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Original

Mortality due to Neurodegenerative Diseases in Ecuadorian Adults

Mortalidad por enfermedades neurodegenerativas en adultos ecuatorianos

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Abstract

Introduction: Neurodegenerative diseases have a variety of debilitating signs which can lead to death. Individuals affected by this group of pathologies show higher mortality rates than those with general and nervous system diseases.
Objective: Describe the epidemiological profile of deaths due to neurodegenerative diseases in Ecuadorian adults in 2023.
Methods: A descriptive study using mortality data from the National Institute of Statistics and Census (INEC, Spanish acronym). The mean, median, standard deviation, skewness and kurtosis were calculated according to age and sex.
Results: The percentage of deaths was higher in women (56 %) than in men. The median age was 85 years, and the predominant age group was 81-90 years (40.9 %). 69% of deaths occurred at home. Most of the deceased had a low educational level (70%). 537 were married, and 402 were widowed. 48% lived in the two most populated provinces of the country (Pichincha, n = 431, and Guayas, n = 210). Alzheimer's disease/dementia was the leading cause of death in both sexes. The 81-90 age group was the most affected (9.4 % for men and 13.8 % for women).
Conclusion: High mortality rates due to dementia/Alzheimer's disease and Parkinson's disease were found among adults of both sexes, primarily in the 81-90 age group. The most populated provinces had the highest number of deaths. Deaths were more frequent among men and in older age groups, with an increasing trend starting at age 80.
Keywords: Parkinson's disease, Alzheimer's disease, neurodegenerative disease, mortality

Resumen

Introducción: las enfermedades neurodegenerativas presentan una variedad de manifestaciones debilitantes que pueden conducir a la muerte. Las personas afectadas por este grupo de patologías muestran tasas de mortalidad más altas que aquellas con otras enfermedades generales y del sistema nervioso.
Objetivo: describir el perfil epidemiológico de las muertes por enfermedades neurodegenerativas en adultos ecuatorianos durante 2023.
Método: estudio descriptivo utilizando datos de mortalidad del Instituto Nacional de Estadística y Censos (INEC). Se calcularon la media, mediana, desviación estándar, asimetría y curtosis según edad y sexo.
Resultados: el porcentaje de muertes fue mayor en mujeres (56 %) que en hombres. La edad mediana fue de 85 años, y el grupo etario predominante fue de 81 a 90 años (40,9 %). El 69 % de las muertes ocurrieron en el domicilio. La mayoría de los fallecidos tenía un nivel educativo bajo (70 %). De ellos, 537 eran casados y 402 viudos. El 48 % residía en las dos provincias más pobladas del país (Pichincha, n = 431, y Guayas, n = 210). La enfermedad de Alzheimer/demencia fue la principal causa de muerte en ambos sexos. El grupo de 81 a 90

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años fue el más afectado (9,4 % en hombres y 13,8 % en mujeres). **Conclusión:** se encontraron altas tasas de mortalidad por demencia/enfermedad de Alzheimer y enfermedad de Parkinson en adultos de ambos sexos, principalmente en el grupo de 81 a 90 años. Las provincias más pobladas concentraron el mayor número de fallecimientos. Las muertes fueron más frecuentes en hombres y en los grupos de mayor edad, con una tendencia creciente a partir de los 80 años.
Palabras clave: enfermedad de Parkinson, enfermedad de Alzheimer, enfermedad neurodegenerativa, mortalidad

Introduction

In 2021, more than 3 thousand million people worldwide were living with a neurological condition.[1] Currently, neurological conditions are the leading cause of poor health and disability globally, with an 18 % increase in the total volume of disability, disease, and premature death (DALY) since 1990.[2] This data indicates that the increase in absolute figures is mainly due to demographic changes and the increase in human lifespan. [3] More than 80% of deaths and poor health due to neurological causes occur in low- and middle-income countries (LMICs), where access to timely and appropriate treatment is limited.[4]

Neurodegenerative diseases (ND) represent one of the most pressing challenges for healthcare systems in the 21st century. These conditions, characterized by the progressive loss of function and structure of neurons, include diseases such as Alzheimer's disease, Parkinson's disease, amyotrophic lateral sclerosis (ALS), frontotemporal dementia, among others.[5] Their prevalence and mortality have been increasing, largely due to the aging of the global population.[1]

Neurodegenerative diseases not only affect quality of life but are also among the leading causes of death in many developed countries. For example, Alzheimer's disease and other dementias rank 7th in the list of global causes of death according to the World Health Organization.[6] In countries such as the United States and the United Kingdom, deaths attributed to NDs have increased significantly in recent decades, particularly among those over 75 years old.[7-9] In most cases, these diseases have a chronic and irreversible course, culminating in complications such as infections, severe falls, or multisystemic organ deterioration.[10]

The mortality associated with these diseases is influenced by factors such as advanced age, which is the main risk factor. As life expectancy increases, so does the incidence of NDs. [11,12] Additionally, comorbidities such as diabetes, cardiovascular diseases, and respiratory diseases worsen the course of NDs, increasing the risk of premature death.[13,14] In many cases, death does not directly result from the neurological disease itself, but from its consequences, such as aspiration pneumonia, pressure ulcers, or systemic infections.[15]

