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ORIGINAL ARTICLE

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Mortality trends from congenital malformations of the heart and the great vessels in children and adults in the seven socioeconomic regions of Mexico, 2000-2015

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Abstract

Background: Congenital heart disease (CHD) represents a global health problem. In Mexico, in children <1 year of age it is the second cause of mortality. The aim was to determine mortality trends from CHD and the great vessels in children and adults nationwide, by state and socioeconomic region.

Methods: Records of mortality associated to CHD and the great vessels for 2000-2015 were obtained from the National Institute of Statistics and Geography. This information is collected from death certificates issued nationwide. International Classification of Diseases, 10th revision, codes corresponding to the basic cause of death from CHD and the great vessels. To calculate mortality rates for individuals ≥1 year of age, population counts from the national population, estimated by the National Population Council for 2000-2015, were used in the denominator; for infant mortality, live birth counts were used. Rates of mortality nationwide, by state, and by socioeconomic region were calculated. The seven socioeconomic regions were elaborated by the National Institute of Statistics and Geography and include the 31 states and Mexico City according to indicators that are related to well-being such as education, occupation, health, housing, and employment.

Results: In the period 2000-2015, 70 741 individuals among children and adults died from CHD. Age-adjusted mortality rate per 100 000 individuals increased from 3.3 to 4. In the age group <1 year of age, mortality rate per 100 000 live births increased from 143.9 to 217.3.

Conclusions: In the period 2000-2015, age-adjusted mortality rate per 100 000 individuals increased from 3.3 to 4. Mexico City as region 7 had the highest mortality from CHD and the great vessels.

KEYWORDS

congenital malformations of the heart, Mexico, mortality, socioeconomic factors

1 | INTRODUCTION

Congenital heart disease (CHD) is the most common cause of major congenital anomalies and represents a global health problem. Twenty-eight percent of all major congenital anomalies consist of heart defects.[1] In fact, CHD are the most frequent congenital malformations and has an incidence that has been estimated between 4 and 12 per 1000 live births, according to different authors, much higher in the stillborn. Cardiac malformations are the leading cause of death due to congenital anomalies in infants; a little more than 1/3 of deaths due to congenital anomalies and about 1/10 of all deaths during this period of life. However, mortality from this cause has decreased considerably in recent years, due to advances in diagnosis, surgical treatment, and postoperative care.[2]

Mortality trends from CHD vary among countries. The mortality for this disease has decreased in recent years in Canada and in 16 European countries, particularly in children <1 year of age. There was also a decrease in mortality from CHD in the United States between 1970 and 1997, which contributed to a reduction of 59% in infant mortality during this period. In contrast, the overall mortality rate for CHD in China increased 62% between 2003 and 2010.[3]

The real prevalence of CHD in Mexico is unknown; the information available on the importance and the repercussion of CHD is based on mortality rates that in 1990, it was ranked in sixth place, as cause of death in children under 1 year of age; in 2002 it was ranked in fourth place; and since 2005, CHD is the second cause of mortality. In children between 1 and 4 years old in 1990, it was ninth cause, in 2002 it passed to the third cause and has remained in that place since 2005. The total mortality from CHD of the pediatric population under 10 years old was 15 548 patients from 2004 to 2007, of which 83% corresponded to children <1 year of age.[4]

The World Bank reported that the prevalence of CHD in Mexico is on average 6 to 8 per 1000 newborns. If this value is extrapolated to the estimated national birth rate in Mexico, there would be 2 000 000 newborns per year, so it can be assumed that there are between 12 000 and 16 000 newborns with CHD per year in Mexico.[5]

In recent years, significant efforts have been made in Mexico, to reduce infant mortality among children <1 year of age; between 1990 and 2010 the infant mortality rate decreased from 24 to 11.8 per 1000 live births. However, mortality from CHD increased. In the year 2000, 2596 children <1 year of age died of CHD, which accounts for 6.7% of the total deaths in this age group. In 2008, mortality from CHD increased to 2848, which accounts for 9.6% of the total.[3]

In Mexico, there are no studies investigating mortality trends from CHD and the great vessels in children and adults nationwide, by state and socioeconomic region; the results of this study could be useful in actions aimed at the management of CHD.

The aim of this study was to determine mortality trends due to CHD and the great vessels in children and adults nationwide, by state and socioeconomic region.

2 | METHODS

An ecological study design was used. Mortality records of children and adults associated with CHD and the great vessels for 2000-2015 were obtained from the National Institute of Statistics and Geography.[6] This information is collected from death certificates issued nationwide. All individual records of mortality in which the basic cause of death was CHD and the great vessels among children and adults in the period of 2000-2015 were included in the study. The codes of the International Classification of Diseases, 10th revision, were identified.[7] They corresponded to the basic cause of death from CHD and the great vessels among children and adults (Q20.0-Q26.9).

Raw and age-adjusted mortality rates nationwide per 100 000 inhabitants were obtained, taking the world population as the standard population.[8,9] Age-adjusted mortality rates per 100 000 inhabitants from each state and from each of the seven socioeconomic regions (Table 1) established by the National Institute of Statistics and Geography, were also obtained.[10] The national population, estimated by the National Population Council for 2000-2015, was used for the rate adjustment for individuals ≥1 year of age.[11] To calculate mortality rates for infant mortality (<1 year of age), live birth counts were used in the denominator.[12]

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 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

TABLE 1 Socioeconomic regions of Mexico

Socioeconomic regions	States
1	Chiapas, Guerrero, Oaxaca
2	Campeche, Hidalgo, Puebla, San Luis Potosí, Tabasco, Veracruz
3	Durango, Guanajuato, Michoacan, Tlaxcala, Zacatecas
4	Colima, State of Mexico, Morelos, Nayarit, Querétaro, 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.

