The HIV Epidemic In Colombia: Spatial And Temporal Trends Analysis

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Abstract

BACKGROUND – Colombia occupies 4th place among all Latin American countries in HIV/AIDS incidence rates, which have been increasing since the 1980s. There is a paucity of studies which address this trend. In this study we employed spatial and temporal trend analyses to study how the epidemic behaves in Colombian territory.

METHODS - Our sample was composed of 72,994 HIV/AIDS cases and 21,898 AIDS-related deaths reported to the National Ministry of Health between 2008 and 2016. We employed the joinpoint regression model to analyze the annual HIV/AIDS incidence and AIDS mortality rates. In the spatial analysis we used univariate autocorrelation techniques and the Kernel density estimator.

RESULTS – While the HIV/AIDS incidence had an increasing trend in Colombia, the AIDS mortality was stabilized. There was a downward trend in HIV/AIDS incidence and AIDS mortality among people between 0 to 14 years of age. An upward trend was observed for HIV/AIDS incidence in people older than 15 years of age and with the highest trend in 65 years and over group. AIDS mortality showed an increased trend in those 65 years old or over. The high-high clusters of HIV/AIDS incidence and AIDS mortality were located in the Andean and Caribbean regions. The HIV epidemic expanded from the North Caribbean region to Midwest Colombia.

CONCLUSION – Sexual tourism and internal or external immigration might be responsible for the highest HIV/AIDS incidence and AIDS mortality rates observed in the Caribbean and Andean regions. Our results showed that Colombia needs to invest in specific and comprehensive public health policies to end HIV by 2030.

Background

Since 1980, 74.9 million people have been infected by the Human Immunodeficiency Virus (HIV), and 32 million have died by Acquired Immunodeficiency Syndrome (AIDS).[1] After all these years, ending HIV remains a challenge to world health authorities. While global AIDS-related deaths have decreased more than 50% after the implementation of Antiretroviral Therapy (ART), the HIV/AIDS incidence rate achieved only a slight decrease.[1-3]

The scarcity of public policies to combat HIV, and economic regional disparities, is directly correlated with the expansion of HIV in Latin America (LA) where 1.9 million people live with HIV and AIDS (PLWHA). Between 2010 and 2018 there was a 7% increase in new HIV infections throughout LA.[1-2,4]

Among all LA countries, Colombia occupies the fourth-ranking position in the HIV/AIDS detection rate. Its national HIV/AIDS prevalence is about 0.7%, but it can be even higher among key populations – men who have sex with men, sex workers, injection drug users, and prisoners. The Colombian Caribbean region has the second-highest prevalence of HIV/AIDS in the world after sub-Saharan Africa. This not only brings social and economic problems to the country but also fetters the health system.[5]

Several factors can contribute to the expansion of HIV in Colombia, such as: social inequalities with the majority of its population living in poverty and with low access to the healthcare system; social discrimination and stigmatization of PLWHA; the forced displacement of the population by internal armed conflicts; the high level of violence against women; sexual tourism; and the internal and external migration of people to Colombian cities in hope of finding jobs and a better quality of life.[6-8]

One challenge to combatting the HIV epidemic can be met by describing how it behaves differently in each Colombian territory, since it is influenced by sociopolitical and economic factors.[2,9-10] We can assume that the HIV epidemic has a different dynamic in each Colombian region considering the regional sociopolitical and economic differences. However, during a literature review, we did not find other studies about the spatial and temporal dynamics of the HIV epidemic in Colombia. Spatial analysis studies are ideal in identifying the more impacted areas by the epidemic, and in highlighting contributing territorial factors. Likewise, temporal trend studies optimize the analysis of the annual impact of public policies against the epidemic.[11]

Therefore, the goal of this study is to analyze the epidemic of HIV/AIDS in Colombia employing spatial and temporal trend analysis techniques. Here, we considered the incidence of HIV/AIDS and AIDS mortality rates. The results found in this study will provide suggestions to Colombian Public Health authorities on implementing new strategies in the war with HIV, and also to evaluate the already implemented policies.

Methods

Study Design and Settings

This is an ecological study employing secondary data provided by the Colombian Ministry of Health.

Colombia has an estimated population of 50,375,594 inhabitants in a 2,070,408 Km^2 area. It is divided into five main political regions (Caribbean, Pacific, Andean, Orinoquia, and Amazon), 32 provinces, and 1,123 municipalities (Fig. 1).

Study Population and Variables

This study population as composed of all HIV/AIDS and AIDS-related deaths reported to the Public Health Surveillance System (PHSS) and to the Department of National Administration and Statistics (DNAS), respectively, from the Colombia National Institute of Health. Only the notifications containing Colombian home addresses and occurring between 2008 and 2016 were included in this study.

