Original Article

Medical geography in the study of Hepatitis A, in the Coffee-triangle region, Colombia, 2007-2011

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Abstract

Objectives: There are few studies of geographical characterization of viral hepatitis. For this reason, we after estimating the incidence rates for Hepatitis A (HAV), we developed epidemiological GIS-based maps for this viral disease, within a well-defined geographic region (the coffee triangle) in Colombia.
Study design: A retrospective cross-sectional analysis of surveillance data and GIS-based developing of epidemiological maps.
Methods: Surveillance cases data (2007-2011) were used to estimate annual incidence rates using reference population data, on hepatitis, to develop the first maps of HAV in the 53 municipalities of the coffee-triangle region of Colombia (departments Caldas, Quindio, Risaralda). GIS used was Kosmo® 3.1. To summarize and compare the data among municipalities and departments (as units of analysis) we generate indicators such as accumulated incidence rates (AIR) and incidence rates ratios.
Results: 1518 HAV cases were reported, 47% from Quindío, 30% Caldas and 22% Risaralda. Quindio presented with the highest AIR (131.54) among all the administrative units under study (Caldas, AIR: 46.39; Risaralda, AIR: 37.62). Interestingly, the highest rates in Quindio, during the period, could be related to the increased number of cases reported in two municipalities from 2008 (Quimbaya, AIR ratio: 4.0 and Montenegro: 3.61). The causes that underlie this augmentation will be subject to further research.
Conclusions: Incidence rates for HAV is still high in the region. Showing epidemiological data, particularly in maps would allow planning actions oriented to interventions at the different forms of transmission that this disease has, which is highly important for decisions in public health policies.

Key words: Hepatitis A, Geographic Information Systems, Mapping, Epidemiology, Colombia.

Introduction

Tens of millions of individuals worldwide are estimated to become infected with hepatitis A virus (HAV) each year.[1, 2] HAV is transmitted primarily via ingestion of contaminated food or water or through direct contact with an infectious person.

The incidence rate is strongly correlated with socioeconomic indicators and with access to safe drinking water: as incomes rise and access to clean water increases, the incidence of HAV decreases.[1, 3, 4]

Immunization has been available since the early 1990s but is not yet widely used, so most individuals with anti-HAV antibodies acquired immunity through infection.[1, 5, 6]

HAV is globally distributed; nonetheless, some regions –such as Latin America, Middle East and the West-Pacific– concentrated the highest proportion of cases.[7]

The incubation period varies from 15 to 50 days (28 days on average) and the affected patients remain infective during the earliest days of the disease.[8]

The determinants that underlie the occurrence of this disease might be grossly divided in two groups: socioeconomic and behavioral.

However, environmental conditions could also influence its occurrence.[9]

The occurrence of the disease is highly concentrated in low and middle-income countries.[2-4, 6, 7]

Some behaviors at this highly endemic areas (e.g. drinking raw water) can also significantly enhance the risk of suffering the disease.[1, 10]

Colombia is considered to be a country with high incidence of hepatitis A.[11-13]

As expected, this high occurrence is highly concentrated among those regions that have less level of income and lack effective access to basic public services.

Recently, Geographical Information Systems (GIS) have been positioned as a new tool of high relevance in public health, particularly in infectious diseases epidemiology, potentially also for HAV.[14-16] One of the most attractive utilities of GIS continues to be its possibilities in basic mapping and its powerful ability to make geographical analyses. These strengthen control decisions for epidemiologists in endemic areas. Wide use of GIS in hepatitis A programs is a promising prospect, however its implementation has slowly started in Latin American countries. Yet, in terms of their applicability to the field of public health in the region, GIS have developed significantly in the last years.[17-19]

As part of enhance efforts in hepatitis A control, the regional information system, together with the Universidad Tecnológica de Pereira (through the Research Group Public Health and Infection), and Health Secretary of Risaralda are working together in the academic analysis of epidemiological information, including hepatitis A. In this setting, this study aims to develop GIS-based epidemiological maps for hepatitis A in the Coffee-Triangle region of Colombia. That is an area of three departments and 53 municipalities with endemic areas of disease. Current analyses cover the period 2007 to 2011.