TABLE 2 Gender and age at death of children and adults who died from congenital malformations of the heart and the great vessels in México, 2000-2015

ICD 10	Congenital malformations of the circulatory system	Gender N = 70 741		Age at death N = 70 741					The minimum year at death	The maximum year at death	Median years at death
		Women n = 32 913 (46.5%)	Men n = 37 828 (53.5%)	Minutes n = 475 (0.7%)	Hours (1-23) n = 5038 (7.1%)	Days (1-29) n = 21 572 (30.5%)	Months (1-11) n = 24 405 (34.5%)	Years (≥1) n = 19 251 (27.2%)			
		n (%)	n (%)	n	n	n	n	n			
Q20	**Congenital malformations of cardiac chambers and connections**										
Q20.0	Common arterial trunk	190 (0.269)	185 (0.262)	0	1	91	228	55	1	59	3
Q20.1	Double outlet right ventricle	75 (0.106)	98 (0.139)	0	2	29	72	70	1	82	3.5
Q20.2	Double outlet left ventricle	8 (0.011)	21 (0.030)	0	0	8	12	9	1	67	2
Q20.3	Discordant ventriculoarterial connection	479 (0.677)	1013 (1.432)	4	33	683	535	237	1	78	4
Q20.4	Double inlet ventricle	390 (0.551)	579 (0.818)	0	24	288	355	302	1	95	5
Q20.5	Discordant atrioventricular connection	551 (0.779)	473 (0.669)	0	6	130	374	514	1	93	9.5
Q20.6	Isomerism of atrial appendages	10 (0.014)	10 (0.014)	0	0	6	7	7	1	76	2
Q20.8	Other congenital malformations of cardiac chambers and connections	177 (0.250)	191 (0.270)	2	10	67	134	155	1	80	5
Q20.9	Congenital malformation of cardiac chambers and connctions, unspecified	34 (0.048)	56 (0.079)	1	5	27	37	20	1	88	3
Q21	**Congenital malformations of cardiac septa**										
Q21.0	Ventricular septal defect	1335 (1.887)	1247 (1.763)	3	15	325	1062	1177	1	96	10
Q21.1	Atrial septal defect	584 (0.826)	440 (0.622)	1	4	146	345	528	1	95	34
Q21.2	Atrioventricular septal defect	537 (0.759)	481 (0.680)	3	8	129	526	352	1	88	2
Q21.3	Tetralogy of Fallot	1342 (1.897)	1541 (2.178)	2	37	342	836	1666	1	88	5
Q21.4	Aortopulmonary septal defect	23 (0.033)	17 (0.024)	1	1	10	24	4	1	76	20
Q21.8	Other congenital malformations of cardiac septa	72 (0.102)	51 (0.072)	1	6	16	19	81	1	71	23.7
Q21.9	Congenital malformation of cardiac septum, unspecified	30 (0.042)	19 (0.027)	0	4	12	16	17	1	80	30
Q22	**Congenital malformations of pulmonary and tricuspid valves**										
Q22.0	Pulmonary valve atresia	64 (0.090)	63 (0.089)	0	2	56	38	31	1	44	2
Q22.1	Congenital pulmonary valve stenosis	35 (0.049)	37 (0.052)	1	1	21	34	15	1	55	2
Q22.2	Congenital pulmonary valve insufficiency	5 (0.007)	6 (0.008)	0	0	2	6	3	8	81	10
Q22.3	Other congenital malformations of pulmonary valve	34 (0.048)	31 (0.044)	0	8	17	25	15	1	61	6
Q22.4	Congenital tricuspid stenosis	285 (0.403)	335 (0.474)	1	5	103	232	279	1	80	4
Q22.5	Ebstein's anomaly	344 (0.486)	291 (0.411)	4	33	240	98	260	1	91	21
Q22.6	Hypoplastic right heart syndrome	81 (0.115)	73 (0.103)	0	1	58	64	31	1	23	2
Q22.8	Other congenital malformations of tricuspid valve	94 (0.133)	99 (0.140)	1	7	68	79	38	1	50	8

(Continues)

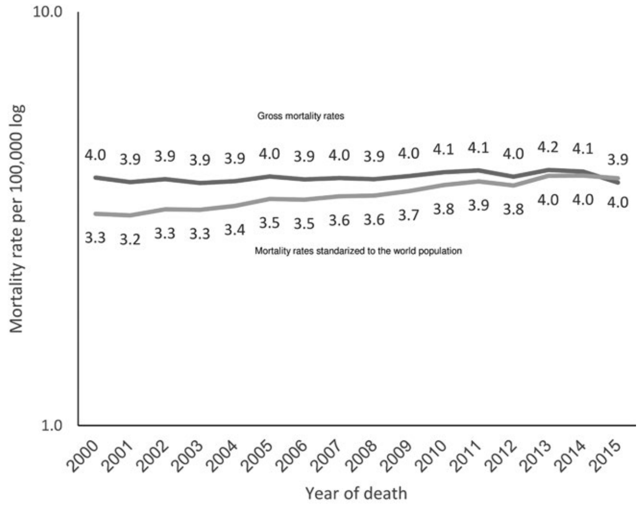
TABLE 2 (Continued)

