Mortality trends from central nervous system tumors in the seven socioeconomic regions and 32 states of Mexico from 2000 to 2017

Juan J. Sánchez-Barriga

Introduction. Central nervous system (CNS) tumors are a public health problem worldwide. In Mexico in 2018, occupied 17th in cancer incidence, that same year ranking 13th among causes of cancer mortality. The aim of this study was to determine mortality trends from (CNS) tumors, nationwide by state and socioeconomic region and determine the risk of died from (CNS) tumors according to the level of education in the period 2000-2017.

Materials and methods. Mortality records associates to central nervous system tumors were obtained of the National Institute of Statistics and Geography for the period 2000-2017. Mortality rates were calculated at the national level, by state, and socioeconomic region, the strength of association between educational level with the mortality from (CNS) tumors was also calculated.

Results. In the years 2000-2017, age-adjusted mortality rates to the world population per 100,000 inhabitants increased from 1.9 to 2.1. A male/female ratio was 1:2. The 65-69 age group had the highest number of deaths with 3,370 (9.8%).

Conclusions. In the study period age-adjusted mortality rates per 100,000 habitants increased from 1.9 to 2.1. Individuals without school or incomplete elementary school had a higher risk of died from (CNS) tumors. The region socioeconomic 6 and 7 had the highest mortality rates from (CNS) tumors.

Key words. Central nervous system tumors. Education. Mexico. Mortality. Risk factors. Socioeconomic factors.

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Introduction

Primary cancers of the brain and spinal cord affect both children and adults and are diagnosed in all anatomical regions of the central nervous system, and the vast majority (> 90%) occur in the brain and the rest in the meninges, spinal cord and cranial nerves [1]. The primary and metastatic brain tumors are an important cause of morbidity and mortality, precise information on the epidemiology of brain tumors is deficient, since registration is not mandatory in many countries of the world [2].

Central nervous system tumors are rare compared with other fatal diseases that shorten life expectancy. However, rarity is a relative term: more than 18,000 people in the United States are diagnosed each year with brain tumors. Two thirds of them die and others survive but with severe restrictions on the function. The etiology of brain tumors is poorly characterized, the relationship of the contribution of hereditary and environmental conditions is unclear. Traditional descriptive epidemiology has been able to accurately show the incidence and differences in the results of these tumors according to ethnic, geographic, occupational and histological factors. However, the investigation of risk factors has been hampered due to inconsistencies in reporting, diagnosis, selection of study subjects, and tumor classification [3].

Central nervous system tumors are a public health problem around the world [1]. In 2018, occurred 162,534 cases of (CNS) tumors, in men worldwide, with an incidence rate of 3.9 per 100,000 individuals, and 134,317 in women with an incidence rate of 3.1. In that same year, 135,843 deaths in men were reported from this cancer and 105,194 in women, with a mortality rate of 3.2 and 2.3 per 100,000 individuals, respectively [4].

In the region of Central America and the south, according to the GLOBOCAN 2012, (CNS) tumors were the eleventh cause of morbidity and mortality from cancer in 2012, with 26,000 new cases of cancer and 19,000 deaths [5]. The highest age-standardized mortality rates (per 100,000) were ob-

Table I. Socioeconomic regions of Mexico.

	States
1	Chiapas, Guerrero, Oaxaca
2	Campeche, Hidalgo, Puebla, San Luis Potosi, Tabasco, Veracruz
3	Durango, Guanajuato, Michoacan, Tlaxcala, Zacatecas
4	Colima, State of Mexico, Morelos, Nayarit, Queretaro, Quintana Roo, Sinaloa, Yucatan
5	Baja California, Baja California Sur, Chihuahua, Sonora, Tamaulipas
6	Aguascalientes, Coahuila, Jalisco, Nuevo Leon
7	Mexico City

Source: National Institute of Statistics and Geography.

served for Cuba in the period 2004-2007 (4.1 males, 3.0 females) in Central America; and for Brazil in the years 2003-2007 (4 males, 3.2 females); and Uruguay in the period 2005-2007 (3.2 and 1.9) in South America. Mortality rates were higher in males than in females. Glioma and unspecified tumors were the most common histological types, accounting for 55.4% and 32.8%, respectively [6].

In Mexico, epidemiological studies related to (CNS) tumors are scarce, and those that exist are at the hospital level [7] [8]. According to GLOBOCAN database in Mexico in 2018, the (CNS) tumors occupied 17th in cancer incidence with 3,451 (2.01%) cases. That same year there were 2,663 (3.46%) deaths, ranking 13th among causes of cancer mortality [9].

