International Journal of Health Sciences and Research
www.ijhsr.org ISSN: 2249-9571

Original Research Article

Cardiovascular Disease Mortality among Under 75 Years Old Population: An Analysis in Colombia of 1998-2011 Period

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Received: 12/03/2015 *Revised: 13/04/2015* *Accepted: 28/04/2015*

ABSTRACT

Introduction: Globally, Cardiovascular Disease (CVD) is the leading cause of death due to non-communicable diseases in the world. There are interventions available to prevent or treat CVD. The purpose of this analysis was to describe the trend pattern and the spatial distribution of mortality due to CVD in Colombia in under 75 years old population, during the period 1998-2011.
Materials and Methods: A mortality trend analysis was performed for death due to CVD in people under 75 years old during the 1998-2011 in Colombia. Crudes and age-adjusted annual mortality rates were estimated from the official data sources. A regression analysis of turning points was performed to identify changes in trends, estimating the annual percentage of change by different population groups: age groups, sex, department of residence, and cause of death. A geographical analysis was also performed to evaluate the differences between 1998-1999, 2000-2002, 2003-2005, 2006-2008 and 2009-2011 periods.
Results: Between 1998 and 2011 there were 628,360 deaths due to CVD, 47.0% occurred among population aged < 75 years. The crude mortality rate for CVD during the study period was 49.4 deaths per 100,000 people under 75 years old, 57.2 for men and 41.9 for women. Rates were higher in the 70-74 years age group, among men, in urban area, and in Andean region. The trend of age-adjusted mortality rates by sex had a decreasing trend with a larger decline among women.
Conclusions: There is an evident trend of reduction in mortality due to CVD in Colombia, between 1998-2011, which could be attributed to multiple factors control.

Key words: mortality, cardiovascular diseases, cause of death, non-communicable diseases, death certification, Colombia.

INTRODUCTION

Mortality statistics are indispensable to evaluate the population health, to plan health policies and services, and to program the epidemiologic evaluation and research. [1] Mortality statistics constitute basic tools to evaluate the burden of non-communicable diseases (NCD), including Cardiovascular Disease (CVD). The CVD is a group of disorders of heart and blood vessels, including coronary heart disease (heart attack), rheumatic heart disease, hypertension (high blood pressure) and cerebrovascular disease (stroke), among others.

The CVD is an important public health issue, due to its high burden of disease, and the economic and social impacts derived from the care cost, disability, and premature mortality. [2] The

measurement of the CVD mortality became a tracer indicator of the population health. Globally, CVD is the leading cause of death due to NCDs. [3] In 2008 17.3 million deaths caused by CVD were reported, i.e. 30% of all register deaths that year, [4] and it was estimated that CVD will increase to 23.3 million for 2030. [5] The 80% of CVD deaths occurred in medium- and low-incomes countries, affecting similarly men and women. For the whole American region in 2007 were reported 1.5 million of deaths due to CVD. [2] Only for Latin America and the Caribbean (LAC) 900,000 deaths were estimated in 2002, and 1.6 million are expected for 2030. [6] In LAC the mortality due to CVD represents a complex problem, because almost a 40% of these deaths are premature, occurred during the most productive stage of life. [2]

CVD deaths could be considered avoidable, because affected individuals have been incurred in harmful health behaviors, such as to choice of restricted life style, unhealthy exposures to living conditions and stressful job, and limited access to health services. [7] It was observed that lifestyles such as tobacco consumption, unhealthy diets, and physical inactivity, have become major contributors to the increased prevalence of intermediate risk factors such as obesity, dyslipidemia, high blood pressure, and diabetes mellitus, which together with society industrialization, urbanization, and globalization are widely recognized as risk factors for occurrence or death due to CVD. [8-11]

In Colombia, the CVD represents an important public health issue, due to it is the main cause of morbidity and mortality. [12] During 1998 – 2011 period, between 21-25% of total deaths were due to CVD. The crude mortality rate varied from 93.5 to 108.8 per 100.000 habitants; while the age-adjusted mortality rate varied from 108.6 to 95.9 deaths per 100.000. [13] Colombia had been generated preventive measurements with the goal to reduce the CVD mortality. [14-16] In spite of that, the implementation of prevention and promotion health policies had been poor in both public and private sector. [17] Given this situation, trend analysis of mortality rates could help understand the impact of interventions established for its prevention and control. In the other hand, this analysis could provide elements that serve to guide decision-making in public health. [18] Additionally, trend analysis also could provide information on the effects of screening programs or new treatment guidelines. The correct interpretation of the trend would guide on the future evolution of the disease and provide decision elements in the distribution of resources. [19] In Colombia the analyses of CVD mortality trends are scarce which are useful for decision making related to the prevention and control of those diseases that have been identified as leading causes of death in the country. [20] Therefore, this analysis was undertaken to describe the trend patterns and the spatial distribution of CVD mortality in Colombia, during the 1998-2011 period.

