Socioeconomic Factors and the Elderly Mortality Profile in a Poor Brazilian State: An Ecological Study Comparing Two Distinct Age Groups

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Abstract

The rate of the aging process of the Brazilian population and the accentuated social inequality and fragile institutions determine differentials in the mortality of the population, with many challenges for the health system. The aim of the present study was to analyze the mortality profile of individuals aged 60 to 69 years (young-old) and those aged 80 years or more (oldest-old) in a poor Brazilian state, as well as to investigate the associated socioeconomic factors. The Specific Mortality Rate by Age was calculated using aggregated data from the Mortality Information System (SIM) and the Brazilian Institute of Geography and Statistics (IGBE). In order to identify the mortality profiles of the municipalities, non-hierarchical clustering (K-means) was applied and Principal Components Analysis was used to reduce the socioeconomic variables. In the young-old age group, the misinformation profile, the development profile and the development paradox were more affected by education and poverty. In addition to the misinformation profile, the oldest-old group exhibited the epidemiological transition profile and the epidemiological paradox profile, associated with municipal development. The results for the oldest-old age group confirmed less of an influence at a contextual level. The mortality profiles and associated socioeconomic aspects differed according to age. Health inequalities among elderly individuals could be reduced by considering the different demands, improving the levels of education and poverty, and optimizing the use of health services.

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Keywords

Aged, Mortality, Cause of Death, Socioeconomic Factors, Brazil

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1. Introduction

Mortality is usually concentrated among the elderly population and accounted for 51% of all deaths worldwide in 2004 [1]. In Brazil, approximately 59% of deaths in the same period were recorded among the elderly population. With the aging of the population, this percentage tends to increase. An increase of 3.5% has been reported in relation to the year 2011 [2] [3]. Thus, modifications in the demographic and epidemiological characteristics of this age group have a great impact on the general mortality profile and consequently, on the population dynamic.

The elderly population currently constitute an expressive segment of the Brazilian population in absolute terms, with accelerated proportional growth (10.8%) [3] [4]. Based on this trend, it is estimated that the number of elderly will overtake the number of children and adolescents by almost four million in the year 2030, and Brazil will have an older population in 2050 than that which currently exists in Europe [5]-[7].

The age group known as the oldest-old (80 years or more) currently exhibits the fastest growth rates in the population, thereby altering the internal composition of the elderly population and revealing heterogeneous characteristics [8]-[10]. This phenomenon, known as overaging, raises questions about the quality of life of the oldest-old individuals, which are potentially vulnerable to cognitive, functional and sensory deficiencies [11].

The rate of the aging process of the Brazilian population has created many challenges for the health system, with repercussions for the rest of society. This is particularly relevant in a country with accentuated social inequality and fragile institutions, which determine differentials in the mortality of the population [6] [12]. This issue is negatively affected by the great regional disparities found in Brazil, particularly in the northeast of the country, which includes the state of Rio Grande do Norte. This region contains the lowest health and development indices in the country [13]. In Rio Grande do Norte, the elderly population represents 10.8% of the total population. The social exclusion of this group constitutes a social determinant of health, with a powerful negative effect that is reflected in morbidity and early mortality rates [14].

In an attempt to contribute to the planning of public policies that address the new population demands, the aim of the present study is to analyze the mortality profile of the elderly population in terms of heterogeneity and contextual factors. To do so, the following neighboring age groups were considered: 60 to 69 years (young-old) and 80 years or more (oldest-old).

2. Methods

2.1. Ethical Considerations

The present study received approval from the Human Research Ethics Committee of the *Hospital Universitário Onofre Lopes-Universidade Federal do Rio Grande do Norte* under protocol number 118/09.

2.2. Study Area

The study area involved was the state of Rio Grande do Norte in the Northeast of Brazil, which contains 167 political districts. The economy of Rio Grande do Norte is one of the least favorable in Brazil, with a Gross domestic product (GDP) value of only 0.9% of the total for the country in 2010 [15].

2.3. Data

This ecological study used variables of aggregate data collected at district level in the state of Rio Grande do Norte. The dependent variables corresponded to deaths by specific causes and referred to two extremes of the elderly population of a developing country (individuals aged between 60 and 69 years—young-old; and those aged 80 years or more—oldest-old), according to the location of their residence. Individuals aged between 70 and 79 years were not included in the present study due to the mix of characteristics found in this group, with similarities to both the younger and older groups.