In Mexico, there are no studies to investigate mortality trends of the (CNS) tumors by state and socioeconomic region. The results of this study could be useful in actions aimed at managing these neoplasms in Mexico.

The objective of this study was to determine mortality trends from (CNS) tumors, nationwide by state and socioeconomic region and determine the risk of died from (CNS) tumors according to the level of education in the period 2000 to 2017.

Materials and methods

An ecological study design was used. Mortality records of children and adults associated to (CNS) tumors for 2000-2017 were obtained from the National Institute of Statistics and Geography [10]. This information is collected from death certificates issued nationwide. All individual records of mortality in which the basic cause of death was (CNS) tumors and among children and adults in the period of 2000 to 2017 were included in the study. The codes of the International Classification of Diseases, 10th revision were identified [11]. They corresponded to the basic cause of death from (CNS) tumors among children and adults (C70.0-C75.3).

Raw and age-adjusted mortality rates nationwide per 100,000 inhabitants were obtained. For the adjustment the mortality rates nationwide were used the world population as the standard population [12,13]. Age-adjusted mortality rates per 100,000 inhabitants from each state and from each of the 7 socioeconomic regions (Table I) established by the National Institute of Statistics and Geography were also obtained [14]. The national population, estimated by the National Population Council for 2000-2017, was used for the rate adjustment [15].

The seven socioeconomic regional categories for Mexico have been defined by the National Institute of Statistics and Geography in which differences observed in the social and economic conditions of the population throughout México are presented according to the XII General Population and Housing Census. The seven socioeconomic regions (Table I) comprise the 31 states and Mexico City according to indicators related to well-being such as education, occupation, health, housing and employment. States classified in the same region have similar characteristics on average; that is, they are homogenous, while the regions differ from one another. According to the indicators used, the socioeconomic conditions increase from Region 1, least favorable, to region 7 most favorable. The methodology used to establish the regions had the objective of forming strata with minimal variance in an effort to group the elements more alike or closer to each other following a criterion of established similarity, which allows for differentiating one region from another. Among the techniques used are Mahalonobis distances and a combination of factorial analysis and the algorithm of the k-means [14].

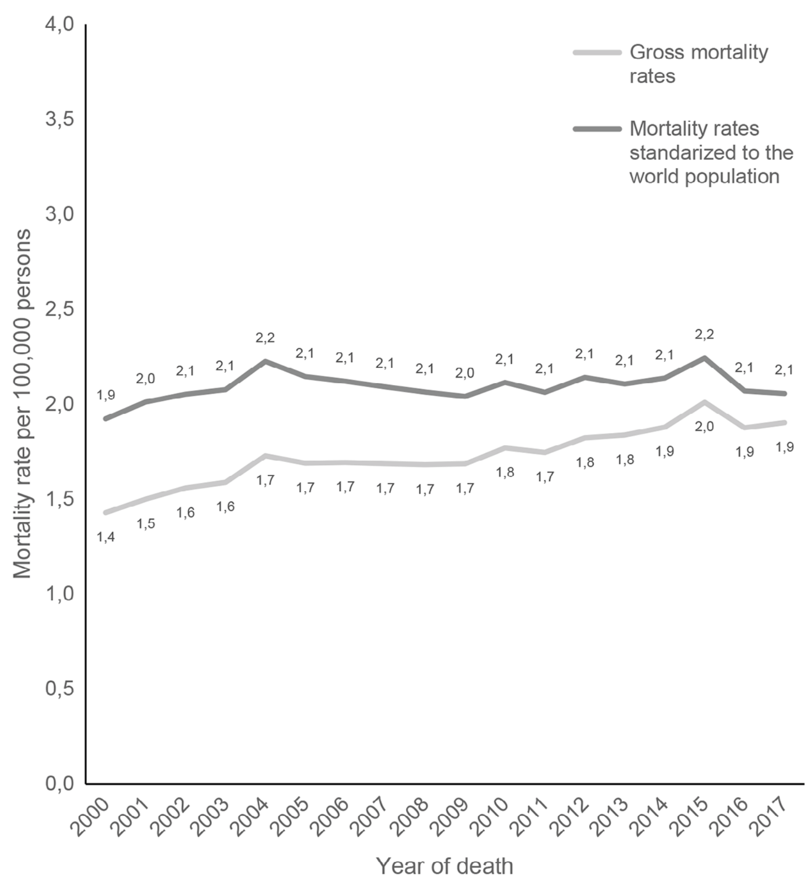
The Poisson regression model was chosen to determine the strength of association (relative risk) between educational level with mortality rates from CNS tumor, because as a dependent variable, the mortality rates of CNS tumors has a Poisson distribution that takes positive whole values. Poisson regression is equivalent to a logarithmic regression of mortality rates. The exponential coefficients allow for estimation of the RR of dying [16].