MATERIALS AND METHODS

A descriptive study was conducted on the trend and the spatial distribution of mortality rates from heart disease (ischemic and chronic rheumatic heart), hypertensive disease, and cerebrovascular disease (stroke) in Colombia, in population under 75 years old during the period of 1998 - 2011. Deaths information was extracted from the records of individual death certificates consolidated in the mortality database of National Statistics Institute (*Departamento Administrativo Nacional de Estadísticas-DANE).* Deaths were included if they were classified as ischemic heart disease (I20-I25), hearth rheumatic disease (I05-I09), hypertensive disease (I10- I15), and cerebrovascular disease (I60-I69) according with the International Classification of Diseases, 10th revision (ICD-10). [21] The

population data to construct the denominators of the rates was obtained from population projections published for the *DANE* during 1998-2011 period. [22] We included in the analysis variables of when death occurred, cause of death, number of deaths, age, sex, population by year, area, and department or municipality of residence.

Specific annual mortality rates by age (in five-year groups), sex, and area of residence were calculated for each event. Rates were expressed per 100,000 people under 75 years old. Annual mortality rates were compared during the period 1998-2011. Overall mortality rates were adjusted by age using the direct method, taking as reference the national population by five-year age groups from the 2005 census. The analysis was limited to deaths occurred among under 75 years old population, because the Colombian population's life expectancy 2010-2015 was 75.2 years. [23] According to previous studies, 100% of deaths in people under 75 years could be considered avoidable. [24,25]

The age-adjusted mortality rates were used to estimate the mortality trend, modeled using the turning points regression analysis (joinpoint Poisson). Joinpoint regression analysis is a nonlinear statistical technique aimed at identifying changes in trends. This procedure identifies the moment when there is a significant change in the trend and estimates the magnitude of the increase or decrease for every interval evaluating the annual percentage of change (APC). In the models, up to four turning points were set up. The software looks for the simplest model that fits the data using weighted least squares technique, and estimates the statistical significance using Monte Carlo simulation with the Bonferroni correction. [26] The trend was statically significant when the slope was different from zero with $p<0.05$. [27] In each department the trend and APC were estimated.

For periods 1998-1999, 2000-2002, 2003-2005, 2006-2008, and 2009-2011 with the age-adjusted mortality rate for municipality a spatial analysis was carried out. Smoothing of age-adjusted mortality rates was performed by Bayesian inference methods, the Marshall's local empirical Bayesian estimator, to reduce the small areas variability. [28] The Marshall's estimator is a weighted average of municipal and country mortality rates. [29]

The Index of Moran was calculated to evaluate the spatial autocorrelation. An index close to 1 or -1 indicates spatial autocorrelation. Due to the huge number of municipalities, it is possible the presence of differences in the spatial association, we used the Local Index of Spatial Autocorrelation (LISA) to evaluate spatial dependency in some areas (i.e. zones were the mortality rates correlated significantly with neighborhoods' mortality rates). [30] Four categories were defined according the municipality and their neighborhood mortality rates: high-high, low-low, low-high, and high-low. [31] The p values were estimated from a Monte Carlo simulation. The data processing was performed in Microsoft Excel spreadsheets, while the data and spatial analyses were done with joinpoint Regression software, Geoda ® and ArcGIS.[32]

According with the ethical requirements established by Colombian Law, framed in the Resolution 8430 of 1993 of the Ministry of Health, [33] this study classifies as "without risk".

RESULTS

Between 1998 and 2011 were reported 628,360 deaths due to CVD in Colombia, 47.0% (295,073) of them occurred in population younger than 75 years old, occurring 57.1% (168,483) in men. The average age of death for CVD mortality in under 75 years old population was 60.8 years for men and 61.4 years for

women. Men to women ratio were 1.3:1. Ischemic heart disease accounted for 58.0% (171,205) of under 75 years old population CVD deaths, cerebrovascular disease 31.4% (92,691), hypertensive diseases 9.7% (28,510), and chronic rheumatic heart disease 0.9% (2,669). The crude mortality rate for CVD during the study period was 49.4 deaths per 100,000 people under 75 years old, 57.2 for men and 41.9 for women. The crude mortality rate for ischemic heart disease was 28.7 deaths per 100,000 people, for cerebrovascular disease the mortality rate was 15.5, and 4.8 for hypertensive disease.

In general, the APC showed that mortality rates declined in all the age groups, but population of 15-19 years, 40-44 years and 45-49 years were the most decreased (Table 1). In general, the age-adjusted mortality rates by sex showed a decreasing trend with a further decline among women (Figure 1). In women, the trend was decreasing between 1998 and 2011 with an APC of -1.9% (95% CI -2.2 to -1.6, $p < 0.05$). Decline by urban residence area was also observed (Figure 2).