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The lack of early diagnosis also becomes a negative factor, as diagnoses are often made in advanced stages, when medical intervention and support are already limited.[16] The treatment of NDs involves high economic and human costs.[17]

Regions with higher socioeconomic levels, such as Europe, have surprisingly high mortality rates from NDs compared to other countries, posing a heavy burden on both individuals and society.[18] Among deaths due to NDs, dementia and Parkinson's disease (PD) are particularly linked to the increase in population longevity.[19,20] In 2021, dementia and PD were among the top 10 NDs contributing most to health loss. However, it is important to note that other factors, such as changes in exposure to risk factors, improvements in diagnostics, multidisciplinary treatments, and the quality of health records may also influence the observed trend.[21]

Currently, research on NDs has mainly focused on their pathogenesis, diagnosis, treatment, and other medical techniques.[22] Previous studies found significant increases in ND mortality worldwide from the start of the century until 2023.[23] Examples of countries with this phenomenon include Iceland, Finland, Malta, and Croatia,[24] as well as the United States.[1,25] In contrast, China showed a decreasing trend in ND mortality from 1990 to 2019 and is likely to continue decreasing between 2020 and 2030.[26]

According to recent data from the World Health Organization (WHO) published in 2020, deaths caused by AD/Dementias in Ecuador reached 2,565 (3.59 % of all deaths) [27,28]. The age-adjusted mortality rate was 14.34 per 100,000 inhabitants, ranking Ecuador 140th in the world. However, regardless of the relevance of NDs in Latin American populations, Ecuador has not had a reliable registry for these diseases. For this reason, this manuscript shows the most up-to-date epidemiology in Ecuador on deaths from NDs, with the goal of generating collaborations to improve diagnosis and treatment due to the increase in the life expectancy of the population.

Methodology

Study design

A retrospective observational study with a quantitative approach, which consisted of the analysis of secondary data from the death registry in Ecuador published by the National Institute of Statistics and Census (INEC, Spanish acronym), from January 1 to December 31, 2023 (n = 84,774).

Data sources

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The data used were obtained from the INEC death reports, which include the cause of death, coded according to the International Classification of Diseases, 10th revision (ICD-10) [29], and sociodemographic information of the deceased individuals (age, sex, place of death, self-identified ethnicity, education level, province of residence, and marital status).

Study population

The data from 1,353 death records of individuals over 18 years old due to NDs were analyzed: Alzheimer's Disease/Dementias (AD/D) (n = 908), Parkinson's Disease (PD) (n = 284), Primary Muscle Disorders (PMD) (n = 22), Huntington's Disease (HD) (n = 9), Cerebellar Ataxia (n = 8), Multiple Sclerosis (MS) (n = 16), and Other (Central Nervous System Demyelinating Disease (CNSDD), Spinal Muscular Atrophy and Related Syndromes (SMARS), Creutzfeldt-Jakob Disease (CJD), Other Neurodegenerative Diseases Not Classified Elsewhere (ONDNE), and Other Neurodegenerative Diseases of the Basal Nuclei (ONDB) (n = 106).

Statistical analysis

The extracted information was analyzed using the statistical package Jamovi® v.2.3.28, and the results are shown in tables and figures for better understanding. The primary outcome of the study was the percentage of deaths for each ND by sex, age, and geographic region. The analysis of sociodemographic characteristics and deaths from NDs was reflected in frequencies and percentages. Descriptive statistics were used, focusing on age and its distribution by sex (mean, median, standard deviation, skewness, and kurtosis). Skewness was calculated to understand the bias in the age distribution. A negative skewness value indicates that the distribution is biased toward older ages. Kurtosis showed the concentration of values around the mean.

Finally, a latent class analysis was performed to classify the deceased into mortality profiles (low, moderate, high) by type of ND, according to the geographic region of Ecuador (Coast, Highlands, and Amazon).

Results

Sociodemographic characteristics of the sample

A total of 1,353 deaths associated with NDs were recorded in Ecuador. Regarding sex, there was a slight predominance of females (56 %, n = 753) compared to males (44 %, n = 600).

With respect to the place of death, most deaths occurred at the patient's home (69 %, n = 930), followed by deaths in Ministry of Public Health (MSP, Spanish acronym) facilities (13 %, n =

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175) and deaths in units of the Ecuadorian Institute of Social Security (IESS, Spanish acronym) (8.6 %, n = 116). 5.8 % (n = 79) died in hospitals, clinics, or private consultations, while 2.8% (n = 38) died in unspecified locations. Only 1.0 % (n = 14) died in other public facilities, and one case (<0.1 %) did not have available information.

With regard to education level, the most common group was people with basic education (29 %, n = 391), followed by those with primary education (22 %, n = 298) and secondary education (20 %, n = 276). 10 % (n = 142) had completed high school, while only 8.2 % (n = 111) had higher education. 3.1 % (n = 42) did not provide information on their education level.

