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Territorial distribution of the demographic transition State of Mexico, 1980-2015

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Resumen

Este artículo tiene como propósito analizar la distribución territorial de la transición demográfica en el Estado de México, durante el período 1980 -2015. La transición demográfica para el Estado de México presenta una evolución diferenciada a lo largo del tiempo y del territorio. Los indicadores considerados son la tasa de natalidad y tasa de mortalidad, calculadas con base en los nacimientos registrados y las defunciones hospitalarias registradas, respectivamente; así como la población total del periodo 1980-2015. Los métodos estadísticos empleados son el Valor Índice Medio (VIM) y el análisis bivariado, los cuales dieron la pauta para generar el comportamiento espacio temporal de la transición demográfica y elaborar la cartografía correspondiente. Algunos hallazgos señalan que en el estado de México la transición demográfica presenta cuatro etapas: dos de ellas en regiones extensas: como la etapa tardía principalmente al poniente; la etapa plena en el centro y occidente del estado; las etapas moderada y avanzada se presentan en pequeñas regiones en forma aleatoria.

Palabras clave: VIM, bivariado, tendencia, mortalidad, natalidad.

Abstract

The purpose of this article is to analyze the territorial distribution of the demographic transition in the State of Mexico, during the period 1980 -2015. The demographic transition for the State of Mexico presents a differentiated evolution over time and territory. The indicators considered are the birth rate and death rate, calculated based on registered births and registered hospital deaths, respectively; as well as the total population for the period 1980-2015. The statistical methods used are the Mean Index Value (MIV) and the bivariate analysis, which gave the guideline to generate the spatial-temporal behavior of the demographic transition and to elaborate the corresponding cartography. Some findings indicate that in the State of Mexico the demographic transition presents four stages: two of them in extensive regions: as the late stage mainly in the west; the full stage in the center and west of the state; the moderate and advanced stages are presented in small regions at random.

Keywords: VIM, bivariate, trend, mortality, birth rate.

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I. INTRODUCTION

The main objective of this document is to identify the territorial distribution of the demographic transition in the State of Mexico. To this end, an analysis of the spatial behavior of the demographic transition in the State of Mexico was made. To determine the various stages of this transition, the following variables were considered: increase in population in the period 1980-2015, growth rate of the following periods: 1980-1990, 1990-1995, 1995-2000, 2000-205, 2005-2010 and 2010-2015 and general birth and death rates per thousand inhabitants, for the State of Mexico.

In this research, different statistical methods were used that allowed to give solidity to the results and to reach a conclusion based on the objective already described. Firstly, birth and death rates per year were generated for the period 1980-2015. The method used to identify the stages of the demographic transition in terms of its territorial distribution was the Mean Index Value. This method made it possible to group all the years of study (1980-2015) into one, and to unify the birth and death rates. Based on the results obtained, the Bivariate Analysis method was applied, which made it possible to carry out a statistical comparison of both variables, and in turn to generate the cartography of their territorial distribution.

The results show that the spatial distribution of some stages of the demographic transition for the State of Mexico is random, while in others it is observed that most of those areas are in the limits of the State. Some stages are in the middle of the areas, with late stages and areas in full transition.

The theory of demographic transition or demographic revolution explains the passage from high levels of birth and death to levels where birth and death rates are very low (Patarra, 1973). Based on this theory, four transitions (stages) were established: a) late transition (stage 1), b) moderate transition (stage 2), c) full transition (stage 3) and d) advanced transition (stage 4) (Ordoñez, 2010).

Late transition (a) is characterized by high birth and death rates and slow population growth, with a high percentage of child population. In the moderate transition (b), the mortality rate drops rapidly, the birth rate remains high and population growth accelerates, with a high percentage of the population of reproductive age. The stage of full transition (c) is characterized by an accelerated decrease in the birth rate, which reaches the death rate; and population growth slows down. There is a high percentage of economically active population. The advanced transition stage (d) is characterized by mortality exceeding the birth rate, population growth is slow, and there is a larger increase in the adult population.

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II. Materials and Methods

For the analysis of the demographic transition and territorial distribution of the State of Mexico, a series of methods were used, in the following order: Firstly, a collection of data on the variables "Registered Births", "Hospital Deaths" and "Total Population" was prepared for the years 1980-2015. Later, data on these variables were processed to calculate birth and death rates. Once obtained, the method of the Mean Index Value (MIV) was applied to each of the rates, and the resulting MIV was subjected to the method of Bivariate Analysis, with which the territorial distribution of the demographic transition for the State of Mexico was generated. The summary of this methodology is shown in Figure 1.