Neither in this region have other studies mapping hepatitis A and there are few studies there on the epidemiology of infectious diseases, with one previous experience in GIS-based mapped of another foodborne infectious diseases (leptospirosis).[18, 20]

Methods

Colombia is a South American country constituted by 32 departments (main administrative level). These departments are grouped by regions, one of them, located in the Andean area, is the Coffee-Triangle. This is a topographical region including three departments (Caldas, Quindío and Risaralda) with 53 municipalities and a total population of 2,463,507 for year 2011. Among these municipalities, located in three departments, there is high variation regard development and poverty.

For reference, Bogota, the country's capital city had in 2011 an index of unsatisfied basic needs (proportion of homes living with at least one unsatisfied basic need) of 9.2% (optimum value is 0%), however Risaralda obtained 17.5%, Caldas 17.8% and Quindío 17.6%. Among the municipalities, rural area of Pueblo Rico obtained 62%. Most urban municipalities in the region are Pereira (Risaralda), Manizales (Caldas) and Armenia (Quindío), capital cities of the three departments, but in every municipality of the region, the capital is a non-considered-rural town or area, then all municipalities are considered to have rural and urban areas.

For this study, the epidemiological data was collected from surveillance system, obtaining the number of cases for each municipality by year (2007-2011). Data was obtained with agreement from the Ministry of Health through the Protection Information System (SISPRO), through a Client Access server, which allowed retrieving cases from the SISPRO server to a local computer. SISPRO surveillance data used for this study are constituted from confirmed cases, which have been revised in terms of data quality, initially from data from the National Institute of Health of Colombia and later by SISPRO and its Data Cubes system. Data proceed for this study from 53 primary notification units, one per municipality, later consolidated in 3 secondary notification units, at department levels, and finally centralized in Bogotá up to the SISPRO system. Currently revised and consolidated data is available for the period 2007-2011.

Using official reference population data (National Administrative Department of Statistics, DANE), estimates of annual incidence rates for all the municipalities during the study period were calculated (53 municipalities, for 5 years) (cases/1,000 pop) to develop the first maps of hepatitis A in the coffee-triangle region of Colombia (departments Caldas, Quindío, Risaralda). Five thematic maps were developed according to municipalities and years.

The software Microsoft Access® was the platform to design the spatial database used, to import incidence rates by municipalities, years, etiology and clinical forms to the GIS software. The Client GIS software Open source used was Kosmo Desktop 3.0 RC1®. For the access to geographic data required and sharing results with institutions, support was provided by the spatial data infrastructure for the Coffee-Triangle region by the Regional Information System. The shapefiles of municipalities (.shp) were linked to data table database through spatial join operation, in order to produce digital maps of annual incidence rates.

Statistical analysis

To determine the occurrence of the disease we calculated the Accumulated Incidence Rate (AIR) according to the following formula:

$$\left[\frac{\text{Number of New Cases per Period}}{\text{Population per Period}}\right] \times 100{,}000 \text{ population}$$

The AIR ratio was calculated to compare each municipality to the average of the department as follows:

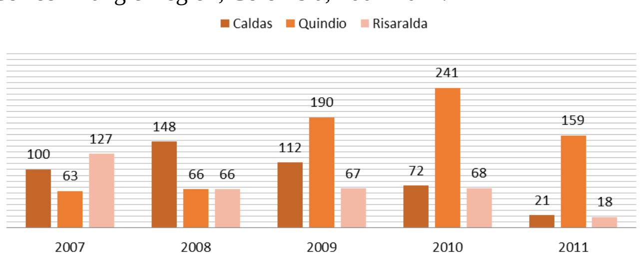
$$\left[\frac{\text{Mean AIR per municipality}}{\text{Mean AIR per Department}}\right]$$

To calculate this indicator, we include the mean AIR, for the departments and municipalities, for the whole period of the study. For the purpose of its interpretation when the AIR ratio is > 1 the municipality is considered to be in greater risk and when the AIR ratio < 1 the municipality is considered to be in lower risk. When AIR ratio is 1 the municipality is considered to have the same basal risk than the department. A database was created to calculate the AIR. As we used secondary-source information, this study was waived to be approved by the Bioethics Committee. However, this study is part of the project “Desarrollo de Mapas Epidemiológicos a través de Sistemas de Información Geográfica para la Caracterización Geográfica de Enfermedades Infecciosas y Tropicales en el Eje Cafetero de Colombia”, which has approved and endorsed by the Committee of Research and Extension of the Faculty of Health Sciences, Universidad Tecnológica de Pereira.

Results

During the study period, a total of 1,518 new cases were reported (Figures 1 and 2). There was not an observed significant trend during the study period.

