Spatio-temporal distribution of Tuberculosis mortality in the urban area of Medellín 2000-2007

Distribución espacio-temporal de la mortalidad por Tuberculosis en el área urbana de Medellín 2000-2007

| Distribuição espaço-temporal da mortalidade por Tuberculose na área urbana de Medellín, 2000-2007 |

Ángela María Segura Cardona[1], Doris Cardona Arango[2], Dedsy Yajaira Berbesi Fernández[2]

[1] Phd en Epidemiología. Investigadora Grupo de Epidemiología y Bioestadística, Universidad CES. e-mail: asegura@ces.edu.co
[2] Phd en Demografía. Investigadora Grupo de Epidemiología y Bioestadística, Universidad CES.
[3] Magíster en Epidemiología. Investigadora Grupo de Epidemiología y Bioestadística, Universidad CES.

Abstract
Aim: Tuberculosis mortality is a major public health problem in developing countries, and given that statistical techniques allow to identify areas of greatest risk for the disease, the aim of this study was to determine the spatio-temporal distribution of tuberculosis mortality in the city of Medellin-Colombia. **Materials and methods**: Analytical study of time series analysis and spatial distribution of TB mortality; data obtained from death certificates where tuberculosis was the underlying cause of death in Medellin between 2000-2007 was collected. The time series analysis was global and stratified by community of residence. The spatio-temporal distribution of tuberculosis and HIV mortality rates for the same period, were also calculated in order to explain the risk and distribution of both diseases, elaborating maps for each of them. **Results**: The global TB and HIV mortality rates ranged between 3.28-3.53 and 7.29-6.20 per 100,000 habitants respectively. In the analysis of TB mortality rates stratified by community, it was found that six communities, registered the major incidence of mortality during the period with rates over four cases per 100,000. **Conclusion:** The statistical techniques of time series analysis and spatial distribution allowed identifying the communities of Medellin with increased risk of death from TB and HIV between 2000-2007.
Key words: Tuberculosis, Mortality Rate, Temporal Distribution, Space-Time Clustering, Models Statistical

Resumen
Objetivo. La mortalidad por tuberculosis es un importante problema de salud pública en los países en desarrollo, teniendo en cuenta que las técnicas estadísticas permiten identificar las áreas de mayor riesgo de la enfermedad, el objetivo de este estudio fue determinar la distribución espacio-temporal de la mortalidad por tuberculosis en la ciudad de Medellín-Colombia. **Materiales y métodos**. Estudio analítico de análisis de series temporales y de distribución espacial de la mortalidad por tuberculosis. Se recogieron los datos obtenidos de los certificados de defunción en los que la tuberculosis fue la causa principal de muerte en Medellín entre 2000-2007. El análisis de series temporales fue global y estratificado por comuna de residencia. La distribución espacio-temporal de la tuberculosis y las tasas de mortalidad por VIH durante el mismo período se calcularon para explicar el riesgo y la distribución de ambas enfermedades, se elaboraron mapas para cada uno de ellos. **Resultados.** Las tasas de mortalidad global por tuberculosis y VIH oscilaron entre 3,28 a 3,53 y de 7,29 a 6,20 por 100.000 habitantes, respectivamente. En el análisis de las tasas de mortalidad por tuberculosis estratificados por comuna, se encontró que seis comunas registraron la mayor incidencia de la mortalidad durante el período con tasas de más de cuatro casos por cada 100.000 habitantes. **Conclusión.** Las técnicas estadísticas de análisis de series temporales y la distribución espacial permitieron la identificación de las comunas de Medellín con mayor riesgo de muerte por TB y el VIH entre 2000-2007.
Palabras clave: Tuberculosis, Tasa de Mortalidad, Distribución Temporal, Agrupamiento espacio-temporal, Modelos estadísticos

Ángela María Segura Cardona, Doris Cardona Arango, Dedsy Yajaira Berbesi Fernández

Resumo
Objetivo. *Mortalidade por tuberculose é um importante problema de saúde pública nos países em desenvolvimento, e dado que as técnicas estatísticas permitem identificar áreas de maior risco para a doença, o objetivo deste estudo foi determinar a distribuição espaço-temporal da mortalidade por tuberculose na cidade de Medellin-Colômbia.* ***Materiais e métodos****. Estudo analítico de análise de séries temporais e distribuição espacial da mortalidade por tuberculose, os dados obtidos a partir de atestados de óbito onde a tuberculose foi a causa básica de morte em Medellin entre 2000-2007 foram coletadas. A análise de séries temporais foi global e estratificada por comunidade de residência. A distribuição do espaço-temporal da tuberculose e as taxas de mortalidade de HIV para o mesmo período, também foram calculadas a fim de explicar o risco e distribuição de ambas as doenças, elaborando mapas para cada um deles.* ***Resultados***. *A TB global e as taxas de mortalidade do HIV variou entre 3,28-3,53 e 7,29-6,20 por 100.000 habitantes, respectivamente. Na análise das taxas de mortalidade por tuberculose estratificados por comunidade, verificou-se que seis comunidades, registrou a maior incidência de mortalidade durante o período com taxas de mais de quatro casos por 100.000.* ***Conclusões****. As técnicas estatísticas de análise de séries temporais e distribuição espacial permitiu identificar as comunidades de Medellin com o aumento do risco de morte por tuberculose e HIV entre 2000-2007.*
Palavras chave: *Tuberculose, Coeficiente de Mortalidade, Distribuição Temporal, Conglomerados Espaço-Temporais, Modelos Estatísticos*

Introduction

The World Health Organization (WHO) in 2007 estimated the incidence rate of tuberculosis as 139 cases per 100,000 habitants in the world, with a total of 9,273,000 cases and 1,772,000 deaths from this disease worldwide (1). In 2008, in the United States, 12,898 cases of tuberculosis (TB) at a rate of 4.2 cases per 100,000 habitants were reported (2).

