Youth mortality, social marginalization and health inequity in Mexico

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Abstract *This study seeks to determine the differences in youth mortality in Mexico based on selected causes by sex and extreme levels of municipal marginalization in two triennia (2004-2006 and 2015-2017) and to establish a relationship between the differences found, the social environment and the availability of health resources. Using official data, years of life lost (YLL) between 0 and 85 years old and YLL for the 15-29-year-old age group were calculated for 15 of the main causes of death in Mexico in both triennia; the YLL was calculated for municipalities grouped into two categories: high and very high marginalization (HaVHMA) and low and very low marginalization (LaVLMA). Violent deaths (especially homicides) are the main causes of death in young women and men throughout Mexico, regardless of the level of marginalization, and increased from the first to second triennia studied. Men aged 15 to 29 years in HaVHMA municipalities had an excess YLL compared to those in LaVLMA municipalities in 13 of the 15 causes analyzed for 2004-2006 and in all causes for 2015-2017; for women, excess was observed for 13 of 15 causes in each triennium. These findings reflect the unfair disadvantages to which young people are exposed in HaVHMA municipalities.*

Key words *Mortality, Social marginalization, Health equity, Adolescents, Mexico*

Introduction

The notable socioeconomic inequalities in most Latin American countries, especially in Mexico[1], are largely responsible for the evident disparities in health indicators that still exist within each of them. A recent study identified differences in life expectancy at birth within six large Latin American cities (including Mexico City), differences that are due mainly to sociospatial inequalities such as socioeconomic status and education[2].

Thus, from different methodological perspectives, several studies have revealed the enormous social contrasts existing both in Mexico and in other countries and how this has affected the indicators of mortality, morbidity or health care, identifying evident disadvantages in the most marginalized populations and marking a clear inequity in access to health services, which harms the most disadvantaged sectors of society[3-6].

In the Mexican context, studies that aim to analyze the relationship between marginalization and youth mortality have been scarce. In general, studies have focused more on examining the impact of marginalization and poverty on certain aspects of adolescent and youth health[7,8], such as adolescent fertility for example[9], than on analyzing mortality[10]. In a country with 32 million young people between 15 and 29 years of age, studying these aspects would seem vital[11]. Young people are a critical population in which social inequalities can grow larger or narrow and, obviously, have a strong impact on health. Life trajectories[12] often intersect and are hindered by a set of social circumstances that prevent young people from finding the right conditions for their development[1], impacting their health and life goals.

In Mexico, one approach to the study of social inequalities from a sociospatial perspective is the analysis of marginalization, both at the state and municipal levels. Mexico's National Population Council (CONAPO)[13] has defined marginalization as a multidimensional structural phenomenon that implicitly leads to unequal access of the population to socioeconomic development and exclusion from the enjoyment of its benefits[14]. As such, it would follow that large geographic areas in the country that are highly marginalized, vulnerable and, therefore, highly deprived would exhibit notable health inequities, that is, systematic, avoidable and markedly unfair differences among the different areas of the country[15].

In turn, in the last two decades, there have been significant changes in the health system (such as the implementation of the "people's insurance" to care for the population without social security)[16], along with an intensification of the neoliberal model that has, in the last few years, driven the economic and social climate of the country, reflected in the growing economic inequality – one of the highest in the world[17] – and, in the specific case of health, in the failing of public services[16]. In this context, it has become important to compare juvenile mortality at two points in time.

In this sense, the aim of the present study is to determine the existing differences in juvenile mortality patterns in Mexico based on selected causes by sex and extreme levels of municipal marginalization in two triennia (2004-2006 and 2015-2017) and to establish a possible relationship between the differences found, the social environment and the availability of resources and health services.

Methods

This is an observational, cross-sectional and descriptive study based on secondary sources of information. Both national and municipal mortality and population data for the six years analyzed were obtained from official databases: mortality data from the General Directorate of Health Information of the Ministry of Health (DGIS)[18] and population data from CONAPO[19]. In particular, the selected causes of death (most of them considered among the main causes of death for both the general population and the juvenile population)[18] were classified based on the International Classification of Diseases (ICD-10): homicides (X85–Y09, Y87.1), motor-vehicle-traffic-injuries (MVTI) [V02-V04 (.1, .9), V09.2-V09.3, V09.9, V12-V14 (.3-.9), V19.4-V19.6,V20-V28 (.3- .9), V29-V79 (.4-.9), V80.3-V80.5, V81.1, V82.1, V83-V86(.0-.3), V87.0-V87.8, V89.2, V89.9], suicide (X60-X84, Y87,0), acute lower respiratory infections (J10-J22), diabetes mellitus (E10-E14), ischemic heart disease (I20-I25), leukemia (C91-C95), HIV/AIDS (B20-B24), alcohol use (F10), cerebrovascular diseases (I60-I69), protein-calorie malnutrition (E43-E46), anemias (D50-D59), intestinal infectious diseases (A01-A09), liver cirrhosis (K70-K76) and chronic obstructive pulmonary disease (COPD) (J40-J44).