According to the Structure and Dimension of the National Educational System [17], the level of education was categorized into the following categories: college and postgraduate studies (3-6 years of school education and 1-4, respectively), complete senior in high school (3 years), complete high school and senior in high school not finished (3 years and < 3, respectively), complete elementary school and high school not finished (5 years and < 3, respectively), no school or incomplete elementary school (< 5 years).

Registrations were handled by the Access 2013 program. The strength of association between educational level with the mortality rates from (CNS) tumors was obtained by Poisson regression through the Number Cruncher Statistical System program 2001 [18]. In which the logarithm of the mortality rate was the dependent variable and educational level the independent variable, with college and postgraduate studies as the reference category. Because previous studies had found that the association between socioeconomic level and cancer mortality [19,20].

The Epidat version 3.1 program was used to determine age-adjusted mortality rates by state, and socioeconomic region [21]. Trends in the mortality rates for the six age groups were assessed using the annual percentage change (APC) and the corresponding 95% confidence interval, with the joint point regression program (version 4.9.0.0) [22]. The joint point regression method identifies points of change in the mortality trend, dividing the total study period into several sections. A regression line corresponds to each period, and a value of the APC of mortality.

Figure 1. Mortality trends from central nervous system tumors in Mexico, 2000-2017.



Note: raw rate of mortality per 100,000 individuals. Age-adjusted rate by the direct method, standardized with world population per 100,000 individuals.

Results

In Mexico, in the period 2000-2017, the age-standardized mortality rate with the world population due to (CNS) tumors increased, from 1.9 to 2.1, with a change percentage of 9.5% (Fig. 1), and 35,621 individuals died from (CNS) tumors (men 19,823 [55.6%] and women 15,798 [44.4%]) (Fig. 2). A male/female ratio was 1.2.

In overall, there was an increase in mortality from (CNS) tumors in men as in women with the age. In the figure 2, two peaks in mortality were identified, one sharp peak (peak 1) correspond to the age group of 5-9 years and another larger peak (peak 2) correspond to the group 65-69 years, with 1,751 (4.6%) deaths and 3,491 (9.7%), respectively.

In the study period, the (CNS) tumors with the highest mortality were malignant tumor of the brain, unspecified part (C71.9) with 16,986 (47.7%); malignant tumor of the brain, except lobes and ventricles (C71.0) with 12,240 (34.4%); malignant neoplasm of the cerebellum (C71.6) with 1,915 (5.4%); malignant tumor of the central nervous system, without other specification (C72.9) with 594 (1.7%) and malignant tumor of the frontal lobe (C71 .1) with 543 (1.5%) (Table II).

In the period 2000-2017 individuals without schooling or incomplete elementary school had a higher risk of dying from (CNS) tumors (RR 3.84512, 95% CI 3.84512-3.84513), while those with

Figure 2. Mortality from central nervous system tumors in women and men by age group. Mexico, 2000-2017.