Basic causes of death were grouped according to ICD chapters (10th Revision), which were obtained from the Brazilian Ministry of Health's Mortality Information System (SIM), and the Coefficient of Specific Mortality by Cause and Age (CMId). This coefficient is calculated using the ratio between deaths from cause "y" and the mean of the population quoted by the Brazilian Institute of Geography and Statistics (IBGE) at the beginning and end of the study period (2001 and 2011), using a base of 10,000 inhabitants.

The contextual variables were obtained from IBGE data for the census of the year 2000, including raw data and data transformed into indicators by the United Nations Program for Development (UNPD) and the Institute of Applied Economic Research (IPEA). In total, 64 variables were submitted to analysis of distribution and Pearson's correlation. Those with poor data distribution and a correlation above 0.8 were eliminated. This left 20 remaining variables, which were grouped in dimensions related to income, education, human development, demographics and housing.

The income dimension considered the following variables: the Gini index; the Theil index L; the percentage of income transference; the percentage of indigents and the proportion of people with an income of less than 1/4 of the minimum wage. The human development dimension considered the following variables: the Firjanindex of Municipal Development (IFDM) and its three sub-divisions (IFDM Job and Income, IFDM Health and IFDM Education); as well as the Human Development Index (HDI).

The demographics dimension considered the following variables: the proportion of elderly; the level of urbanization; the ratio of dependence and the ratio of dependence above 75%. The proportion of illiterate individuals among the total population and among the elderly population were used to assess the education dimension. The housing dimension considered the following variables: access to electricity; access to trash collection; household density greater than 2; access to a bathroom and piped water.

2.4. Statistical Analysis

In order to group similar districts based on mortality data, the analysis of non-hierarchical conglomerates method was employed (K-means), with convergence criteria of 0.5. The adequate number of groups for the present study was established by hierarchical analysis, using the Between-groups linkage method as the algorithm of grouping and the squared Euclidean distance as the dissimilarity measurement. The contextual variables were summarized using Analysis of Principal Components, besides Varimax rotation method was used to facilitate their interpretation.

Bivariate analysis was conducted using the non-parametric Kruskal-Wallis test (level of significance of 5%) to identify significant differences among the clusters and in relation to the factorial scores of the contextual variables. This principal analysis was monitored using Mann-Whitney paired tests and the Bonferroni correction.

3. Results

Between 2001 and 2011, a total of 163,896 deaths were recorded in the state of Rio Grande do Norte, of which 13.31% occurred among the young-old and 30.9% occurred among the oldest-old.

3.1. Clustering Analysis

Prior to the grouping of the 167 districts of Rio Grande do Norte in terms of their mortality characteristics, the data were examined to confirm the validity of the multivariate analysis. The causes of death with more than 25% of the CMId values recorded as zero and the districts identified as outliers (Mahalanobis Distance—D^2) were eliminated.

Three groups were formed for the two age groups investigated. **Table 1** displays the mean values and differences of the variables in each group for the young-old age group and **Table 2** displays the data for the oldest-old age group.

With regard to the young-old age group, 92 districts with low mortality rates were grouped in the first cluster, with the exception of ill-defined causes, which exhibited the highest mean value of the three clusters. Therefore, it is believed that these districts exhibited a deficiency in the recording of deaths and the detection of the cause

Table 1. Mean values of the coefficients of specific mortality per cluster for the young-old.

Chapter ICD-10	*Cluster*			*p*
	1	2	3	
I—Infectious and parasitic diseases	3.46	40.38	45.41	0.066
II—Neoplasm	187.60[a]	348.54[b]	308.47[b]	<0.001
IV—Endocrine, metabolism and nutritional diseases	112.95[a]	120.68[a,b]	161.12[b]	0.007
IX—Circulatory diseases	345.10[a]	390.58[b]	586.20[c]	<0.001
X—Respiratory diseases	59.79[a]	83.30[b]	84.34[b]	0.004
XI—Diseases of the digestive system	63.78	56.91	70.63	0.519
XVIII—Ill-defined causes	189.23[a]	99.09[b]	173.63[a]	<0.001
XX—External Causes	64.23	75.66	76.69	0.088

Superscript letters indicate equality or differences in the means between the groups, obtained using the Kruskal-Wallis and Mann-Whitney tests, penalized for the number of combinations.