Based on the definition provided by the Mexican Institute of Youth[20], this study recognizes the youth population as those who are between 15 and 29 years of age; this age range considers de-

mographic changes, particularly the aging of the population, and social experiences by the Mexican population in recent decades.

Information on the level of municipal marginalization was obtained from CONAPO[13], which, in 1990, developed a marginalization index based on nine indicators; the index is updated every 5 years. These indicators (illiteracy, population with incomplete primary education, overcrowding, private houses without sewage systems, without electricity, without piped water or with a dirt floor, employed population that receives less than two minimum wages and population in localities with less than 5000 inhabitants) reflect deficiencies in four dimensions (education, housing, monetary income and population distribution). Based on the index developed, CONAPO classifies municipalities – and states – into five categories: very high, high, medium, low and very low marginalization. For practical reasons, this study decided to work only with two categories of marginalization, combining high or very high marginalization (HaVHMA) and low and very low marginalization (LaVLMA).

In 2015, Mexico was administratively divided into 32 states and 2,457 municipalities (2,454 in 2005), whose economic and social development is notoriously different. Based on CONAPO criteria[21], 1,100 of these municipalities were classified in 2015 as HaVHMA (1251 in 2005); 95% of the HaVHMA municipalities in 2015 (1050) had the same classification in 2005; 515 met the criteria for medium marginalization (502 in 2005); and 842 met the criteria for LaVLMA (701 in 2005). A total of 674 LaVLMA municipalities in 2015 (80%) had the same classification in 2005. Given that a large majority of the municipalities remained in the same marginalized condition in both triennia, a comparison between the two selected moments seemed appropriate.

For the mortality analysis, the method used by Arriaga, which has been used by various authors and is described in detail in the literature[22-24], was utilized. This method involves calculating an index that represents the difference between the maximum possible years that one may live between two ages and the years actually lived; in other words, the number of years that are not lived – called by Arriaga as years of life lost (YLL), which in practice is a measure of the potential impact that a reduction in mortality due to a certain cause would have on life expectancy at birth or at a particular age[22].

With the existing data on deaths and population, abbreviated mortality tables for both sexes were constructed, both at the national level and for the two categories of municipalities created (HaVHMA and LaVLMA) in the selected triennia, using the program EPIDAT v3.1[25]. The choice of triennia was due to the availability of information. The time frame 2015-2017 was the most recent triennium for which data, based on the 2015 intercensal survey[26], were available to carry out the analysis, allowing for reliable and updated estimates of the municipal population for the selected triennium[11]; 2004-2006 was the triennium with the most information in the previous decade because the National Population and Housing Count was carried out in 2005, allowing possible changes to be seen in a reasonable period of time.

From the mortality tables and based on the mentioned method, the following were calculated using the program EPIDAT v3.1[25]: temporary life expectancy (TLE) between 0 and 85 years and the YLL between the two ages (in general, for each selected cause and by age group in each triennium, for each sex) as well as the YLL between ages 15 and 85, 20 and 85 and 25 and 85 years, constituting subset of the total YLL between 0 and 85 years. The latter can be considered a refined and robust indicator of both cause-related juvenile mortality in the analyzed triennia and the change in mortality observed between the two moments.

In addition, for each triennium, ratios were calculated by dividing the YLL (total and 15 to 29 years, by cause) for the grouped HaVHMA municipalities by those for LaVLMA municipalities, aiming to determine whether mortality is higher in HaVHMA municipalities.

The data on health resources for 2005 and 2016 were also obtained from official DGIS databases[27], but only at the state level; therefore, the 32 states in the country were organized into four quartiles, where quartile I included the eight states with the lowest level of marginalization and quartile IV included the eight states with the highest level of marginalization. Likewise, information on the characteristics of the municipalities – referenced by the dates for which there is information, 2005 and 2015 – was obtained from CONAPO databases[24]. As in the mortality analysis, ratios were used to measure the differences between the extreme groups in terms of health resources (state level) and in terms of the characteristics of HaVHMA and LaVLMA municipalities.

The research protocol "Mortality and Fecundity in Jalisco and Mexico", from which this study was derived, was approved by the Center

for Studies in Health, Population and Human Development of the University of Guadalajara (approval code: SyP- 2015-002). The project complies with the Declaration of Helsinki as well as with the ethical guidelines set forth in the Regulations of the General Health Law in the field of health research in Mexico. This study was considered "risk-free research", as it only analyzed secondary (protected) data, using documentary research techniques and methods that do not affect any individual.