ICD 10	Congenital malformations of the circulatory system	Gender N = 70 741		Age at death N = 70 741							
		Women n = 32 913 (46.5%)	Men n = 37 828 (53.5%)	Minutes n = 475 (0.7%)	Hours (1-23) n = 5038 (7.1%)	Days (1-29) n = 21 572 (30.5%)	Months (1-11) n = 24 405 (34.5%)	Years (≥1) n = 19 251 (27.2%)	The minimum year at death	The maximum year at death	Median years at death
		n (%)	n (%)	n	n	n	n	n			
Q22.9	Congenital malformation of tricuspid valve, unspecified	10 (0.014)	16 (0.023)	0	2	6	10	8	1	15	5.5
Q23	**Congenital malformations of aortic and mitral valves**										
Q23.0	Congenital stenosis of aortic valve	154 (0.218)	274 (0.387)	1	8	120	142	157	1	86	17
Q23.1	Congenital insufficiency of aortic valve	24 (0.034)	55 (0.078)	0	1	6	12	60	2	95	46.5
Q23.2	Congenital mitral stenosis	88 (0.124)	95 (0.134)	0	2	22	86	73	1	88	16
Q23.3	Congenital mitral insufficiency	65 (0.092)	83 (0.117)	1	3	26	61	57	1	73	13
Q23.4	Hypoplastic left heart syndrome	405 (0.573)	649 (0.917)	3	36	727	252	36	1	58	2
Q23.8	Other congenital malformations of aortic and mitral valves	10 (0.014)	17 (0.024)	0	0	8	9	10	1	58	18.5
Q23.9	Congenital malformation of aortic and mitral valves, unspecified	37 (0.052)	27 (0.038)	0	1	12	21	30	1	81	44.5
Q24	**Other congenital malformations of heart**										
Q24.0	Dextrocardia	100 (0.141)	131 (0.185)	4	33	55	70	69	1	83	13
Q24.1	Levocardia	3 (0.004)	3 (0.004)	0	0	2	2	2	1	8	4.5
Q24.2	Cor triatriatum	6 (0.008)	4 (0.006)	0	0	2	5	3	1	3	2
Q24.3	Pulmonary infundibular stenosis	10 (0.014)	11 (0.016)	0	2	5	7	7	1	23	4
Q24.4	Congenital subaortic stenosis	22 (0.031)	26 (0.037)	0	0	3	8	37	1	80	13
Q24.5	Malformation of coronary vessels	25 (0.035)	31 (0.044)	0	3	12	21	20	1	102	27.5
Q24.6	Congenital heart block	32 (0.045)	38 (0.054)	0	7	43	10	10	1	45	21.5
Q24.8	Other specified congenital malformations of heart	764 (1.080)	996 (1.408)	8	97	422	478	755	1	98	25
Q24.9	Congenital malformation of heart, unspecified	20 570 (29.078)	23 467 (33.173)	428	4542	13 828	14 858	10 381	1	104	11
Q25	**Congenital malformations of great arteries**										
Q25.0	Patent ductus arteriosus	1820 (2.573)	1783 (2.520)	2	38	1877	1170	516	1	89	8
Q25.1	Coarctation of aorta	472 (0.667)	692 (0.978)	0	9	461	445	249	1	92	20
Q25.2	Atresia of aorta	0	7 (0.010)	0	1	3	2	1	14	14	14
Q25.3	Supravalvular aortic stenosis	32 (0.045)	63 (0.089)	0	0	6	8	81	1	102	60
Q25.4	Other congenital malformations of aorta	130 (0.184)	168 (0.237)	0	4	118	96	80	1	93	31.5
Q25.5	Atresia of pulmonary artery	606 (0.857)	650 (0.919)	1	14	464	447	330	1	90	3
Q25.6	Stenosis of pulmonary artery	191 (0.270)	214 (0.303)	2	4	80	165	154	1	92	11
Q25.7	Other congenital malformations of pulmonary artery	72 (0.102)	79 (0.112)	0	8	35	63	45	1	78	5

(Continues)

TABLE 2 (Continued)

ICD 10	Congenital malformations of the circulatory system	Gender N = 70 741		Age at death N = 70 741							
		Women n = 32 913 (46.5%)	Men n = 37 828 (53.5%)	Minutes n = 475 (0.7%)	Hours (1-23) n = 5038 (7.1%)	Days (1-29) n = 21 572 (30.5%)	Months (1-11) n = 24 405 (34.5%)	Years (≥1) n = 19 251 (27.2%)	The minimum year at death	The maximum year at death	Median years at death
		n (%)	n (%)	n	n	n	n	n			
Q25.8	Other congenital malformations of other great arteries	14 (0.020)	24 (0.034)	0	0	9	16	13	1	78	3
Q25.9	Congenital malformation of great arteries, unspecified	20 (0.028)	32 (0.045)	0	1	14	15	22	1	90	39
Q26	**Congenital malformations of great veins**										
Q260	Congenital stenosis of vena cava	0	3 (0.004)	0	0	1	1	1	2	2	2
Q26.1	Persistent left superior vena cava	1 (0.001)	1 (0.001)	0	0	1	1	0	NA	NA	NA
Q26.2	Total anomalous pulmonary venous connection	150 (0.212)	261 (0.369)	0	3	112	250	46	1	36	1
Q26.3	Partial anomalous pulmonary venous connection	8 (0.011)	10 (0.014)	0	0	3	7	8	1	39	2.5
Q26.4	Anomalous pulmonary venous connection, unspecified	272 (0.385)	512 (0.724)	0	4	199	476	105	1	52	1
Q26.5	Anomalous portal venous connection	3 (0.004)	5 (0.007)	0	0	4	2	2	1	1	1
Q26.6	Portal vein-hepatic artery fistula	0	1 (0.001)	0	1	0	0	0	NA	NA	NA
Q26.8	Other congenital malformations of great veins	10 (0.014)	26 (0.037)	0	0	5	21	10	1	73	1
Q26.9	Congenital malformation of great vein, unspecified	8 (0.011)	17 (0.024)	0	1	7	10	7	1	80	19



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

FIGURE 1 Mortality from congenital malformations of the heart and the great vessels. Mexico, 2000-2015

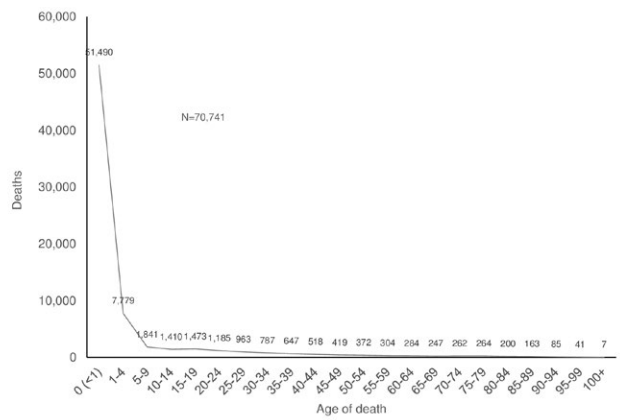


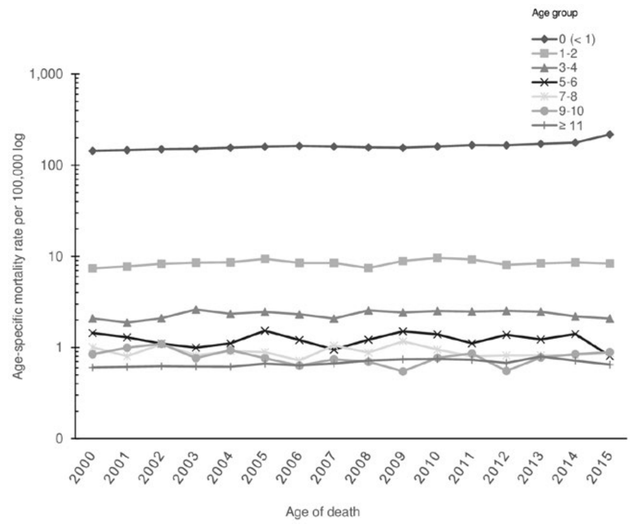
FIGURE 2 Mortality from congenital malformations of the heart and the great vessels by age group. Mexico, 2000-2015

distances and a combination of factorial analysis and the algorithm of the k-means.[10]