Table 1. APC and trend of age-adjusted mortality rates due to cardiovascular disease in Colombia, 1998-2011

Strata	Period	Global APC	CI 95% Inf	CI 95% Sup	Trend
Total	1998 - 2011	-2.8*	-3.1	-2.4	Falling
	1998 - 2000	0.8	-3.5	5.4	No change
	2000 - 2011	-3.1*	-3.4	-2.8	Falling
Age group (years)					
0-4	1998 - 2011	-0.9	-4.7	2.9	No change
5-9	1998 - 2011	-3.6	-7.3	0.2	No change
10-14	1998 - 2011	-1.6	-3.7	0.6	No change
15-19	1998 - 2011	-4.1*	-5.9	-2.4	Falling
20-24	1998 - 2011	-3.9*	-5.0	-2.8	Falling
25-29	1998 - 2011	-2.6*	-3.8	-1.4	Falling
30-34	1998 - 2011	-3.1*	-4.2	-2.1	Falling
35-39	1998 - 2011	-3.1*	-3.9	-2.4	Falling
40-44	1998 - 2011	-4.7*	-5.4	-4.1	Falling
45-49	1998 - 2011	-4.2*	-4.6	-3.7	Falling
50-54	1998 - 2011	-3.2*	-3.6	-2.8	Falling
55-59	1998 - 2011	-2.9*	-3.3	-2.5	Falling
60-64	1998 - 2011	-3.1*	-3.6	-2.6	Falling
65-69	1998 - 2011	-2.6*	-3.0	-2.1	Falling
	1998 - 2000	0.3	-5.3	6.2	Stable
	2000 - 2003	-4.9	-10.7	1.3	No change
	2003 - 2007	-0.3	-3.4	2.9	Stable
	2007 - 2011	-4.8*	-6.7	-2.9	Falling
70-74	1998 - 2011	-2.1*	-2.8	-1.4	Falling
	1998 - 2000	6.9	-0.3	14.7	No change
	2000 - 2011	-2.8*	-3.2	-2.4	Falling
Sex					
Males	1998 - 2011	-0.6*	-1	-0.3	Falling
	1998 - 2000	2.7	-2.8	8.5	No change
	2000 - 2011	-0.9*	-1.2	-0.5	Falling
Females	1998 - 2011	-1.9*	-2.2	-1.6	Falling
Residence area					
Urban	1998 - 2011	-1.5*	-1.7	-1.3	Falling
	1998 - 2000	1.2	-	-	
	2000 - 2003	-2.8	-	-	
	2003 - 2006	-0.3	-	-	
	2006 - 2009	-2.6	-	-	
	2009 - 2011	-0.9	-	-	
Rural	1998 - 2011	0.1	-0.5	0.7	Stable

CI: confidence interval
APC: Annual percent of change
*The APC is significantly different of 0 ($p<0.05$)

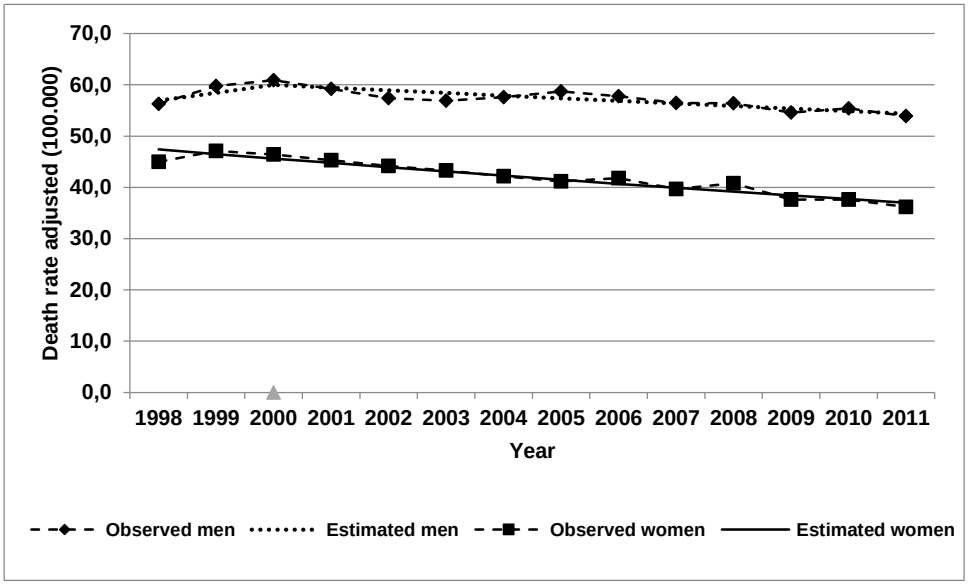

Figure 1. Age-adjusted mortality rates due to cardiovascular disease by sex. Colombia, 1998-2011

