pairwise and complex contrasts. Pairwise contrasts are contrasts between two means. The means for which we build a contrast receive the coefficients $w_i = 1$ and $w_j = -1$, for any i and j, such that $\sum_{j=1}^{k} w_j = 0$. The total number of possible pairwise contrasts is equal to $k(k-1)/2$. Complex contrasts are built by comparing one mean with the mean of two or more means. If we want to build a contrast between the mean $\bar{y}_j$ on one hand and all the other means on the other hand, the contrast coefficients assigned to the means are: ($w_j = 1$) for the mean $\bar{y}_j$, and ($w_i = -1/(k-1)$) for the other ($k - 1$) means.

When evaluating a contrast of means, we assume the null hypothesis $H_0 : \psi = 0$, that we test using Student statistics (Kachigan, 1986):

$$t = \frac{\sum w_j \bar{y}_j}{\sqrt{S_R^2 \sum \frac{w_j^2}{n_j}}} \sim t(n-k) \qquad (3)$$

The probability associated with t Student statistics for contrasts is equal to the product of the probabilities associated with each contrast of means. This probability is used for the interpretation of the significance of the difference between the compared means.

The analysis of the simultaneous influence of two explanatory variables on *Y* is carried out using GLM (General Linear Model). The model incorporating the two independent variables is a conceptualization of a two-way independent ANOVA. By applying GLM, we obtain the profile on Y of the groups defined by the two explanatory variables.

3. Results

3.1. Life Expectancy Variation by Geographic Region

Life expectancy varies among countries and regions. Population in African countries have the lowest life expectancy compared to other world regions; the average life expectancy in African region is 56.22 years in 2009. The highest life expectancy is observed for population living in Europe; in 2009, the average life expectancy in European Regions is 75.96 years. The highest variation among the countries is observed for the Eastern Mediterranean Region as life expectancy ranges from 48 years in Afghanistan to 78 years in Kuwait, Qatar and United Arab Emirates. The African countries are also heterogeneous, with a minimum life expectancy of 47 years in Malawi and a maximum life expectancy of 73 years in Seychelles. The distribution of life expectancy of the population in the analysed countries grouped by geographical region is presented in Fig.1.

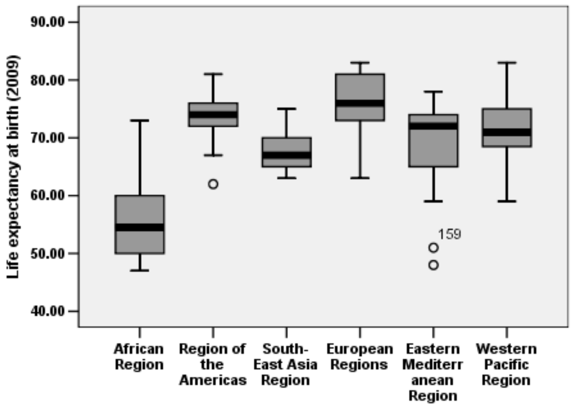

Fig. 1. Life expectancy in the world countries grouped by geographical region

We want to compare life expectancy in African Region to life expectancy of the rest of the world. The statistical hypotheses are: H_0: $\mu_{Africa} = \mu_{Rest of the World}$ and H_1: $\mu_{Africa} \neq \mu_{Rest of the World}$. We also want to test that life expectancy of the population living in the Region of the Americas is different than life expectancy of the population living in the European Regions. We test the null hypothesis H_0: $\mu_{America} = \mu_{Europe}$ against H_1: $\mu_{America} \neq \mu_{Europe}$. Another pairwise comparisons is between life expectancy of the population living in the Region of the Americas and life expectancy of the population living in the South-East Asia Region. We test the null hypothesis H_0: $\mu_{America} = \mu_{Asia}$ against H_1: $\mu_{America} \neq \mu_{Asia}$. In order to check if life expectancy of the population living in countries from the Region of the Americas is different than life expectancy of the population living in the Western Pacific Region, we test the folowing hypotheses: H_0: $\mu_{America} = \mu_{Pacific}$ against H_1: $\mu_{America} \neq \mu_{Pacific}$.

According to our goal of comparing the group life expectancy means, we define one complex contrast and three pairwise contrasts.