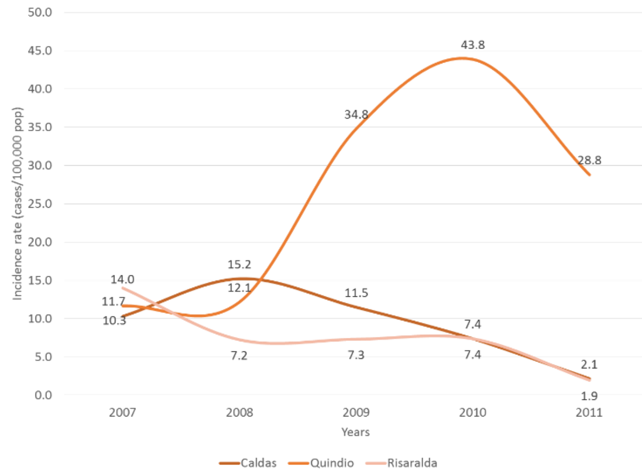
Figure 1. Number of hepatitis A cases per year and department, Coffee Triangle Region, Colombia, 2007-2011.



The Department of Quindío reported 719 cases (47.36%) during the study period for an AIR of 131.54 cases/100,000 pop (Figure 3). The highest incidence was observed in the municipality of Quimbaya (AIR: 525.68 cases/100,000 pop) and then the municipality of Montenegro (AIR: 474.71 cases/100,000 pop) (Figure 3). The lowest incidence was observed in the municipality of Pijao (AIR: 5.48 cases/100,000 pop) (Figure 3). This Department reported the highest AIR and demonstrated a tendency to increment during the period (Figures 1 and 2).

The department of Caldas reported 453 (29.8%) cases in the study period for an AIR of 46.39 cases/100,000 pop (Figure 3). The highest incidence at this department was observed in the municipality of Victoria (AIR: 213.44 cases/100,000 pop) and then the municipality of Belalcázar (AIR: 200.51 cases/100,000 pop) (Figure 3). The lowest incidence was observed in the municipality of Villamaría (AIR: 5.98 cases/100,000 pop) (Figure 3). The AIR tends to decrease from 2008 (Figures 1-3).

Figure 2. Variation on the incidence rates of hepatitis A for the three departments, Coffee Triangle Region, Colombia, 2007-2011.