Results

The figures presented in Table 1 indicate that the Mexican population increased by almost 21 million inhabitants between 2004-2006 and 2015-2017, reaching 122 million inhabitants in the second triennium. Similarly, the population residing in LaVLMA municipalities increased by 21 million, and in the second triennium, the inhabitants of municipalities in this condition represented approximately three-quarters of the total population of the country. In contrast, the population living in HaVHMA municipalities decreased slightly between the two triennia, representing only 14% of the total national population in 2015-2017; however, the fact that more than 16 million people were living in highly marginalized municipalities is undoubtedly relevant.

As also seen in Table 1, while at the national level – especially in LaVLMA municipalities – there was an increase in TLE for both sexes (more marked in females), in HaVHMA municipalities, the TLE decreased significantly between the two triennia: almost two years for men and one year for women.

Table 2 provides the socioeconomic characteristics of the municipalities for 2005 and 2015 based on their level of social marginalization, emphasizing, to the extent possible, the situation of young people.

First, in 2015, the proportion of the youth population in HaVHMA municipalities was somewhat higher than that in LaVLMA municipalities. Likewise, the proportion of the youth population without social security in HaVHMA municipalities (approximately 90%) was 80% higher than that in LaVLMA municipalities for both triennia. The percentage of women aged 15 to 19 years with incomplete primary education in HaVHMA municipalities was more than triple that in LaVLMA municipalities in the two triennia analyzed, and the proportion of young

Table 1. Temporary life expectancy (TLE) between 0 and 85 years and absolute change between the two triennia: Average annual population and average annual deaths in each triennium, by sex. Mexico, municipalities with high and very high marginalization and low and very low marginalization, 2004-2006 and 2015-2017.

	Males	Females
	High and very high marginalization	
TLE 2004-2006	71,03	74,89
TLE 2015-2017	69,05	73,87
Absolute change	-1,98	-1,02
Average annual population (2004-2006)	8225543	8628305
Average annual deaths (2004-2006)	45720	34806
Average annual population (2015-2017)	8200253	8551283
Average annual deaths (2015-2017)	63285	50084
	Low and very low marginalization	
TLE 2004-2006	71,10	75,21
TLE 2015-2017	71,67	76,30
Absolute change	0,57	1,09
Average annual population (2004-2006)	35014849	36961508
Average annual deaths (2004-2006)	187924	155503
Average annual population (2015-2017)	45351704	47672067
Average annual deaths (2015-2017)	265873	212771
	Mexico	
TLE 2004-2006	71,07	75,18
TLE 2015-2017	71,26	75,81
Absolute change	0,19	0,63
Average annual population (2004-2006)	49328900	51991852
Average annual deaths (2004-2006)	280913	227128
Average annual population (2015-2017)	59640464	62625390
Average annual deaths (2015-2017)	376428	299674

Source: Own elaboration based on study results.

people who were already married or had partners at this age increased in HaVHMA municipalities and decreased in LaVLMA municipalities, thereby widening the gap between them.

Overall, the data reflect – at both moments – contrasting social profiles for the two groups

of municipalities, profiles that were maintained (or even increased) over time. The population in HaVHMA municipalities lived mostly in small towns (many of them rural) and in houses that lacked basic services, such as piped water, more than two-thirds of the households had very low incomes, and more than one-third of the inhabitants 15 years of age or older did not complete primary education. In contrast, in the LaVLMA municipalities, the characteristics indicate that in general, the resident population had better living conditions.

As seen in Table 3, for 2004-2006, the causes associated with the highest YLL for the male population in HaVHMA municipalities were cirrhosis, diabetes and homicide (in that order), while for young people from 15 to 29 years of age, the causes were homicide, MVTI and suicide. In LaVLMA municipalities, for all males, the causes associated with the highest YLL were diabe-

tes, ischemic heart disease and cirrhosis, while for those who were 15 to 29 years of age, MVTI, homicide and suicide were the causes associated with the highest YLL.

A similar trend was observed for the 2015-2017 triennium, although with some repositioning: in HaVHMA municipalities, diabetes, cirrhosis and homicide (in that order) were the main causes of YLL for males in general, but for young people 15 to 29 years of age, the main causes were homicide, MVTI and suicide. In LaVLMA municipalities, for the male population, the causes associated with the highest YLL were diabetes, ischemic heart disease and homicide, while for those who were 15 to 29 years of age, homicide, MVTI and suicide were the cause associated with the highest YLL.

In HaVHMA municipalities, for residents who were 15 to 29 years of age, YLL increased for seven of the 15 causes: the YLL for ischemic heart

Table 2. Socioeconomic characteristics of the population (in percentage) based on the level of marginalization; Ratio of municipalities with high and very high marginalization/municipalities with low and very low marginalization. Mexico, 2005 and 2015.