Registrations were handled by the Access 2013 program. The Epidat version 3.1 program was used to determine age-adjusted mortality rates by state, and socioeconomic region.[13]

3 | RESULTS

In Mexico, in the period 2000-2015, the mortality rates standardized to the world population increased from 3.3 to 4 per 100 000 individuals (Figure 1). Seventy thousand seven hundred forty-one individuals among children and adults died from CHD, 32,913 (46.5%) women and 37 828 (53.5%) men (Table 2). Children <1 year of age who died of CHD were 51 490 (72.8%) and those > 1 year of age were 19 251 (27.2%) (Figure 2).



NOTE: To calculate mortality rates for infant mortality (< 1 year of age), live birth counts were used in the denominator. To calculate mortality rates for individuals ≥ 1 year of age, the national population, estimated by the National Population Council for 2000-2015, was used in the denominator.

FIGURE 3 Mortality trends from congenital malformations of the heart and the great vessels by age group. Mexico, 2000-2015

Of the age groups analyzed, in the age groups <1 year of age, 1-2 and 9-10, the trends in mortality rates increased; while in the age groups of 5-6 and 7-8; they decreased and in the age groups of 3-4 and ≥11, the trends in mortality rates were not modified. In the age group <1 year of age, the trends in mortality rate increased from 143.9 to 217.3 per 100 000 live births (percentage of change of 51%) (Figure 3).

The five CHD that occurred most frequently in the study period were (1) Congenital malformation of the heart, unspecified (Q24.9) with 44 037 (62.3%), (2) Patent ductus arteriosus (Q25.0) with 3.603 (5.1%), (3) Tetralogy of Fallot (Q21.3) with 2883 (4.1%), (4) Ventricular septal defect (Q21.0) with 2582 (3.6%), and (5) Other malformations of the heart, specified (Q24. 8) with 1760 (2.5%) (Table 2).

The states with the highest mortality rates from CHD in the study period were Mexico City in 2000 and 2012; Queretaro in 2001; Guanajuato 2002; Puebla 2003, 2004, 2006-2008 and 2015; Tlaxcala 2005; Tabasco 2009-2011, 2013 and 2014. Mortality rates in Mexico City in the year 2000 and 2012 were 5.5, 95%CI 4.9-6 and 5.2, 95%CI 4.7-5.7, respectively; Queretaro in 2001, 6.3, 95%CI 5.1-7.5; Guanajuato in 2002, 5.4, 95%CI 4.8-6; Puebla in 2003 and 2015, 5.4, 95%CI 4.8-6 and 5.1, 95%CI 4.5-5.6, respectively; Tlaxcala 2005, 5.9, 95%CI 4.5-7.3; Tabasco 2009 and 2014, 5.9, 95%CI 4.9-6.9 and 6, 95%CI 5-7, respectively (Table 3).

The states with the lowest mortality rates in the years 2000-2015 were Guerrero 2000-2002, 2004-2005, and 2007; Durango 2003 and 2008; Nayarit 2006; Tamaulipas 2009; Sinaloa 2010; Coahuila 2011; Baja California Sur 2012 and 2014; Colima 2013; Aguascalientes 2015. In the state of Guerrero the mortality rate in the years 2000 and 2007 were 1.7, 95%CI 1.2-2.1 and 1.9, 95%CI 1.4-2.3, respectively; Durango in 2003 and 2008, 1.4, 95%CI 0.8-1.9 and 2.3, 95%CI 1.6-3, respectively; Nayarit 2006, 1.6, 95%CI 0.8-2.4; Tamaulipas 2009, 2.4, 95%CI 1.8-2.9; Sinaloa 2010, 2.7

TABLE 3 Age-adjusted mortality rate and 95% confidence interval by state of residence of people who died from congenital malformations of the heart and the great vessels Mexico, 2000-2015