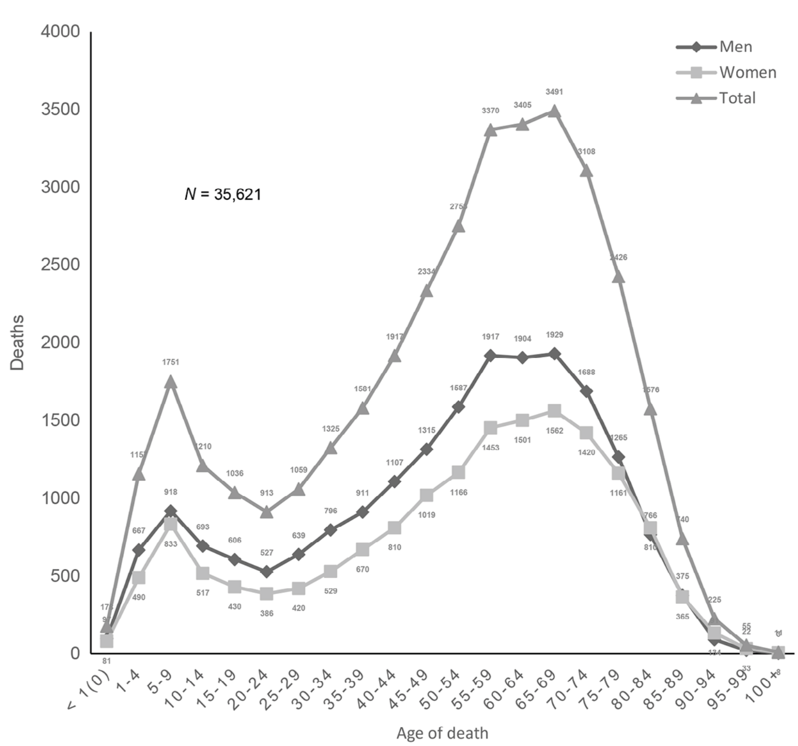
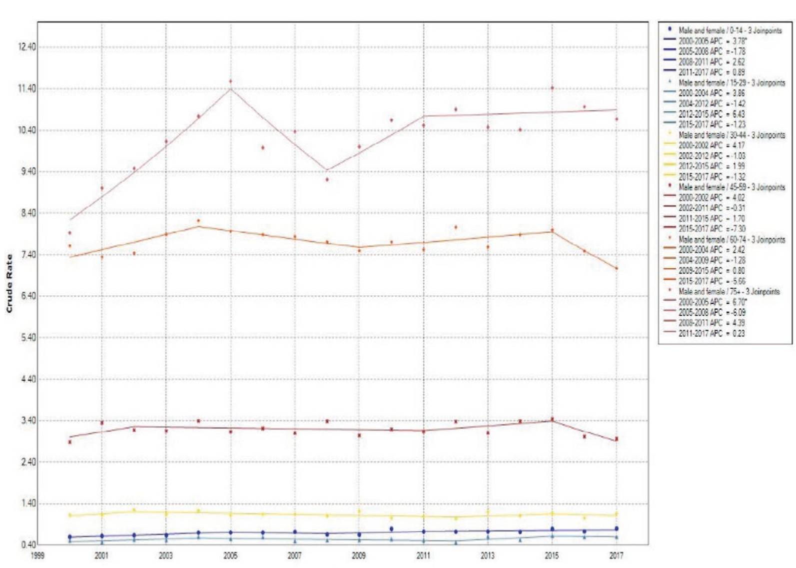


Figure 3. Mortality trends from central nervous system tumors by age group (0-14 years, 15-29, 30-44, 45-59, 60-74, y ≥ 75); and join point regression, Mexico, 2000-2017.



*Indicates that the annual percentage change (APC) is significantly different form zero at the alpha = 0.05 level.

complete senior in high school the risk of presenting (CNS) tumors was considerably lower (RR 0.75287, 95% CI 0.75287-0.75287) (Table III); college and postgraduate studies was taken as reference category.

When age-specific mortality trends were analyzed by joint point regression models, in the years 2000-2017; in the 0–14-year-old group had an increase in mortality in the period 2000-2005, with annual percentage change (APC) of 3.78% 95% CI 0.6 -7%, and in the age group ≥75 years in the period 2000-2005, there was also an increase in APC of 6.7%, 95% CI 3.5-10% (Fig. 3)

In the study period, the states with the highest mortality rates from (CNS) tumors were in 2000, Nuevo León with 2.6; in 2001 and 2014, Mexico City with 2.2 and 2.4, respectively; in 2002, Chihuahua with 2.2; in 2003 and 2015, Zacatecas with 2.3 and 2.9, respectively; Campeche in 2004, with 3.1; in 2005 and 2017 Colima with 2.8 and 2.9, respectively; in 2006 and 2011, Aguascalientes with 3 and 2.5, respectively; in 2007-2010 and 2012, Baja California Sur with 2.9-3 and 2.7, respectively; in 2013, Colima with 2.9, and in 2016, Nayarit with 3 (Fig. 4).

The states with the lowest mortality rates were in 2000, Tabasco with 0.7; in 2001, 2004-2009, 2011-2012 and 2017, Guerrero with a rate of 0.7, 0.6-0.9, 1-1.1 and 1.1, respectively; in 2002, Campeche with 0.7; in 2003 and 2014, Quintana Roo with 0.7 and 1.3, respectively; Durango in 2010, with 1.3; in 2013, Hidalgo with 1.2; in 2015, Yucatan with 1.3 and in 2016 Baja California Sur with 0.9 (Fig. 4) .