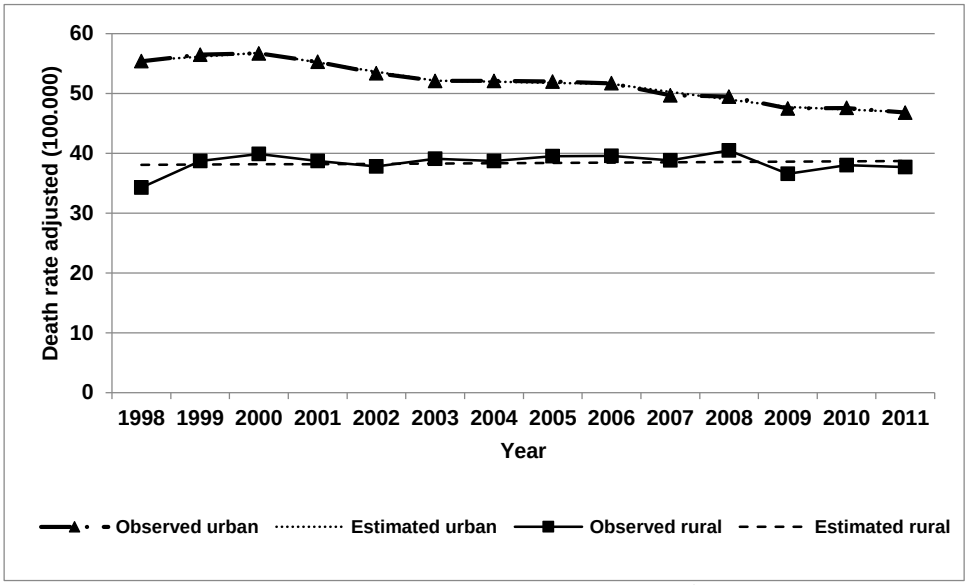

Figure 2. Age-adjusted mortality rates due to cardiovascular disease by area of residence. Colombia, 1998-2011

Table 2 shows the age-adjusted CVD mortality rates by department during the study period. Rates in 2011 ranged between 18.3 and 56.7 per 100,000 habitants being lowest in Vaupés and highest in Meta. An important reduction in age-adjusted mortality rates was observed in 20 departments, with APC reductions ranging from -0.5% (Amazonas) to -4.2% (Bogotá, the capital city) (Table 3). The regression analysis of inflection points showed one pattern in the entire period: statistically significant decrease in age-adjusted rates in Bogotá D.C., Atlántico, Bolívar, Valle del Cauca, Cauca, Risaralda, Caldas, Arauca, Santander, Quindío, Huila, Sucre, Caquetá, Norte de Santander, Cundinamarca, Boyacá, Magdalena, Cordoba, San Andrés and Tolima. The largest decline in age-adjusted rates occurred in Vichada, where the APC was -44.4% in 2000-2003 (Table 3).

Table 2. Age-adjusted mortality rates due to cardiovascular disease by department of residence. Colombia. 1998-2011.

Department	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Meta	57.5	63.6	62.6	56.4	57.3	56.6	63.5	54.0	57.2	54.9	60.0	51.2	57.5	56.7
Tolima	59.5	63.7	69.1	66.2	64.4	57.7	52.9	59.3	61.2	58.7	59.8	57.8	58.7	56.3
Boyacá	74.0	79.5	73.0	72.4	68.3	69.9	62.9	64.9	61.8	59.1	60.0	49.7	52.3	54.8
Caldas	74.0	79.5	73.0	72.4	68.3	69.9	62.9	64.9	61.8	59.1	60.0	49.7	52.3	54.8
Quindío	65.4	77.4	75.8	70.8	64.9	69.4	58.8	62.6	56.8	58.0	57.8	57.4	52.5	50.1
Arauca	64.4	73.5	62.7	63.6	60.6	57.3	48.7	53.9	56.6	48.7	47.0	42.0	56.8	49.6
Casanare	44.1	47.2	42.5	50.2	36.5	51.6	47.4	42.4	43.6	43.4	45.1	41.4	46.9	48.6
Risaralda	75.6	68.0	73.0	69.4	62.1	61.2	60.3	56.9	54.7	60.1	52.8	51.3	50.8	48.5
Norte de Santander	61.3	59.4	66.8	55.2	55.3	48.5	51.0	56.0	52.9	47.3	49.3	51.1	54.1	47.8
Cundinamarca	50.0	50.6	53.9	56.1	54.9	55.4	51.2	51.6	53.2	48.6	47.8	40.1	44.6	45.2
Valle del Cauca	68.3	73.6	77.8	73.5	68.8	62.3	63.4	61.9	59.2	55.0	51.0	51.1	49.0	45.1
Boyacá	49.1	55.3	56.5	48.9	52.2	51.8	49.7	51.4	47.3	47.9	49.3	44.6	44.4	43.8
Chocó	45.8	44.3	60.6	59.4	51.2	60.4	47.5	50.2	51.6	51.1	53.5	48.0	45.1	43.0
Huila	51.1	61.7	60.6	64.8	60.4	59.2	54.1	55.5	54.8	52.2	49.2	47.9	43.0	43.0
San Andrés	59.5	62.2	53.3	69.8	54.2	40.5	53.3	47.2	51.4	38.6	42.2	40.3	37.0	42.7
Antioquia	67.0	63.2	59.3	58.5	55.6	56.4	54.9	55.5	54.5	50.6	48.9	45.3	43.7	42.6
Magdalena	50.1	55.5	52.9	54.0	54.2	56.3	56.6	52.4	55.3	51.2	50.9	52.3	46.2	42.3
Guaviare	15.8	37.4	46.9	61.6	40.0	45.5	39.3	47.3	31.1	44.8	44.6	42.4	38.7	41.6
Caquetá	49.9	60.4	51.9	48.2	45.8	49.8	46.2	52.7	48.1	46.2	43.5	36.5	47.2	41.5
Cesar	42.1	51.1	51.9	51.0	54.4	56.9	56.2	48.8	47.6	43.8	51.9	50.0	41.2	40.7
Sucre	44.8	58.7	65.3	54.7	48.6	43.9	48.5	41.1	44.8	48.1	45.2	43.3	45.7	40.2
Santander	59.6	65.2	60.8	59.4	61.3	56.7	54.6	56.8	54.2	50.7	52.2	46.8	49.3	40.2
Córdoba	45.2	43.4	40.8	41.8	43.7	43.4	45.5	42.8	44.4	42.4	36.7	39.4	37.5	39.7
Atlántico	62.7	64.4	64.5	61.7	62.6	62.1	62.6	52.9	53.3	49.4	48.6	44.2	40.3	37.9
Vichada	25.3	33.4	59.0	22.5	29.4	8.8	9.5	30.1	41.3	34.3	32.6	25.6	29.5	34.6
Putumayo	25.4	23.3	28.0	22.4	31.8	20.1	22.1	22.4	28.3	24.3	23.1	20.5	27.7	34.5
Cauca	48.2	52.1	52.8	49.7	46.3	46.0	45.6	50.3	42.3	38.2	38.2	34.5	34.6	34.3
Bogotá. D.C.	58.0	59.4	52.3	53.3	47.1	45.6	45.2	43.2	41.5	40.3	39.9	34.7	34.8	34.1
Bolívar	47.1	53.8	52.3	47.8	45.2	45.4	41.7	42.0	41.2	33.8	38.5	36.0	30.5	32.8
Nariño	29.3	30.9	37.5	29.6	33.0	29.3	31.0	22.4	28.1	30.6	32.0	31.9	30.2	28.5
Guainía	42.5	53.7	30.0	0.0	21.4	51.0	37.8	20.9	22.4	58.8	30.9	10.3	41.6	23.3
La Guajira	22.5	30.6	34.8	29.4	24.3	19.5	28.5	29.3	26.9	28.5	26.9	25.6	25.9	22.2
Amazonas	23.2	22.5	11.4	25.2	13.7	22.4	30.5	17.6	31.5	18.1	30.9	10.6	20.5	19.5
Vaupés	4.1	11.4	21.1	17.7	11.3	13.9	10.7	19.6	7.3	20.4	20.5	6.5	12.7	18.3