More than 75% of the new cases of tuberculosis in the world could be explained by demographic factors such as aging of the population (3); decreased immunity related to age and increased longevity; as well as the co-infection by HIV. Additionally to the former factors, in developing countries, there are other problems related to poverty, overcrowding, malnutrition, stress, and pollutants exposure (4).

In Colombia, more than 11,000 new cases of tuberculosis per year were reported during 2008; the incidence rate was of 25.6 per 100,000 habitants (5); while the mortality rate in 2006 was of 2.5 cases per 100,000 habitants (6) being the fourth cause of mortality from communicable diseases (7). In 2009, in Antioquia, a north western region of Colombia, a mortality rate of 2.3 per 100,000 habitants was reported. In Medellín, the capital city of Antioquia, during the same year, a mortality rate of 3.1 per 100,000 habitants was also reported (8).

In recent years, research of infectious diseases like tuberculosis has been enriched by the application of statistical techniques such as time series analysis (9), generalized linear models (such as linear regression) (10), discontinuous piecewise linear regression or piecewise regression (11,12), Markov models (10), survival analysis, categorical data analysis, regression analysis and classification tree, generalized estimating equation (GEE), models for longitudinal data, spatial statistics (13), Bayesian methods, meta-analysis, hierarchical models, neural networks, among others; allowing the description of the incidence of these diseases and to make predictions for specific populations. The trend analysis and the spatio-temporal distribution methods identify high densities of phenomenon occurrences in certain places at certain times (14). They can detect the different changes that have occurred in the trend of cases or deaths over a study time (9). These methods have been used in the study of infectious diseases like tuberculosis (15-18), HIV (19), and malaria (10) in many countries.

Since tuberculosis mortality is a major public health problem in developing countries, and given that statistical techniques such as trend analysis and spatial statistics allow to identify areas of greatest risk for the disease, the aim of this study was to determine the spatio-temporal distribution of tuberculosis mortality in the city of Medellin-Colombia in order to identify the communities most at risk of death and vulnerability by this disease.

Materials and methods

Type of study. An analytical study of time series analysis and spatial distribution of mortality from tuberculosis in Medellín-Colombia was performed.

Study subjects. Data obtained from death certificates where tuberculosis was the underlying cause of death, in the city of Medellín between 2000 and 2007 was collected. The secondary source of information was provided by the Colombian state department of demographic statistics -Departamento Administrativo Nacional de Estadística (DANE)-.

Variables. Demographic variables from the death

certificate such as age, sex, suburb and community of residence were considered.

Place of study. The study was carried out in the city of Medellín in its sixteen communities clustering roughly 260 suburbs; the population of Medellín is close to 2,200,000 habitants.

Statistical analysis. A time series analysis with overall mortality rates was performed. For the mortality rate calculation, the population projections for the years of study, supplied by the DANE, were used as denominator. The time series analysis was global and stratified by communities of residence.

For the analysis of changes in mortality rates, the Chi-square for Trend test was used. The significance level was defined in 5%. This analysis was made in the statistical program STATA 10.0® and Epi-Info 2007®.

The spatio-temporal distribution of tuberculosis mortality was developed with the ArcGIS® program; the city´s map was provided by the government of Medellín. Additionally, HIV mortality rates for the same period of study were also calculated in order to explain the risk and distribution of both diseases, elaborating maps for each of them.

According to Colombian law, this study is without risk to people because it uses secondary sources of information such as death certificates, therefore did not require the endorsement of the Ethics Committee.

Results

Between 2000 and 2007, 496 and 1134 deaths from TB and HIV respectively, were reported in Medellin. The global TB and HIV mortality rates ranged between 3.28 to 3.53 and 7.29 to 6.20 per one hundred thousand habitants during the study period, respectively. The overall mortality trend by TB and HIV displayed in Table 1, did not present statistically significant changes during the study period (Chi-square for trend by TB = 0.016, p value = 0.8982, Chi-square for trend by trend HIV = 0.018, p value = 0.8928).

The TB mortality rate presented higher incidences during the years 2001 and 2007; rates of 3.64 and 3.53 per 100,000 habitants respectively; while the HIV mortality rate, presented higher incidences during 2001 and 2005; rates of 8.51 and 7.36 per 100,000 habitants respectively (Figure 1).

In the analysis of TB mortality rates stratified by community, it was found that communities like La Candelaria, Santa Cruz, Popular, Castilla, Manrique and Buenos Aires registered the major incidence of mortality during the evaluated period with rates over four cases per one hundred thousand habitants. In communities like El Poblado, Robledo, Belén, La América and Laureles-Estadio, there was lower incidence of mortality with rates under one case per one hundred thousand habitants (Figure 2). Maps of TB mortality risk are displayed in Figure 3.