Socioeconomic regions 6 (in the years 2000, 2006-2008, 2011-2012 and 2017) and region 7 (in the years 2001-2005, 2009-2010 and 2013-2016) had the highest mortality rates from (CNS) tumors. Mortality rates for region 6, in the specified years were 2.1, 2-2.1, 2.2-2.3, and 2.2, respectively. For region 7, in the specified years were 2.2-2, 2.1-2.2 and 2.4-2.4 (Figure 5). Region 1 had the lowest mortality rate in the study period; in 2000 the rate was 0.8 and in 2017 was 1.5 (Fig. 5).

Discussion

In Mexico, in the period 2000-2017, the age-standardized mortality rate with the world population from (CNS) tumors increased from 1.9 to 2.1 (percentage change of 9.5%) (Fig. 1). The increase in the mortality could be related to inadequate treatment and late diagnosis. In the period of 1990-2016, worldwide age-adjusted incidence rates (per 100,000

Table II. Gender and age at died of children and adults who died from central nervous system tumors in Mexico, 2000-2017.

ICD 10	Nervous system neoplasms	Gender N = 35,621		Age at died N = 35,621								The minimum year at died	The maximum year at died	Median years at died
		Women n = 15,798 (44.4%)	Men n = 19,823 (55.6%)	Days (1-29) n = 15 (0.0309%)	Months (1-11) n = 163 (0.04576%)	1-15 years n = 4,347 (12.203%)	16-30 years n = 3,045 (8.548%)	31-45 years n = 4,991 (14.011%)	46-60 years n = 8,730 (24.508%)	61-75 years n = 9,821 (27.571%)	≥76 years n = 4,509 (12.658%)			
		n (%)	n (%)											
C70.0	Malignant neoplasm of cerebral meninges	68 (0.19)	70 (0.2)	0	0	5	6	17	36	51	23	5	94	62
C70.1	Malignant neoplasm of spinal meninges	3 (0.01)	4 (0.01)	0	0	0	1	2	3	1	0	20	63	51
C70.9	Malignant neoplasm of meninges, unspecified	179 (0.5)	239 (0.67)	0	0	32	39	56	114	107	70	1	102	57
C71.0	Malignant neoplasm of cerebrum, except lobes and ventricles	6.685 (18.77)	5.555 (15.59)	3	26	974	893	1.577	2.956	3.727	2.084	1	105	59
C71.1	Malignant neoplasm of frontal lobe	267 (0.75)	276 (0.77)	0	0	8	35	101	164	164	71	1	97	57
C71.2	Malignant neoplasm of temporal lobe	197 (0.55)	162 (0.45)	0	2	11	23	47	111	112	53	1	98	59
C71.3	Malignant neoplasm of parietal lobe	199 (0.56)	131 (0.37)	0	0	7	15	43	105	109	51	3	96	60
C71.4	Malignant neoplasm of occipital lobe	31 (0.09)	38 (0.11)	0	0	3	4	9	22	23	8	3	89	59
C71.5	Malignant neoplasm of cerebral ventricle	83 (0.23)	78 (0.22)	0	8	47	32	15	24	20	15	1	93	30
C71.6	Malignant neoplasm of cerebellum	1.154 (3.24)	761 (2.14)	0	37	959	368	226	165	107	53	1	95	15
C71.7	Malignant neoplasm of brain stem	210 (0.59)	189 (0.53)	0	3	219	57	37	45	28	10	1	89	13
C71.8	Malignant neoplasm of overlapping sites of brain	210 (0.59)	163 (0.46)	0	3	39	28	61	99	92	51	1	98	54
C71.9	Malignant neoplasm of brain, unspecified	9.602 (26.96)	7.384 (20.73)	10	68	1.788	1.322	2.569	4.530	4.887	1.812	1	101	56

Table II. Gender and age at died of children and adults who died from central nervous system tumors in Mexico, 2000-2017 *(cont.)*.