We collected the following variables: age, gender, year of diagnosis and death, province, and city of residency. Data were double-checked in order to remove inconsistencies and redundancies. After data validation, the sample size revealed 72,994 HIV/AIDS cases and 21,898 AIDS-related deaths for the nine year timeframe of the study.

Statistics Analyses

Temporal trends analysis

We employed joinpoint regression to analyze changes in the annual incidence of HIV/AIDS as well as in AIDS mortality rates during the period of the study. All analysis steps have been described previously.[12] Briefly, both incidence and mortality rates were directly age-adjusted following the joinpoint regression model. Joinpoint regression continues to add joinpoints in a linear trend until the number of joints cumulate in order to distinguish two different periods from one trend. The best-fitting adjusted model was assessed by the Monte Carlo permutation test. Here, we considered annual percent changes (APC), 95% confidence interval (CI 95%), and also p-value. Upward and downward trends were considered only with positive or negative APC, respectively, and $p<0.05$. If these conditions were not reached, it was considered a stationary-trend.

All data were grouped by year, gender, counties, region, and age range. The age ranges (years) were categorized into four groups: 0 – 14, 15 - 44, 45 - 64, 65 and over. These categorizations were due to the DNAS database being available with these age groups already. The annual incidence of HIV/AIDS and AIDS mortality were calculated based on annual population projections for all Colombia, regions, and for the specific age groups and genders. Both rates were standardized by 100,000 inhabitants.

We considered the incidence and mortality coefficients as the dependent variables. The study years were considered the independent variable.

Spatial analysis

Here we analyzed the spatial distribution of HIV/AIDS incidence and AIDS mortality rates and their spatial autocorrelation and Kernel intensity estimator. In order to avoid the annual variation in the reported cases of HIV/AIDS and AIDS-related deaths, we grouped the data in three-year periods: 2008-2010, 2011-2013, 2014-2016.

Municipal HIV/AIDS incidence and AIDS mortality rates were analyzed through choropleth maps. Both rates were calculated for each Colombian city based on the average of their population projection for each three-year period. The results were standardized for 100,000 inhabitants.

In order to assess the overall trend pattern of these variables, we analyzed the spatial autocorrelation incidence and mortality rates employing Global Moran's I. The Global Moran's I index ranges from -1 to 1: an index of -1 means dispersion, 0 is random behavior, and an index of 1 means perfect association. However, to localize the clusters we used the Local Indicator of Spatial Association (LISA) method. In LISA maps we can identify four different spatial relationship groups of the variable under analysis. High-high and low-low aggregations are areas with a high or low value of the variable under study surrounded by neighboring areas which have like values above- or below-average, respectively, of the specific variable. By contrast, high-low or low-high groups are areas with a high or low value of the analyzed variable surrounded by neighboring areas which have opposite values below- or above-average of the same variable, respectively. We used the standardized first-order queen neighbors and the p-value obtained from 999 permutations as the definition of "neighborhood". We only considered spatial dependency with Global's I index (I) above 0 and with $p<0.05$. [13]

The spatial distribution and the autocorrelation analyses were done in the software ArcGis 10.6.1. The maps were constructed in the Universal Transverse Mercator Coordinate System (UTM), datum D_Bogota, on a scale of 1:12.000.000.

To analyze the direction of expansion or contraction of the HIV epidemic in Colombia we used the Kernel density estimator. This method allows estimation of how a density of an event occurring in one area can influence its neighborhood. Events occurring in places closer to each other receive a higher weight than events occurring in distant places.[14] Kernel analysis employs the adaptive influence radius and quartic Kernel smoothing function using the software TerraView (4.2.2). We considered the municipalities as units of analysis.

Results

From 2008 to 2016, Colombia recorded 72,994 cases of HIV/AIDS. Most of these notifications were in men (Men: 53,432 cases, 73.20%; Women: 19,563 cases, 26.80%). HIV was the preponderant diagnostic when compared with AIDS in both men and women (Men: 42,787 HIV, 10,645 AIDS; Women: 16,322 HIV; 3,240 AIDS). During the same period of the study 21,898 of AIDS-related deaths were notified to the Health Ministry with a higher frequency in men (Men: 16,505 deaths, 75.37%; Women: 5,393 deaths, 24.63%).

Temporal trends analyses

Table 1 shows the results of the temporal trend of the HIV epidemic in Colombia, considering the incidence of HIV/AIDS and AIDS mortality rates in the nine years of the study. The incidence had an upward trend in the entire country, in all age groups except for 0-14 years of age (decreasing trend). Caribbean, Andean, Orinoquia, and Amazon regions also had an upward trend. Joinpoint regression identified two different periods in trend for the 15-44 age group with a higher APC in the second period (2008-2013: APC 6.2%, p=0.000; 2013-2016: APC 11.2%, p=0.000).