When analyzing HIV mortality rates stratified by community, it was found that La Candelaria had the highest incidence of death during the studied period; rates higher than 11 cases per 100,000 habitants were reported, with the exception of 2003 when the rate was of 7.71 per 100,000 habitants. The other communities that reported high HIV mortality were Aranjuez, Manrique, Santa Cruz and Buenos Aires, and the communities with the lowest incidence were El Poblado and Laureles-Estadio(Figure 2). Maps of HIV mortality risk are displayed in Figure 4.

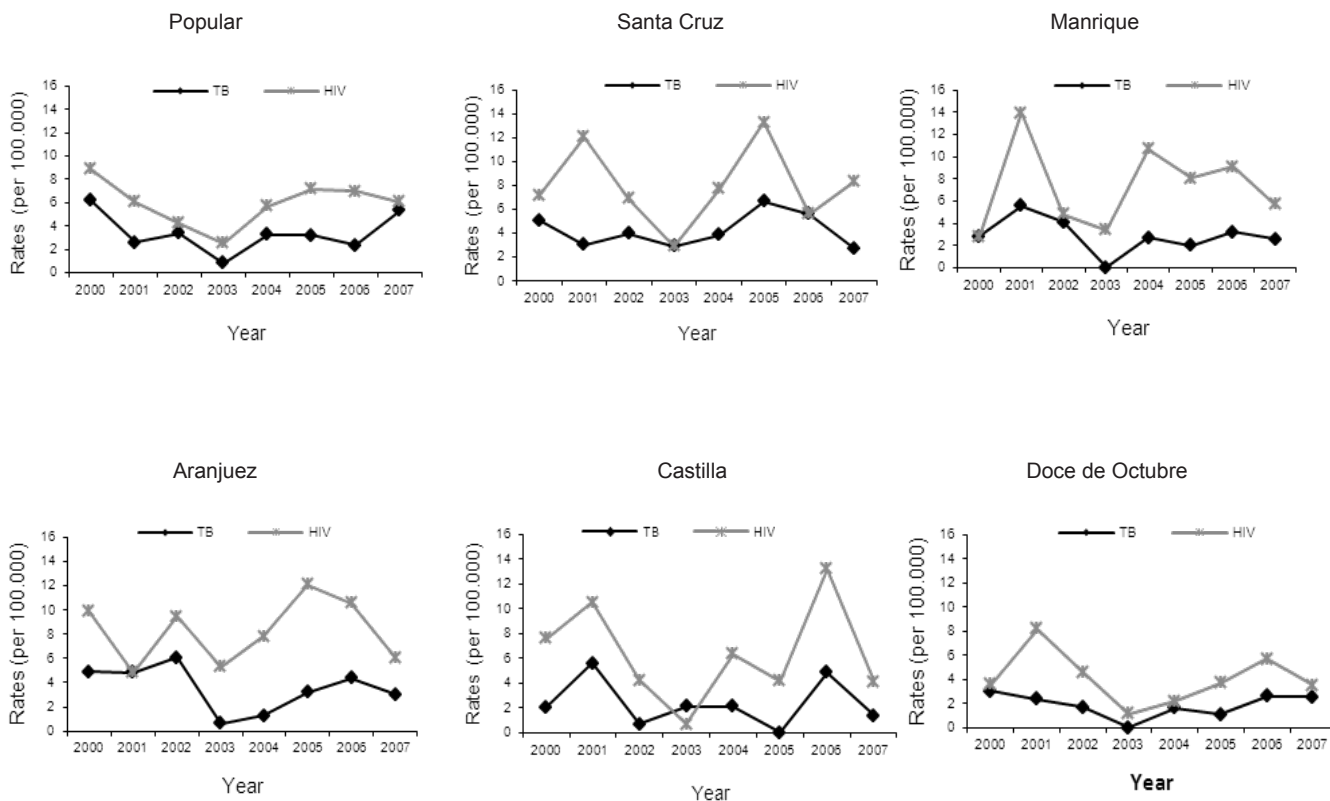**Table 1.** TB and HIV mortality rates between 2000 to 2007 in Medellin