Table 2. Mean values of the coefficients of specific mortality per cluster for the oldest-old.

Chapter ICD-10	*Cluster*			*p*
	1	2	3	
I—Infectious and parasitic diseases	230.12[a]	302.70[a]	451.44[b]	<0.001
II—Neoplasm	659.66[a]	820.60[b]	1066.23[c]	<0.001
IV—Endocrine, metabolism and nutritional diseases	695.34[a]	857.77[b]	1035.75[b]	0.001
IX—Circulatory diseases	2588.41[a]	3356.36[b]	4692.88[c]	<0.001
X—Respiratory diseases	777.31[a]	1075.81[b]	1147.02[b]	<0.001
XI—Diseases of the digestive system	197.23[a]	245.70[a]	276.87[a]	0.027
XIV—Diseases of the genitourinary system	157.86	175.55	224.18	0.242
XVIII—Ill-defined causes	2831.99[a]	1824.97[b]	1350.13[c]	<0.001
XX—External causes	137.78	136.07	145.21	0.936

Superscript letters indicate equality or differences in the means between the groups, obtained using the Kruskal-Wallis and Mann-Whitney tests, penalized for the number of combinations.

of death. Consequently, this cluster was labeled the *Misinformation Profile*.

Cluster 2 contained the majority of the deaths (53.6%) and the lowest rate of deaths due to ill-defined causes. Chronic and degenerative diseases, particularly neoplasms, were the most significant cause of death in this cluster. The mortality profile of this group was similar to that of developed regions, in which the process of epidemiological transition has already been completed. Therefore, this profile suggests that better living conditions are found in the 41 districts in question and this cluster was labeled the *Development Profile*.

High mortality rates were found in the 31 districts that formed the third grouping, labeled the *Development Paradox*, with a significant amount of circulatory diseases. The death records in this group are considered satisfactory, although it is difficult to determine the basic cause of death.

With regard to the oldest-old age group, the first cluster was composed of 68 districts and exhibited a high mean value of mortality by ill-defined causes, contrary to all other causes, which exhibited the lowest values of all groups. These characteristics are similar to the first cluster of the young-old age group and as such, the same name was adopted: the *Misinformation Profile*.

In cluster 2, the mortality rates of the 70 districts were characterized with an intermediary value, in relation to those of the other groups, with relatively high rates of chronic and degenerative diseases and relatively low rates of infectious and parasitic diseases. Therefore, this group, which contained 64.8% of all deaths, was labeled the *Epidemiological Transition Profile*.

In comparison to the other groups, the third cluster formed contained the lowest amount of deaths attributed to chapter XVIII (ill-defined causes) and the highest mean CMId values for all other chapters, especially for those corresponding to chronic and degenerative diseases. This profile was associated with a satisfactory SIM and satisfactory death records and basic cause of death detection. Due to the high death rates from chronic and degenerative diseases, this group has similar characteristics to developed countries, which tend to follow a traditional process of epidemiological transition. However, it is worth noting the expressive mean value of the CMId for infectious and parasitic diseases, characterizing a counter-transition event. Consequently, cluster 3, which contained 24 districts, was labeled as the *Epidemiological Paradox*.

3.2. Principal Components Analysis

The contextual variables included in the Principal Components Analysis based on their correlations involved those that were reduced to three common factors which represented the different dimensions associated with socioeconomic and demographic conditions. The data were examined and the applicability of the technique was confirmed based on the matrix of correlations, the anti-image matrix, Bartlett's sphericity test ($p < 0.001$) and the Kaiser-Meyer-Olkinindex (KMO = 0.829). Subsequently, the factors were extracted using analysis of principal components and nine relevant variables. Based on the Kaiser criteria, three factors represented 76.25% of the total variance of the variables included in the model.

Based on the structure of the factorial rotated model, factor 1, labeled "*illiteracy and poverty*", accounted for 39.3% of the total variables of the model and obtained the greatest factorial load among the variables. This factor was represented by income less than 1/4 of the minimum wage, the dependency ratio, dependency of less than 75%, household density under 2 and illiteracy among the elderly. Factor 2 was labeled "*development and health*" and was best represented by IFDM and IFDM Health, which accounted for 18.9% of the variance. Factor 3 was labeled "*extreme poverty*" and accounted for 18% of the model, with the greatest factorial load of the variable proportion of indigents, as well as a low proportion of households with bathrooms and piped water.