		Gender *N* = 35,621		Age at died *N* = 35,621								The minimum year at died	The maximum year at died	Median years at died
		Women *n* = 15.798 (44.4%)	Men *n* = 19.823 (55.6%)	Days (1-29) *n* = 15 (0.0309%)	Months (1-11) *n* = 163 (0.04576%)	1-15 years *n* = 4.347 (12.203%)	16-30 years *n* = 3.045 (8.548%)	31-45 years *n* = 4.991 (14.011%)	46-60 years *n* = 8.730 (24.508%)	61-75 years *n* = 9.821 (27.571%)	≥76 years *n* = 4.509 (12.658%)			
		n (%)	*n* (%)											
C72.0	Malignant neoplasm of spinal cord	245 (0.69)	183 (0.51)	0	1	47	38	61	90	116	75	1	100	57
C72.1	Malignant neoplasm of cauda equina	3 (0.01)	2 (0.01)	0	0	1	2	1	0	0	1	9	90	30
C72.2	Malignant neoplasm of olfactory nerve	2 (0.01)	5 (0.01)	0	0	1	0	1	3	0	2	15	77	56
C72.3	Malignant neoplasm of optic nerve	12 (0.03)	19 (0.05)	0	0	12	2	1	4	7	5	1	94	49
C72.4	Malignant neoplasm of acoustic nerve	11 (0.03)	7 (0.02)	0	0	0	4	3	4	4	3	17	90	54,5
C72.5	Malignant neoplasm of unspecified cranial nerve	10 (0.03)	7 (0.02)	0	0	1	6	1	2	2	5	6	85	51
C72.8	Overlapping lesion of brain and other parts of central nervous system	16 (0.04)	12 (0.03)	0	1	6	3	4	6	5	3	2	84	47
C72.9	Malignant neoplasm of central nervous system, unspecified	317 (0.89)	277 (0.78)	2	10	84	60	69	132	162	75	1	95	55
C75.1	Malignant tumor of the pituitary gland	171 (0.48)	150 (0.42)	0	0	9	28	62	101	85	36	4	99	56
C75.2	Malignant tumor of the craniopharyngeal duct	18 (0.05)	12 (0.03)	0	0	8	8	5	3	4	2	1	78	30
C75.3	Malignant neoplasm of pineal gland	130 (0.36)	74 (0.21)	0	4	86	71	23	11	8	1	1	79	17

ICD-10: International Statistical Classification of Diseases and Related Health Problems, 10th revision.

individuals) increased by 17.3 %, while in the same period the mortality rates decreased by 10%. This decrease in mortality worldwide possibly be due to improved treatment and timelier, accurate diagnosis [1].

In study period, the mortality from (CNS) tumors were higher in men (55.6%) than in women (44.4%). Epidemiological studies in different parts of the world have shown that men have a higher risk of suffering from (CNS) tumors than women. Piñeros M, et al, observed that men in Central America and South America had incidence and mortality rates 10 to 50% higher than in women, with the exception of Bolivia, which had a male to female incidence ratio of 0.4: 1 and Suriname of 0.8: 1 [6].

As the age of the individuals increased, the risk of presenting an (CNS) tumors increased. The age groups of 65-69, 60-64, and 55-59 had a higher mortality from (CNS) tumors (Fig. 2). The median age of onset of all primary brain tumor is 53 years. Since cancers are generally considered diseases of old age, the increasing incidence of most types of brain tumors in elderly may be due to the duration of exposure to risk factors associated to (CNS) tumors, genetic alterations before clinical disease, or a decrease in the immunity of individuals [1,3].

In the study period, individuals without schooling or incomplete elementary school had a higher risk of dying from (CNS) tumors (RR 3.84512, 95% CI 3.84512-3.84513), while those with complete senior in high school, the risk of dying from this condition decreased considerably. (RR 0.75287, 95% CI 0.75287-0.75287) (Table III), college and postgraduate studies was taken as reference category. The level of education is an indicator of health, since it has been observed that people with more education are more likely to be employed and to have a better income and consequently greater well-being, which directly affects their health [23]. In Mexico, lack of education has contributed to the prevalence of social inequality and poverty [24]. A high level of education is related to low mortality and better health of the population [25]. It has been identified in Mexico that people without education or with a low level of education are usually found in marginalized populations, in social, geographic and economic aspects [24]. This situation has conditioned those patients with brain cancer have a late diagnosis, poor clinical care and treatment, resulting in an increase in mortality from this type of cancer in Mexico [19].

In the study period, there was not a state that for many years had the highest mortality rates from (CNS) tumors (Fig. 4). In the period 2000-2017, socioeconomic regions 6 and 7 had the highest mortality rates from (CNS) tumors (Fig. 5). Regions 6 and 7 had the best socioeconomic levels of the country. Region 6 is integrated by Aguascalientes, Coahuila, Jalisco, Nuevo Leon; and region 7 only for Mexico City (Table I). In the world, the countries with higher economic incomes have a higher incidence rate of (CNS) tumors than those with lower incomes [3]. It is probable that this situation can be extrapolate to the regions 6 and 7. However, in high-income countries the mortality rates are lower from (CNS) tumors, it is probably because individuals have a more timely and accurate diagnosis and a better treatment [1], which does not happen in developing countries such as Mexico, where the incidence rate from (CNS) tumors is high and the mortality rate also.