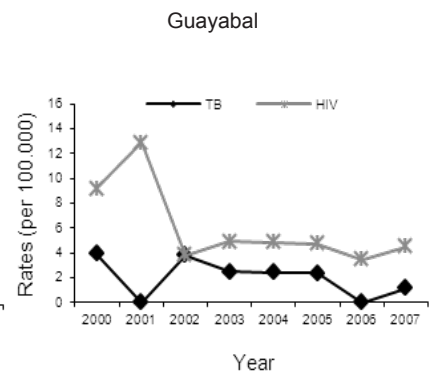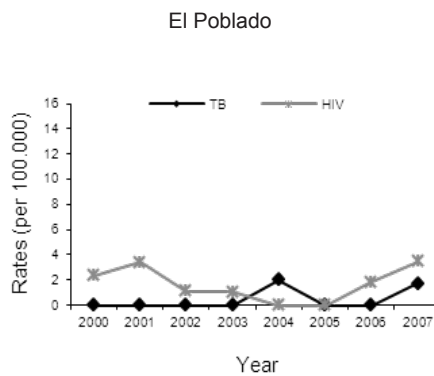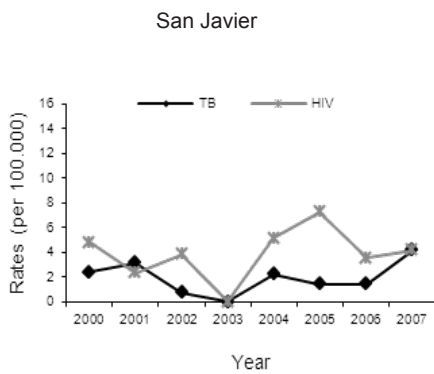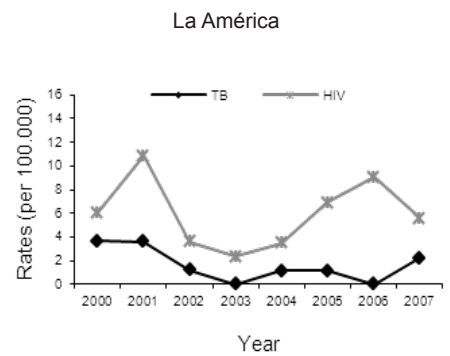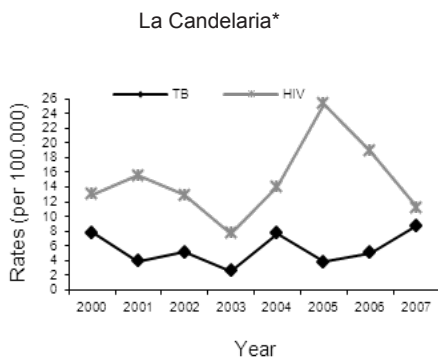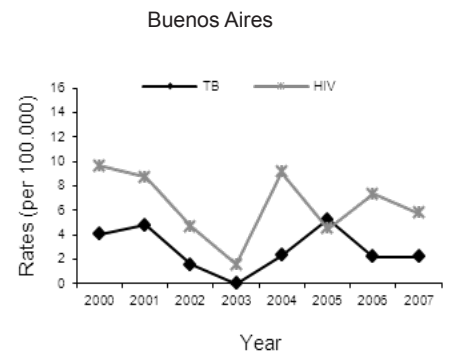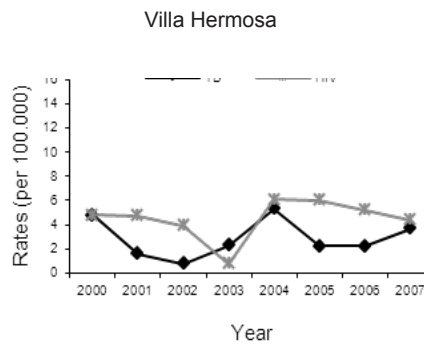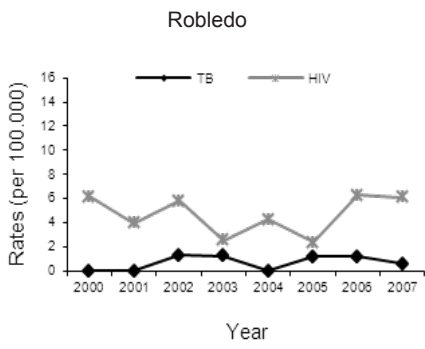| Year	Habitants	TB Deaths	HIV Deaths	TB Mortality Rate (per 100,000 hab.)	HIV Mortality Rate (per 100,000 hab.)
2.000	1919853	63	140	3,28	7,29
2.001	1949961	71	166	3,64	8,51
2.002	1983610	64	116	3,23	5,85
2.003	2020861	52	127	2,57	6,28
2.004	2061924	62	136	3,01	6,60
2.005	2104617	52	155	2,47	7,36
2.006	2155860	54	157	2,50	7,28
2.007	2209433	78	137	3,53	6,20
Total		**496**	**1134**		

Figure 1. TB and HIV mortality rates distribution between 2000 to 2007 in Medellin
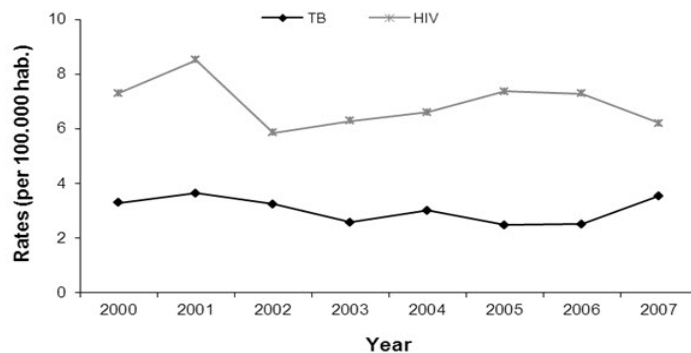
The trends of TB and HIV mortality rates are shown. Between 2000 and 2007, there were not statistically significant changes in trends of TB and HIV mortality rates, although in 2002 a turning point in HIV rates was found (Chi-square for trend by TB mortality rate = 0,016, p value = 0,8999 and Chi-square for trend by HIV mortality rate = 0,001, p value = 0,9728).