2005	**High and very high (HVH)**	**Low and very low (LVL)**	**Ratio HVH/ LVL**
Percentage of young people between 15 and 29 years among the total population	25,75	27,44	0,94
Percentage of young people between 15 and 29 years without social security	91,42	50,37	1,81
Percentage of women between 15 and 19 years of age who did not complete primary school	9,51	2,62	3,63
Percentage of women between 15 and 19 years who were married or had a partner	17,63	14,12	1,25
Percentage of houses without piped water	31,03	4,58	6,77
Percentage of inhabitants >14 years who did not complete primary school	47,38	16,40	2,89
Percentage of households with an income <2 minimum wages*	75,42	36,65	2,06
Percentage of the population residing in localities >5000 inhabitants	81,22	12,44	6,53
2015	**High and very high (HVH)**	**Low and very low (LVL)**	**Ratio HVH/ LVL**
Percentage of young people between 15 and 29 years among the total population	28,24	25,49	1,11
Percentage of young people between 15 and 29 years without social security	91,56	50,41	1,82
Percentage of women between 15 and 19 years of age who did not complete primary school	6,03	1,88	3,21
Percentage of women between 15 and 19 years who were married or had a partner	19,11	13,53	1,41
Percentage of houses without piped water	17,35	2,85	6,09
Percentage of inhabitants >14 years who did not complete primary school	36,95	12,03	3,07
Percentage of households with an income <2 minimum wages*	65,88	32,60	2,02
Percentage of the population residing in localities >5000 inhabitants	80,65	14,91	5,41

*2 minimum wages = 8 USD per day approximately in both years.

Fuente: Consejo Nacional de Población (CONAPO). Índice de marginación por entidad federativa y municipio 1990-2015. Available from: https://www.gob.mx/conapo/documentos/indice-de-marginacion-por-entidad-federativa-y-municipio-2015 [cited 2020 Aug 15].

Table 3. Years of life lost (YLL) by males between 0 and 85 years, total and 15 to 29 years of age, based on selected causes and level of municipal marginalization; ratio of YLL for males in municipalities with high and very high marginalization/YLL for males in municipalities with low and very low marginalization. Mexico, 2004-2006 and 2015-2017.

2004-2006	High and very high (HVH)		Low and very low (LVL)		ratio HVH total/LVL	ratio HVH 15-29/LVL
	Total	15 a 29	Total	15 a 29	total	15-29
Homicide	0,9102	0,3052	0,5140	0,2005	1,77	1,52
Protein-calorie malnutrition	0,2127	0,0134	0,1037	0,0053	2,05	2,53
Motor-vehicle-traffic-injuries	0,5343	0,2180	0,5345	0,2264	1,00	0,96
Diabetes Mellitus	0,9881	0,0216	1,8498	0,0157	0,53	1,38
Ischemic heart disease	0,8198	0,0281	1,4262	0,0238	0,57	1,18
Anemia	0,1173	0,0142	0,0475	0,0051	2,47	2,78
Intestinal infectious diseases	0,2544	0,0179	0,0757	0,0025	3,36	7,16
HIV/AIDS	0,1988	0,0662	0,2896	0,0605	0,69	1,09
Liver cirrhosis	1,8348	0,0608	1,1345	0,0232	1,62	2,62
Alcohol use	0,4583	0,0341	0,1404	0,0088	3,26	3,88
Cerebrovascular diseases	0,4902	0,0161	0,5315	0,0125	0,92	1,29
Leukemia	0,1154	0,0311	0,1233	0,0275	0,94	1,13
COPD	0,2655	0,0036	0,3563	0,0026	0,75	1,38
Suicide	0,2127	0,0979	0,2377	0,1019	0,89	0,96
Acute lower respirat. infections	0,3816	0,0267	0,3195	0,0164	1,19	1,63
Rest of causes	6,1724	0,7787	6,2170	0,5738	0,99	1,36
YLL total	13,9662	1,7337	13,9012	1,3064	1,00	1,33
2015-2017						
Homicide	1,4287	0,4953	1,1376	0,4885	1,26	1,01
Protein-calorie malnutrition	0,1530	0,0105	0,0590	0,0041	2,59	2,56
Motor-vehicle-traffic-injuries	0,6327	0,2669	0,4286	0,1853	1,48	1,44
Diabetes Mellitus	1,7886	0,0263	1,7906	0,0151	1,00	1,74
Ischemic heart disease	1,3966	0,0583	1,4973	0,0354	0,93	1,65
Anemia	0,0928	0,0104	0,0371	0,0038	2,50	2,74
Intestinal infectious diseases	0,1602	0,0115	0,0507	0,0021	3,16	5,48
HIV/AIDS	0,1718	0,0473	0,2057	0,0468	0,84	1,01
Liver cirrhosis	1,7414	0,0497	0,8784	0,0167	1,98	2,98
Alcohol use	0,2692	0,0189	0,0858	0,0035	3,14	5,40
Cerebrovascular diseases	0,5219	0,0156	0,4541	0,0138	1,15	1,13
Leukemia	0,1356	0,0325	0,1100	0,0279	1,23	1,16
COPD	0,2621	0,0031	0,2637	0,0016	0,99	1,94
Suicide	0,2803	0,1240	0,2674	0,1183	1,05	1,05
Acute lower respirat. infections	0,4239	0,0311	0,3643	0,0248	1,16	1,25
Rest of causes	6,4941	0,6637	5,7035	0,5081	1,14	1,31
YLL total	15,9530	1,8651	13,3337	1,4956	1,20	1,25