Regarding marital status, 40 % (n = 537) of the deceased were married at the time of death, followed by widowed (30 %, n = 402) and single (25 %, n = 332). Divorced accounted for 5.3 % (n = 72), whereas separated individuals and those in common-law unions were less frequent (<1 %). Only 0.1 % (n = 2) had no available information.

In terms of province of residence, the province with the highest number of cases was Pichincha (32 %, n = 431), followed by Guayas (16 %, n = 210), Manabí (8.0 %, n = 108), and Azuay (7.5 %, n = 102). Other provinces had percentages lower than 6 %. Only one case (<0.1 %) involved a person residing abroad.

Regarding self-identified ethnicity, the majority of the deceased were mestizo (87 %, n = 1,181). Other groups included montubio (2.7 %, n = 37), indigenous (2.8%, n = 38), Afro-Ecuadorians (0.9 %, n = 12), white (1.8 %, n = 25), mulattos and blacks (<1%). In 3.8 % (n = 51), this information was not recorded.

Finally, the distribution by age group showed a high concentration of older individuals: 40.9 % (n = 554) were between 81 and 90 years old, 25.2 % (n = 341) were 91 years or older, and 24.2 % (n = 328) were between 65 and 80 years old. Only 9.6% (n = 130) were between 19 and 64 years old.

Table 1. Socio-demographic variables of those who died of neurodegenerative diseases in Ecuador

Sociodemographic characteristics	**n (%)**
Sex	
Male	600 (44%)
Female	753 (56%)
Place of death	
Home	930 (69%)
IESS facilities	116 (8.6%)
Ministry of Health facilities	175 (13%)
Hospital, clinic or private practice	79 (5.8%)

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Other	38 (2.8%)
Other public facilities	14 (1.0%)
No information	1 (<0.1%)
Level of education	
Basic Education	391 (29%)
Secondary education / Baccalaureate	142 (10%)
High School	276 (20%)
Primary	298 (22%)
Secondary	93 (6.9%)
No information	42 (3.1%)
Higher	111 (8.2%)
Marital status	
Married	537 (40%)
Divorced	72 (5.3%)
Separated	1 (<0.1%)
No information	2 (0.1%)
Single	332 (25%)
Unmarried	7 (0.5%)
Widowed	402 (30%)
Province of residence	
Azuay	102 (7.5%)
Bolívar	20 (1.5%)
Carchi	15 (1.1%)
Cañar	36 (2.7%)
Chimborazo	32 (2.4%)
Cotopaxi	20 (1.5%)
El Oro	58 (4.3%)
Esmeraldas	27 (2.0%)
Exterior	1 (<0.1%)
Guayas	210 (16%)
Imbabura	73 (5.4%)
Loja	64 (4.7%)
Los Ríos	34 (2.5%)
Manabí	108 (8.0%)
Morona Santiago	11 (0.8%)
Napo	3 (0.2%)
Orellana	1 (<0.1%)
Pastaza	3 (0.2%)
Pichincha	431 (32%)
Santa Elena	14 (1.0%)
Santo Domingo de los Tsáchilas	33 (2.4%)
Sucumbíos	11 (0.8%)
Tungurahua	43 (3.2%)
Zamora Chinchipe	3 (0.2%)
Ethnicity	
Afro-Ecuadorian / Afro-descendant	12 (0.9%)
White	25 (1.8%)
Indigenous	38 (2.8%)
Mestizo	1,181 (87%)
Montubio	37 (2.7%)
Mulatto	3 (0.2%)
Black	6 (0.4%)
No information	51 (3.8%)

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Note: *Age range = 81-90 years n =554 (40.9 %), 91 and over n = 341 (25.2 %), 65-80 years n = 328 (24.2 %), 19-64 years n = 130 (9.6 %).*

Age and sex analysis

The overall average age was 81.9 years (SD = 13.4; M = 85 years), with a range between 19 and 109 years. The age distribution showed negative skewness (skewness = −1.67). The kurtosis was 3.80.

When breaking down the data by sex, it was observed that deceased women (n = 753) had a higher average age (M = 83.3, SD = 13.3) compared to men (n = 600; M = 80.2, SD = 13.2). The median age was also higher in women (86 years) compared to men (83 years). The minimum age was 22 years for women and 19 years for men, while the maximum age was 109 and 102 years, respectively.

The age distribution was more skewed in men (skewness = −1.79) than in women (skewness = −1.64), and kurtosis was also higher in the male group (4.59 vs. 3.38).