State	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Aguascalientes	4.1 (2.9-5.3)	4.1 (3-5.3)	3.7 (2.6-4.7)	3.5 (2.4-4.6)	4.8 (3.5-6)	4 (2.9-5.1)	3.6 (2.6-4.7)	3.5 (2.5-4.6)	3.9 (2.8-5)	2.7 (1.8-3.6)	3.1 (2.2-4.1)	2.9 (2-3.9)	2.7 (1.8-3.6)	3.1 (2.2-4.1)	3.2 (2.2-4.1)	2.1 (1.3-2.9)
Baja California	3.5 (2.8-4.3)	4.5 (3.6-5.3)	3.7 (3-4.5)	3.6 (2.9-4.3)	3.8 (3.1-4.5)	4.5 (3.7-5.3)	3.5 (2.9-4.2)	4.3 (3.5-5)	3 (2.3-3.6)	4.3 (3.6-5)	5 (4.2-5.8)	3.4 (2.8-4.1)	3.3 (2.6-3.9)	3.1 (2.5-3.7)	3 (2.4-3.6)	2.8 (2.2-3.4)
Baja California Sur	4.8 (2.8-6.8)	3.8 (2.1-5.6)	2.4 (1.1-3.8)	2.7 (1.3-4.2)	3.8 (2.1-5.4)	3.5 (1.9-5.1)	3.4 (1.9-4.9)	3.2 (1.8-4.7)	3.7 (2.2-5.3)	3.5 (2-4.9)	3.4 (2-4.9)	3 (1.7-4.3)	2.4 (1.2-3.5)	2 (0.9-3)	2.7 (1.5-3.9)	3 (1.8-4.2)
Campeche	3 (1.7-4.3)	3.9 (2.4-5.3)	3.9 (2.4-5.3)	4.7 (3.1-6.3)	3.9 (2.4-5.3)	4.1 (2.6-5.6)	3.6 (2.2-4.9)	2.5 (1.4-3.6)	2.7 (1.5-3.8)	3.6 (2.3-4.9)	4.3 (2.9-5.7)	3 (1.8-4.2)	3.9 (2.5-5.2)	5.5 (3.9-7)	4 (2.7-5.3)	4 (2.7-5.3)
Chiapas	2 (1.6-2.4)	2.2 (1.8-2.6)	2.4 (2-2.9)	2.4 (2-2.9)	2.6 (2.1-3)	2.7 (2.3-3.2)	2.4 (2-2.8)	2.7 (2.2-3.1)	3.1 (2.6-3.6)	3 (2.5-3.5)	3.5 (3-4)	4 (3.5-4.5)	3.9 (3.4-4.5)	4.5 (3.9-5)	3.8 (3.3-4.3)	4.1 (3.6-4.7)
Chihuahua	3.3 (2.7-4)	3.7 (3-4.3)	3.3 (2.6-3.9)	2.6 (2-3.1)	2.8 (2.2-3.4)	3.3 (2.7-4)	3.7 (3.1-4.4)	3.7 (3-4.3)	3.2 (2.6-3.8)	3.8 (3.1-4.4)	3.2 (2.6-3.8)	3.9 (3.2-4.5)	2.6 (2.1-3.1)	3.2 (2.6-3.8)	4.1 (3.4-4.8)	3.5 (2.9-4.1)
Coahuila	3.2 (2.5-3.9)	3.5 (2.8-4.2)	3.4 (2.7-4.2)	2.9 (2.3-3.6)	2.7 (2.1-3.3)	3.1 (2.4-3.7)	2.2 (1.6-2.7)	3.5 (2.8-4.2)	2.9 (2.2-3.5)	2.5 (1.9-3.1)	2.8 (2.2-3.4)	2.3 (1.7-2.9)	3.4 (2.7-4.1)	2.7 (2.1-3.3)	3.5 (2.8-4.2)	3.3 (2.6-3.9)
Colima	4.4 (2.6-6.1)	4.3 (2.6-6.1)	5.2 (3.2-7.1)	4.3 (2.6-6.1)	2.8 (1.4-4.2)	3.3 (1.8-4.8)	4.8 (3-6.5)	3.6 (2.1-5.2)	2.9 (1.5-4.2)	4.4 (2.7-6)	4.7 (3.1-6.4)	4.8 (3.1-6.4)	3.3 (1.9-4.6)	1.7 (0.8-2.7)	2.9 (1.6-4.1)	3.4 (2-4.8)
Durango	1.8 (1.2-2.5)	1.9 (1.2-2.6)	2.6 (1.8-3.3)	1.4 (0.8-1.9)	2.3 (1.6-3)	3.2 (2.3-4)	2.9 (2.1-3.7)	2.1 (1.4-2.8)	2.3 (1.6-3)	3.4 (2.6-4.3)	3.5 (2.6-4.4)	3.3 (2.4-4.1)	3.6 (2.7-4.4)	3.5 (2.7-4.4)	2.7 (1.9-3.4)	3.6 (2.8-4.5)
Guanajuato	4.9 (4.3-5.5)	4.5 (3.9-5.1)	5.4 (4.8-6)	4.8 (4.3-5.4)	4.6 (4-5.1)	4.4 (3.9-5)	4.2 (3.7-4.8)	4.2 (3.7-4.7)	4 (3.4-4.5)	4.4 (3.9-5)	4.7 (4.2-5.3)	4.6 (4.1-5.2)	4.3 (3.8-4.8)	4.1 (3.6-4.6)	4.5 (3.9-5)	4 (3.5-4.5)
Guerrero	1.7 (1.2-2.1)	0.9 (0.6-1.3)	1.5 (1.1-1.9)	1.7 (1.3-2.2)	2 (1.5-2.4)	1.7 (1.2-2.1)	1.8 (1.4-2.3)	1.9 (1.4-2.3)	2.8 (2.3-3.4)	2.9 (2.4-3.5)	2.8 (2.2-3.3)	3.1 (2.6-3.7)	3.1 (2.5-3.6)	3.9 (3.3-4.6)	3.3 (2.7-3.9)	2.8 (2.3-3.4)