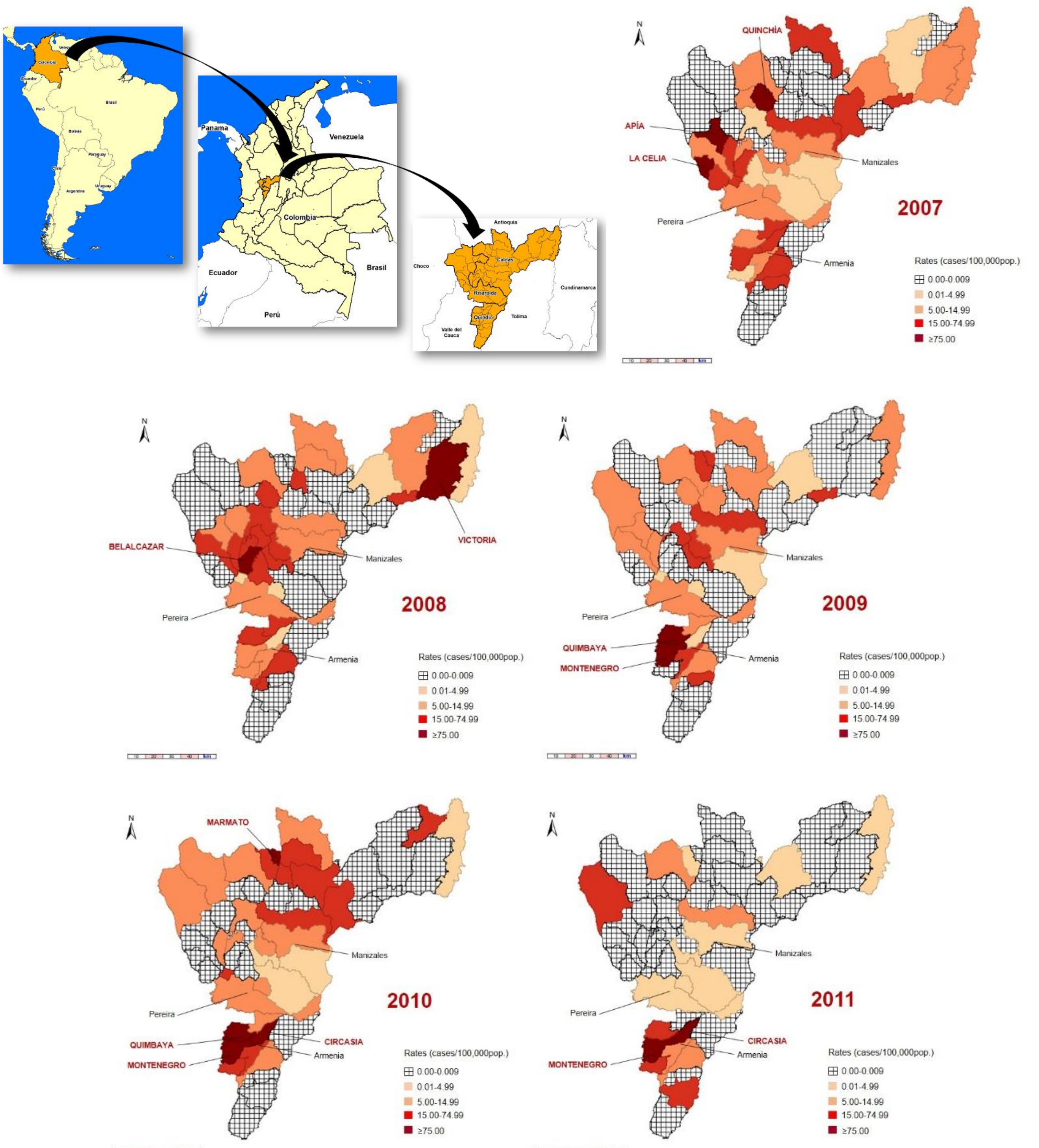


The Department of Risaralda reports 346 (22.8%) cases during the study period for an AIR of 37.62 cases/100,000 pop (Figure 3). The highest incidence was observed in the municipality of Quinchia (AIR: 125.50 cases/100,000 pop) and then the municipality of Celia (AIR: 115.01 cases/100,000 pop) (Figure 3). The lowest incidence was observed in the municipality of Guática (AIR: 6.42 cases/100,000 pop) (Figure 3). This Department reported the lowest AIR and demonstrated a tendency to decrease during the period (Figures 1 and 2).

Interestingly, the AIR starts nearly equal at the beginning of the period, but in 2009 the department of Quindío experienced a significant increase in the number of cases (it presented neatly three times more cases than the previous year, Figures 1 and 2). In this sense, if we compared the incidence rates among departments (e.g. AIR ratio for departments) we could observe that Quindío has a mean AIR ratio of 3.5 when compared with Risaralda and of 2.8 when compared with Caldas.

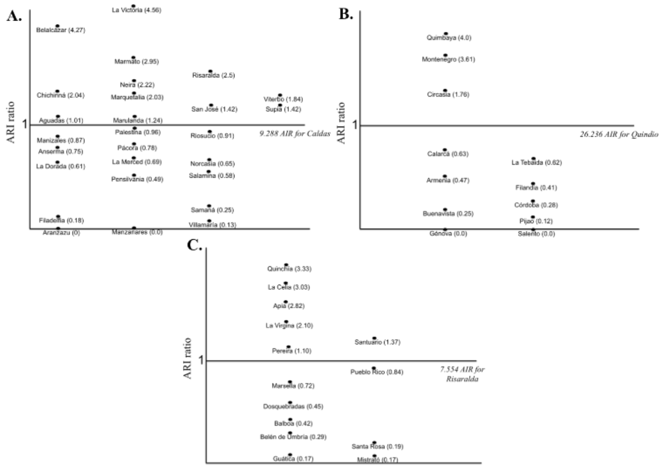
When we analyzed the situation department by department –and within each department- we can observe that the highest incidence experienced by Quindío is mainly explained by the extremely high mean AIR in two municipalities: Quimbaya and Montenegro (Figure 4).

Figure 3. Epidemiological maps discriminating by hepatitis A incidence rates for the three departments, Coffee Triangle Region, Colombia, South America, 2007-2011.



The proportion of municipalities with significant high AIR (those with an AIR ratio >1) per department is as follows: Caldas (44%), Quindío (25%) and Risaralda (42%) (Figure 4). Interestingly, Pereira was the only capital city that presented with an AIR ratio > 1 (Figure 4).