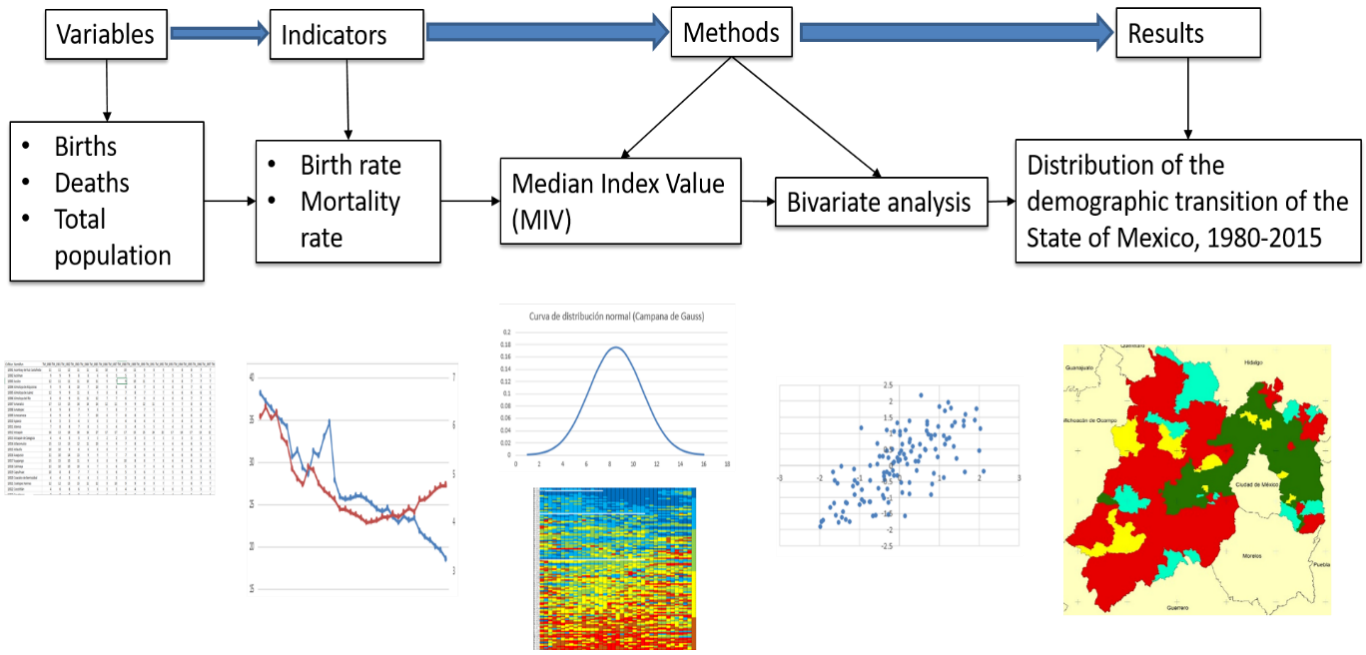

Figure 1. Methodological scheme for the analysis of the distribution of the demographic transition. Source: Hernández Bernal Jesús Emilio; Santana Juárez Marcela Virginia; Pineda Jaimes Noel Bonfilio; (2020), based on INEGI, 2020, SINAIS, 2020 and Garcia de Leon, 1989.)

This research was carried out in the State of Mexico, which is located in the center of the Mexican Republic. The extreme coordinates of the state are: North 20°17', South 18°22', East 98°36', West 100°37'. The State of Mexico borders on the north with the States of Michoacan de Ocampo, Queretaro de Arteaga and Hidalgo; on the east with Tlaxcala, Morelos, Puebla and Mexico City; on the south with Guerrero and on the west with Michoacan de Ocampo. It occupies an approximate territorial extension of 22357 square kilometers. The evolution of population growth in the study period (1980-2015), has registered its highest increase in the nineties; from that event, population growth decreased drastically. This has influenced, in part, the behavior of

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the demographic transition in the State of Mexico. The variables that directly influence this transition are birth rate and mortality.

This research is descriptive, quantitative and longitudinal. The demographic transition in the period 1980-2015 is analyzed, using registered births, registered hospital deaths and total population per year.

The variables that were taken up for the study of the demographic transition are:

- Registered births. For each year in the range 1980-2015.
- Hospital deaths. For each year in the range1980-2015.
- Total population. For the years1980, 1990, 1995, 2000, 2005, 2010 y 2015.

From these variables the indicators of the birth rate and the death rate were generated.