The complex contrast and the contrast coefficients or the weights are:

$$\psi_1 = \mu_{Africa} - \frac{1}{5}\mu_{America} - \frac{1}{5}\mu_{Asia} - \frac{1}{5}\mu_{Europe} - \frac{1}{5}\mu_{Mediterrane} - \frac{1}{5}\mu_{Pacific},$$
$$w = \left(1, -\frac{1}{5}, -\frac{1}{5}, -\frac{1}{5}, -\frac{1}{5}, -\frac{1}{5}\right).$$

The pairwise contrasts and the contrasts coefficients are:

$$\psi_2 = \frac{1}{2}\mu_{America} - \frac{1}{2}\mu_{Europe}, \quad w = \left(0, \frac{1}{2}, 0, -\frac{1}{2}, 0, 0\right)$$
$$\psi_3 = \frac{1}{2}\mu_{America} - \frac{1}{2}\mu_{Asia}, \quad w = \left(0, \frac{1}{2}, -\frac{1}{2}, 0, 0, 0\right)$$
$$\psi_4 = \frac{1}{2}\mu_{America} - \frac{1}{2}\mu_{Pacific}, \quad w = \left(0, \frac{1}{2}, 0, 0, 0, -\frac{1}{2}\right).$$

The results of the contrasts tests indicate which contrasts are significant. After testing the assumption of equal variances, we considered the results for equal variances assumed for the third contrast (ψ_3) and for unequal variances assumed for the other contrasts (ψ_1, ψ_2 , and ψ_4). The value of the contrasts with the standard errors in brackets as well as the Student t test values with the significance level in brackets are presented in Table 1.

Table 1. Contrasts for testing differences in life expectancy by geographic region

Contrast	**Value of the contrast**	**t**
African Region and the rest of the world	-76.5306	-12.725
	(6.0140)	(0.000)
Regions of the Americas and European	-2.2194	-2.247
Regions	(0.98774)	(0.027)
Regions of the Americas and South-East	6.0156	2.804
Asia Region	(2.14524)	(0.006)
Regions of the Americas and Western	2.5577	1.748
Pacific Region	(1.46286)	(0.088)

The results obtained for the four contrasts and their tests show that only the first three differences proved to be statistically significant. The first contrast show that average life expectancy of the population in African countries differs significantly from average life expectancy of the population of the rest of the world. The value of the contrast is equal to the sum of the differences between average life expectancy of the African Region and average life expectancy of each of the other groups. The negative high value show that average life expectancy in African regions is smaller than average life expectancy in other Regions.

The second contrast shows that, in European countries, average life expectancy is 2.22 years higher than average life expectancy in the Region of the Americas. This difference is statistically significant as the probability of the t Student test is equal to 0.027, thus being smaller than 0.05.

The results for the third contrast highlight that life expectancy in American Regions is significantly higher than in South-East Asia Region. The average life expectancy in the countries of the American region is 6 years greater than in South-East Asia countries.

As tested by the fourth contrast, the difference between Region of the Americas and West Pacific Region is not statistically significant. The differences between average life expectancy of the countries in the two regions is equal to 2.56 years, but the probability for the Student test is higher than 5%.

3.2. Life Expectancy Variation by Income Group

Life expectancy varies among the groups of countries with different incomes. Life expectancy is highest for the population in the countries with a high income. In 2009, the average life expectancy for high income group countries is 78.47 years, while the average life expectancy of the population from low income group countries is 57.53 years. The variation of life expectancy among countries is smallest for the high income group, as measured by standard deviation indicator, while countries from low income group are the most heterogeneous. Life expectancy ranges from 47 years in Malawi to 72 years in Vietnam, in the case of low income group. For the lower income group, life expectancy varies from 48 years in Lesotho to 75 years in Tunisia. In the case of high income group, life expectancy has a minimum in Equatorial Guinea (53 years) and maximum in San Marino and Japan (83 years). The distribution of countries according to life expectancy of the population, by income group, is presented in Fig. 2.