Different from the incidence, the AIDS mortality rate was stabilized in all Colombia, in both genders and all regions. Considering the age groups, the mortality rate had a decreasing trend in the 0-14 and 15-44 groups. However, in the 15-44 group the joinpoint regression distinguished two different periods with a decreasing trend in the first period and stabilization in the second one (2008-2013: APC -2.8%, p= 0.006; 2013-2016: 3.2%, p=0.41). The same also occurred in the Caribbean region where two periods were identified with different behaviors: between 2008-2011 the mortality rate was stable (APC -2.9%, p=0.079), after 2011 it increased (2011-2016: APC 2.4%, p=0.014).

Table 1: Temporal trend analysis of HIV/AIDS incidence and mortality in Colombia, 2008-2016

		INCIDENCE		MORTALITY	
	Joinpoint results	APC (CI 95%)	P	APC (CI 95%)	P
Total		7.8 (6.7; 8.9)	0.000	-0.1 (-1.1; 1.0)	0.707
Gender					
Male		9.8 (8.5; 11.1)	0.000	-0.3 (-1.5; 0.9)	0.464
Female		2.5 (1.1; 3.9)	0.005	0.7 (-0.3; 1.6)	0.158
Age (years)					
0 - 14		-7.4 (-12.4; -2.0)	0.014	-9.7 (-16.6; -2.3)	0.018
15 - 44		8.3 (7.1; 9.5)	0.000	-1.7 (-2.8; -0.6)	0.005
	2008-13	6.6 (4.6; 8.6)	0.000	-2.8 (-4.2; 1.2)	0.006
	2013-16	11.2 (7.5; 14.9)	0.000	3.2 (-5.9; 13.1)	0.410
45 - 64		5.5 (3.7; 7.3)	0.000	0.6 (-0.5; 1.7)	0.342
65+		10.2 (6.9; 13.5)	0.000	7.5 (3.6; 11.6)	0.002
REGIONS					
Caribbean		8.6 (6.3; 10.9)	0.000	0.6 (-0.6; 1.9)	0.317
-	2008-11	---------	----	-2.9 (-6.3; 0.7)	0.079
-	2011-16	---------	----	2.4 (0.8; 4.0)	0.014
Pacific		3.2 (-0.8; 7.3)	0.113	0.4 (-1.2; 2.0)	0.661
Andean		8.8 (7.2; 10.4)	0.000	-0.9 (-2.1; 0.3)	0.090
Orinoquia		10.2 (5.4; 15.3)	0.001	2.8 (-1.4; 7.2)	0.172
Amazon		5.1 (1.9; 8.5)	0.008	-0.6 (-5.0; 4.0)	0.736

Our next task was to investigate differences between gender. Table 2 shows an increasing trend of HIV/AIDS incidence in males in all regions and all age groups above 15 years old. A decreasing trend was observed only in the 0-14 age group (APC -7.5%, p=0.040). The joinpoint regression detected two periods of time when analyzing the 15-44 age group with higher APC in the second period (2008-13: APC 8.2%, p=0.000; 2013-2016: APC 15.0%, p=0.000). Similarly, the female incidence rate had a downward trend in the 0-14 age group, but upward trends were only detected after 45 years of age (45–64 years: APC 7.0%, p=0.000; 65+ years: APC 11.0%, p=0.024). Female incidence showed increases only in the Caribbean and Andean regions (APC 5.9%, p=0.006; APC 1.9%, p=0.014, respectively), as opposed to males.

Concerning the AIDS mortality rate, the only alteration in men was in the age group 65+ years old with a significantly increasing trend (APC 7.8%, p=0.003). However, although the general trend to the 15-44 age group has been described as stable, the joinpoint regression identified two different periods with a decreasing trend in the first period (2008-2012: APC -4.8%, p=0.002) and a stabilization in the second one (2012-2016: APC 0.5%, p=0.65). Among women, there was a decreasing trend in the 0-14 age group (APC -11.2%, p=0.045) and increasing trends in the 45-64 age group (APC 3.2%, p-0.033) and in the Caribbean and Pacific regions (APC 1.9%, p=0.010; APC 2.1%, p=0.007, respectively).

Table 2 – Temporal trend analyses of HIV/AIDS incidence and mortality among men and women in Colombia, 2008-2016.

