Analysis of demographic processes in Antioquia, Colombia, based on inter-municipal kinship

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Introduction

Antioquia department, one of the 32 administrative regions in which the Colombian territory is divided, is located in the northwestern sector of the country, and consists of 125 municipalities. Given the size of the department, 62,840 km², it is divided in nine regions which have between six and 26 municipalities each (map 19). The geography of the department’s central zone is fairly rugged; it includes surfaces reaching heights of 2,500 m.a.s.l. and peripheral flat, low-altitude zones. One of these zones is Urabá, which borders the Caribbean Sea.
The implementation of administrative modernization processes enable us to have plenty of quantitative information related to the populations living in the area at present. In this regard, tools that analyze and manage this information are important elements to approach to the social and cultural dynamics of the population.

One of these tools is the isonomy\(^1\) methodology, which, by means of statistical methods, analyses the last names of the populations as indicators of recent and past migration processes. This paper aims to identify blood kinships and settlement processes existing in the municipalities of Antioquia department.

The first part provides an analysis on isonomy as a methodology; the second one provides a technical description of the method that was used in this study. The third part recounts the results of the study and the last part provides some conclusions and perspectives on the research topic.

**Isonomy as a research methodology**

Conceptually speaking, isonomy, understood as the “mating of individuals with identical last names” (Rodríguez; 1997: 259) has its methodological basis on the quality by which last names are transmitted so that they “pass from one generation to another following a model of heritage and a distribution between the population which enables to determine the genetic relationship” (Rodríguez et al., 2005). Such a relationship shall be understood, at the same time, as the “The probability that subjects belonging to the same or different population share an identical gene by descendance” (Rodríguez et al., 2005).

The first studies that resorted to the isonomic method occurred in the Biology field during the 60’s. Crow and Mange’s published a study in 1965 (Crow and Mange, 1965: 199-203) on the estimation of the blood relationship among populations by means of isonomy (Rodríguez, 1997: 270).

Isonomy has been essential in the case of the genetics of the populations given the fact that it allows the study of the genetic relations (inbreeding) among individuals. Identifying the degree of consanguinity of different populations has allowed genetics to consider last names as markers which enable the description of the structure of a specific population and establish their genetic distance with other populations.

From the assumption that last names can be taken as “cultural features transmitted through the father and/or the mother by means of a vertical mechanism that is similar to genetic transference” (Barrai et al., 2005: 36), one can assert

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\(^1\) The idea underlying this project at the beginning was derived from the project: “Geografía de las movilidades poblacionales en el departamento de Antioquia” (Geography of the demographic mobilities in Antioquia department), carried out by means of an administrative agreement between the Administrative Planning Department, the Antioquian Government and the Institute of Regional Studies of the University of Antioquia (Giraldo et al., 2007).
the existence of a common core for several populations. These populations have a specific distribution of their last names, and it would demonstrate migration processes that occurred in past and recent times. In the same way, when comparing the distribution of the last names in one or more populations, one can establish the degree of compatibility among them or the relations that are present, and which are a result of the history that is common to the communities.

Isonomy studies have increased in number since Crow and Mange’s proposal appeared. Ever since, works have been directed toward two main areas (Colantonio, 2003: 785). On the one hand, great samples of populations that coincide in general with national, and in some cases regional, studies have been analyzed. On the other, studies have been developed at micro level, and they are, in general, appropriate to establish the difficulties and limits that appear when the correspondence with the genetic parameters is taken, and on which, one can also research the effects cultural dispositions of relationship have on the population structuring.

In the case of large populations, those coinciding with national studies; they are led by Barrai and Rodríguez Larralde, who analyze the isonomy of populations from Germany, Italy, Holland, Belgium, France and they perform as well a general study of Europe (Barrai et al., 1998, 1999, 2002, 2003, 2005, 2007). These studies take advantage of the potential that exists in the systematization of a great amount of information, obtained mostly from telephone directories, given the fact that they are free to access and are available in a digital format.