The following data from official sources are used for this research:

- The variable "Total population" at the municipality level was obtained from the 1980, 1990, 2000, 2010 population and housing censuses, and from the 2005 and 2015 intercensal survey of the National Institute of Statistics and Geography (INEGI, 1980, 1990, 2000, 2005, 2010 2015).
- The data of "Registered births" were obtained from the National Institute of Statistics and Geography (INEGI), and were chosen under the criteria of the number of registered births per entity and municipality of registration in each of the years (INEGI, 1980-2015).
- The data on "Hospital deaths" were chosen by the criteria of municipality of residence and date of registration of the dynamic cubes of the National System of Information in Health (SINAIS).

With the information collected, a data matrix was implemented in the Excel program, 2013, where the calculations of mortality rates were elaborated, as well as the method of the Average Index Value, to later elaborate the cartography in the software of free access QGIS.

The Crude Birth Rate expresses the frequency of births in each population. It corresponds to the number of live births per thousand inhabitants in a certain period. The Birth Rate or Coefficient is expressed as the number of live births per thousand inhabitants.

The birth rate is obtained using the following formula:

$$\mathrm{TBN} = \frac{\mathrm{N(LAx)}}{\mathrm{PT(LAX)}} * 1000 \quad (1)$$

Where:

TBN = Gross Birth Rate

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N (LAx): Births registered from a certain place and a certain year.

PT (LAx): Total population of the same place and year.

The Gross Mortality Rate expresses the relative annual reduction of a given population, which is attributed to the deaths of a part of the population. The Gross Mortality Rate is obtained by dividing the number of deaths that occurred in a given period of time by the population exposed to death in the same period.

The formula for the overall crude death rate is as follows:

$$TBM = \frac{D(LAx)}{PT(LAX)} * 1000 \quad (2)$$

Where:

TBM: Gross death rate.

D (LAx): Deaths in a given place and in a given year.

TP (LAx): Total population of the same place and year.

The method used was the Average Index Value (García de León, 1989). To apply this method, the normalization of the study variables must be carried out first. In this case, the birth and death rates per year (1980-2015) were used, with the aim of avoiding confusion that is usually found in the variables that express diverse aspects in different units (Johnston, 1984). For this normalization, initially the arithmetic mean and the standard deviation of the data must be obtained, for which the following formulas are used (Haber, 1973):

Arithmetic mean of the variable i =

$$\frac{\sum_1^N Xi}{N} = \frac{X1+X2+X3.....+Xn}{N} \quad (3)$$

Standard deviation of the variable i =

$$\sigma = \sqrt{\frac{\sum_i^N (Xi-X)^2}{N}} \quad (4)$$

Once the arithmetic mean and the standard deviation were calculated, the normalization of the birth and death rates was carried out, using the following equation:

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Values Zi =

$$Zi = \frac{Xi - Xi}{\sigma} \quad (5)$$

Where:

i is the number of the variable

Xi is the value of each case of the variable i

Xi is the value of the arithmetic mean of the variable i

σ is the standard deviation of the variable i

Z is the resulting normalized value of the variable i in each case

The result obtained from the normalization of the birth and death rates was classified in 6 ranges, using the Gauss bell model, which is a continuous model of a data group. This data group is distributed in values in a range from Very Low to Very High (Table 1), creating a flared and symmetrical graph with respect to a given parameter (Figure 2).

Table 1. Values of the normal distribution curve Source: Hernández Bernal Jesús Emilio; Santana Juárez Marcela Virginia; Pineda Jaimes Noel Bonfilio; (2020), based on García de León (1989).

Symbology	Standard deviation	Range
Very high	Mayor a 1	6
High	de 0.5 a 1	5
Medium high	de 0 a 0.5	4
Medium low	de -0.5 a 0	3
Low	de -1 a -0.5	2
Very low	Menor a -1	1