		INCIDENCE		MORTALITY	
	Joinpoint results	APC (CI 95%)	P	APC (CI 95%)	P
MALE					
Age (years)					
0 a 14		-7.5 (-14.0; -0.4)	0.040	-6.0 (-16.5; 5.8)	0.261
15 a 44		10.8 (9.2; 12.5)	0.000	-2.2 (-3.5; -1.0)	0.003
-	2008-12	---------	----	-4.8 (-6.6; -2.9)	0.002
-	2008-13	8.2 (6.2; 10.3)	0.000	---------	----
-	2012-16	---------	----	0.5 (-1.5; 2.5)	0.650
-	2013-16	15.0 (11.4; 18.8)	0.000	---------	----
45 a 64		5.0 (3.1; 7.1)	0.000	0.0 (-1.3; 1.4)	0.869
65+		10.1 (7.6; 12.7)	0.000	7.8 (3.6; 12.1)	0.003
Regions					
Caribbean		10.1 (8.4; 11.8)	0.000	0.3 (-1.2; 1.8)	0.821
Pacific		5.5 (1.1; 10.1)	0.023	-0.3 (-2.4; 1.7)	0.600
Andean		10.6 (8.9; 12.4)	0.000	-0.8 (-2.2; 0.5)	0.149
Orinoquia		13.7 (8.6; 19.0)	0.000	2.9 (-1.5; 7.4)	0.186
Amazon		9.2 (4.0; 14.6)	0.003	0.5 (-5.1; 6.5)	0.867
FEMALE					
Age (years)					
0 - 14		-7.0 (-13.0; -0.6)	0.035	-11.2 (-20.9; -0.4)	0.045
15 - 44		1.6 (0.0; 3.3)	0.069	-0.5 (-2.2; 1.1)	0.404
45 - 64		7.0 (5.0; 9.0)	0.000	3.2 (0.4; 6.0)	0.033
65+		11.1 (1.9; 21.1)	0.024	6.6 (-1.0; 14.9)	0.081
Regions					
Caribbean		5.9 (2.3; 9.6)	0.006	1.9 (0.6; 3.2)	0.010
Pacific		-2.1 (-5.2; 1.1)	0.139	2.1 (0.8; 3.3)	0.007
Andean		1.9 (0.6; 3.2)	0.014	-1.0 (-3.0; 1.0)	0.250
Orinoquia		3.5 (-1.1; 8.3)	0.125	2.9 (-3.3; 9.5)	0.316
Amazon		-0.8 (-4.8; 3.3)	0.613	-2.4 (-8.8; 4.3)	0.400

Spatial analysis

Figure 2 shows the spatial distribution of HIV/AIDS incidence (Figs. 2A, C, and E) and AIDS mortality rates (Figs. 2B, D, and F). One notices a territorial expansion of HIV/AIDS incidence and a contraction for AIDS mortality. The most impacted municipalities are localized in the Caribbean, Andean, and Orinoquia regions. After 2014, there was an increase in incidence and mortality rates in municipalities bordering Venezuela, in the Caribbean and Orinoquia regions.

All univariate spatial autocorrelations of Global Moran's I indexes were positive and statistically significant to both HIV/AIDS incidence and AIDS mortality (HIV/AIDS incidence: 2008-2010 - I=0.15 p=0.00, 2011-2013 - I=0.28 p=0.00; 2014-2016 - I=0.22 p=0.00; AIDS mortality: 2008-2010 - I=0.26 p=0.00; 2011-2013 - I=0.24 p=0.00; 2014-2016 - I=0.23 p=0.00). Figures 3A, C, and E show the LISA maps for the HIV/AIDS incidence and figures 3B, D, and F for AIDS mortality rates. One notes the high-high clusters for both rates are located on the Caribbean coast and in the 'coffee belt' of the Andean region. The low-low clusters were restricted to the Orinoquia and Amazon regions. Also, between 2014 and 2016, a high-high cluster of incidence and mortality appeared in the Caribbean and Orinoquia regions bordering Venezuela (Figs.3C, E, and F).

Our next question was about the direction of the HIV epidemic expansion in Colombia. To answer it, we employed the Kernel density estimator. Figure 4 shows the Kernel maps of HIV/AIDS incidence (Figs. 4A, C, and E) and AIDS mortality rates (Figs. 4A, D, and F). In these maps one can notice a higher density in municipalities of the 'coffee belt' for both incidence and mortality rates. While the HIV/AIDS incidence expands from the North of the Caribbean to the Northeast and Midwest of Colombia, AIDS mortality contracted in zones toward the Andean region's 'coffee belt'.

Discussion

This study showed a temporal and spatial panoramic view of the HIV epidemic in Colombia. While there was an upward trend in HIV/AIDS incidence in the period of the study, the AIDS mortality rate was stable. The higher impact of the HIV epidemic was in men and in the 15 - 44 and 65+ age groups. Among men, the epidemic had an increasing trend in all Colombian regions; among women, only in the Andean and Caribbean regions.