Hidalgo	3.1 (2.4-3.8)	3.5 (2.8-4.3)	3.1 (2.4-3.8)	3.2 (2.5-3.9)	3 (2.4-3.7)	3 (2.3-3.7)	2.7 (2-3.3)	3.9 (3.1-4.6)	3.7 (2.9-4.4)	2.7 (2.1-3.3)	3.1 (2.4-3.7)	3.9 (3.2-4.7)	3.2 (2.6-3.9)	3.8 (3.1-4.5)	3.5 (2.8-4.2)	3.2 (2.6-3.9)
Jalisco	4.9 (4.3-5.4)	4.2 (3.7-4.7)	4 (3.5-4.4)	4.3 (3.8-4.8)	4.1 (3.7-4.6)	4.4 (3.9-4.9)	4.6 (4.1-5.1)	4.4 (3.9-4.9)	4.2 (3.7-4.7)	4.7 (4.2-5.2)	4.2 (3.7-4.6)	4.8 (4.3-5.3)	4.5 (4-4.9)	4.4 (3.9-4.8)	4.4 (3.9-4.8)	4.2 (3.8-4.6)
México City	5.5 (4.9-6)	4.8 (4.3-5.3)	5.3 (4.8-5.8)	5.1 (4.6-5.6)	4.9 (4.4-5.4)	4.6 (4.1-5)	5 (4.5-5.5)	4.5 (4-5)	4.8 (4.4-5.3)	5.2 (4.6-5.7)	5.2 (4.7-5.8)	5.7 (5.2-6.3)	5.2 (4.7-5.7)	5.2 (4.7-5.7)	5 (4.5-5.5)	5.1 (4.5-5.6)
Michoacan	2.3 (1.8-2.7)	2.8 (2.3-3.3)	2.2 (1.7-2.6)	2.9 (2.4-3.4)	2.9 (2.4-3.4)	3.4 (2.8-3.9)	3.1 (2.6-3.7)	3.2 (2.7-3.8)	3.8 (3.2-4.4)	3.4 (2.9-4)	3.6 (3-4.1)	3.6 (3-4.1)	3.3 (2.7-3.8)	3.1 (2.6-3.7)	3.3 (2.8-3.8)	3.2 (2.7-3.8)
Morelos	4 (3-5)	3 (2.2-3.9)	4 (3-5)	3.5 (2.5-4.4)	4.2 (3.2-5.3)	4 (3-5)	4.3 (3.3-5.3)	2.8 (2-3.6)	4.1 (3.1-5)	4 (3.1-5)	3.9 (3-4.8)	4 (3.1-5)	4.4 (3.5-5.4)	4.1 (3.2-5.1)	3.7 (2.8-4.5)	4.5 (3.5-5.4)
Nayarit	2.3 (1.3-3.3)	3.5 (2.3-4.8)	3 (1.9-4.1)	1.9 (1-2.8)	4.1 (2.8-5.4)	3.2 (2.1-4.3)	1.6 (0.8-2.4)	2.5 (1.6-3.5)	3.3 (2.2-4.5)	2.8 (1.8-3.8)	2.9 (1.9-3.9)	3.1 (2.1-4.1)	3.6 (2.5-4.6)	3.8 (2.7-5)	3.2 (2.2-4.3)	3.1 (2.1-4.1)
Nuevo Leon	4.6 (3.9-5.3)	3.6 (3-4.2)	4 (3.4-4.6)	3.2 (2.6-3.7)	3.4 (2.8-3.9)	3.8 (3.2-4.4)	3.7 (3.1-4.2)	3 (2.5-3.6)	3.4 (2.9-4)	3.8 (3.2-4.3)	3.2 (2.7-3.7)	3 (2.5-3.5)	3.1 (2.6-3.6)	3.4 (2.9-4)	3.3 (2.8-3.8)	3.5 (3-4.1)
Oaxaca	3.6 (3-4.2)	3.5 (2.9-4.1)	3.6 (3-4.3)	3.4 (2.8-4)	3.7 (3.1-4.3)	2.9 (2.3-3.4)	3.5 (2.9-4.1)	3.7 (3.1-4.3)	3.2 (2.6-3.7)	4.1 (3.5-4.7)	3.9 (3.3-4.5)	4.1 (3.5-4.8)	3.7 (3.1-4.3)	3.9 (3.3-4.5)	3.5 (3-4.1)	3.7 (3.1-4.3)
Puebla	4.9 (4.3-5.5)	4.2 (3.7-4.8)	5.4 (4.8-6)	5.4 (4.8-6)	5.9 (5.2-6.5)	5.4 (4.8-6)	5.6 (5-6.2)	5.5 (4.9-6.1)	5.5 (4.9-6)	5.1 (4.6-5.7)	5.2 (4.6-5.8)	5.3 (4.7-5.9)	5.1 (4.6-5.7)	5.9 (5.3-6.5)	5.5 (5-6.1)	5.1 (4.5-5.6)
Queretaro	4.4 (3.4-5.5)	6.3 (5.1-7.5)	4.5 (3.5-5.5)	4.5 (3.5-5.5)	5.1 (4-6.2)	5.1 (4.1-6.2)	3.6 (2.7-4.4)	5.1 (4-6.1)	5 (4-6)	4.8 (3.8-5.8)	5.2 (4.2-6.2)	4.9 (3.9-5.9)	4.7 (3.7-5.6)	4 (3.2-4.9)	4.1 (3.2-4.9)	4.4 (3.5-5.3)
Quintana Roo	3.4 (2.2-4.5)	3 (1.9-4.1)	4.7 (3.4-6.1)	3 (2-4.1)	2.7 (1.8-3.7)	3.6 (2.5-4.7)	4.3 (3.1-5.5)	2.8 (1.9-3.8)	4.6 (3.5-5.8)	3.3 (2.3-4.2)	2.7 (1.8-3.6)	2.9 (2-3.8)	3.2 (2.3-4.1)	3.4 (2.4-4.3)	3.5 (2.6-4.4)	3.3 (2.4-4.2)