Figure 2. TB and HIV mortality trends by community

Popular

Santa Cruz

Manrique

Aranjuez

Castilla

Doce de Octubre

Robledo

Villa Hermosa

Buenos Aires

La Candelaria*

Laureles-Estadio

La América

San Javier


El Poblado

Guayabal

Belén
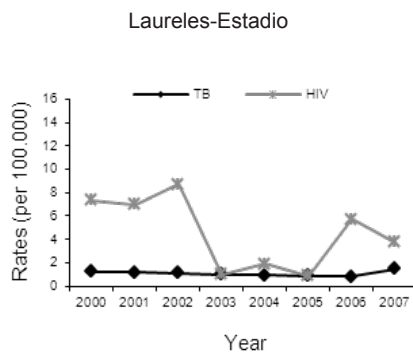
*The mortality rates for La Candelaria community have different scale in Y axis due to high frequency of deaths by TB and HIV in compared with the other communities.
The TB and HIV mortality trends by the sixteen communities of the city are displayed. The community of La Candelaria showed the highest rates of TB and HIV mortality. None of the changes of the trends were statistically significant during the study period. Only the community El Poblado showed significant changes in the trend of TB mortality rate but not in the trend of HIV mortality rates (Chi-square for trend by TB mortality rate =11,816, p value=0,00059 and Chi-square for trend by HIV mortality rate =0,024, p value=0,8765).
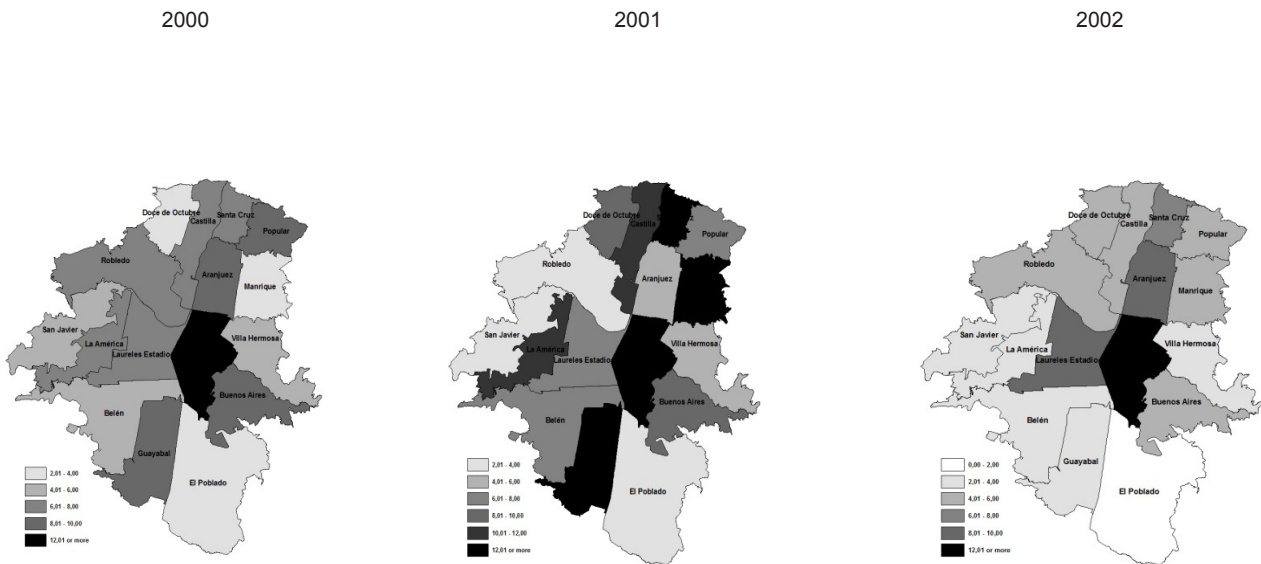
Figure 3. Maps of TB mortality risk per year