Such studies aim at performing comparisons in the structure of the last names, and they are essentially supported by the results of two indicators: the Fisher’s index and isolation by distance. The results, by and large, are a positive correlation between the age of the populations and the results of the indicators. In the case of the populations with low levels of immigration, the geographic distance is a clear indicator of distances between populations, and it is measured by means of last names (Barrai et al., 2005: 85). From said data, one infers the genetic distance and confirms empirically that the behavior of the transfer of last names follows the same rules; its structure is affected in the same way as the genetic structure, by processes of population migration or demographic stability.

Another significant finding from these projects is the existence of a correlation between the linguistic difference of the populations and their genetic difference. In the case of Europe, the creation of clusters by distances of last names resulted in a linguistic division of Europe, that is, the territorial units that were used as a base, and which are grouped according to the similarity of their last names, coincide with the fact that they are regions with a common language (Barrai et al., 2007: 47). This relation is maintained even if one compares the results to the geographical difference of dialects within a single language, as in the case of France (Barrai et al., 2005: 85).
National isonomy studies provide a broad view on the constitution of the populations of different territories that undergo an analysis, and it is of great value given the fact that it provides information that is otherwise difficult to obtain.

In the case of the studies in which the size of the population is small, the potential and restrictions in the use of this method take another nuance, especially because the results provided by the different parameters can be contrasted with works and information originated in other sources. This way, it is possible to find limits in the methodology when populations have certain kind of structures in social and relationship terms.

Branco and Mota’s (2005) work is a good example of this, considering that despite being directed to a relatively small amount of population — the Portuguese archipelago of the Azores Islands (240 thousand inhabitants in 2001) — their results correspond much to the population dynamics known for the territory that is studied: higher diversity in the biggest islands, with a higher level of population exchange and low levels of differentiation in general (Branco and Mota, 2005). A significant aspect in this study is the construction of a dendogram by distances of last names among the populations of the islands; this significance exists because it reproduces their geographical distance, which is related to the fact that the closest islands have stronger processes of exchange and contact among their populations (Branco and Mota, 2005: 42-44). This validates the fact that results provided by this methodology are not very effective in the case of small and medium size populations.

The importance of these studies lies in the use of the results when comparing socio-cultural phenomena by demonstrating the relations among them; which do not disregard, and at the same time, do not emphasize the relation between genetic structure and the last names of the populations. This way, it is possible to consider this methodology a useful tool to approach to social and cultural phenomena of the populations.

An example of the last kind of studies is the work performed by Little and Malina, which took place in an indigenous Zapoteca community in Mexico (Little and Malina, 2005). They demonstrated how blood kinship levels, measured by means of the isonomy coefficient, are culturally affected. Not only do the relationship rules, including marriage preferences, have influence on higher or lower levels of blood kinship, poverty is also significant considering that the higher it is, the more probable it is to subvert the social preferences of marriage; so that populations with higher poverty levels have higher levels of blood kinship.
Materials and methods

Information source

This paper uses the SISBEN 2004 database for the Antioquia department. It was provided by the Planning Administrative Department. This database is constituted by a survey which is performed among the whole population so as to determine their affiliation to the healthcare system.

With the exception of Medellin, the database contains information for the 124 municipalities that constitute the Antioquia department; municipalities that are distributed in new sub-regions according to their geographical location (map 1). The total number of processed records was of 2,847,702.

Information processing

The paternal last name was used as a variable of control of the population. The frequency of the last names per municipality was obtained by means of R statistical software. In the case of Antioquia 14,037 last names were obtained. A filter was applied to the database in order to avoid procedural problems, both in terms of the technical processing of 14,037 last names from the 125 municipalities in the SPSS software and in terms of technical and human errors that may come from the collection of data. Last names whose total frequency was two times higher than the average standard deviation of the department were considered.

185 representative last names were obtained from the Antioquia department; they represent 75.78 percent of the total population, which is a quite robust sample when one considers the level of significance of the results.