(Continues)

TABLE 3 (Continued)

State	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
San Luis Potosi	4.4 (3.5-5.2)	4.6 (3.8-5.5)	4.4 (3.6-5.2)	4.1 (3.3-4.9)	3.8 (3-4.5)	4.3 (3.5-5.1)	4.4 (3.6-5.2)	4.2 (3.5-5)	3.4 (2.7-4.1)	3.8 (3-4.5)	3.6 (2.8-4.3)	3.7 (3-4.5)	3.6 (2.9-4.3)	3.2 (2.5-3.9)	3.2 (2.6-3.9)	3 (2.4-3.7)
Sinaloa	2.6 (1.9-3.2)	2.5 (1.9-3.2)	2.7 (2.1-3.4)	2.3 (1.7-2.9)	2.8 (2.1-3.4)	2.6 (1.9-3.2)	2.9 (2.3-3.5)	2.7 (2.1-3.3)	3.4 (2.7-4)	3.3 (2.6-4)	2.7 (2.1-3.3)	2.6 (2-3.2)	3.7 (3-4.4)	3.2 (2.5-3.8)	2.8 (2.2-3.4)	3.2 (2.5-3.8)
Sonora	4 (3.2-4.9)	3.6 (2.8-4.3)	3.5 (2.7-4.2)	4 (3.2-4.8)	3.8 (3-4.6)	4.1 (3.3-4.9)	4 (3.2-4.7)	3.9 (3.2-4.7)	3.3 (2.6-4)	3.7 (3-4.4)	3.3 (2.6-4)	3.2 (2.5-3.8)	3.3 (2.7-4)	3.3 (2.6-4)	3.3 (2.6-4)	3.1 (2.5-3.8)
State of Mexico	4.9 (4.6-5.3)	5 (4.6-5.4)	4.8 (4.4-5.1)	5.1 (4.7-5.5)	5 (4.6-5.4)	5 (4.6-5.3)	4.8 (4.5-5.2)	5.3 (4.9-5.6)	4.9 (4.5-5.2)	4.4 (4.1-4.8)	4.8 (4.5-5.2)	4.8 (4.5-5.2)	4.9 (4.5-5.2)	5.2 (4.9-5.6)	5.4 (5.1-5.8)	4.4 (4.1-4.8)
Tabasco	5.2 (4.2-6.2)	5.5 (4.5-6.5)	4.8 (3.8-5.7)	4.9 (4-5.8)	4.3 (3.4-5.2)	5.5 (4.5-6.4)	4.7 (3.8-5.6)	5.1 (4.2-6)	4.2 (3.4-5.1)	5.9 (4.9-6.9)	5.6 (4.6-6.5)	5.8 (4.8-6.8)	4.9 (4-5.8)	6.6 (5.6-7.7)	6 (5-7)	4.8 (3.9-5.7)
Tamaulipas	3.8 (3.1-4.5)	2.5 (1.9-3.1)	2.9 (2.3-3.5)	2.9 (2.2-3.5)	3.3 (2.7-4)	3.4 (2.7-4)	3.1 (2.5-3.7)	3.2 (2.5-3.8)	3.3 (2.7-3.9)	2.4 (1.8-2.9)	4 (3.3-4.6)	3.3 (2.7-4)	3.3 (2.7-3.9)	3.3 (2.7-3.9)	3 (2.4-3.6)	3.4 (2.8-4)
Tlaxcala	4 (2.8-5.2)	4.6 (3.3-5.9)	4.3 (3.1-5.5)	4 (2.8-5.1)	4.5 (3.3-5.7)	5.9 (4.5-7.3)	5 (3.7-6.3)	5.2 (3.9-6.5)	4.4 (3.2-5.6)	4.9 (3.7-6.1)	4.3 (3.1-5.4)	4 (2.9-5)	4.6 (3.4-5.8)	3.5 (2.5-4.5)	3.6 (2.6-4.6)	3.9 (2.9-5)
Veracruz	3.7 (3.3-4.2)	4.2 (3.8-4.7)	4 (3.6-4.5)	3.8 (3.3-4.3)	3.6 (3.1-4)	3.9 (3.4-4.4)	4.2 (3.7-4.7)	3.9 (3.4-4.3)	4.1 (3.7-4.6)	4.1 (3.6-4.6)	4.3 (3.8-4.8)	4.3 (3.8-4.8)	4 (3.5-4.4)	4.2 (3.7-4.6)	4.6 (4.1-5.1)	4.1 (3.6-4.5)
Yucatan	4.6 (3.5-5.6)	4.4 (3.4-5.3)	4.4 (3.4-5.3)	4.8 (3.8-5.9)	4.3 (3.3-5.2)	4.2 (3.3-5.2)	2.9 (2.1-3.7)	3.1 (2.3-3.9)	4.3 (3.3-5.2)	3.5 (2.6-4.3)	4 (3.1-4.9)	3.2 (2.4-4)	3.5 (2.7-4.3)	3.6 (2.8-4.4)	3 (2.3-3.8)	2.9 (2.1-3.6)
Zacatecas	2.8 (2-3.7)	3 (2.1-3.9)	2.8 (2-3.7)	2.7 (1.9-3.6)	2 (1.3-2.8)	3.7 (2.7-4.7)	3.7 (2.7-4.7)	3.9 (2.9-4.9)	2.9 (2-3.7)	3 (2.2-3.9)	3.4 (2.5-4.3)	3.1 (2.2-4)	2.8 (2-3.6)	3.2 (2.3-4)	2.9 (2-3.7)	3.7 (2.8-4.6)

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

TABLE 4 Age-adjusted mortality rate and 95% confidence intervals by socioeconomic region of people who died from congenital malformations of the heart and the great vessels. Mexico, 2000-2015

Region	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1	2.4 (2.1-2.7)	2.2 (2-2.5)	2.6 (2.3-2.8)	2.6 (2.3-2.8)	2.8 (2.5-3.1)	2.5 (2.2-2.8)	2.6 (2.3-2.9)	2.8 (2.5-3.1)	3 (2.7-3.3)	3.3 (3-3.6)	3.4 (3.1-3.7)	3.8 (3.5-4.1)	3.6 (3.3-3.9)	4.1 (3.7-4.4)	3.6 (3.3-3.9)	3.6 (3.3-4)
2	4.2 (3.9-4.5)	4.3 (4-4.6)	4.4 (4.1-4.7)	4.4 (4.1-4.6)	4.3 (4-4.5)	4.4 (4.1-4.7)	4.5 (4.2-4.8)	4.5 (4.2-4.8)	4.3 (4-4.6)	4.4 (4.1-4.6)	4.5 (4.2-4.7)	4.6 (4.3-4.9)	4.3 (4-4.5)	4.8 (4.5-5)	4.7 (4.4-5)	4.2 (3.9-4.5)
3	3.5 (3.2-3.8)	3.5 (3.2-3.9)	3.7 (3.4-4.1)	3.6 (3.3-3.9)	3.5 (3.2-3.8)	4 (3.7-4.3)	3.8 (3.5-4.1)	3.7 (3.4-4)	3.6 (3.3-3.9)	3.9 (3.6-4.2)	4.1 (3.7-4.4)	3.9 (3.6-4.3)	3.8 (3.5-4.1)	3.6 (3.3-3.9)	3.7 (3.4-4)	3.7 (3.4-4)
4	4.4 (4.1-4.6)	4.5 (4.2-4.7)	4.4 (4.1-4.6)	4.4 (4.1-4.7)	4.5 (4.2-4.7)	4.4 (4.2-4.7)	4.2 (4-4.5)	4.4 (4.1-4.7)	4.5 (4.2-4.8)	4.1 (3.9-4.4)	4.3 (4.1-4.6)	4.3 (4-4.5)	4.4 (4.2-4.7)	4.5 (4.3-4.8)	4.5 (4.3-4.8)	4 (3.8-4.3)
5	3.7 (3.3-4)	3.5 (3.2-3.9)	3.3 (3-3.6)	3.2 (2.9-3.5)	3.4 (3.1-3.8)	3.8 (3.4-4.1)	3.6 (3.2-3.9)	3.7 (3.4-4.1)	3.2 (2.9-3.5)	3.5 (3.2-3.8)	3.8 (3.5-4.2)	3.4 (3.1-3.8)	3.1 (2.8-3.4)	3.1 (2.9-3.4)	3.3 (3-3.6)	3.2 (2.9-3.5)
6	4.4 (4.1-4.8)	3.9 (3.6-4.2)	3.9 (3.5-4.2)	3.7 (3.4-4)	3.7 (3.4-4)	4 (3.6-4.3)	3.8 (3.5-4.1)	3.8 (3.5-4.1)	3.7 (3.4-4)	3.9 (3.6-4.2)	3.6 (3.3-3.9)	3.7 (3.4-4)	3.8 (3.5-4.1)	3.7 (3.4-4)	3.8 (3.5-4.1)	3.7 (3.4-4)
7	5.5 (4.9-6)	4.8 (4.3-5.3)	5.3 (4.8-5.8)	5.1 (4.6-5.6)	4.9 (4.4-5.4)	4.6 (4.1-5)	5 (4.5-5.5)	4.5 (4-5)	4.8 (4.4-5.3)	5.2 (4.6-5.7)	5.2 (4.7-5.8)	5.7 (5.2-6.3)	5.2 (4.7-5.7)	5.2 (4.7-5.7)	5 (4.5-5.5)	5.1 (4.5-5.6)