Table III. Relative risk of dying from central nervous system tumors according to educational level, and 95% confidence interval according to Poisson regression, Mexico, 2000-2017.

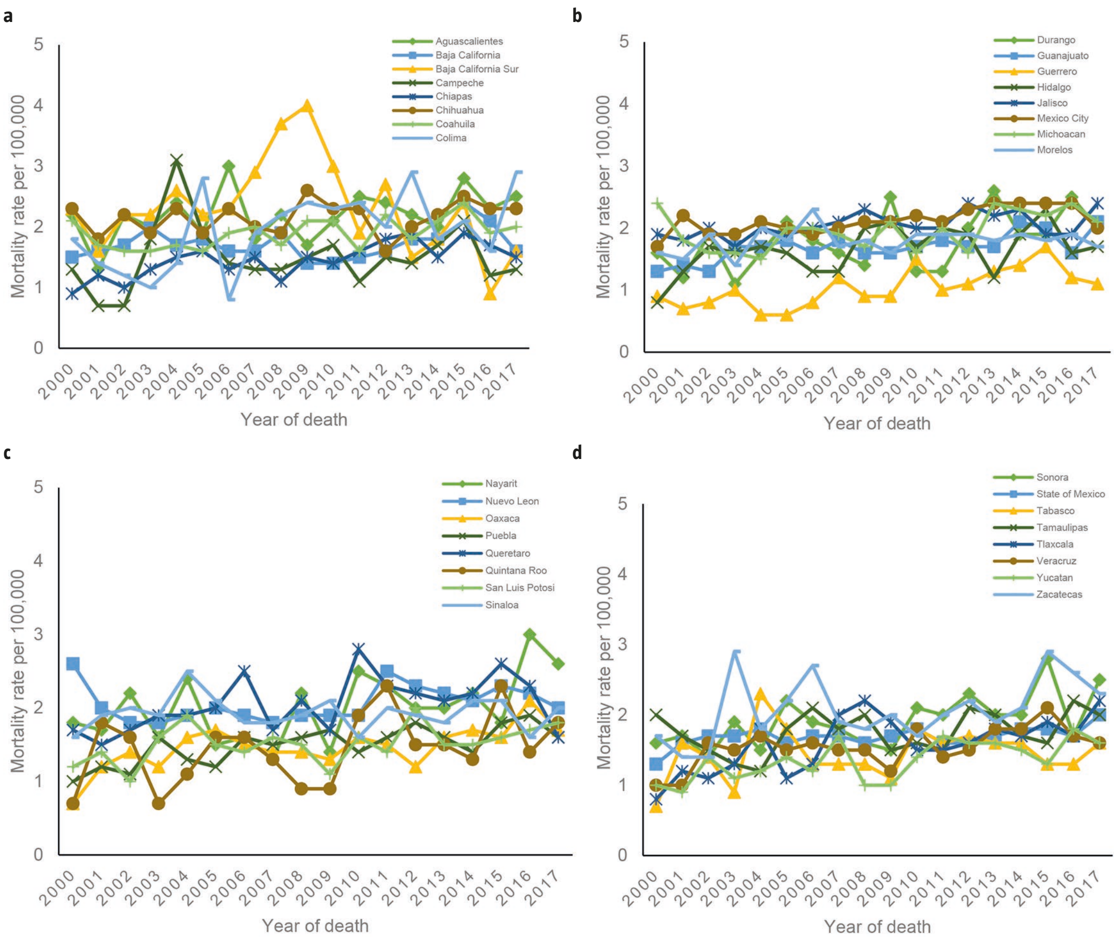
	Deaths	Person-years at risk	Relative Risk	95% confidence Interval
No school or incomplete elementary school	16,088	833,722,783	3.84512	3.84512-3.84513
Complete elementary school and high school not finished	4,886	244,905,274	1.16778	1.16778-1.16778
Complete high school and senior in high school not finished	4,815	120,734,342	1.15081	1.15081-1.15082
Complete senior in high school	3,150	156,287,629	0.75287	0.75287-0.75287
College and postgraduate studies	4,184	419,500,830	1	N.A

N.A: not applicable.

The results obtained in this article are similar to the estimates of other international organizations; since the data and the methods employed in this study are the same. International agencies such as the International Agency for Cancer Research consider the INEGI registry as the gold standard for death statistics in Mexico and use these data to estimate cancer incidence and mortality [26].