Table 2. Descriptive of age and sex

		n	Mean	Median	SD	Minimun	Maximun	Skewness	Kurtosis
Age	Total	1353	81.9	85	13.4	19	109	-1.67	3.80
	Men	600	80.2	83.0	13.2	19	102	-1.79	4.59
	Women	753	83.3	86	13.3	22	109	-1.64	3.38

Causes of death, sex, and age group

The analysis of specific causes of death from NDs revealed differences in distribution by sex and age group. Overall, AD/D was the most prevalent cause of death. In women, deaths due to AD/D were most frequent in the 81–90 years age range (n = 240, 17.74 %), followed by the 91 years and older group (n = 221, 16.33 %) and the 65–80 years group (n = 89, 6.58 %). In comparison, men showed lower proportions in the same age groups: 81-90 years (n = 174, 12.86 %), 91 years and older, and 65–80 years (n = 85, 6.28 %).

Regarding PD, there was a higher incidence in men, particularly in the 81–90 years (5.5 %) and 65–80 years (5.0 %) groups. In women, the frequency was lower: 3.9 % in the 81–90 years group and 2.7 % in the 65–80 years group.

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Other less prevalent conditions included PMDs, with higher representation in the 19–64 years age group, especially in men (0.9 %, n = 12). HD, CA, MS, CNSDD, SMARS, and CJD also showed low percentages, mostly concentrated in the 19–64 years age group, indicating an earlier onset of these conditions.

Notably, OED was present in all age groups starting from 65 years, though in very low proportions. A similar trend was observed with ONDB, whose presence was marginal.

Table 3. Cause of death, sex and ethnic group

Cause of death	Sex	Age group	n	%
Alzheimer's disease / Dementia	Male	81-90	174	12.86
		91 and more	85	6.28
		65-80	85	6.28
		19-64	2	0,15
	Female	81-90	240	17.74
		91 and more	221	16.33
		65-80	89	6,58
		19-64	12	0,89
Parkinson Disease	Male	81-90	74	5.47
		91 and more	17	1.26
		65-80	68	5.03
		19-64	12	0.89
	Female	81-90	53	3.92
		91 and more	15	1.11
		65-80	36	2.66
		19-64	9	0.67
Muscular Diseases	Male	81-90	0	0.00
		91 and more	0	0.00
		65-80	2	0.15
		19-64	12	0.89
	Female	81-90	0	0.00
		91 and more	0	0.00
		65-80	1	0.07
		19-64	7	0.52
Huntington Disease	Male	81-90	0	0.00
		91 and more	0	0.00
		65-80	0	0.00
		19-64	2	0.15
	Female	81-90	0	0.00
		91 and more	0	0.00
		65-80	0	0.00
		19-64	7	0.52
Cerebellar Ataxia	Male	81-90	0	0.00
		91 and more	0	0.00
		65-80	1	0.07
		19-64	3	0.22
	Female	81-90	0	0.00
		91 and more	0	0.00
		65-80	0	0.00
		19-64	4	0.30
Cause of death	Sex	Age group	**n**	**%**
Multiple Sclerosis	Male	81-90	0	0.00
		91 and more	0	0.00
		65-80	4	0.30

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	Female	19-64	5	0.37
		81-90	1	0.07
		91 and more	0	0.00
Others (Demyelinating diseases of the central nervous system. Muscular Atrophy, Spinal. Creutzfeldt-Jakob Syndrome. Degenerative disease of the nervous system, unspecified. Other degenerative diseases of the basal ganglia).	Male	65-80	2	0.15
		19-64	4	0.30
		81-90	5	0.37
		91 and more	1	0.07
		65-80	22	1.63
		19-64	26	1.92
	Female	81-90	7	0.52
		91 and more	2	0.15
		65-80	18	1.33
		19-64	25	1.85

Overall, the data show that AD/D and PD are the leading causes of death from NDs in the Ecuadorian population, predominantly in women and older adults. In contrast, other less frequent NDs are concentrated in younger age groups and have a lesser proportional impact on overall mortality.

Causes of death according to geographic region

The analysis of the geographic distribution of causes of death revealed marked differences between the three regions of Ecuador that contributed cases. The Sierra region had the highest number of deaths (n = 836, 61.79 %), and AD/D represented more than 50 % of all deaths in each geographic zone (see figure 1).