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

95%CI 2.1-3.3; Coahuila 2011, 2.3, CI95 1.7-2.9; Baja California Sur 2012 and 2014, 2.4, 95%CI 1.2-3.5 and 2.7, 95%CI 1.5-3.9, respectively; Colima 2013, 1.7, 95%CI 0.8-2.7 and Aguascalientes 2015, 2.1, 95%CI 1.3-2.9 (Table 3).

Region 7 had the highest mortality from CHD in the period 2000-2015. In the year 2000 and 2015, the mortality rate was 5.5, 95%CI 4.9-6 and in 2015 was 5.1, CI95% 4.5-5.6 (Table 4).

Region 1 (years 2000-2010) and region 5 (2011-2015) had the lowest mortality rates due to CHD. The mortality rates in region 1 in the years 2000 and 2010 were 2.4, 95%CI 2.1-2.7 and 3.4, 95%CI 3.1-3.7, respectively; and in region 5 in the years 2011 and 2015 were 3.4, 95%CI 3.1-3.8 and 3.2, 95%CI 2.9-3.5, respectively (Table 4).

4 | DISCUSSION

In Mexico in the period 2000-2015, the standardized mortality rates for CHD increased from 3.3 to 4 per 100 000 individuals (Figure 1). There was also an important increase in mortality rates in the age group <1 year of age from 143.9 to 217.3 per 100 000 live births (Figure 3). In other studies, similar results have been found. In a study conducted by Torres-Cosme et al, on mortality from CHD in Mexico, reported that, in the period of 1998-2013, mortality rate in children <1 year of age, increased from 114.4 to 146.4 per 100 000 live births. There is no clear explanation for the increase in the trend of CHD, some of the risk factors associated with CHD are increasing in Mexico. Diabetes and substance abuse, both known to be associated with CHD, are more prevalent now in women of reproductive age than 10 years ago. In addition, the number of specialists per capita has increased in recent years; therefore, it is possible that deaths from CHD that were not previously detected are now diagnosed and recorded as causes of infant mortality.[3]

In the 2000-2015 study period, more men (37 828 [53.5%]) than women (32 913 [46.5%]) died from CHD (Table 2). Similar results have been reported in other studies; Gilboa et al, in a study on mortality due to CHD in children and adults in the United States over the period 1999-2006,[14] found that out of 27 960 individuals who died directly from CHD, 12 940 (46.3%) were women and 15 020 (53.7%) were men.

The five top CHD for which children and adults died in Mexico during the study period were (1) Congenital malformation of the heart, unspecified (Q24.9) with 44 037 (62.3%), (2) Patent ductus arteriosus (Q25.0) with 3.603 (5.1%), (3) Tetralogy of Fallot (Q21.3) with 2.883 (4.1%), (4) Ventricular septal defect (Q21.0) with 2.582 (3.6%), and (5) Other malformations of the heart, specified (Q24.8) with 1760 (2.5%) (Table 2). Other studies, very similar results have been found. Gilboa et al,[14] identified as the five most frequent CHD: (1) Congenital malformation of the heart, unspecified (Q24.9) that occurred in 9543 (34.1%) individuals, (2) Other malformations of the heart, specified (Q24.8) with 5242 (18.7%), (3) Left heart hypoplasia syndrome with 3043 (10.9%), (4) Atrial septal defect (Q21.1) with 2098 (7.5%), and (5) Tetralogy of Fallot (Q21.3) with 1472 (5.3%). The patent ductus arteriosus was found ranked number 9 with 507 (1.8%) and the ventricular septal defect (Q21.0) was found ranked number 6 with 1394 (5%).

Region 7, which corresponds to Mexico City had the highest mortality from CHD in the period 2000-2015. In other studies, conducted in Mexico, very similar results have been found in children <1 year of age. In the year 2013, it was seen that out of the four regions (North, South, Center, and Mexico City), Mexico City had the highest mortality rate with 188.5 per 100 000 live births, which could be due to genetic or environmental factors, or to underreporting of deaths in states with fewer resources.[3] The obesity epidemic with phenotypes associated with diabetes mellitus and hypercholesterolemia are considered as emerging risk factors for CHD.[15] Obesity and diabetes are highly prevalent among adults living in Mexico City.[16-18] Twenty-nine percent of men and 41% of women aged 35-54 are obese (BMI ≥ 30 kg/m^2).

Environmental pollution could be another factor associated with the highest mortality rate of CHD in region 7. Mexico City has high levels of environmental contamination.[19] Ambient air pollution has been linked to CHD. Among the CHD associated with environmental contamination are coarctation of the aorta, tetralogy of Fallot and atrial septal defect.[20] The altitude of Mexico City in relation to sea level has been related with the high incidence of patent ductus arteriosus.[5]

Technological advances continue to influence the size of the population of patients with CHD. The prenatal evaluation has led to an increase in the rates of pregnancy termination. Improved management of complications has changed the time and mode of death caused by CHD. It has been shown that several genetic and environmental factors are involved in the etiology of CHD, although this knowledge has not yet led to the implementation of preventive measures.[21]

In Mexico, a national plan has been implemented for the regionalization of the care of patients with CHD, which consists of the rational use of resources with emphasis on specialized medical care, to increase the number of cases treated, improve the quality of care, obtain optimal use of existing resources and, thereby, achieve a decrease in mortality of CHD.[4,5]

5 | CONCLUSIONS

In the period 2000-2015, age-adjusted mortality rate per 100 000 individuals increased from 3.3 to 4. Mexico City as region 7 had the highest mortality from CHD of the heart and the great vessels.

CONFLICT OF INTEREST

None.

AUTHOR CONTRIBUTIONS

I am the only author of the work.

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