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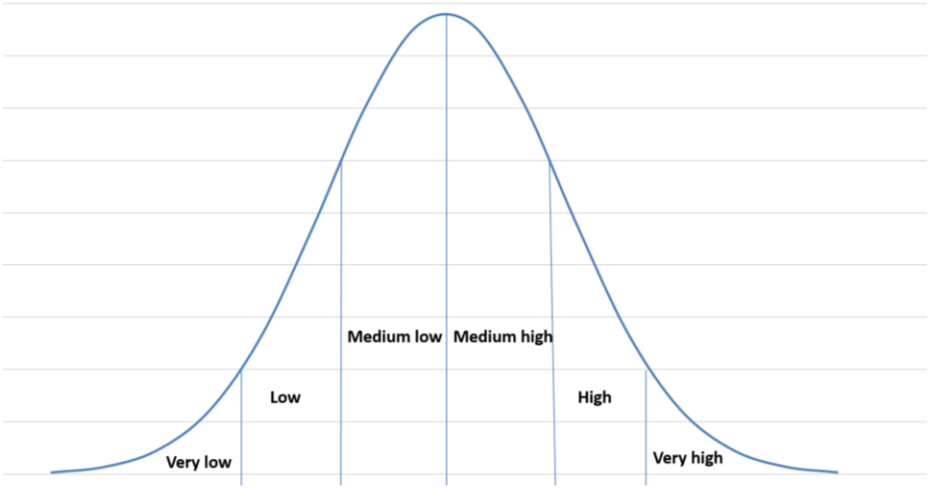

Figure 2. Normal distribution curve. Source: Hernández Bernal Jesús Emilio; Santana Juárez Marcela Virginia; Pineda Jaimes Noel Bonfilio; (2020), based on García de León, 1989.

The final step of the Average Index Value method consisted in the realization of the average of each one of the variables (mortality rate and birth rate) for the range of years of study (1980-2015). This resulted in that if the ranges obtained were between 5 and 6, the average would be very close to 6; if the ranges were between 1 and 2 the resulting average would be very close to 2; and the intermediate ranges had to resemble an average between 3 and 4 (García de León, 1989).

Bivariate Analysis Method: This method made it possible to examine whether there is a relationship or association between two variables (birth rate and death rate). To obtain this association, a normalization of the MIV result of the previously obtained birth and death rates was elaborated. Subsequently, the results of the normalization were classified by assigning the value 1 to the values that are above the mean, and the value 0 to the values that are below the mean. From the normalized values, the scatter plot was made, showing the distribution and a comparison of the behavior of the birth rate with respect to the mortality rate (Figure 3).

For the elaboration of the thematic map of the relationship between the birth rate and mortality in the period 1980-2015 (which indicates the demographic transition that occurred in the study period), a classification of 4 ranges was used: High (Birth) - High (Mortality) Quadrant I, indicates a Late Stage; Low (Birth) - High (Mortality) Quadrant II, indicates an advanced Transition, Low (Birth) - Low (Mortality) Quadrant III, indicates a full Transition and High (Birth) - Low (Mortality) Quadrant IV, indicates a moderate transition.

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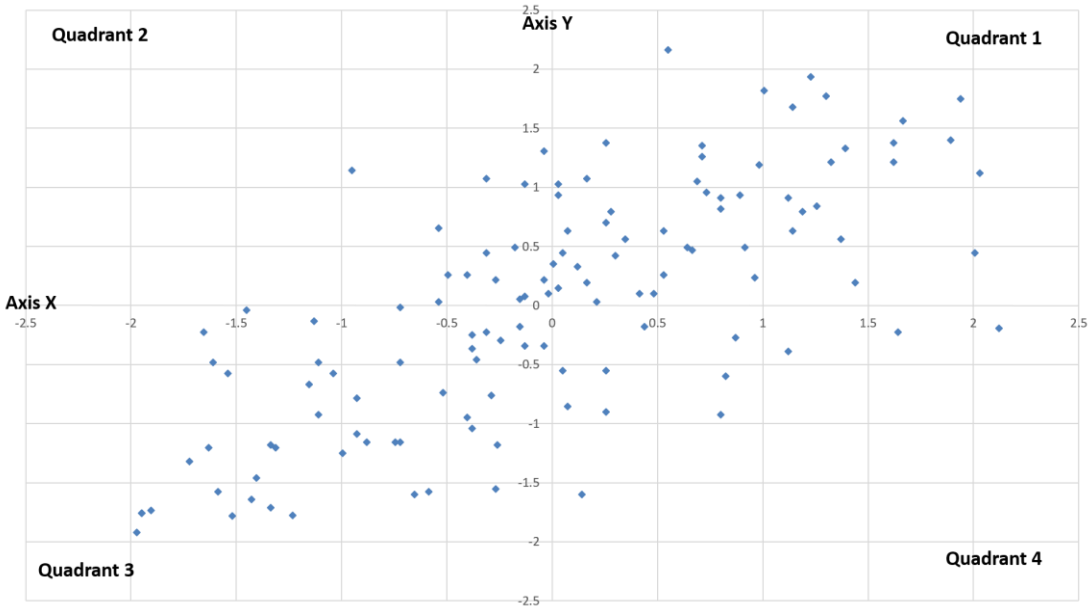

Figure 3. Graph of the distribution of birth and death rates in the State of Mexico for the years 1980-2015. Source: Hernández Bernal Jesús Emilio; Santana Juárez Marcela Virginia; Pineda Jaimes Noel Bonfilio (2020), based on the Average Index Value (VIM) of the birth and death rate (1980-2015).