The HIV epidemic in Colombia follows the observation from all LA which increased its HIV/AIDS incidence by 7% from 2010 to 2018.[1] However, this phenomenon is not only particular to LA: Between 2017 and 2018, Canada also reported an increase of 8.2% in new HIV infections.[15] These figures reflect the low investment in public policy against HIV.[6] By contrast, South Africa had the largest investment in ART and it's report of new HIV infections shows a substantial decrease.[16]

There remains much to do in Colombia in order to reach the 2030 UNAIDS goals through 90-90-90 targets. Even after a health system restructuring in 2008 that guaranteed more access to ART,[9] Colombia still ranks low on various indices among all LA countries: overall ARV coverage, HIV testing, and also in the proportion of PLWHA that have suppressed viral load. In addition, by the end of 2018 Colombia still had not adopted the Pré-Exposition Profilaxy to HIV.[17-18] Countries that adopted the Universal Treatment and Test for HIVA policy (UTT) have observed an increasing number of PLWHA with suppressed virus load, decreasing HIV incidence and AIDS-related deaths.[19] The fact that our AIDS mortality data shows a pause in a decreasing trend after 2013, among men in the 15-44 age group, should sufficiently warn health authorities.

We observed an increasing trend in HIV/AIDS incidence occurring earlier in men than in women and the inverse occurring in AIDS mortality. This may be due to socio-cultural barriers such as female subservience, that prevent women from seeking HIV testing earlier, or from starting treatment earlier, or to abandon treatment altogether.[20-22] The increasing trend in rates in the Caribbean and Andean regions, noticed among women, may be due to the sex tourism.[7]

The decreasing trends observed in HIV/AIDS incidence and AIDS mortality in the 0-14 age group reflects ownward mother-to-child HIV transmission. In 2003 the Colombian Health Ministry launched the project "Elimination Strategy to the elimination of mother-to-child HIV and Syphilis transmission". This strategy guarantees antenatal care~~,~~ with multiple tests for HIV and Syphilis, including treatment for pregnant women, their partners and babies, cesarean delivery, and implementation of formula milk breastfeeding. From 2008 to 2016 there was a decrease in mother-to-child HIV transmission from 5.8% to 2.6%.[23] A recent study showed a high percentage of HIV pregnant women starting antenatal care late, as well as late ARV treatment and absence of the virus load exam after the 34th week of pregnancy.[24] Cuba invested in the same strategy and it was the first country in the world to eliminate mother-to-child HIV transmission, followed by Thailand, Armenia and Belarus.[25] To reach the OMS goals[26] more effort has to be employed.

The high increasing trend in HIV/AIDS noticed in the 65+ age group is another alert for health authorities. Although this can be due to late HIV diagnosis, it may also be due to prolonged sexuality in elders because of a flood of new pharmacological products. Unprotected intercourse due to low level of knowledge about transmission of HIV/STI at this age has been implicated in the increase of HIV/AIDS incidence in this specific demographic. More dangerous yet is the fact that elders succumb faster than younger persons to AIDS and, consequently, to death.[27-30] We did not find any public health policy articulated to this demographic regarding STI prevention.

In agreement with the temporal trends analyses, the results from the spatial analyses showed that the Caribbean, Andean and Orinoquia regions were the most affected by the HIV epidemic. The LISA maps evidenced high-high clusters of HIV/AIDS incidence and AIDS mortality rates in Andean (coffee belt) and Caribbean regions, the coast and in the border of Venezuela. The Caribbean and Andean regions are highly touristic regions and receive a huge number of migrants seeking jobs and a better quality of life. Sexual tourism and population growth without investment on public health policies are directly correlated with increasing STIs.[31-32] The municipalities bordering Venezuela received a huge quantity of Venezuelan immigrants due to the economic and political crisis in that country. From all reported cases of HIV/AIDS in 2017 in Colombia, 0.8% were imported from other countries and 94% of this total was from Venezuela.[33]

This is an ecological study, therefore we cannot claim causality between HIV transmission, demographic groups, migration, stigma or other social phenomena, or highway patterns. Various confounders may be overlooked in these types of analyses. In addition, this study was limited by particular gaps in the data due to the sources of information. However, one gap represents a small proportion (576 cases of

HIV/AIDS and 312 deaths) of the entire database, not compromising the analyses. Related to that, a last limitation was the employment of two particular datasets (PHSS and DNAS) without identifiers which made it impossible to extend analyses between variables.

Conclusions

Our study showed that while HIV/AIDS incidence increased annually in Colombia, the AIDS mortality was stable. Caribbean and Andean regions were the most impacted regions by the recent HIV epidemic, which may be associated with sexual tourism and high inter- or external migration. Our data show that women seem to have a later HIV diagnosis than men and died prematurely compared to men.