Figure 4. Graphic representation of the hepatitis A AIR ratio per department, Coffee Triangle Region, Colombia, 2007-2011 (A: Caldas; B: Quindío; C: Risaralda).



Discussion

South-America, according to the latest results of the Global Burden of Disease Study, suffers a heavy burden from infectious diseases like hepatitis A.[21] Colombia is among the countries that registers high-incidence of hepatitis A. As discussed previously the major factors associated with this disease might be mainly socioeconomic and behavioral: both factors widely present in our country. The Coffee-triangle region should focuses efforts that can avoid and reduce the impact of hepatitis A in this highly vulnerable area of the country. This vulnerability must be addressed and that was one of our aims in this study when identifying areas of high risk and mapping its occurrence in the region over the time.

Even more, in developed countries (such as Italy in Europe), also areas with social and behavioral risks (eg. North Italy), presented with significant number of HAV infections, and the burden of this viral disease is similar than our findings, 313 cases for the whole country in 2011,[22] which is slightly higher than reported by the Coffee-triangle region of Colombia in the same year (198 cases). In both settings, GIS-based maps would be useful and important, linked to reporting timeliness to also detect outbreaks of acute viral hepatitis.[22]

World, but also country and sub country, maps are among the most effective ways to convey public health messages such as recommended vaccinations, but creating useful and valid maps require careful deliberation.[14] The changing epidemiology of HAV in many world regions heightens the need for up-to-date risk maps,[14] as we developed for the Coffee-triangle region of Colombia. This information provided in these GIS-based map, would be also useful globally for the setting of travel health and medicine, informing the risk of hepatitis A stratified according specific areas, then providing tools for prevention according specific destinations.[23-25]

In that way, the coffee-triangle region is a favorite touristic place by domestic and foreign that look for activities such as hiking, camping, swimming in rivers destinations; these could be considered as an important risk factors not only for locals but[18] also for the tourists who come into direct or indirect contact with water and other sources contaminated by HAV.

The municipalities that presented with high AIR should be further study to determine the level of exposure of some environmental factors (contaminated-sources of water, for example). This is specially the case of Montenegro and Quimbaya. Very recently in China, HAV was included, among other infectious diseases (dysentery, HFM, hepatitis A, hemorrhagic fever, typhoid fever, malaria, meningitis, influenza, and schistosomiasis) to investigate whether they would be affected by changes in the selected climatic variables.[9] In that study, temperature and humidity were significantly correlated with the incidence of hepatitis A and other infectious diseases.[9] Then, other studies, including in Colombia, should follow these methodologies in order to assess the impact of environmental variables and climate change, and define its associated risk, which could be also mapped using GIS.

Those two municipalities (Montenegro and Quimbaya) –located in the Department of Quindío– are separated for no more than 15 miles and share common social and behavioral background. From 2009 these two municipalities double the number of cases reported. The further studies aim to comprehend this trend should consider the social determinants as a suitable framework to understand it. We have no evidence to indicate that the record of cases significantly changes and would be then related those as well also environmental factors that should be more studied.

It is also interesting to note that only one of the three capital cities (Pereira) presented an AIR ratio > 1. We could expect this, as epidemiological data in big urban areas are bearded with referred patients; nonetheless this was not true for Armenia and Manizales, thus we could hypothesize that some other reasons might be pursued to explain this and should be also studied in the immediate future.

Ideally, all the health authorities related to hepatitis A control and programs would have and routinely use GIS to support public health surveillance and epidemiological investigations. The development of HAV maps for the Coffee-triangle would be useful for local health authorities as well for physicians assessing cases from this region of Colombia.

To the best of our knowledge, we have provided the first geographic analysis of hepatitis A infection in Risaralda but also in Colombia. We aim to continue to work in these efforts to ultimately contribute with evidence that can be used to construct public policy supported by GIS and other public health tools.

Finally, the development of epidemiological maps will be useful to identify geographic areas with prevalence and/or risk of outbreaks of HAV. Also to guide the allocation of resources and public health interventions by public entities, and to encourage a greater interest in the issue and develop other studies in the near future, both in general and occupational epidemiology and other infectious diseases in the region.[18] More studies in the country should be perform and the use of GIS in the development of epidemiological maps will be of utmost importance in the geographical characterization of the distribution of cases and epidemiological indicators, but also other related factors, such as social and environmental aspects.[18]

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Conflict of interest: No conflict of interest is declared.