III. RESULTS

The dynamics of Mexico's demographic transition are changing, and population growth rates are declining (Tuiran, 1999). In 1900, Mexico had a population of 13.5 million and in 1950, it increased to 25.8 million. Fifty years later, Mexico had a population of 97.4 million, a 3.8-fold increase in 50 years. In 2010, there were 112.3 million people, a more than four-fold increase between 1950 and 2010 (Santana, 2018).

In 1900, the mortality rate stood at 33.7 deaths per 1,000 inhabitants, decreasing to 5.0 deaths per 1,000 inhabitants in 2010. The population declined due to several factors: the Mexican revolution of 1910-1921, increased emigration to the United States, increased deaths due to the spread of parasitic and infectious diseases, and a decrease in the number of births because of poor health and deficiencies in public health services. These factors contributed to changing demographic characteristics, as the population fell to 14.3 million in 1921, almost 800,000 fewer inhabitants than in 1910 (Mendoza and Tapia, 2010; Flores, 1962 in Santana, 2018).

The population dynamics of the State of Mexico is derived from the accelerated population growth it suffered at the beginning of the second half of the 20th century; however, the decrease in birth rate has originated a hindrance to population growth. With this, the process of population aging began. The theory of the demographic transition points to the abandonment of large contingents of children, and that these have

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now been transformed into young people of reproductive and productive age, who demand greater opportunities to expand their capabilities.

The population registered in the State of Mexico for 1980 was 7,564,335, and for 1990 the registered population was 9,815,795. During this period, a growth rate of 2.64% was obtained, which represented an increase in the population of 2,251,460 inhabitants in 10 years. For the year 1995 the population was 11,707,964, which meant a growth rate of 3.59% between 1990 and 1995. This was reflected in the increase of the population by 1,892,169 inhabitants. The growth rate for the period 1995-2000 was 2.27%, with an increase in the population of 1,388,722 inhabitants. The registered population for the years 2000 and 2005 was 13, 096,686 and 14, 007,495 respectively; which meant a registered growth rate of 1.35%.

The increase in population from one year to the next was an average of 910,809 inhabitants. For the period 2005-2010, the growth rate was 1.62%, with an increase in the population of 1,168,367 inhabitants. Finally, the growth rate recorded in 2010-2015 was 1.3%.

The growth rate has decreased; however, the population continues to grow in absolute numbers (Figure 4, Table 2).