Table 3. Deaths due to cardiovascular disease by department. Colombia. 1998-2011.

	Period	APC	CI 95% Inf	CI 95% Sup	Trend	Period	Global APC	CI 95% Inf	CI 95% Sup	Trend
National										
Antioquia	1998 - 2000	-6.4*	-11.4	-1.0	Falling	1998 - 2011	-3.1*	-3.5	-2.6	Falling
	2000 - 2006	-1.5*	-2.8	-0.2	Falling					
	2006 - 2011	-4.9*	-6.1	-3.6	Falling					
Atlántico	1998 - 2004	-0.9	-2.3	0.6	No change	1998 - 2011	-3.9*	-4.9	-3.0	Falling
	2004 - 2011	-6.4*	-7.6	-5.3	Falling					
Bogotá. D.C.	1998 - 2011	-4.2*	-4.7	-3.8	Falling					
Bolívar	1998 - 2011	-3.7*	-4.7	-2.8	Falling					
Boyacá	1998 - 2011	-1.4*	-2.1	-0.7	Falling					
Caldas	1998 - 2011	-3.1*	-3.8	-2.4	Falling					
Caquetá	1998 - 2011	-1.8*	-3.1	-0.5	Falling					
Cauca	1998 - 2011	-3.3*	-4.2	-2.3	Falling					
Cesar	1998 - 2002	5.7	-2.3	14.4	No change	1998 - 2011	-0.8	-2.2	0.7	No change
	2002 - 2011	-3.0*	-5.4	-0.5	Falling					
Córdoba	1998 - 2011	-1.0*	-1.8	-0.3	Falling					
Cundinamarca	1998 - 2001	5.0	-3.5	14.3	No change	1998 - 2011	-1.6*	-2.6	-0.5	Falling
	2001 - 2011	-2.7*	-4.0	-1.4	Falling					
Chocó	1998 - 2000	15.1	-7.8	43.7	No change	1998 - 2011	-0.9	-2.4	0.6	No change
	2000 - 2011	-2.3*	-3.7	-0.9	Falling					
Huila	1998 - 2001	6.5*	0.1	13.2	Rising	1998 - 2011	-2.2*	-3.4	-1.0	Falling
	2001 - 2011	-4.0*	-5.1	-2.9	Falling					
La Guajira	1998 - 2011	-0.8	-3.0	1.4	No change					
Magdalena	1998 - 2009	-0.2	-1.1	0.8	Stable	1998 - 2011	-1.1*	-2.1	-0.2	Falling
	2009 - 2011	-10.9	-22.4	2.3	No change					
Meta	1998 - 2011	-0.6	-1.4	0.2	No change					
Nariño	1998 - 2011	-0.6	-2.2	1.1	No change					
Norte de Santander	1998 - 2011	-1.8*	-2.7	-0.8	Falling					
Quindío	1998 - 2011	-2.7*	-3.6	-1.8	Falling					