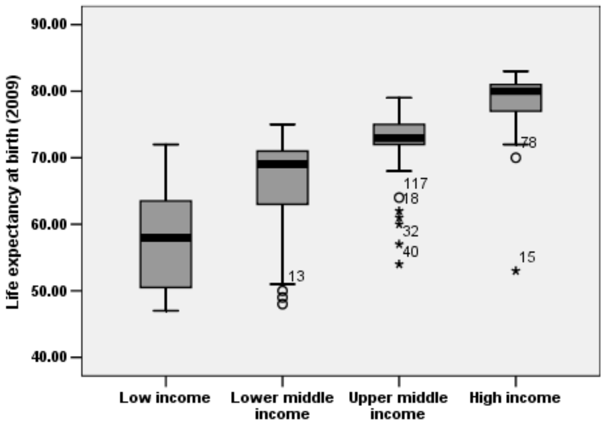

Fig. 2. Life expectancy in the world countries grouped by income level

We want to compare life expectancy of the population in the countries with high income with life expectancy of the population of the rest of the world. The statistical hypotheses are: H_0: $\mu_{High} = \mu_{Rest of the World}$ and H_1: $\mu_{High} \neq \mu_{Rest of the World}$. We also want to compare life expectancy of the population living in countries with high income with life expectancy of the population in countries with upper middle income. We test the null hypothesis H_0:

$\mu_{High} = \mu_{Upper\_middle}$ against H_1: $\mu_{High} \neq \mu_{Upper\_middle}$. Another a priori differences that we aim to check regarding life expectancy are between low income group and lower middle income group (the statistical hypotheses are H_0: $\mu_{Low} = \mu_{Lower\_middle}$ against H_1: $\mu_{Low} \neq \mu_{Lower\_middle}$), and between lower middle income group and upper middle income group. Statistical hypotheses are H_0: $\mu_{Lower\_middle} = \mu_{Upper\_middle}$ against H_1: $\mu_{Lower\_middle} \neq \mu_{Upper\_middle}$). In order to test de differences between the mean life expectancies, we define one complex contrast and three pairwise contrasts. The complex contrast and the contrast coefficients are:

$$\psi_1 = -\frac{1}{3}\mu_{Low} - \frac{1}{3}\mu_{Lower\_middle} - \frac{1}{3}\mu_{Upper\_middle} + \mu_{High}$$

$$w = \left(-\frac{1}{3}, -\frac{1}{3}, -\frac{1}{3}, 1\right)$$

The pairwise contrasts and the contrast coefficients are:

$$\psi_2 = \frac{1}{2}\mu_{Upper\_middle} - \frac{1}{2}\mu_{High} \qquad w = \left(0, 0, \frac{1}{2}, -\frac{1}{2}\right)$$

$$\psi_3 = \frac{1}{2}\mu_{Low} - \frac{1}{2}\mu_{Lower\_middle} \qquad w = \left(\frac{1}{2}, -\frac{1}{2}, 0, 0\right)$$

$$\psi_4 = \frac{1}{2}\mu_{Lowe\_middle} - \frac{1}{2}\mu_{Upper\_middle} \qquad w = \left(0, \frac{1}{2}, -\frac{1}{2}, 0\right)$$

The value of the contrasts with the standard errors in brackets as well as the Student t test values with the significance level in brackets are presented in Tab. 2. After testing the assumption of equal variances, we considered the results for equal variances assumed for the contrasts ψ_2 and ψ_3, and for unequal variances assumed for the other contrasts, ψ_1 and ψ_4. The results show that all the contrasts are significant.

Table. 2: Contrasts for testing differences in life expectancy by income group

Contrast	Value of the contrast	t
High income group and the rest of the world	39.0900 (2.66425)	14.672 (0.000)
Upper middle income group and High income group	-6.4268 (1.28315)	-5.009 (0.000)
Low income group and Lower middle income group	-9.2059 (1.28453)	-7.167 (0.000)
Lower middle income group and Upper middle income group	-5.3018 (1.26170)	-4.202 (0.000)

The first contrast shows that average life expectancy of the High income group is statistically different than the rest of the world. The value of the contrast is equal to the sum of the differences between average life expectancy of different income groups of countries: High–Low, High–Lower middle, High–Upper middle. The positive value of the contrast implies higher average life expectancy for High income group comparing to the other groups.

The result for the second contrast proves that average life expectancy of the countries with upper middle income is statistically different than countries with high income. The difference in average life expectancy between the two groups is equal to - 6.4 years.

When comparing countries with low income to countries with lower middle income, the contrast shows that former group has a worse performance in life expectancy than the latter group. Average life expectancy of Low income group is smaller with 9.2 years than average life expectancy of Lower middle income group.

The fourth contrast illustrates a statistically significant difference in life expectancy between Lower middle and Upper middle groups. The difference is equal to – 5.3 years.