Source: Own elaboration based on study results.

diseases doubled between the two triennia, while the YLL due to homicides, suicides and diabetes also significantly increased. In LaVLMA municipalities, for residents who were 15 to 29 years of age, the YLL decreased for nine causes (cirrhosis, diabetes and MVTI among them), with homicides being the cause in which the YLL increased

the most, more doubling from 2004-2006 to 2015-2017.

When comparing the number of YLLs by cause between HaVHMA and LaVLMA municipalities, for residents who were 15 to 29 years of age, an excess of YLLs was observed for HaVH-MA municipalities; in addition to intestinal in-

fectious diseases, which caused two times more YLLs in HaVHMA municipalities than in LaVL-MA municipalities, protein-calorie malnutrition, anemia and cirrhosis also presented a significant excess of YLLs. Only suicide and MVTI had ratios lower than one; that is, the number of YLLs was higher in LaVLMA municipalities.

When conducting a similar comparison for the 2015-2017 triennium, the calculated ratios showed that for all 15 cause, for residents who were 15 to 29 years of age, YLL was higher in HaVHMA municipalities than in LaVLMA municipalities. In addition to infectious intestinal diseases and alcohol use, which caused more than five times more YLLs in HaVHMA municipalities than in LaVLMA municipalities, protein-calorie malnutrition and anemia also presented a significant excess of YLLs. Diabetes and ischemic heart disease, but not homicides, also had relatively high ratios.

In addition, in nine of the 15 causes, in 2015-2017, compared with 2004-2006, there was a greater excess of YLLs in HaVHMA municipalities than in LaVLMA municipalities. For example, the excess YLLs for diabetes in 2004-2006 was 44%, increasing to 74% in 2015-2017. In addition, in both triennia, the total number of YLLs for young people in HaVHMA municipalities was higher than that for young people in LaVL-MA municipalities (33% higher in 2004-2006 and 25% higher in 2015-2017).

For women (Table 4), the analysis of YLL based on the level of marginalization is largely similar. While the causes associated with the highest YLL in 2004-2006 in HaVHMA municipalities for the general female population were diabetes, ischemic heart disease and cirrhosis (in that order), for young people 15 to 29 years of age, MVTI, homicide and suicide were the causes associated with the highest YLL. In LaVLMA municipalities, for all women, the causes associated with the highest YLL were diabetes, ischemic heart disease and cerebrovascular disease, while for females 15 to 29 years of age, MVTI, homicide and suicide were the causes associated with the highest YLL.

In 2015-2017, a similar trend was observed, with some repositioning. In HaVHMA municipalities, diabetes, ischemic heart diseases and cirrhosis (in that order) caused the highest YLL for all women, with diabetes alone causing the loss of more than 2 years of life expectancy; however, for females 15 to 29 years of age, homicide, suicide and MVTI were the causes associated with the highest YLL. In LaVLMA municipalities, for

the total female population, the causes associated with the highest YLL were diabetes, ischemic heart disease and cerebrovascular diseases, while for females 15 to 29 years of age, homicide, MVTI and suicide were the causes associated with the highest YLL.

In HaVHMA municipalities, for females 15 to 29 years of age, an increase in YLL was observed for five causes: the YLL for homicides almost doubled between the two triennia, and the YLL due to suicide, ischemic heart diseases and diabetes also increased significantly. In LaVLMA municipalities, for females 15 to 29 years of age, the YLL decreased for 11 causes (diabetes and MVTI among them), with the YLL for homicide increasing the most, more than doubling from 2004-2006 to 2015-2017.

The ratios calculated to compare the number of YLLs by cause between HaVHMA municipalities and LaVLMA municipalities indicated that in 2004-2006, for females 15 to 29 years of age, for 13 of 15 causes, an excess of YLLs was observed in HaVHMAmunicipalities. Intestinal infectious diseases accounted for almost eight times more YLLs in HaVHMA municipalities than in LaVLMA municipalities, and protein-calorie malnutrition, anemia and cirrhosis also higher, accounting for three times the number of YLLs in LaVLMA municipalities. Only homicide and MVTI had ratios lower than one; that is, the number of YLLs was higher in LaVLMA municipalities.