One of limitations of this study was that the mortality rate, and strength of association between educational level and mortality from CNS tumors could be even greater, since in Mexico there is an underreporting of mortality, in the period 2001-2003, it was 9.7%. However, Mexico is considered by the Pan American Health Organization as a

Figure 4. Age-adjusted mortality rate by state of residence of people who died from central nervous system tumors, México, 2000-2017.



Note: rate per 100,000 inhabitants adjusted by direct method using national population as standard population.

country where the underreporting of mortality is low [27].

Conclusions

In Mexico, in the period 2000-2017, the age-standardized mortality rate with the world population from (CNS) tumors increased from 1.9 to 2.1 per 100,000 individuals. Mortality from (CNS) tumors was higher in men (55.6%) than in women (44.4%). Individuals without schooling or incomplete elementary school had a higher risk of dying from (CNS) tumors (RR 3.84512, 95% CI 3.84512-3.84513). Socioeconomic regions 6 and 7 had the highest mortality rates from (CNS) tumors.

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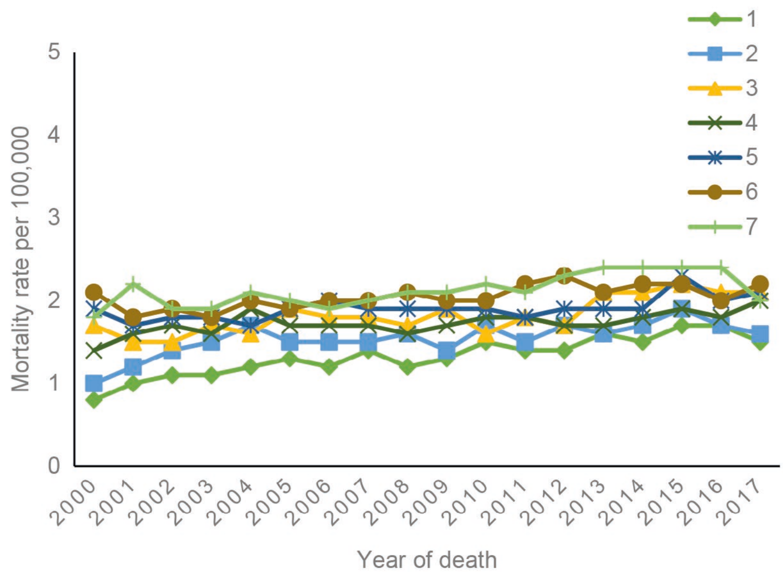
Figure 5. Age-adjusted mortality rate by socioeconomic region of people who died from central nervous system tumors. Mexico, 2000-2017.



Note: rate per 100,000 inhabitants adjusted by direct method using national population as standard population.

Tendencias de mortalidad por tumores del sistema nervioso central en las siete regiones socioeconómicas y en los 32 estados de México entre 2000 y 2017

Introducción. Los tumores del sistema nervioso central (SNC) son un problema de salud pública en el mundo. En México, en 2018, ocuparon el número 17 en incidencia de cáncer. Ese mismo año ocuparon el número 13 entre las causas de mortalidad por cáncer. El objetivo de este estudio fue determinar las tendencias de mortalidad por tumores del SNC a nivel nacional por estado y región socioeconómica, y determinar el riesgo de muerte por tumores del SNC según el nivel de escolaridad en el período 2000-2017.

Materiales y métodos. Se obtuvieron del Instituto Nacional de Estadística y Geografía los registros de mortalidad asociados a tumores del SNC para el período 2000-2017. Las tasas de mortalidad se calcularon a nivel nacional, por estado y región socioeconómica, y también se calculó la fuerza de asociación entre el nivel educativo con la mortalidad por tumores del SNC.

Resultados. En los años 2000-2017, las tasas de mortalidad ajustadas por edad de la población mundial por cada 100.000 habitantes se incrementaron de 1,9 a 2,1. La proporción hombre/mujer fue de 1:2. El grupo de 65 a 69 años tuvo el mayor número de muertes, con 3.370 (9,8%).

Conclusiones. En el período de estudio, las tasas de mortalidad ajustadas por edad por cada 100.000 habitantes aumentaron de 1,9 a 2,1. Las personas sin escolaridad o con escuela primaria no terminada tuvieron mayor riesgo de morir por tumores del SNC. Las regiones socioeconómicas 6 y 7 tuvieron las tasas de mortalidad más altas.

Palabras clave. Educación. Factores de riesgo. Factores socioeconómicos. México. Mortalidad. Tumores del sistema nervioso central.