3.3. Life Expectancy Variation According to Income Level by Geographic Regions

Life expectancy varies under the simultaneous influence of income level and geographic position. (Fig. 3). Life expectancy according to the income shows a similar pattern for four regions (America, Europe, Western Pacific and South-East Asia). The Mediterranean region has a distinct model for the countries with low income. Another particular pattern of life expectancy is observed for the countries from the South-East Asia Region, as all countries in the region have low or lower middle income.

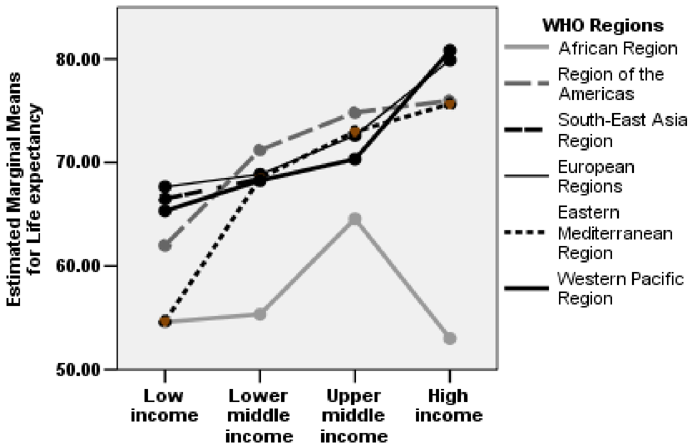

Fig. 3. Mean life expectancy by income level and geographical region

An exception of the general pattern is life expectancy in the African Region., especially for the countries in the high income group.

4. Conclusion

The analysis of life expectancy of the world population allows to identify the regions that perform best in health care and to explain the differences in health between countries grouped by income level and geographic position.

The results of the paper show that the higher the income level of a country, the higher the life expectancy of its population. Thus, countries with high income level have the highest average life expectancy of the population. The health status of the population in countries with high income is statistically better than the rest of the world. Moreover, health status of the population of countries with lower middle income is superior to the population of countries with low income. Furthermore, life expectancy in countries with upper middle income is higher than life expectancy of countries with lower middle income.

Considering the geographic position of the countries, the results of the paper show that African population has the lowest life expectancy comparing to the rest of the world countries. The are also other differences in health status of the population due to geographic position. In European countries, average life expectancy is higher than average life expectancy in the Region of the Americas. Moreover, life expectancy in the American Regions is significantly higher than in South-East Asia Region.

The relevance of such differences in life expectancy reveal the need for differentiated health policies in order to eradicate factors that have negative effects on population health.

Acknowledgment

This work was co-financed by the European Social Fund through Sectoral Operational Programme Human Resources Development 200732013, project number POSDRU/89/1.5/S/59184 "Performance and excellence in postdoctoral research in Romanian economics science domain".

5. References

Casabonne, U., Kenny, C. (2012). The Best Things in Life are (Nearly) Free: Technology, Knowledge, and Global Health. *World Development* 40 (1): 21-35

Cutler, D., Deaton, A., Lleras-Muney, A. (2006). The determinants of mortality. *Journal of Economic Perspectives* 20 (3): 97-120

French, D. (2012). Causation between health and income: a need to panic. *Empirical Economics* 42 (2): 583-601

Hertz, E., Hebert, JR., Landon, J. (1994). Social and environmental-factors and life expectancy, infant-mortality, and maternal mortality-rates - results of a cross-national comparison. *Social Science & Medicine* 39(1): 105-114

Jaba, E. (2002). *Statistica*, ed. a 3-a, Ed. Economică, Bucureşti

Joumard, I., André, C., Nicq C., Chatal O. (2008). Health Status Determinants: Lifestyle, Environment, Health Care Resources and Efficiency. *OECD Economics Department Working Papers* No. 627, OECD, Paris

Kachigan, S.K. (1986). *Statistical Analysis*, Radius Press, New York

Karpinsky, A. (2006). *Contrasts for oneway ANOVA – Lecture Notes*, Temple University

Kenny, C. (2009). There's More to Life Than Money: Exploring the Levels/Growth Paradox in Income and Health. *Journal of International Development* 21(1): 24-41

Or, Z. (2000). *Determinants of health outcomes in industrialised countries: a pooled cross-country, time-series analysis*. OECD Economic Studies 30(1): 53-77