Table 3. Continued….										
Risaralda	1998 - 2011	-3.2*	-3.7	-2.6	Falling					
Santander	1998 - 2011	-2.7*	-3.5	-1.9	Falling					
Sucre	1998 - 2000	18.5	-5.6	48.6	No change	1998 - 2011	-1.9*	-3.5	-0.3	Falling
	2000 - 2003	-11.5	-30.6	12.9	No change					
	2003 - 2011	-0.4	-2.8	2.2	Stable					
Tolima	1998 - 2000	8.0*	0.5	16.0	Rising	1998 - 2011	-0.9*	-1.8	0.0	Falling
	2000 - 2004	-4.7*	-8.1	-1.1	Falling					
	2004 - 2011	0.4	-0.6	1.4	Stable					
Valle del Cauca	1998 - 2000	5.4	-2.7	14.2	No change	1998 - 2011	-3.7*	-4.5	-2.9	Falling
	2000 -2011	-4.6*	-5.1	-4.0	Falling					
Arauca	1998 - 2011	-2.9*	-4.1	-1.6	Falling					
Casanare	1998 - 2011	0.2	-1.2	1.6	Stable					
Putumayo	1998 - 2011	0.7	-1.5	3.0	No change					
San Andrés	1998 - 2011	-3.7*	-5.3	-2.0	Falling					
Amazonas	1998 - 2011	-0.5	-5.4	4.7	Stable					
Guainía	1998 - 2011									
Guaviare	1998 - 2011	1.4	-2.2	5.0	No change					
Vaupés	1998 - 2011	4.4	-1.6	10.7	No change					
Vichada	1998 - 2000	44.9	-55.1	367.9	No change	1998 - 2011	0.8	-5.1	7.0	No change
	2000 - 2003	-44.4	-80.4	58.0	No change					
	2003 -2006	60.1	-44.2	359.5	No change					
	2006 - 2011	-4.1	-18.7	13.0	No change					

CI: confidence interval
APC: Annual percent of change
*The APC is significantly different of 0 ($p<0.05$)

The municipalities' age-adjusted CVD mortality rates show a spatial pattern in all the 14 years of analysis. After the smoothing, the higher rates (>60 CVD deaths per 100,000) were found in most municipalities from Risaralda, Caldas, Quindío, north of Valle del Cauca, Middle-south of Antioquia, South-west of Santander, north of Tolima, north of Meta and diffusely in some municipalities in Cundinamarca and Boyacá. However, for the final period there was a remarkable reduction of mortality rates by municipalities (Figure 3).

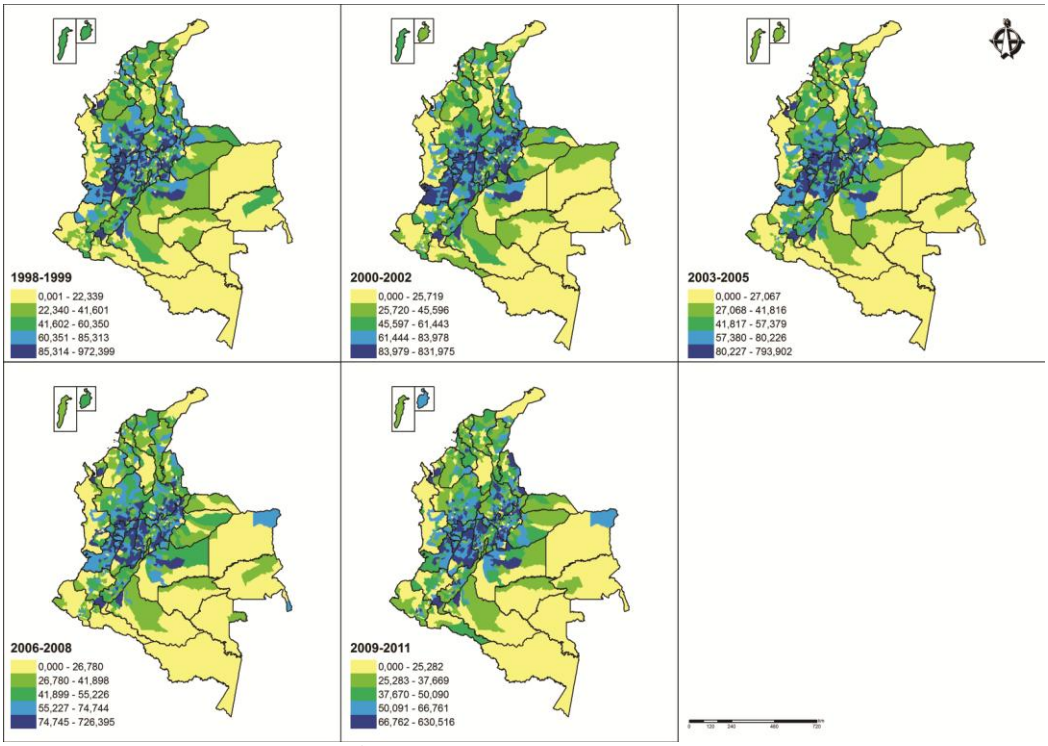

Figure 3. Adjusted mortality rates by age for deaths due to cardiovascular disease by municipality. Colombia, 1998-2011

The Moran index varied between 0.27 and 0.35 ($p < 0.05$). Figure 4 shows the significant aggrupation of CVD mortality estimated with the LISA; aggrupation of higher rates were identified in the middle of the country, with a mild rotation to the west at the end of the period (Figure 4).