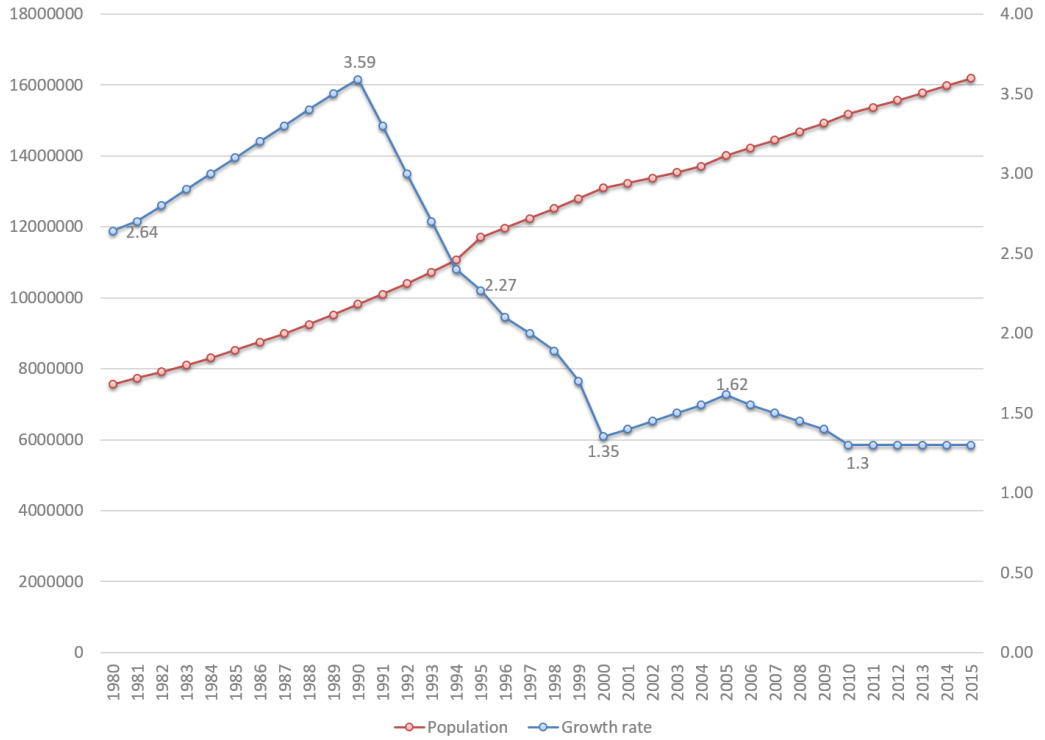

Figure 4. State of Mexico: Population and population growth rate, 1980-2015. Source: Hernández Bernal Jesús Emilio; Santana Juárez Marcela Virginia; Pineda Jaimes Noel Bonfilio; (2020), based on INEGI and SINAIS, 2020.

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Table 2. State of Mexico: Growth Rate Source: Hernández Bernal Jesús Emilio; Santana Juárez Marcela Virginia; Pineda Jaimes Noel Bonfilio, based on INEGI and SINAIS, 2020.

Period	Growth rate	Population	
1980-1990	2.64	7564335	9815795
1990-1995	3.59	9815795	11707964
1995-2000	2.27	11707964	13096686
2000-2005	1.35	13096686	14007495
2005-2010	1.62	14007495	15175862
2010-2015	1.30	15175862	16187608

The changes in the increase and decrease in the volume and structure of the population are the result of the demographic transition, which refers to the passage from high to low mortality and birth rates. For the State of Mexico, the continuous decrease in the mortality rate places this indicator at 6 deaths per thousand inhabitants in 2015, a figure lower than that recorded in 1980 (11 deaths per thousand people). The decline in mortality began in the 1930s, when the expansion of health infrastructure and educational services began, leading to greater use of health services (Gómez de León et al., 2001).

The birth rate has experienced a more rapid decline due, in large part, to the use of contraceptive methods, which stems from the family planning policy implemented in the 1980s. In 1980, the birth rate in the State of Mexico reached levels of 38 births for every thousand registered live births; by the year 1990 the registered rate was 31 births. In 1993 there was an increase in the birth rate, with 35 births per thousand registered live births. By 2000 the birth rate dropped to 26 registered live births; by 2010 the registered rate was 22 births and by 2015 the birth rate figure dropped to 19 births per thousand registered live births.

To sum up, from 1980 to 2015 there was a considerable reduction in the birth rate of 50%. The mortality rate throughout the period studied has shown little change. In 1980 there was a general mortality rate of 6 deaths per thousand inhabitants, while in 1990 the rate was 5 deaths. For 2000 and 2010 the registered rate was 4 deaths in both years; and for 2015 the rate increased to 5 deaths per thousand inhabitants (Figure 5, Table 3).

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Table 3. State of Mexico: Birth and death rates per thousand inhabitants, 1980-2015 Source: Hernández Bernal Jesús Emilio; Santana Juárez Marcela Virginia; Pineda Jaimes Noel Bonfilio; (2020), based on National Health Information System (SINAIS, 1980-2015) and National Institute of Statistics and Geography (INEGI, 1980-2015) (INEGI, 2019).

Year	Births	Deaths	Population	Birth Rate	Mortality Rate
1980	287895	46764	7564335	38	6
1981	288671	49550	7755819	37	6
1983	289724	48908	7957497	36	6
1984	291063	51347	8169847	36	6
1985	292696	48499	8393387	35	6
1985	294638	48604	8628677	34	6
1986	271610	45348	8876326	31	5
1987	286978	44888	9136988	31	5
1988	275343	44985	9411368	29	5
1989	277487	49978	9700230	29	5
1990	307558	49954	9815795	31	5
1991	310381	48579	10097769	31	5
1992	342650	48469	10398386	33	5
1993	371621	49026	10718475	35	5
1994	307577	49437	11058965	28	4
1995	303005	50102	11707964	26	4
1996	307261	51106	11967123	26	4
1997	315216	51476	12235161	26	4
1998	325457	52071	12512480	26	4
1999	333250	52552	12799505	26	4
2000	335085	52509	13096686	26	4
2001	332113	53271	13229258	25	4
2002	326754	54240	13374411	24	4
2003	327694	55836	13532673	24	4
2004	337544	56359	13704693	25	4
2005	330115	58458	14007495	24	4
2006	325973	58648	14221342	23	4
2007	342347	60734	14444546	24	4
2008	339124	63017	14677641	23	4
2009	349977	63017	14921204	23	4
2010	332209	67827	15175862	22	4
2011	325268	68817	15368332	21	4
2012	323733	71405	15565612	21	5
2013	316110	73885	15767829	20	5
2014	313780	75970	15975116	20	5
2015	300553	77206	16187608	19	5