2000

2001

2002

2003

2004
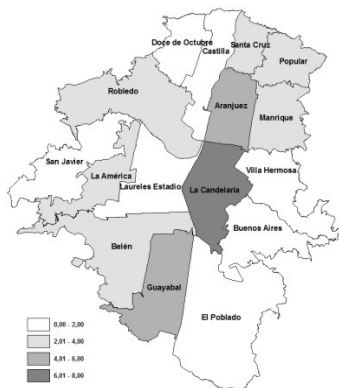

2005

2006   2007
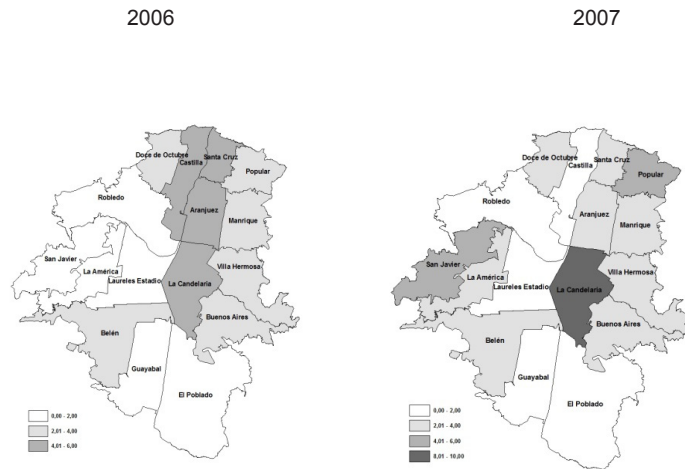
The maps of TB mortality rates per year of study are displayed. It is observed that the communities located in the northeast and central-east areas had higher TB mortality during the study period. The northeast area is composed by the following communities: Popular, Santa Cruz, Aranjuez and Manrique; and the central-east area by: Villa Hermosa, Buenos Aires and La Candelaria. The communities of Robledo, Laureles-Estadio and El Poblado showed a lower risk of TB mortality during the study period.
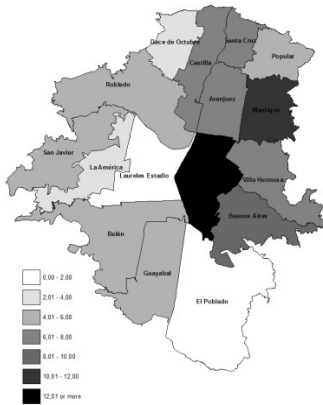
Figure 4. Maps of TB mortality risk per year

2000   2001   2002

2003

2004

2005
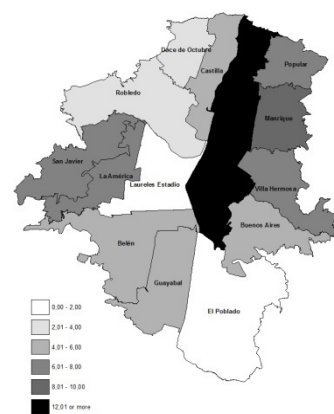
2006
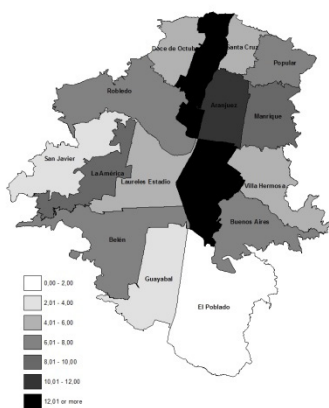
2007
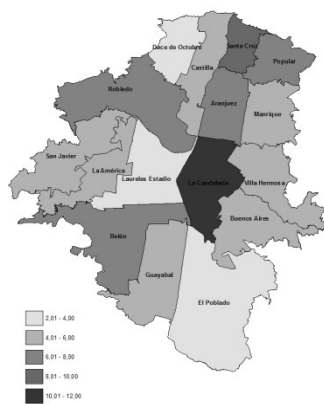
The maps of HIV mortality risk per year during the study period are shown. The habitants of communities of eastern and central area of the city had the highest risk of death, specifically in the communities of La Candelaria, Santa Cruz, Aranjuez, Manrique and Guayabal; in other communities such as Castilla, Doce de Octubre, Popular, Buenos Aires, San Javier and La America, their habitants had a moderate risk of death, while the habitants of Laureles-Estadio and El Poblado had the lowest risk of death for this disease.

Discusión

In the present study the spatio-temporal distribution of TB and HIV mortality identified communities at the greatest risk of death from these diseases in the city of Medellin between the years 2000-2007; these communities were La Candelaria (located in the central-east area of the city) and Aranjuez, Manrique and Santa Cruz (located in the northeast area). The communities of Laureles-Estadio and El Poblado displayed the lowest risk of mortality during the study period. The remaining communities had a moderate risk of death from TB and HIV.

The habitants of the communities at highest risk of TB and HIV mortality are of low income or of low to middle income classification in the socioeconomic status of the city. In 2007, these communities represented nearly a quarter of the population of the city accounting for 3.5 to 4.3 persons per household; between 4.2% and 6.1% of this population is illiterate (20). In 2009, between 11% and 12% of households in Manrique and Santa Cruz reported at least one of the unsatisfied basic needs (UBN); while in Aranjuez and La Candelaria, 5.4% and 1.4% reported at least one of the UBN, respectively. UBN consist in at least of the following: inadequate housing (mobile homes, life in the wild, houses without walls, houses with dirty floors or walls without finish); housing without public services (not access to water, sewage or septic tank); severe overcrowding (households with more than three people per room); truancy (households with at least one child between 7 and 11 years not attending school); and high economic dependence (the head of household has less than three years of schooling and there are more than three dependents of a worker member).

Approximately 7% or less of the households in these communities live under severe overcrowding conditions; between 38.9% and 69.7% of these households had food insecurity (low birth weight, protein-energy malnutrition, and vitamins and minerals deficiencies) (21); between 10.2% and 19.9% of this population were unemployed (22).

Additionally, one of every three people who died from TB and HIV during the study, belong to one of these communities. This is consistent with the fact that 27% of the population without any affiliation to health care or access to health services through state subsidies, lived in the same four communities (20). Additionally the conditions of poverty, hunger and malnutrition may increase therefore the susceptibility to infection, disease and severity (23), which can lead ultimately to death.