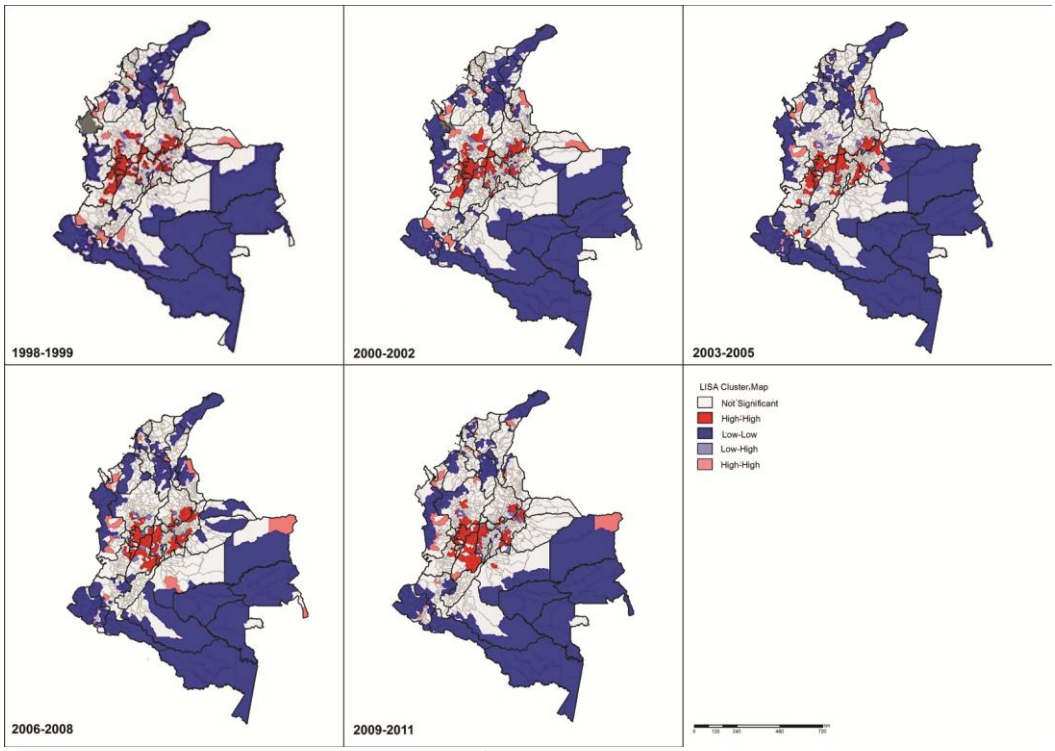

Figure 4. Spatial autocorrelation: LISA map. Spatial clusters of CVD mortality rates adjusted by age, smote by municipality. Colombia, 1998-2011

DISCUSSION

This study showed a reduction in the trend of mortality rates due to cardiovascular disease (CVD) in Colombia, after adjusting for age. Reduction was higher in 40-49 age group, women, and the urban areas. In the country, in 1998, Risaralda, Boyacá, Caldas, Valle del Cauca, Antioquia, and Quindío had the highest rates, while in 2011 the highest rates were found in Meta, Tolima, Boyacá, Caldas, Quindío, and Arauca. The greatest rate decrease occurred in Bogotá city.

In Colombia between 1990 and 2001 the trend in age-adjusted rates of ischemic heart disease and stroke increased, while mortality due to hypertensive disease declined; likewise mortality rates were highest between men as the age increased. For the same period, the behavior of CVD mortality varied between different regions of the country. Higher mortality rates were present in the more developed regions of the country (Caldas, Quindío, Risaralda, Antioquia, Bogotá and Valle del Cauca) and the lowest in the less developed regions (Orinoco Region), similar to the reports for the last decade of the twentieth century. [34,35]

For the study period, the overall age-adjusted mortality trend was toward reduction, similar to results for the period 1996-2006, in the eastern region, Bogotá, and Central and Pacific regions, where the decline was quite marked. [36,37] In the case of stroke, the trend of mortality rates tended

towards reduction, as reported in other studies; [38,39] however, it has been reported that the stroke was associated with mortality over 60 years. [40]

Causes of geographical variation CVD have not yet been fully identified. Changes in the trend of mortality rates at the departmental and municipal levels could be influenced by regional differences in access and quality of care in health services, [41] socioeconomic and cultural changes in lifestyles and levels of exposure to risk factors. [42,43] Regarding the factors related to lifestyle those acting on CVD mortality has been seen that are geographically independent, particularly cigarette smoking, dietary habits and physical activity. [44] Similarly, in the interpretation of differences, would take into account the influence of various demographics, environmental and even genetic factors. [45] In Colombia, in recent decades, in several regions the rural population migrated to urban areas, a fact which led to major changes in lifestyle, diet and physical activity patterns, with the consequent appearance of overweight and obesity mainly among individuals with low incomes. [46] According to the results of this study, the possible explanations given about changes in the trend of mortality rates from CVD require more research.