Colombia has to invest more in public health policies in order to end HIV transmission by 2030. It is necessary to make testing and ART universally available as well as pre-exposure prophylaxis (PREP), to combat social discrimination against HIV and discrimination and violence against women. Even so, Colombian authorities need to outreach beyond these traditional high risk groups to implement HIV/STI prevention policies to truck drivers. Lastly, our study showed the necessity and the urgency of establishing STI prevention for elderly people.

Abbreviations

AIDS – Acquired immunodeficiency syndrome

APC – Annual percentual change

ART - Antiretroviral Therapy

DNAS - Department of National Administration and Statistics

HIV – Human Immunodeficiency Virus

LA – Latin America

LISA – Local indicator of spatial autocorrelation

PLWHA – People living with HIV and AIDS

PHSS - Public Health Surveillance System

PREP - Pre-exposure prophylaxis

STI – Sexually transmitted infections

Declarations

Ethics approval and consent to participate

This study was approved by the Research Ethic Committee of the Science Health Institute of the Federal University of Pará under recording number CAAE 12473119.4.0000.0018

Consent for publication

Not applicable

Availability of data and materials

The cartographic bases used in this study can be accessed on website of the Institute of Geography Augustin Codazzi (https://www.igac.gov.co). Population databases were taken from DANE website (http://www.dane.com.co). The maps in figures 1 to 4 were constructed by the authors of this paper. The data that support the findings regarding to compulsory notification of HIV/AIDS are available from the Colombia National Institute of Health and the data about mortality from the National Statistic Administrative Department. Restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

Concept and designed the study: JFM, GRONF, DCCC; EPB;

Collection of data: JFM, EPB;

Analysis and interpretation of data: JFM, GRONF, DCCC, CLFC, WAAF;

Revision of the paper: SHIP, LHTG, WAAF, DCCC, EG, RKR, WS, EPB

All authors reviewed and approved the final manuscript

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Figures

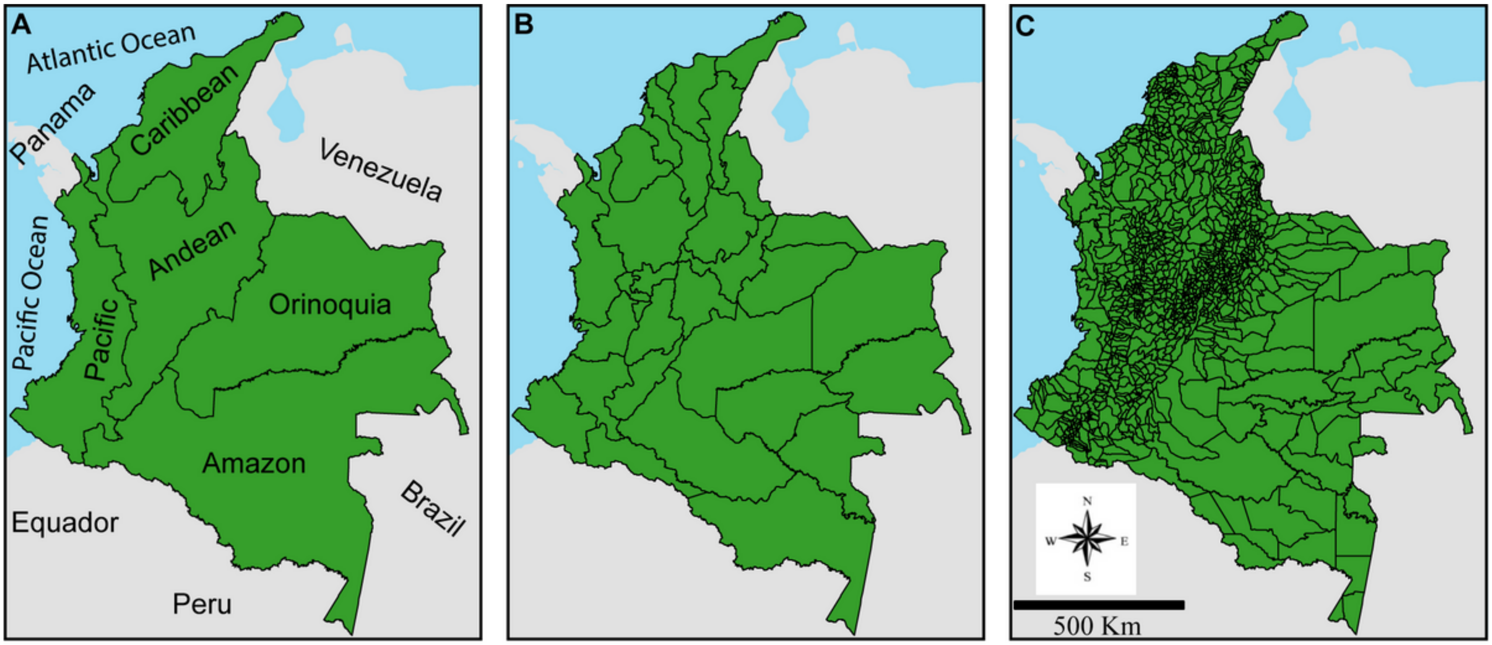

Figure 1

Colombian regions (A), provinces (B) and Municipialities (C).