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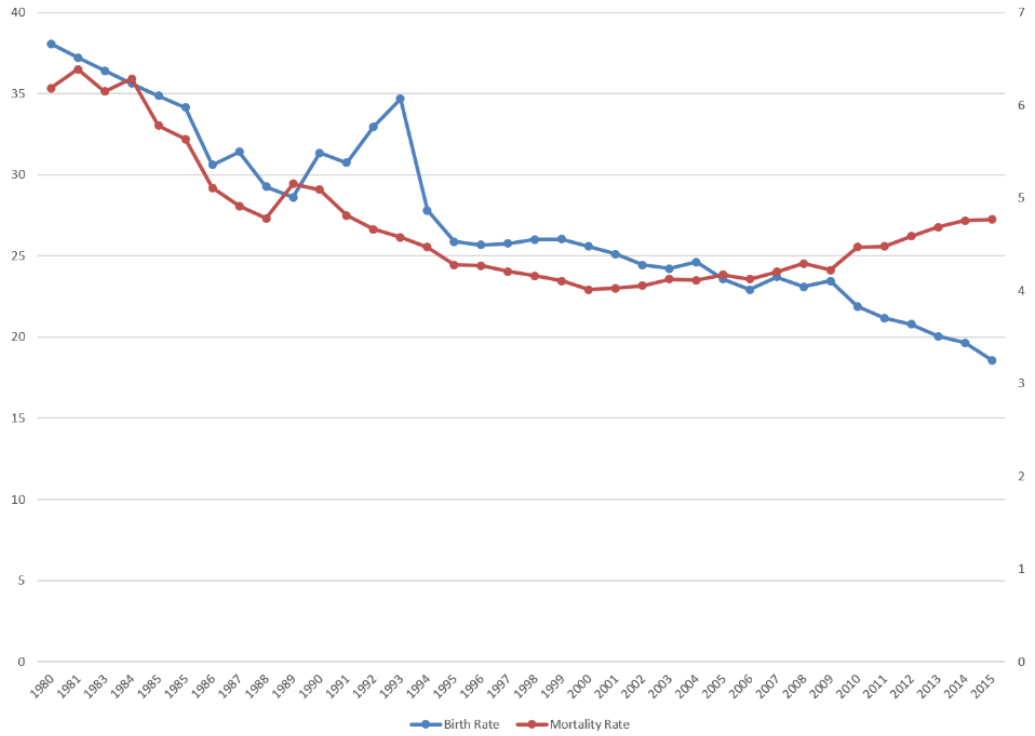

Figure 5. State of Mexico: Demographic Transition, 1980-2015. Source: Hernández Bernal Jesús Emilio; Santana Juárez Marcela Virginia; Pineda Jaimes Noel Bonfilio; (2020), based on National Health Information System (SINAIS) and National Institute of Statistics and Geography (INEGI, 2019).

The demographic transition for the State of Mexico in the period 1980-2015 is spatially distributed in the territory in a heterogeneous way, locating areas with a low birth rate and a low mortality rate in the area surrounding Mexico City, Puebla and Hidalgo. This behavior of the rates places these areas in a demographic stage of full transition (green color).

The areas that registered low birth rates and high death rates are randomly distributed throughout the State of Mexico. Some are located more specifically to the north, others to the northeast and south of the state, these areas have an advanced transition stage (blue color). The areas where birth rates were high and death rates were low are in the center and west center of the state, indicating a moderate transition stage (yellow color). Finally, the areas with high birth rates and high mortality rates represent an incipient stage of transition (red color) and cover most of the state's territory, primarily the southern, northern and central-western parts of the state (Figure 6).