For the 2015-2017 triennium, for young females, for 13 of the 15 causes, an excess of YLLs was observed in HaVHMA municipalities relative to those in LaVLMA municipalities, with infectious intestinal diseases, alcohol use and protein-calorie malnutrition as the causes with the highest ratios.

Likewise, for six of the 15 causes, in 2015-2017, compared with 2004-2006, there was an excess of YLL in HaVHMA municipalities relative to LaVLMA municipalities. For example, for diabetes, there was a 12% excess of YLL in 2004-2006, increasing to 78% in 2015-2017. Finally, the total number of YLLs per 15 to 29-year-old female in HaVHMA municipalities was higher than that in LaVLMA municipalities in the two triennia (40% higher in 2004-2006 and 34% higher in 2015-2017).

Finally, Table 5 provides data regarding how human and material resources and health services are distributed in the country, based on the degree of state marginalization, for the central years of the two triennia. The 32 states were ar-

Table 4. Years of life lost (YLL) by females between 0 and 85 years, total and 15 to 29 years of age, based on selected causes and level of municipal marginalization; ratio of YLL for females in municipalities with high and very high marginalization/YLL for females in municipalities with low and very low marginalization. Mexico, 2004-2006 and 2015-2017.

2004-2006	AHigh and very high (HVH)		Low and very low (LVL)		ratio HVH total/LVL total	ratio HVH 15-29/LVL 15-29
	Total	15 a 29	Total	15 a 29		
Homicide	0,0937	0,0265	0,0776	0,0285	1,21	0,93
Protein-calorie malnutrition	0,2160	0,0100	0,0721	0,0030	3,00	3,33
Motor-vehicle-traffic-injuries	0,1293	0,0392	0,1498	0,0501	0,86	0,78
Diabetes Mellitus	1,3212	0,0182	1,9354	0,0162	0,68	1,12
Ischemic heart disease	0,6142	0,0133	0,8033	0,0068	0,76	1,96
Anemia	0,1402	0,0136	0,0502	0,0046	2,79	2,96
Intestinal infectious diseases	0,2347	0,0139	0,0655	0,0016	3,58	8,69
HIV/AIDS	0,0488	0,0181	0,0533	0,0129	0,92	1,40
Liver cirrhosis	0,5293	0,0128	0,3234	0,0040	1,64	3,20
Alcohol use	0,0295	0,0015	0,0055	0,0004	5,36	3,75
Cerebrovascular diseases	0,5108	0,0140	0,5049	0,0091	1,01	1,54
Leukemia	0,1004	0,0236	0,1070	0,0189	0,94	1,25
COPD	0,2520	0,0031	0,2342	0,0013	1,08	2,38
Suicide	0,0460	0,0257	0,0452	0,0216	1,02	1,19
Acute lower respirat. infections	0,3186	0,0143	0,2268	0,0086	1,40	1,66
Rest of causes	5,5267	0,4137	5,1268	0,2859	1,08	1,45
YLL total	10,1114	0,6614	9,7810	0,4736	1,03	1,40
2015-2017						
Homicide	0,1459	0,0502	0,1454	0,0636	1,00	0,79
Protein-calorie malnutrition	0,1610	0,0094	0,0404	0,0023	3,99	4,09
Motor-vehicle-traffic-injuries	0,1284	0,0359	0,1108	0,0397	1,16	0,90
Diabetes Mellitus	2,0886	0,0262	1,5885	0,0147	1,31	1,78
Ischemic heart disease	0,9240	0,0197	0,7832	0,0094	1,18	2,10
Anemia	0,0951	0,0077	0,0324	0,0029	2,94	2,66
Intestinal infectious diseases	0,1540	0,0081	0,0526	0,0014	2,93	5,79
HIV/AIDS	0,0429	0,0094	0,0416	0,0079	1,03	1,19
Liver cirrhosis	0,5342	0,0091	0,2548	0,0031	2,10	2,94
Alcohol use	0,0158	0,0007	0,0036	0,0002	4,39	3,50
Cerebrovascular diseases	0,5234	0,0101	0,3772	0,0081	1,39	1,25
Leukemia	0,1272	0,0226	0,0921	0,0177	1,38	1,28
COPD	0,2869	0,0019	0,1870	0,0012	1,53	1,58
Suicide	0,0751	0,0403	0,0644	0,0322	1,17	1,25
Acute lower respirat. infections	0,3457	0,0211	0,2382	0,0121	1,46	1,74
Rest of causes	5,4780	0,3624	4,6866	0,2562	1,17	1,41
YLL total	11,1272	0,6352	8,6987	0,4730	1,28	1,34

Source: Own elaboration based on study results.

ranged into quartiles, with quartile I comprising the eight states with the lowest marginalization (including states such as Mexico City, Nuevo León or Baja California; the same states coincide in both years) and quartile IV comprising the eight states with the highest marginalization index (among them, Chiapas, Oaxaca and Guerrero, with only one change between the two years studied).