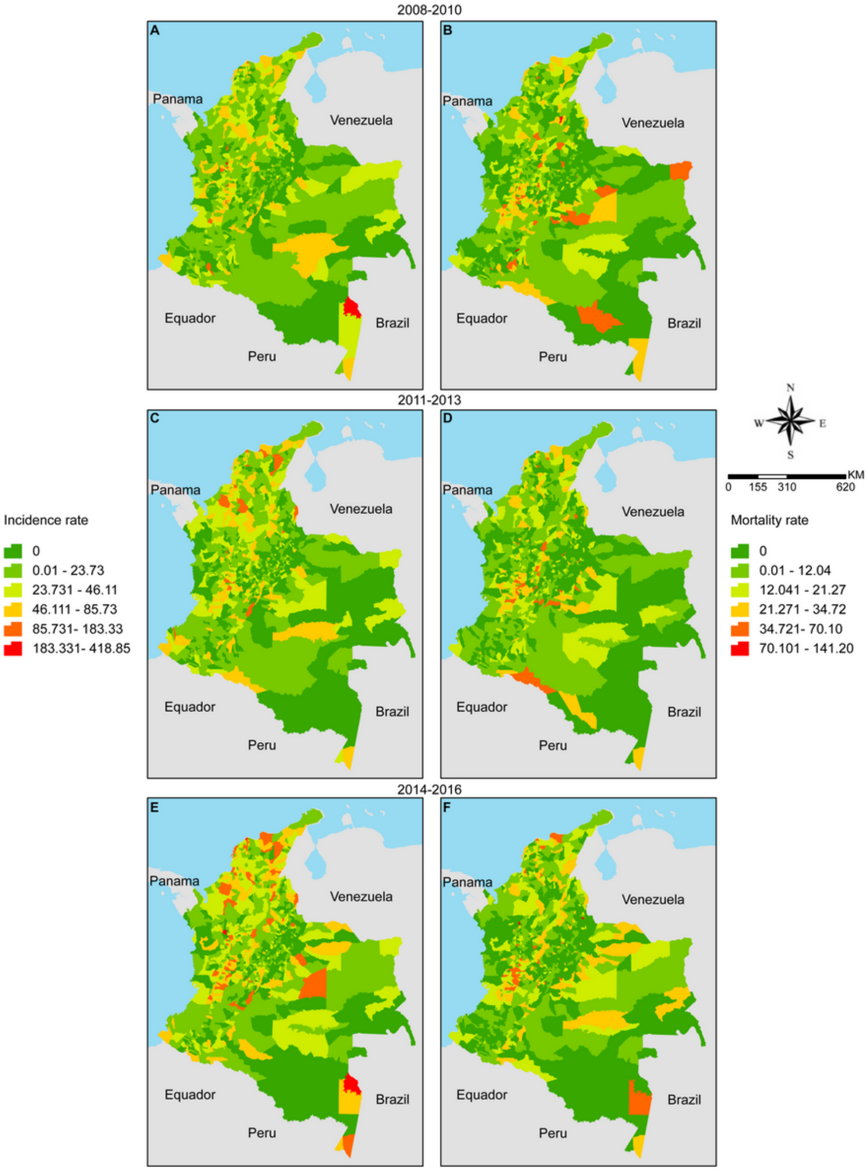

Figure 2

Spatial distribution of HIV/AIDS incidence (A, C, E), AIDS mortality (B, D, E).