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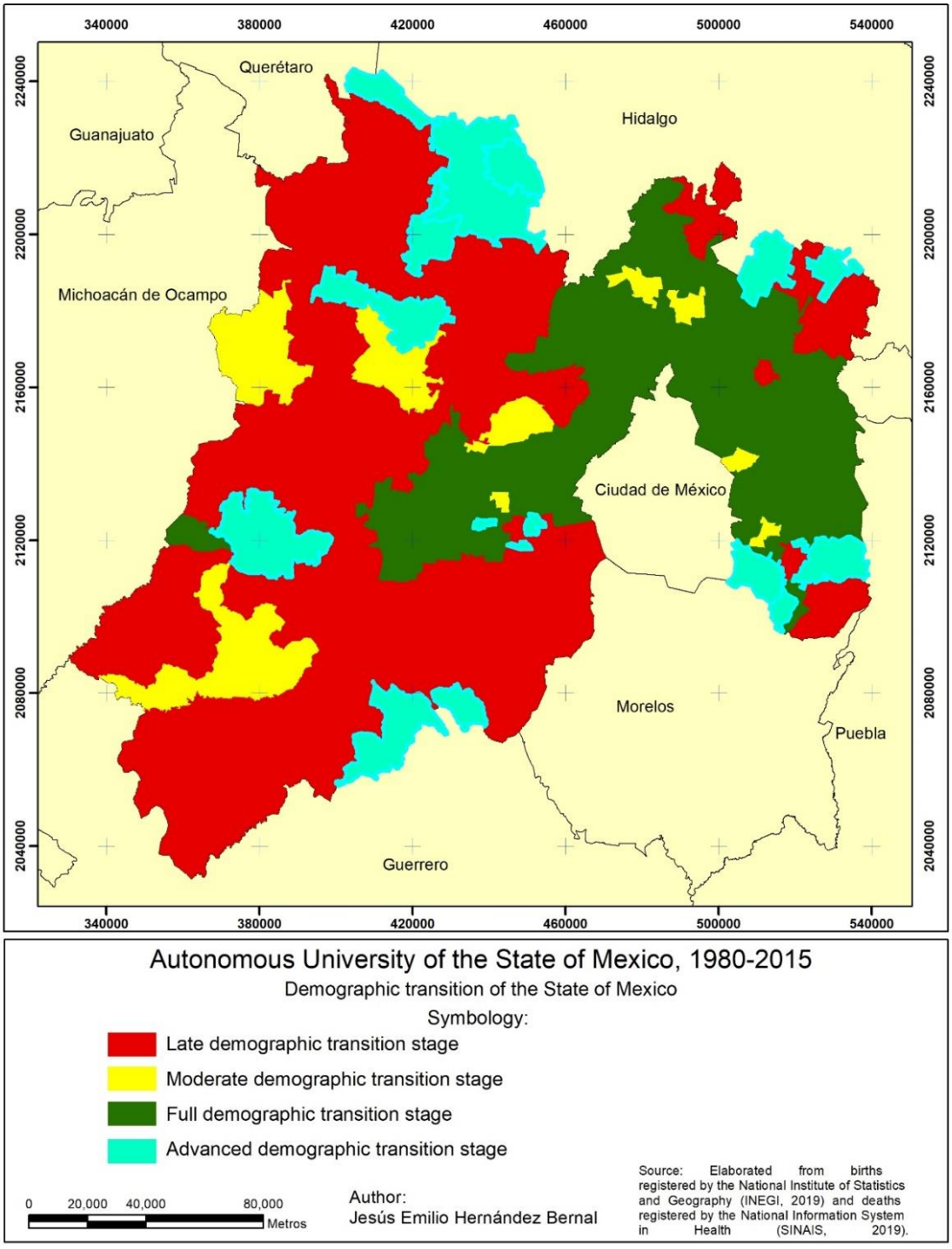

Figure 6. State of Mexico: Spatial distribution of the demographic transition in the State of Mexico in the period 1980-215. The scale is shown in meters. Red: late demographic transition stage. Yellow: moderate demographic transition stage. Green: Full demographic transition stage. Blue: Advanced demographic transition stage. Source: Hernández Bernal Jesús Emilio, based on INEGI and SINAIS, 2020.

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IV. CONCLUSIONS

The demographic transition in the State of Mexico during the period 1980 - 2015, has been registered in a differentiated way in the territory and space, presenting four stages

Two stages are presented in a defined way in the territory: on the one hand, a late stage was identified in the central and southwestern areas; while in the areas surrounding Mexico City, they are in full transition. The areas with a moderate transition and an advanced transition are randomly distributed in the State of Mexico.

Knowing the stage of population dynamics, specifically the demographic transition, provides elements for health policies and strategies, according to their specific characteristics.

It is worth mentioning that in order to carry out an analysis and identify the reasons for the distribution in the territory of the various stages of the demographic transition, it would be relevant to annex social and economic variables, in addition to analyzing the impact of the State of Mexico's social programs. This will be decisive in order to know if the State of Mexico has the necessary conditions to face the challenges in a focused way in the territory.

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