Although several of the indicators for the states with the highest marginalization (quartile IV) in 2016 improved with respect to 2005

(increased public spending on health, number of hospital beds, doctors and registered nurses, among others), there were still significant deficits in terms of medical specialists and nurses per doctor, and notable disparities persist between states with extreme marginalization.

In this sense, in 2016, public spending on health in the states in quartile I was still 68% higher than that in the states in quartile IV, and this finding is reflected in other indicators, which are more favorable in states with less marginalized than in those with the highest marginalization.

Discussion

Although people today are living longer[28], "…there is still a considerable gap between rich and poor: people in high-income countries are still much more likely to live longer than people from low-income countries"[29].

This gap is more evident within nations that, like Mexico, have large socioeconomic disparities. In this sense, the present study has highlighted relevant aspects such as those cited below.

The TLE between 0 and 85 years for both sexes was higher in the two triennia studied in the LaVLMA municipalities than in the HaVHMA municipalities. In the latter group, the TLE was lower in 2015-2017 than in 2004-2006 for both sexes (especially men).

The total number of YLLs due to juvenile mortality, for both sexes and in both triennia, was higher – at least 25% more – in HaVHMA municipalities than in LaVLMA municipalities (a higher proportion than that of the general population).

Males 15 to 29 years of age in HaVHMA municipalities had an excess of YLLs in relation to those in LaVLMA municipalities in 13 of the 15 causes analyzed in 2004-2006 and in all causes in 2015-2017; for females, an excess of YLLs was observed for 13 of 15 causes in each triennium.

Compared to the previous triennium, in 2015-2017, for nine of the 15 causes, the number of YLLs increased for males 15 to 29 years of age in HaVHMA municipalities in relation to LaVLMA municipalities; for young females, the number of YLLs increase for six causes.

In HaVHMA municipalities, the proportion of young people between 15 and 29 years old increased and was higher than that in LaVLMA municipalities, but the social security coverage of this population is 80% lower, and their educational lag is greater.

In general, there is a noticeable contrast between the socioeconomic characteristics and profile of the population – particularly the youth – of LaVLMA municipalities with respect to

Table 5. Indicators of human and material health resources based on the level of marginalization and Quartile I (lowest marginalization)/Quartile IV (highest marginalization) ratio. Mexico, 2005 and 2016.

Indicators 2005	I	II	III	IV	Ratio I/IV
Hospital beds census per 10,000 inhabitants	4,27	2,86	2,88	2,85	1,50
Medical doctors in contact with patients per 10,000 inhabitants	5,65	3,06	4,41	3,79	1,49
Medical specialists per each general practitioner	2,92	1,21	0,87	0,71	4,11
Registered nurses per 10,000 inhabitants	6,17	3,26	4,43	3,80	1,62
Nurses per doctor	1,09	1,06	1,01	1,00	1,09
Public spending on health per capita (in Mexican pesos)*	3479	1717	2007	1660	2,10
Indicators 2016	**I**	**II**	**III**	**IV**	**Ratio I/IV**
Hospital beds census per 10,000 inhabitants	3,89	2,77	3,37	3,09	1,26
Medical doctors in contact with patients per 10,000 inhabitants	7,22	5,79	7,11	6,71	1,08
Medical specialists per each general practitioner	2,48	1,17	0,81	0,77	3,22
Registered nurses per 10,000 inhabitants	8,05	6,56	8,01	6,48	1,24
Nurses per doctor	1,13	1,11	1,04	0,97	1,16
Public spending on health per capita (in Mexican pesos)*	6496	4585	4327	3861	1,68

*1USD=11 Mexican pesos in 2005/1USD=18 Mexican pesos in 2016, approximately.

Source: Dirección General de Información en Salud (DGIS). Base de datos de Recursos en Salud. Cubos Dinámicos. Available from: http://sinerhias.salud.gob.mx/cubos/sinerhias/recursos_2001_2018_sinerhias.htm [cited 2020 Aug 15].

HaVHMA municipalities, putting the latter at a clear social disadvantage. Likewise, public spending on health and available health resources, such as specialists, nurses, and beds, though improved, continue to be much lower in the most marginalized states, where they are most needed.

The aforementioned findings strongly point to the existence not only of higher youth mortality in HaVHMA municipalities relative to LaVLMA municipalities but also to a larger gap that separates these municipality types in terms of juvenile mortality, a situation that manifests itself more markedly than that observed for the general population.

It is in this scenario that some results of this research should be evaluated more carefully. First, importantly, violent deaths (homicides, suicides, and MVTI), essentially preventable causes, are the main causes of death in young women and men throughout Mexico – regardless of the level of marginalization – and increased substantially in the triennia studied. In particular, among males, homicides caused the loss of almost half a year of life expectancy in each municipality type in 2015-2017, and the reduction in increased mortality observed in HaVHMA municipalities between the two five-year periods – or even the higher excess mortality of females residing in LaVLMA municipalities – seems to be associated with the "urbanization of violence"[30,31], a result of drug cartels and the struggle for controlling plazas in the cities of the country, which has caused an increase in homicide mortality in LaVLMA municipalities.