On the other hand, the communities of Laureles-Estadio and El Poblado presented the lowest risk of death from TB and HIV; their habitants belong to middle income or to upper income classification in the socioeconomic status of the city. In 2007, these communities represented 11.2% of the population of the city, accounting for 2.8 to 3.4 persons per household. Between 96.7% and 97.9% of the inhabitants are members of the social security system as taxpayers and only the 0.6% of this population is illiterate (20). In 2009, the 0.2% of households in these communities reported at least one of the UBN; the 0.2% or less of households lived under severe overcrowding conditions. Between 6.6% and 10.2% of these households reported food insecurity, and 4.9% of the population were unemployed (22).

Findings like these have recently developed an interest in social determinants of not only HIV but also TB, since this disease is concentrated in the most disadvantaged population groups in terms of poverty, hunger and ethnic minorities (22). These determinants include food insecurity and malnutrition, poor housing, environmental condition, overcrowding, homelessness, addiction, and financial, geographic and cultural barriers to health care access (22,24).

In terms of the overall TB mortality trends have remained relatively constant between 2000 and 2007, oscillating around three cases per hundred thousand habitants; rates slightly above the national average for 2006 that reported 2.5 per hundred thousand habitants (6). Similarly, trends of HIV mortality rates recorded an average of six cases per hundred thousand habitants between 2000 and 2007, these rates were also slightly above the national average for 2006 that reported 5.4 per hundred thousand habitants (1,25).

Stratified by communities, the TB and HIV mortality rates in the study period showed no change in the trends, with the exception of El Poblado where the trend in TB mortality changed in the years 2004 and 2007, recording two deaths each year with no deaths reported in the remaining years. This increase in mortality in 2004 and 2007 coincided with the increase in the trend in overall TB mortality of the city.

The statistical techniques of time series analysis and spatial distribution allowed identifying the communities of Medellin with increased risk of death from TB and HIV in the years 2000 and 2007. This information is useful for the municipal government as it will help to prioritize interventions in health, and will target resources to address this public health problem in most vulnerable communities, due to their life, residential and nutritional conditions, and access to health services.

Although the analysis of mortality in a population does not provide a complete diagnosis of its health status,

it provides useful information for the health situation, public health surveillance, formulation and evaluation of health programs and policies. The analysis of mortality represents the tool not only for assessing risk of death of the population and the impact of disease on health, but also the severity of disease and survival of the population (26).

The identification of geographic areas and population groups that have higher unsatisfied health needs is an essential function of public health; it allows monitoring and tracking these areas and groups in order to guide the formulation of policies and programs that help to eliminate or reduce health inequalities. Unsatisfied health needs, understood as damage, health risks or shortcomings, not only expressed as morbidity and mortality rates, should also take into account determinants of health, socioeconomic indicators, resources as well as access and coverage of health services (27).

The main limitation of this study was the utilization of secondary sources of information which may underestimate or overestimate the real mortality rates from TB and HIV, due to under-reporting on death certificates and the use of population projections during the study period that served as denominators for the rates calculation. In Colombia, under-reporting on death certificates has been estimated at about 24.6% (28), and population censuses are conducted at intervals between 10 and 12 years; therefore, population projections for the years 2000 to 2004 were calculated based on 1993 census, and projections for the years 2006 and 2007 were based in the 2005 census.

Conclusion

The communities at the greatest risk of TB and HIV mortality in the city of Medellin between the years 2000-2007, were La Candelaria, Aranjuez, Manrique, and Santa Cruz. The communities of Laureles-Estadio and El Poblado displayed the lowest TB and HIV mortality risk; the remaining communities had a moderate risk of death from TB and HIV.

The overall TB and HIV mortality rates trends remained relatively constant between 2000 and 2007, with rates of three and six cases per hundred thousand habitants, respectively; by communities, the rates showed no change in the trends in the study period, with the exception of El Poblado.

Data Confidentiality

The author(s) declare that they have no competing interests.

References

1. World halth Organization. Report 2009: Global tuberculosis control, epidemiology, strategy, financing. Ginebra, Suiza: WHO; 2009.
2. Department of Health and human services, Centers for Disease Control and Prevention. Trends in tuberculosis United States, 2008. MMWR. 2009;58(10):249-53.
3. World Health Organization. Global tuberculosis control 2008: surveillance, planning, financing. Ginebra, Suiza: WHO; 2008.
4. Pešut DP, Gledović ZB, Grgurević AD, Nagorni-Obradović LM, Adžić TN. Tuberculosis Incidence in Elderly in Serbia: Key Trends in Socioeconomic Transition. Croat Med J. 2008;49(6):807-812.
5. Ministerio de Protección Social, Instituto Nacional de Salud, Organización Panamericana de la Salud. Plan Estratégico Colombia Libre de Tuberculosis 2010-2015 para la Expansión y Fortalecimiento de la Estrategia Alto a la TB. Vivamos sin tuberculosis: todos somos parte de la solución. 3o ed. Bogotá: El Ministerio; 2009.
6. Departamento Administrativo Nacional de Estadística. Registros de estadísticas vitales Colombia 1985-2006. En: Plan Estratégico Colombia Libre de Tuberculosis 2010-2015 para la Expansión y Fortalecimiento de la Estrategia Alto a la TB. Vivamos sin tuberculosis: todos somos parte de la solución. Bogotá: El Ministerio;
7. Instituto Nacional de Salud. Protocolo para la vigilancia de la tuberculosis en Colombia. Bogotá DC: INS, Subdirección de Vigilancia y Control en Salud Pública; 2007. En: Plan Estratégico Colombia Libre de Tuberculosis 2010-2015 para la Expansión y Fortalecimiento de la Estrategia Alto a la TB. Vivamos sin tuberculosis: todos somos parte de la solución. Bogotá: El Ministerio;
8. Dirección Seccional de Salud de Antioquia. Mortalidad por tuberculosis según región y municipio. Antioquia 2000-2009 [Internet]. [citado 2011 Feb 3];Available from: http://www.dssa.gov.co/index.php/estadisticas/mortalidad
9. Muñoz MP, Orcau A, Caylà J. Tuberculosis en Barcelona: modelo predictivo basado en