In general, our findings show a decreasing CVD mortality rate, similar to reported in other American countries and Ireland. [47,48] Variations in CVD mortality trends could be attributable to multiple factors. First, it could be due to combination of changes in the treatment and diagnosis methods, diseases coding and recoding, and death certificate completeness. [49] Second, changes in the trend could be due to impact of preventive and control interventions, and a best quality o health care, [50,51] or a faster treatment adoption. [49, 52,53] Finally, trend could have been influenced by changes in health determinants such as socioeconomic level, health care access, [54] rising in survival rates due to better treatments, [55,56] population aging, [57] and side effects due to polypharmacy. [58]

We found lower mortality rates at ages less than 20 years. However, in our country, studies in children have reported high prevalence of alcohol consumption (46%), physical inactivity (50%), high fat diets (48%), excess carbohydrate diets (47%), passive exposure to cigarette smoke (31.5%), family history of obesity (0.6%), high blood pressure (17.6%), heart disease (14.1%), overweight (9.2%) and obesity (4.4%).[59,60]

Mortality rates were also higher in urban areas; this is likely a result of the abandonment of the fields in the country, mainly due to forced displacement from rural areas to urban areas to escape the armed conflict prompted the urbanization process. [61] Currently, more than 70% of the Colombian population lives in urban centers. [62] Moreover, studies have shown that urbanization have both positive and negative influences on CVD mortality. The urban population theoretically has greater access to health care resources, but urbanization also has been associated with less healthy life styles. [10]

A large percentage of CVD is avoidable and among the public health interventions have been campaigns against the consumption of cigarette and alcohol, promoting healthy diets and physical activity, reducing salt intake, providing care health services to people with CVD, and strengthening the first level service to do early detection activities, health promotion and primary prevention. [63,64]

In Colombia CVD is the main cause of death. In the country, many initiatives had been implemented to development prevention and control programs. Some measures include the smoking quitting, promoting healthy life-stiles, and screening of blood pressure and glucose. However,

those interventions have many limitations in their implementation, regulatory public policies, low access to cardiovascular health care, lack of access to medication, and low adherence to the treatment. [65]

Among the strengths of the study it should be mentioned that the analysis of regression of turning points to estimate the annual percentage of change determine the trend changes in successive periods and the increase or decrease of the same after selecting the best fit model, thus avoiding possible biases that occur when specifying the periods for analysis of trends. To estimate mortality rates this analysis based on official information from the national mortality rates for a period of 14 years, the rates were age-adjusted in order to control the potential confounding effect of this variable. We established the age limit for include a CVD death as avoidable death in 75 years old. Others authors have discussed previously that limit. With the technological advance and the increase of life expectancy, the age limit to consider a cause of death as avoidable, including CVD, increased to 75 years in 2001. [66]

This analysis has limitations. First, quality of the information used from the death register, although it is coming from the official source for Colombia, it may have problems with coverage and content (misclassification). Second, the calculation of the APC that assumes a constant change during the time intervals, and this may be questionable. [67] Third, the present results should be interpreted with caution as CVD death can be affected by misclassification, as suggested by Lozano *et al*. [68] These flaws can be derived from diagnostics errors or registry problems. For coronary disease there are contradictory results. Some studies reported an overestimation of coronary disease as cause of death on death certificates, especially in elderly population. [69] On the other hand, some authors report an underestimation due to misclassification in non-specified causes of death, [70] or coding errors. [71] For the case of hypertensive disease, the misclassification could have depended on blood pressure measure method employed and the cut-off points used. [72]

CONCLUSION

We showed a trend of reduction in mortality due to coronary heart- chronic rheumatic-, hypertensive- and cerebrovascular-disease in Colombia, between 1998-2011 in population under 75 years old, which could be attributed to multiple factors including changes in diagnosis and treatment methods, the selection of the basic cause in the death records, the impact of preventive measurement on the control of risk factors, and the role of the health care. The next steps should be aimed at further constraining mortality due to these causes through the guidance of current policies to control modifiable risk factors associated with lifestyle (obesity, excessive intake of sodium, fat, alcohol, stress and physical inactivity), [73] and risk factors detection for focusing secondary prevention, however, that requires the joint effort of the health sector and other sectors.

ACKNOWLEDGMENTS

The authors are grateful to Colombian National Health Institute that allows the development of this research as part of their public service activities. To Clara Delgado and Sandra Salas who collaborated in the translation and grammar review of the manuscript.

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How to cite this article: Chaparro-Narváez P, Castañeda-Orjuela C, León-Quevedo W et. al. Cardiovascular disease mortality among under 75 years old population: An analysis in Colombia of 1998-2011 period. Int J Health Sci Res. 2015; 5(5):325-338.

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