All municipalities have a different level of representativeness in the sample. Since different last names are related to different populations and minority populations at the interior of the department are not vigorously represented in the sample, we found municipalities where only 40 percent of the population is included. In general, they are municipalities from low zones (Urabá, Bajo Cauca, Magdalena Medio) which, unlike other territories at the interior of the department, have an acute influence from populations of other departments. The procedure restricts the results to the processes of expansion and to the relations of the main population groups that have shaped the territory of Antioquia’s department. In order to analyze other populations, it is necessary to perform more specific studies.
Fisher’s \( \alpha \) indicator\(^2\) was calculated once the base was constructed. The indicator was aimed at determining the effective number of alleles in a genetic system, such indicator, in the case of isonomy studies, equals the effective number of last names (Barrai, 2002). High levels in \( \alpha \) indicate high diversity and low blood kinship, hence, a high level of migration. Conversely, low levels indicate low diversity, high blood kinship and isolation in time. This way, one can recognize the territories that have recent immigration dynamics and those with isolation dynamics and stability in time.

The matrix of relative distances among municipalities was created after dividing the squared Euclidian distance by the standardized frequencies of the last names.\(^3\) This allows creating a hierarchical cluster, so that municipalities with low distances create close groups, and municipalities with very high distances create different groups. That is, the more similar the frequencies of the last names that are common to two municipalities, the higher the probability that they will create a close group.

Ward’s method (minimal variance) was used in order to obtain the hierarchical grouping. This method creates clusters by joining each element that has the lowest possible variance. The method operates hierarchically; two municipalities with low distance are classified together, they create a cluster or case that acts as a new element that replaces the previous. The matrix of distances is then recomputed and the two elements that guarantee the lower variance are classified together. This procedure is performed successively until one single cluster is created.\(^4\)

A dendogram and icicle plots were obtained as a result of this procedure; they represent the different clusters created. The distances that exist in the frequency of their respective last names show the relations among municipalities. Both, the dendogram and the icicle plots are the basis to create the spatial zonifications: maps that show the distribution in the space of the main clusters that were obtained. The program ArcGIS 9.2 was used in this procedure.

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\(^2\) Fisher’s Alpha (\( \alpha \)): \( \alpha = 1 / (\Sigma p_i^2) \) where \( p_i \) is the frequency of the last name \( i \) in the population (Barrai et al., 2007: 43).

\(^3\) Square Euclidean distance: \( d(Q, P) = \Sigma (q_i - p_i)^2 \), where the distance between the municipality \( Q \) and municipality \( P \), is obtained from the total sum of the differences squared to the frequencies of each of the 185 last names that were considered in the sample.

\(^4\) In both cases, in the creation of the matrix of distances and in that of the hierarchical clusters, SPSS 14 software was used.
Results

Fisher’s Indicator

The sensibility of the indicator to the size of the population places the municipal average (102.52) below the department value (191.79).

However, there are 14 municipalities where the α value is above the department value. This implies that they have the highest population variability in the department, and hence, hypothetically, high levels of immigration. The municipalities in this category, in descending order are: Yondó (285.4), el Bagre (262.1), Caucasia (254.8), Turbo (242.4), Apartado (240.5), Cáceres (240.2), Nechí (236.5), Chigorodó (234.4), Zaragoza (226.8), Arboletes (223), San José de Urabá (222), Carepa (216.3), Mutatá (214.2) and Necoclí (200.7). More than half of them are part of the Urabá sub-region.

On their side, low values in the indicator are located in the direction of the center of the department, areas that are out of the Valle del Aburrá. In this case, the first municipalities in ascending order are: Belmira (13.1), Giraldo (19.2), Granada (20.9), Buriticá (24.2), El Santuario (24.5), San Andrés de Cuerquia (27.2), Liborina (29.8), Entrerríos (30.6), Abriaquí (34.7) and San Vicente (37.1) (map 2 and table 2). Low Fisher values suppose low migration rate, and isolation of the population in time. Conversely, high values would imply high migration and population exchange.