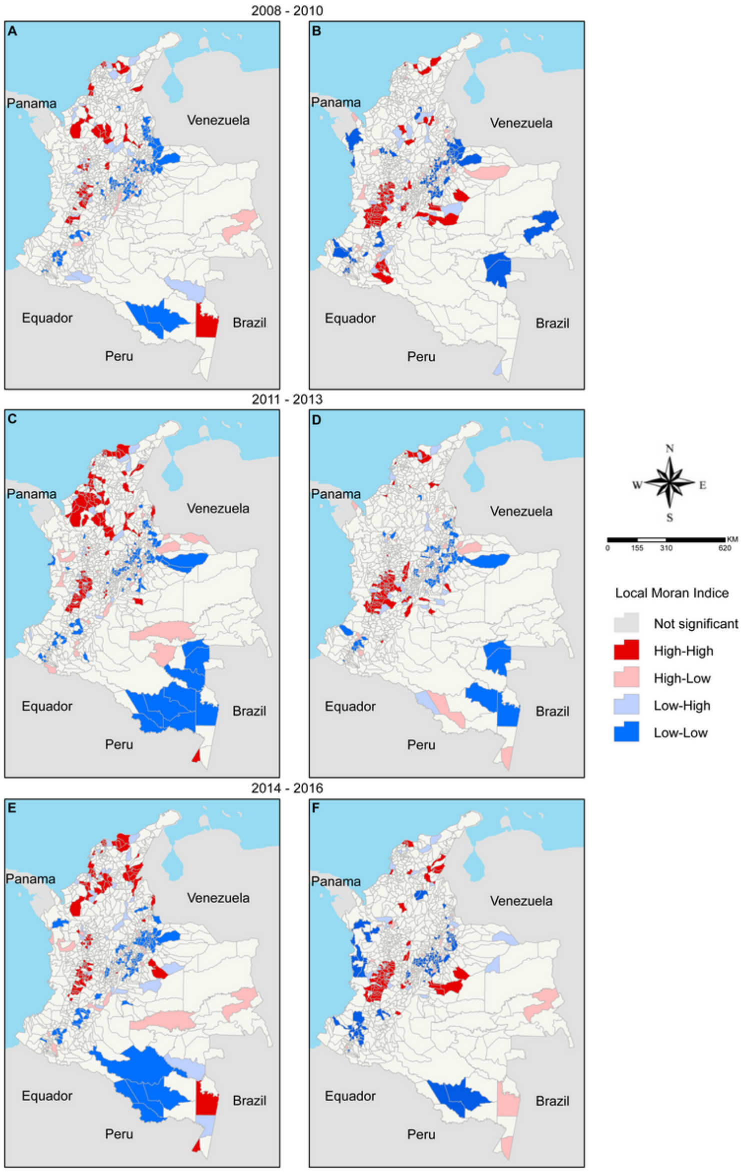

Figure 3

LISA maps of HIV/AIDS incidence (A, C, E) and mortality rates (B, D, E).

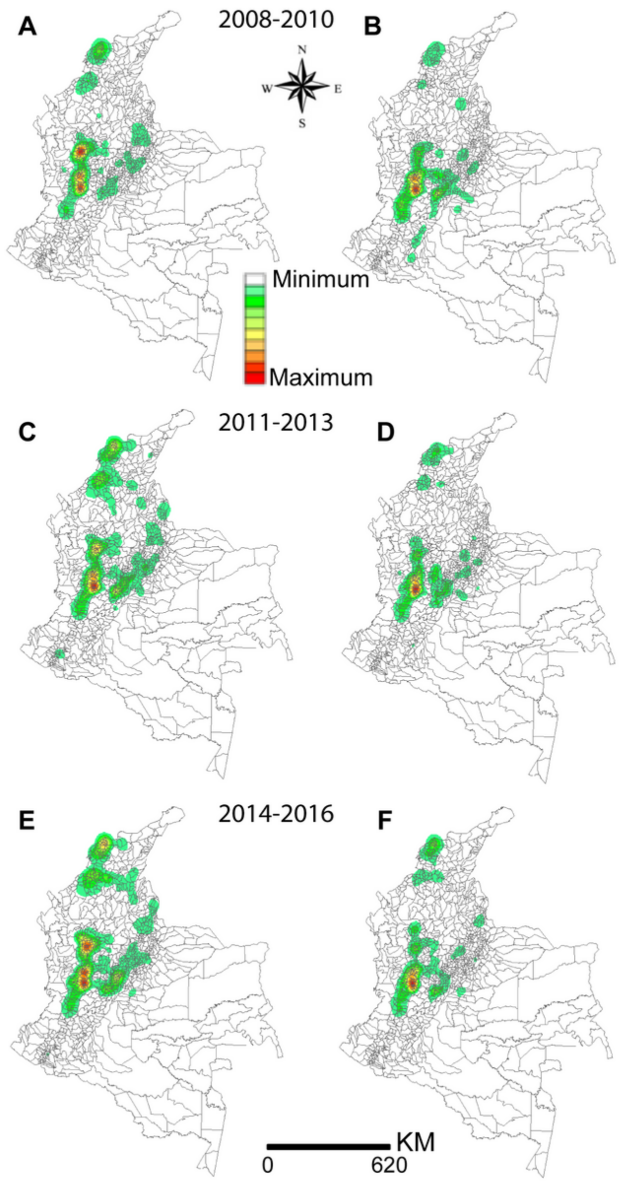

Figure 4

Kernel maps of HIV/AIDS incidence (A, C, E) and AIDS mortality (B, D, F) rates.