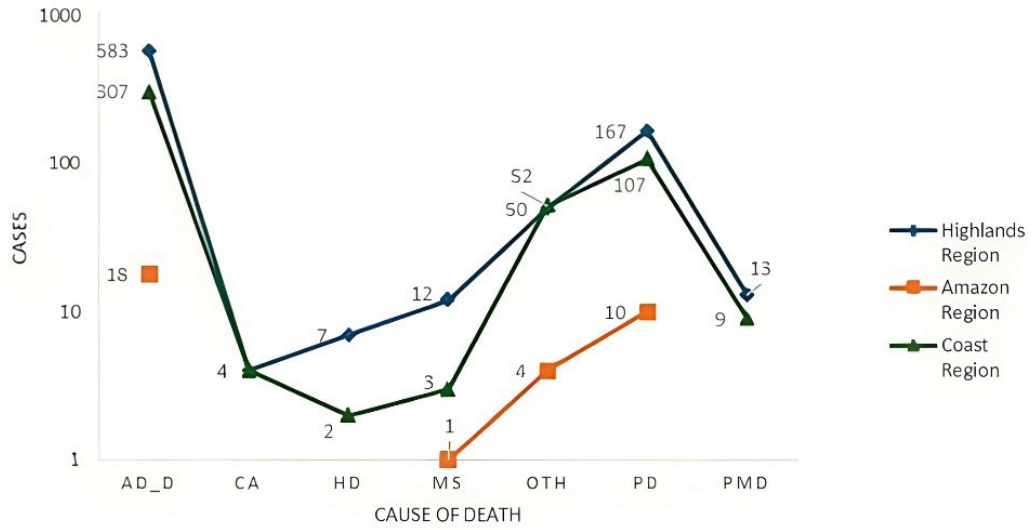


Figure 1. *Causes of death due to neurodegenerative diseases by region of Ecuador*
Note: *AD/D (Alzheimer's disease/Dementias), CA (Cerebellar ataxia), HD (Huntington's disease), MS (Multiple sclerosis), OTH (Other neurodegenerative diseases), PD (Parkinson's disease), PMD (Primary muscle disorders).*

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The lowest number of deaths occurred in the Amazon (2%). AD/D was the most frequent cause in this region (n = 18, 54.55 %), followed by PD (n = 10, 30.3 %). The low mortality from NDs in this region could be influenced by the low population density and diagnostic underreporting, as it is mostly made up of indigenous populations that turn to their ancestral practices for health issues.

In the Coast region, AD/D was also the most common cause of death, accounting for 63.43 % of deaths (n = 307), reflecting a significant burden of these conditions in this region. Following AD/D, PD was the second most frequent (22.11 %, n = 107) and PMDs (1.86 %, n = 9).

The majority of deaths nationwide occurred in the Sierra region. The AD/D group accounted for the highest percentage of deaths in this area (69.73 %, n = 583), followed by PD (19.98 %, n = 167). This region also showed high mortality from PMDs (1.55 %, n = 13) and MS (1.43 %, n = 12).

Figure 2 shows the latent class analysis that identified three hidden mortality profiles (low, moderate, high), considering both the cause of death from NDs and regional distribution (Amazon, Coast, and Sierra). The following proportions were identified in each latent class: 38.7 % (low mortality), 15.7 % (moderate mortality), and 45.6 % (high mortality).

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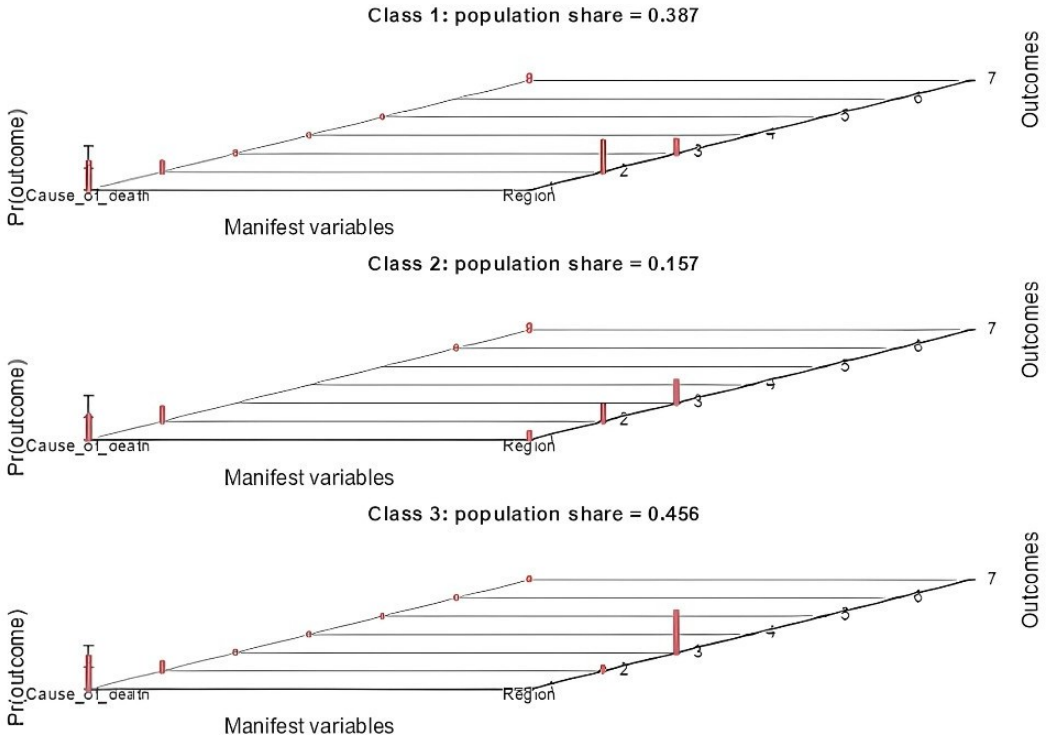


Figure 2.