series temporales. Rev. Esp. Salud Publica. 2009;83(5):751-757.

10. Casals M, Guzmán K, Caylà JA. Modelos matemáticos utilizados en el estudio de las enfermedades transmisibles. Rev. Esp. Salud Publica. 2009;83(5):689-695.

11. Kleiber C. Applied Econometrics with R. [New York]: Springer; 2008.

12. Thistlethwaite Donald L, Campbell Donalt T. Regression discontinuity análisis: An alternative to the ex post factor experiment. J Edu. 1960;51(6):309-317.

13. Gómez-Barroso D, Rodríguez Valín E, Flores Segovia V, Ramis Prieto R, Barrio Fernández JL del, Simón Soria F. Distribución espacial de la tuberculosis en España mediante métodos geoestadísticos. Rev. Esp. Salud Publica. 2009;83(5):737-744.

14. Nunes C. Tuberculosis incidence in Portugal: spatiotemporal clustering. Int J Health Geogr. 2007;6(1):30.

15. Touray K, Adetifa IM, Jallow A, Rigby J, Jeffries D, Cheung YB, et al. Spatial analysis of tuberculosis in an urban west African setting: is there evidence of clustering? Trop. Med. Int. Health. 2010 Jun;15(6):664-672.

16. Jia Z-W, Jia X-W, Liu Y-X, Dye C, Chen F, Chen C-S, et al. Spatial analysis of tuberculosis cases in migrants and permanent residents, Beijing, 2000-2006. Emerging Infect. Dis. 2008 Sep;14(9):1413-1419.

17. Randremanana RV, Sabatier P, Rakotomanana F, Randriamanantena A, Richard V. Spatial clustering of pulmonary tuberculosis and impact of the care factors in Antananarivo City. Trop. Med. Int. Health. 2009 Abr;14(4):429-437.

18. Neeraj T, CMS A, Ajoy T, Vineeta K. Investigation of geo-spatial hotspots for the occurrence of tuberculosis in Almora district, India, using GIS and spatial scan statistic. Int J Health Geogr. 2006;5:33.

19. Uthman OA, Yahaya I, Ashfaq K, Uthman MB. A trend analysis and sub-regional distribution in number of people living with HIV and dying with TB in Africa, 1991 to 2006. Int J Health Geogr. 2009;8(1):65.

20. Departamento Administrativo de Planeación, Alcaldía de Medellín. Encuesta de calidad de vida. Medellín 2007. Medellín: El Departamento; 2007.

21. Organización de las Naciones Unidas para la Agricultura y la Alimentación. El estado de la inseguridad alimentaria en el mundo 2005 la erradicación del hambre en el mundo: clave para la consecución de los objetivos de desarrollo del milenio. Roma: FAO; 2005.

22. Área Metropolitana del Valle de Aburrá, Gobernación de Antioquia, Alcaldía de Medellín. Indicadores de calidad de vida 2009: Antioquia, área metropolitana del Valle de Aburrá y Medellín. Medellín: La Comisión; 2009.

23. Hargreaves JR, Boccia D, Evans CA, Adato M, Petticrew M, Porter JDH. The social determinants of tuberculosis: from evidence to action. Am J Public Health. 2011 Abr;101(4):654-662.

24. Murray JF. The Year of the Lung. Series editor: John F. Murray. Int J Tuberc Lung. 2010;14(10):1215.

25. Grupo de Trabajo Observatorio en Salud. Los objetivos de desarrollo del milenio (ODM) en Colombia y en el mundo. Boletín del Observatorio en Salud. 2009;2(5):24-37.

26. Organización Panamericana de la Salud. De Datos Básicos a Índices Compuestos: Una Revisión del Análisis de Mortalidad. Boletín Epidemiológico. 2002;23(4):1-2.

27. Organización Panamericana de la Salud. Análisis de salud: Desarrollo del Índice de Condiciones Saludables Usando Sistemas de Información Geográfica en Salud. Boletín Epidemiológico. 2002;23(4):7-11.

28. Organización Panamericana de la Salud. Sobre la estimación de tasas de mortalidad para países de la Región de las Américas. Boletín Epidemiológico. 2003;24(4):1-5.

UNIVERSIDAD CES

Un Compromiso con la Excelencia

Resolución del Ministerio de Educación Nacional No. 1371 del 22 de marzo de 2007