The lack of employment or the precariousness of it, the lack of sufficient places to access higher education, or daily coexistence with violent behavior are factors associated with young people being victims of homicide, a situation that is accentuated in the most marginalized communities, in which a young person is more likely to neither study nor work[12,31]. Many of these aspects are also related to the increase in suicide mortality in young people of both sexes, more marked in residents in HaVHMA municipalities.

Other preventable causes, such as intestinal infectious diseases, protein-calorie malnutrition and anemia, although their mortality has decreased in HaVHMA municipalities, still occur in significant excess relative to that in LaVLMA municipalities. That excess – for some causes – has even increased, given that the decrease in these causes in LaVLMA municipalities has been greater. Malnutrition problems, much more prevalent in the most marginalized communities[32] – associated with a lack of economic resources to reverse this situation – and the previously documented disadvantages in terms of education and access to health services[5] make this excess mortality unjust and unacceptable because at present, these causes should not, in practice, cause deaths - and reflects the vulnerability of the youth population living in highly marginalized areas.

Unlike potentially preventable causes, mortality from chronic degenerative diseases – diabetes and ischemic heart disease, in particular – has increased in HaVHMA municipalities and, coincidentally, has decreased (or not increased as much) in LaVLMA municipalities, explaining the excess mortality in 2015-2017 that almost did not exist in 2004-2006. Even when these causes are not currently the most relevant with respect to juvenile mortality, their greater growth in HaVHMA municipalities shows, above all, a greater acceleration in the increase in overweight and obesity in the most marginalized population[32] and, in particular, in the rural adolescent population (which lives mostly in HaVHMA municipalities)[33]. The impact of junk food on changes in the eating habits of children and adolescents in marginalized rural communities of the country[8] and the prevalence of diets in which foods with high caloric content predominate[7] have been documented, and these are more accessible to low-income families, such as those in HaVHMA municipalities.

Leukemia deserves a special mention. The upward trend in cancer mortality – especially leukemia – was documented in Mexican adolescents between 1990 and 2009 in HaVHMA states[10]; this cause also presents in women and young men residing in HaVHMA municipalities, with YLL values higher than those for young people living in LaVLMA municipalities, an excess that increased in the period analyzed. Even when improvements in the quality of records may have influenced the increase in the numbers for the most marginalized areas, socioeconomic disadvantages and access to health services (insurance excludes care for most of the high-cost diseases, whose treatment would have to be paid by the patient, and in particular does not include the treatment of leukemias in people over 18 years of age)[16,34] are undoubtedly hindering the successful treatment and survival of young people who suffer from this disease.

To address – and try to reverse – this inequitable situation in health and respond to the growing demands of the youth population, profound structural changes are needed to promote

social and economic development (decent jobs, access to higher education), to strengthen the health and social security systems - and implement true universal health and social protection systems[35] – and to reduce the unjust disadvantages to which important population centers of the country are exposed, especially those in HaVHMA municipalities. In this sense, social policies – which mostly do not address the youth population or, in the best of cases, consider it the recipient of welfare actions[1] – should make young people protagonists and provide them with the necessary elements to change their situation, even more so for those who live in conditions of social disadvantage.

The present study may have some limitations, referring substantially to the mortality data collection. The level of underreporting of mortality may be related to socioeconomic inequalities, being generally higher in the most marginalized municipalities. This could be reflected in an underestimation of the mortality observed for the HaVHMA municipalities, potentially causing an increase in excess mortality in these municipalities with respect to those in LaVLMA municipalities. Although the coverage and quality of mortality records in Mexico has been recognized by the Pan American Health Organization as satisfactory[36], one should regard with some caution any result extracted from the mortality tables, such as TLE or YLL, as well as the comparisons made.

Although the absence of malignant tumors could be considered a limitation of the study, the inclusion of leukemia – responsible for a third of deaths from malignant tumors in the juvenile population in recent years[18] – can mitigate this situation.

Despite the limitations previously outlined, the novel approach and the results found allow determining the recent trend in cause-related juvenile mortality in Mexico, and in particular, the finding reveal the existing disparities based on the level of marginalization. The use of an indicator such as YLL adds strategic value to the analysis of changes in juvenile mortality by cause in recent years and offers decision-makers concrete evidence of persistent health inequities in the country.

Collaborations

GJ González-Pérez participated in the design and coordination of the study, data collection, statistical analysis, interpretation of the data and writing of the manuscript. MG Vega-López participated in the design of the study, data collection, analysis and interpretation of the data and writing of the manuscript. All authors reviewed and approved the final version of the article.

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