Latent Class Analysis plot

Note: *Class 1= Low mortality, Class 2= Moderate mortality, Class 3= High mortality. Cause of death: 1= Alzheimer's disease/Dementias), 2= Parkinson's disease, 3= Primary muscle disorders, 4=. Huntington's disease, 5= Cerebellar ataxia, 6= Multiple sclerosis, 7= Other neurodegenerative diseases. Región: 1=Amazon, 2=Coast, 3=Highlands*

Class 1 (Low Mortality Profile) was mostly composed of individuals who died from AD/D (63.9 %) and PD (20.9 %). This class was strongly associated with the Coast region (68.9 %).

Class 2 (Moderate Mortality) showed a predominance of AD/D (54.6 %) and a notable increase in deaths from PD (30.3 %) compared to Class 1. It had a more balanced regional distribution: 48.8 % from Sierra, 35.7% from Coast, and 15.5 % from the Amazon. Additionally, there was a growth in the proportion of deaths from MS (3.0 %), indicating greater clinical diversity.

Class 3 (High Mortality Profile) showed AD/D as the primary cause of death (74.2 %), although deaths from PD (17.8 %) and MS (1.56 %) were also observed. This class was highly concentrated in the Sierra region (92.3 %), with marginal presence in the Coast (7.7 %).

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Discussion

Mortality, place of death, education level, marital status, residence province, and ethnic self-identification

Most deaths occurred at the patient's home. The most common educational level was basic education. Most of the deceased were married at the time of death. The provinces of Pichincha and Guayas contributed the highest number of cases. Most of the deceased identified as mestizo. Finally, the age distribution showed a high concentration of deaths in people aged 81 to 90 years.

Regarding the place of death, the results of this study differ significantly from the literature reviewed, as it was found that over 69 % of deaths occurred at home, which contrasts with data from countries such as France, Hungary, and South Korea, where hospital deaths predominate, ranging from 40%-60 %. In countries like Belgium, the United States, and Canada, 48%-52% of cases die in nursing homes.[24] It is important to note that only in Italy and Spain do the results show a pattern similar to Ecuador (46%-54 %), with the home being the main place of death,[30] and particularly in Mexico, where the indicators exceed the results of this study (73 %). This finding could be linked to cultural factors, limitations in access to hospital services, or family preferences related to end-of-life care.

Ethnic self-identification revealed that 84 % of the deceased identified as mestizo, in line with the general demographic composition of the country. However, this concentration could also reflect a bias in the formal diagnosis of neurodegenerative diseases (ND) across different ethnic groups. Previous studies have pointed to the underrepresentation of ethnic minorities in clinical records of neurodegenerative diseases due to structural barriers in healthcare systems.[31]

Mortality, age, and sex

The results of this study show an average age of the deceased of 81.9 years, with a range from 19 to 109 years. The negative skew of the age distribution suggests a higher concentration of values in older age groups, while the kurtosis result indicates a leptokurtic distribution, with more pronounced tails than expected in a normal distribution.

Deceased women had a higher average age compared to men. The minimum age for women was 22 years and 19 years for men, while the maximum age was 109 and 102 years, respectively. The higher skewness in the male distribution suggests that the age range is slightly more extreme in men, with a greater concentration of values around the mean but also the presence of outliers at both ends.

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These results reflect greater longevity in women affected by neurodegenerative diseases compared to men, which aligns with global epidemiological patterns showing a higher life expectancy in the female population. Additionally, the high median and negative skew reinforce the concentration of these deaths in older ages.

Consistent with European studies on Alzheimer's disease (AD), it was observed that the mortality rate for women was higher than for men, which is consistent with literature reporting rates of 4.7 % in men and 6 % in women in European countries between 1994 and 2013.[23] This difference may be influenced by the higher life expectancy of women and a higher prevalence of AD in older ages.

Regarding sex and age, various studies in high-income countries have demonstrated that men, particularly those under 80 years of age, are more likely to die in hospitals, as reported in Belgium, France, Italy, the United States, Mexico, and Canada, [32,33] Our data, however, reflect a different pattern, considering all neurodegenerative diseases (ND) globally, not just a single condition like Parkinson's disease (PD), where international trends are better documented.[34] This suggests the need for disaggregated studies by disease type, sex, and age in Ecuador for a more detailed understanding of the factors associated with mortality and place of death.

In summary, the findings of this study show both similarities and divergences with international literature and highlight the importance of considering sociocultural and structural contexts when analyzing ND mortality in different countries. As the Ecuadorian population ages, it will be essential to implement public policies that ensure equitable access to diagnosis, treatment, and palliative care, especially in rural areas and historically marginalized groups.

Age distribution and regional mortality

The age group 81 to 90 years represented the highest percentage of deaths (40.9 %), confirming the strong association between aging and the prevalence of neurodegenerative diseases. Geographically, the provinces of Pichincha (n = 431) and Guayas (n = 210) accounted for the highest number of deaths, which can be explained by their high population density, greater availability of healthcare services, and better registration systems. This concentration is consistent with findings by Tharwani et al. in the U.S. [35,36], where high rates of Parkinson’s disease (PD) were also reported in rural and suburban areas with aging populations.