Bordering zones that are integrated to territorial dynamics which occur outside of the Antioquian department, in this case Córdoba and Bolívar, are the ones that have, in theory, higher isonomy coefficient, lower genetic relationship and high migration. In the opposite situation, eastern municipalities and some from the north and western have the lowest indicator. Therefore, in theory, they have the oldest populations and higher isolation from the department.

Cluster analysis and hierarchical clustering

The dendogram is not presented in full on account of the great amount of municipalities. It is, instead, presented as a summary that shows the relations between the main clusters of municipalities found in the analysis (graph 1).

The theory that underlies the analysis of the dendogram asserts that the similarity in the structure of the last names is caused by two processes: a) population exchanges: the changes that the population performs in terms of residence within the municipalities;5 b) a common origin for the population.6

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5 That is, people born in a municipality have descendants and transmit their last names in other(s). In none of the cases we refer to economic relations and mobility and/or to pendular or temporal.

6 Either the population of one municipality originated from that from another by a migration process, or because both have their origin in the same migration originated in another place.
The former refers to constant processes of exchange of population at the interior of the municipalities, and the common origin of the population refers to migration waves that took place at specific moments in time.

In the first case, the closer the municipalities, the higher the population exchange, in the second case, the closer the municipalities, the more recent the migration process.
Given the fact that the population exchange between two territories has to be very marked in order for differentiated population to coincide on significant similarities regarding the structure of last names, the migration hypothesis related to the closeness of the municipalities is, at first sight, the most probable.

A primary analysis allows detecting a pattern in which the resulting clusters involve always adjacent municipalities; in few cases clusters from municipalities that are not geographically adjoined occur. This implies the existence of a geographical logic inherent to the measurement process. The nearness of two towns enables the exchange of population and this exchange operates according to the logic that distributes migrating populations spatially.

Six clusters were found in the dendogram. The first one is constituted by municipalities belonging to Urabá,7 Bajo Cauca and western (A). The second one consists of municipalities of the Antioquian eastern (B).

7 We refer to that in general terms, some municipalities of the administrative sub-region do not take part in the grouping. This is the case for all sub-regions.
There are clusters with high levels of diversity among them,\(^8\) that is, they would have taken part in slow processes of population exchange throughout long periods of time and would have very old settlements that have the same origin. They are referred, in first place, to the group consisting in municipalities of the northern sub-region (D) in its western sector (San José de la Montaña, Toledo, San Andrés de Cuerquia, Entrerríos, Liborina, Belmira), and those which are part of the Eastern sub-region, especially those included as one single group with Marinilla\(^9\) (E).

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\(^8\) The distance of union between the municipalities that belong to it is relatively high.

\(^9\) Marinilla, San Luis, Cocorná, El Carmen de Viboral, San Francisco, El Santuario, Granada.
In contrast, there are other clusters with very low diversity levels, very homogeneous among themselves, and they allude to populations derived from population migratory processes that are relatively recent. Among these clusters one finds municipalities of the Urabá and Bajo Cauca (A), which are the most homogenous, and those of the southwest, north and northeast (C).

These great groups have a structure of relations that indicate the closeness that they have due to the origin of their populations (graph 1). The group from Antioquia’s center, which includes municipalities of the sub-regions from the north, southwest and northeast (C), is the most extensive unit, and has higher closeness to populations of the north (B), followed by populations from Urabá and Bajo Cauca (A).

Given the fact that the cluster with higher intensity is that from the east (B), and the most homogeneous is Urabá / Bajo Cauca (A), it would be feasible to think that the native populations are in the east, and it would be also possible to
It is necessary to take into account that given the methodology that was used, in the case of low zones we measure the populations of the zone that was created at the interior of the department, other populations that may represent a significant percentage of population are not included in the processing (see methodology).

I think that the group from Urabá-Bajo Cauca\textsuperscript{10} (A) corresponds to a more recent process of arrival of population.

In fact, Fisher results coincide with that, higher levels in low zones and lower levels in the eastern zone.