A new variable was also included to represent a weighted indicator for the entire construct, corresponding to the sum of the scores for the three factors (*factorial sum*). Given the greater load of the factorial model in relation to poverty and illiteracy, high values for the factorial sum indicated unfavorable conditions at a contextual level.

3.3. Association between the Mortality Profile Groups and the Independent Variables

Table 3 displays the results of the comparisons between the clusters and the factorial scores of the independent variables for the two age groups studied.

With regard to the young-old age group, the findings indicated significant differences between the clusters and the factors *illiteracy and poverty*, *extreme poverty* and *factorial sum*. For the latter factor, the Mann-Whitney test indicated significantly better results for the group *development paradox* than for the *misinformation profile*.

Although an association was found between the factor *extreme poverty* and the mortality profiles, it was not possible to identify the location of the difference between the clusters. The factor *illiteracy and poverty* obtained significantly different values in the *development profile* and *misinformation profile*, with higher values found for the latter. Thus, it is possible to infer that the *misinformation profile* group exhibited the most unfavorable conditions for the young-old throughout most of the contextual level.

The mortality profiles of the young-old and the oldest-old were associated with different variables, with the former age group more affected by socioeconomic factors. The profile of the oldest-old age group seems to have only been affected by the *development and health* factor, in relation to which the *misinformation profile* involved more negative aspects than the *epidemiological paradox*. With regard to the *epidemiological transition profile*, the transitory character was also manifested at a contextual level, with intermediary values of factorial scores and an absence of significant differences between the clusters.

Table 3. Associations between clusters and independent variables for mortality among the elderly.

Independent variables	Clusters-young-old (60 to 69 years)			p
	Misinformation profile	Development profile	Development paradox	
Illiteracy and poverty	0.21[a] (−0.57 - 0.82)	−0.55[b] (−1.24 - 0.57)	−0.28[a,b] (−0.98 - 0.79)	0.042
Development and health	−0.09 (−0.80 - 0.64)	−0.05 (−0.54 - 0.77)	−0.33 (−0.61 - 0.24)	0.469
Extreme poverty	0.23[a] (−0.29 - 0.74)	−0.21[a] (−0.87 - 0.53)	−0.29[a] (−0.98 - 0.49)	0.024
Factorial sum	0.41[a] (−0.89 - 1.32)	−0.27[a,b] (−1.26 - 0.42)	−0.52[b] (−1.60 - 0.63)	0.018
Independent variables	**Clusters-oldest-old (80 years or more)**			**p**
	Misinformation profile	**Epidemiological transition profile**	**Epidemiological paradox**	
Illiteracy and poverty	0.21 (−0.90 - 0.86)	−0.02 (−0.85 - 0.60)	−0.02 (−0.81 - 0.86)	0.803
Development and health	−0.28[a] (−0.97 - 0.36)	−0.01[a,b] (−0.54 - 0.78)	0.36[b] (−0.52 - 0.98)	0.015
Extreme poverty	0.18 (−0.44 - 0.66)	−0.05 (−0.72 - 0.60)	0.01 (−0.80 - 0.65)	0.556
Factorial sum	−0.07 (−1.32 - 1.04)	−0.12 (−1.21 - 1.16)	0.06 (−0.28 - 1.13)	0.695

Superscript letters denote the absence of a significant difference between the groups in terms of the dependent variables, with the level of significance set at 5%.

4. Discussion

Analysis of the data from a poor Brazilian state, Rio Grande do Norte, revealed three types of mortality patterns for both the young-old (60 to 69 years) and the oldest-old (80 years or more) age groups. These two age groups also had one group in common (*the misinformation profile*), with a relevant quantity of districts, and were characterized by deficiencies in the determination of the basic cause of death and the suggestion of underreported deaths. This finding reflects the precarious quality of the data in the period studied, thereby limiting their interpretation.