Cause of death and geographic region

The analysis of the geographic distribution of ND deaths in this study revealed marked differences between the three natural regions of the country: Amazon, Coast, and Sierra. The

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highest number of deaths occurred in the more populated regions, with fewer deaths in the Amazon, likely influenced by multiple factors, including low population density, limited access to specialized services, and diagnostic underreporting. However, the high concentration in more populated areas suggests a more balanced distribution and greater availability of diagnoses compared to the Amazon. The high concentration in the Sierra region may be related to the greater concentration of neurological and geriatric services in cities located in the Sierra, closer to the capital, with better coverage by both the public and private healthcare systems compared to other regions.

The results of this study confirm that Alzheimer's disease (AD) and dementia (D) were the leading causes of death from ND in Ecuador in 2023, affecting the age group of 81 to 90 years more significantly, in both men and women. This age distribution remained consistent across other conditions such as Parkinson's disease (PD), though with lower absolute percentages. In all cases, deaths among younger individuals were exceptional (<0.1 %), reaffirming the strong relationship between aging and neurodegeneration.

In contrast with more common neurodegenerative diseases, rarer or less frequent diseases, such as Huntington's disease (HD), multiple sclerosis (MS), and muscular dystrophy (MD), have a different age distribution, affecting mainly the 19 to 64-year-old group, with no significant differences between sexes. In Ecuador, the incidence and mortality of HD is low, consistent with trends observed internationally. For instance, reported mortality rates range from 0.2x100,000 inhabitants in countries like Malta and Spain, to 1.58x100,000 inhabitants in the United Kingdom.[37,38] In the United States, HD mortality is estimated at 0.97x100,000 inhabitants.[39] These figures reflect the relative rarity of HD, although its clinical and social impact is considerable due to its degenerative progression and lack of curative treatments.

This study also shows a slight female predominance in MS, consistent with global indicators from the *Atlas of MS*, which indicates that approximately two-thirds of MS cases occur in women.[40] While MS does not significantly reduce life expectancy, it does considerably affect the quality of life. Mortality estimates from the *Atlas of MS* and *Global Burden of Disease* (GBD) report national rates for Ecuador and Argentina around 0.11x100,000 inhabitants, slightly higher than Peru (~0.10x100,000) [41] suggesting a moderate burden in this Andean region, possibly influenced by genetic and environmental factors.

In Ecuador, while MD cases were rare, their impact is considerable due to early disease onset, often during adolescence or early adulthood, and the high disability rate associated with these conditions. International studies show a clear male predominance: in Spain, 73.8% of deaths from muscular dystrophies between 1981 and 2016 were male [42] in the U.S., between 2006 and 2015, the mortality rate among non-Hispanic white males was 0.46x100,000, significantly higher than in other ethnic groups, with 71% of deaths occurring between the

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ages of 15 and 29.[43,44] This pattern highlights the aggressive nature and early onset of the disease, particularly in non-Hispanic white males.

Overall, national data reflect both coincident and divergent patterns compared to international literature. While more prevalent NDs follow a global trend, less common diseases require greater visibility in health systems, along with strengthened epidemiological and genetic registries to better quantify their true burden and plan effective intervention strategies.

Parkinson's disease (PD) is one of the most prevalent neurodegenerative disorders globally, second only to dementias. Its estimated prevalence exceeds 1 % in people over 65 years of age, making it one of the leading causes of neurological morbidity in the elderly population. In Ecuador, the Ministry of Public Health (MSP, Spanish acronym) reported 27,710 consultations for PD in 2024, approximately two-thirds of which (18,000) were among older adults, aligning with the global trend of an aging affected population.

Regarding mortality, according to the World Health Organization (WHO), in 2020 there were 658 deaths attributed to Parkinson's disease in Ecuador, representing 0.92 % of total deaths in the country.[45] This corresponds to an age-adjusted mortality rate of 3.88x100,000 inhabitants, placing Ecuador 105th globally.[45] This level is comparable to neighboring countries like Peru, but significantly lower than Bolivia, where an estimated rate of about 7.53x100,000 inhabitants was reported.[45] This regional difference may be related to factors such as demographic profile, diagnostic coverage, access to healthcare services, or possible underreporting in health information systems.

Internationally, a sustained increase in mortality from PD has been documented. In Brazil, mortality shows a significant upward trend in both sexes (APC males = 3.32; females = 2.81), particularly in the 70-79 age group (APC = 4.93) [46, 47, 48]. Similarly, in China, from 2004 to 2021, PD mortality rates significantly increased in both sexes, with a global APC of 7.14 % (7.65 % in males and 7.03% in females); the fastest-growing age group was females over 85 years (APC = 5.69 %) [49]. In Mexico, between 2000 and 2020, the adjusted mortality rate was 1.26x100,000 inhabitants [50] with a male-to-female ratio of 1.60, consistent with patterns observed in Ecuador.