One shall add the municipalities from the north located in its western border to these clusters: San José de la Montaña, Toledo, San Andrés de Cuerquia, Entrerríos, Liborina, Belmira (D). This group has a high diversity within; this fact suggests the presence of very old populations, maybe older than those previously mentioned in the east. This is confirmed by low Fisher levels in these municipalities.

\textsuperscript{10} It is necessary to take into account that given the methodology that was used, in the case of low zones we measure the populations of the zone that was created at the interior of the department, other populations that may represent a significant percentage of population are not included in the processing (see methodology).
In the last part, groups from the east (E) and western, in the Rio Sucio Canyon, (F) are joined. The east group seems to refer to very old populations, according to the corresponding Fisher indicator, and it does not seem to be very high in the case of the Rio Sucio Canyon, according to the same indicator.

The results obtained by means of isonomy coincide with the main migration processes which took place in the department during the bibliographically referenced XIX and XX centuries. Migration flows originated in Aburrá Valley and Oriente Cercano took populations to the southwest (the so called “Antioquian colonization”), the north (city foundation) and northeast (mining). Each of these migration processes effectively corresponds to the three subgroups found for the C zone (c1, c2 and c3). Zones of the far east (Marinilla, San Luís, Cocorná, El Carmen de Viboral, San Francisco, Santuario, Granada municipalities; which are cluster E) did not actively provide population to these processes (Jaramillo, 1987).

The arrival of populations from the interior of the department to the low zones, especially toward Urabá and Bajo Cauca, occurred during the XX century, and they are associated to economic interests in the region: in Urabá, with the creation of large farming lands to grow banana, and in Bajo Cauca, with the consolidation of stockbreeding (Uribe, 1992 and Ocampo, 1988).

The group consisting of municipalities in the Rio Sucio Basin, in the antioquian west (cluster F), does not seem to provide a clear location in the dendogram considering the historical settlement processes. It can be said that part of its clear difference is related to the presence of populations that are not found in other locations, maybe populations that are descendants from indigenous people, and who lived in the shelter of Cañasagordas. It is necessary to perform specific research in said place to clarify this idea.

Conclusions and perspectives

The isonomy method, especially the results obtained from the creation of hierarchical clusters by distances of last names among populations, and the estimation of Fisher’s index, show isonomy as a solid method at the moment of accounting for the structure of the populations and its relation with the migration processes, stability and population exchange. This occurs specifically due to the concordance with the main migration and settlement processes that have been recorded for Antioquia.

The results of the study present us the low zones of the department, especially Urabá, Bajo Cauca and to a lesser extent Magdalena Medio, as the zones which have stronger migration processes in their municipalities, all of them with Fisher indicator above the total of the department (191.79). In descending order, with a lower Fisher indicator, one finds the municipalities of the northeast and southwest.
In the east, and in specific zones of the north and west of the department, one finds municipalities with higher population isolation, with a Fisher indicator that does not go beyond 40.

Clusters from the southwest, north, Aburrá Valley and northeast evidence a zone with a homogeneous population structure that creates an extended territory of relatively new population. The relation of said zone, a central part of the department, with the low lands of Urabá, Bajo Cauca, Magdalena Medio, and the west part, is derived from the fact that the latter become places of arrival for populations which depart from the central zones.

There are, on the other hand, municipalities of the Antioquian east that given the higher age and isolation of their populations seem to become the main origin of the populations which constitute the great territory of the center of the department, and of the low lands.11

The isonomy method is valid to identify the main population processes of a territory. In so doing, it enables the formulation of hypotheses and research questions, which sharpen the methodology. The methodology is valuable because it allows recognizing the general characteristics of a population, corroborating demographic processes which have already been identified by other means and, consequently, making advances in terms of new research proposals. In other words, the methodology of mathematical base can be used as argument and validation to support qualitative analysis of the social phenomena perceived in a territory.

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11 It is important to remember that the populations of these low lands include a significant percentage, that is not visible in the sample, and that seem, due to this reason, to have their origin in external territories of the department.
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