Despite the lower proportion of ill-defined causes, the data for the young-old age group contained a greater number of districts (92) classified as the *misinformation profile* than the oldest-old age group (68 districts). This finding suggests that population groups with lower mortality rates are more subject to the negative effects of under-reporting on the delineation of the epidemiological profile. In addition, this profile was associated with socioeconomic disadvantages, as shown by the contextual variables, particularly in terms of education and income, which reflects the national reality. According to Sivieiro (2009) [16], the quality of death-related data in Brazil is strictly associated with socioeconomic conditions and as such, the data should be used with caution in regions where coverage is of average or low quality. Better levels of education and reduced poverty are aspects that converge with the characterization of the mortality pattern of the young-old age group known as the *development profile*.

People have greater access to education in developed regions and this education provides them with the knowledge and skills that lead to healthier behavior, as well as enabling them to incorporate more quickly the technological innovations that apply to healthcare. Therefore, the health of men and women is positively affected by education and can be measured by variables of risky behavior, leading to a reduction in the quantity of avoidable deaths [17]. Similarly, there is a consensus in the literature about the association between poverty and lower levels of health. Circumstances arising from the lack of economic resources result in biological abnormalities that determine health risks from the time of pregnancy to adulthood. In addition, due to social factors, poverty leads to low levels of education, which affect health habits and access to health services [18]-[20].

In the *paradox of development* profile for the young-old age group, the capital city of the state (Natal) confirmed better socioeconomic conditions in the set of contextual variables, as represented by the *factorial sum* indicator. Thus, this profile has been affected by education and the reduction in poverty (as well as extreme poverty). However, the high total of deaths, particularly those caused by circulatory diseases, indicates that there is still a need for better public health strategies if early mortality rates are to be reduced. The current fragmented strategies, which are focused on medical assistance, need to be transformed into a model of care based on the principles of prevention, promotion and inter-sectoral action, thereby strengthening basic healthcare [21].

The results for the oldest-old age group confirmed less of an influence at a contextual level. They were also affected by different aspects than the results for the young-old age group. Municipal development, particularly healthcare, was the only factor that was associated with the mortality pattern of the oldest-old age group. Consequently, it was clear that the oldest-old rely more on public structures, particularly healthcare services.

The *development and health* factor obtained better indices in the *epidemiological paradox* group. Therefore, the use of health services on behalf of the oldest-old seems to be more efficient in the small number of districts that composed this profile. On the other hand, the *misinformation profile* exhibited the lowest values for this factor, confirming the association between the quality of data and socioeconomic conditions, as recorded in both of the age groups studied. These findings reflect poorly on the public health network of many districts in Rio Grande do Norte. According to Justino (2010) [22], there is a lack of quality healthcare services available in this state.

Also in the *epidemiological paradox* group, there was a notably higher quantity of deaths caused by infectious and parasitic diseases, contrary to the characteristic of development. This could be explained by more accurate death records. Furthermore, given the suggestion that there is a greater use of health services on behalf of those in this cluster, this higher quantity could be associated with common hospital infections, which represent a great challenge due to their significant incidence and lethality, as well as the costs involved in the complex antibiotic treatment strategies used to control the outbreaks [23] [24].

5. Conclusion

The present study found that among the sixties, the Misinformation Profile, Development Profile and the Development Paradox were formed. In addition to the Misinformation Profile, we found the Epidemiologic Transition Profile and the Epidemiological Paradox in individuals older than 80. The results indicate that the mortality patterns of the young-old and the oldest-old are affected by distinct socioeconomic aspects, although the oldest-old group is less affected by these factors. Poverty and low levels of education are among the most significant determinants. The *epidemiological profile* of the oldest-old age group is affected by the characteristics of municipal development, particularly in terms of healthcare services. Given the lower level of education among the elderly and its importance to mortality patterns, health education programs should be considered to encourage healthy habits and facilitate the more effective use of healthcare services. These services are hindered by poverty in some districts. Thus, the creation of an integral network of care for the elderly would be beneficial.

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Abbreviations

CMId—Coefficient of Specific Mortality by Cause and Age;
GDP—Gross Domestic Product;
HDI—Human Development Index;
ICD-10—Classification of Diseases 10th Revision;
IFDM—Firjan Index of Municipal Development;
IGBE—Brazilian Institute of Geography and Statistics;
IPEA—Institute of Applied Economic Research;
SIM—Mortality Information System;
UNPD—United Nations Program for Development.