Other studies highlight that, beyond aging, factors such as race, sex, and geographic region significantly influence mortality patterns. In the U.S., age-adjusted PD mortality doubled in males compared to females between 1999 and 2019 (from 5.4 to 8.8x100,000), with higher rates in non-Hispanic white individuals [46, 51,52]. Similarly, research in Italy, Estonia, and the United Kingdom has shown a progressive increase in age-standardized PD mortality rates, contrasting with the decline seen in many other causes of death.[47] In England and

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Wales, for instance, PD mortality increased by 105% between 2001 and 2014, reflecting a pattern seen in countries with robust surveillance systems.[53]

These findings may be attributed, at least in part, to improved diagnostic accuracy and heightened medical awareness of movement disorders. It has been suggested that the apparent increase in mortality from neurodegenerative diseases may be due more to better clinical recognition and more rigorous coding in death certificates than to a true rise in incidence. However, factors related to access to treatment, comorbidities, age at diagnosis, motor progression, and cognitive decline also contribute to the disease burden and mortality rates.

In this context, it should be noted that other forms of parkinsonism, such as progressive supranuclear palsy (PSP), multiple system atrophy (MSA), corticobasal degeneration (CBD), and dementia with Lewy bodies (DLB), although less common, present high mortality rates and reduced survival. PSP and CBD have an average onset age of 63 years, with post-diagnosis survival ranging from 6.9 to 7.2 years, respectively. Meanwhile, MSA has an average life expectancy of 6.2 to 7.5 years, and its clinical presentation varies geographically, being more prevalent in North America, Europe, and Japan.[54,55]

Improving the quality of vital records, particularly the accuracy of death certificates and standardization of diagnostic criteria, remains a challenge in Ecuador. The lack of an integrated epidemiological and clinical information system limits the country's ability to effectively monitor the evolution of these diseases. Implementing a national neurodegenerative disease repository that integrates data on mortality, morbidity, outpatient and inpatient care would enable a more accurate assessment of the health and social impact of these diseases, fostering more effective and equitable public policies.

Although HD, MS, and MD represent a smaller fraction of ND mortality in Ecuador, their identification in younger groups and their complex clinical evolution highlight the need to strengthen early diagnosis, genetic registries, and specialized care. The implementation of public health policies focused on rare diseases, such as dystrophies and cerebellar ataxias, is critical to ensuring access to innovative therapies and appropriate supportive care.

Finally, national data aligns with global estimates of the prevalence and incidence of neurodegenerative disorders, particularly AD/dementias and PD. This concordance can be attributed to various factors, such as the sustained increase in longevity, favorable changes in lifestyle, decreased tobacco and other neurotoxic substance consumption, as well as the indirect effects of industrialization and urbanization. These findings underscore the urgent need for public policies that recognize the growing impact of NDs on the health system, promoting early diagnosis and access to comprehensive palliative care.

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Conclusion

This study significantly contributes to the understanding of the sociodemographic variables associated with mortality due to neurodegenerative diseases (ND) in Ecuador. The findings provide valuable information on the most common diagnoses, as well as the distribution of deaths by age, sex, and geographical region. Given that currently 8.2 % of the Ecuadorian population is 65 years or older, and the country ranks 159th globally with an overall mortality rate of 5.17x1,000 inhabitants,[28] there is a high likelihood of an increase in deaths from aging-related diseases such as neurodegenerative diseases.

As strategies are developed to reduce the burden of these diseases and improve clinical outcomes, it is crucial to recognize the complexity in both the diagnosis and the assessment of mortality related to ND. In this context, the development and implementation of innovative treatments and comprehensive public policies are essential to slow their progression and improve the quality of life for those affected.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships.

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Ethical Considerations

This study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki and adhered to national and institutional research ethics guidelines. Participation was voluntary, and informed consent was obtained electronically from all students prior to data collection. Confidentiality and anonymity of participants were strictly maintained throughout the study.

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Declaration of Conflicting Interests

The authors declare that there are no conflicts of interest in relation to the research presented in this manuscript.

Data Availability Statement

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Anonymized data that support the findings of this study may be made available from the corresponding author upon reasonable request.

Contribuciones de autoría

José Alejandro Valdevila Figueira: participó en la conceptualización, el análisis formal, la metodología, la redacción del borrador original y la redacción, revisión y edición.

María Alejandra Espinosa de los Monteros Andrade: participó en la conceptualización, la curación de datos, el análisis formal, la investigación, la metodología, la validación, la visualización, la redacción del borrador original y la redacción, revisión y edición.

Xavier Rodrigo Yambay-Bautista: participó en la curación de datos, el análisis formal, la investigación, la utilización del software, la visualización y la redacción, revisión y edición.

Rocío Valdevila Santiesteban: participó en la redacción, borrador original y la redacción, revisión y edición.

Indira Dayana Carvajal Parra: participó en la investigación, la metodología, la validación y la redacción, revisión y edición.

Pedro Martínez-Suarez: participó en la metodología, la supervisión, la validación, el manejo de recursos y la redacción, revisión y edición.

María José Pico Cucalon: participó en la conceptualización, la curación de datos, la investigación, la visualización, la redacción, borrador original y la redacción, `evisión y edición.

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