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Analysis of territorial patterns of age population structure at the subnational level in Chile

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Abstract: From the evidence obtained in the 2017 Chilean population census pyramid for the country scale, the question arises whether the population structure by age is replicated homogeneously at the subnational level or, on the contrary, it presents heterogeneous local characteristics based on age groups. For each of the third-level subnational units ($n = 346$), the standard deviation of the different age classes was compared in relation to the national population pyramid. With these differences, the k-means method was used to identify eight groups of communes, and four demographic indicators were calculated. The results allow to affirm that the population structure by age and sex at the communal level presents heterogeneous characteristics. The analysis of territorial patterns identified groups of the aging population, households with active aging, transition to aging, adult population, men in terminal productive age, men in initial age, households with children under 15 years and households with children over 15 years.

Keywords: population structure; territorial pattern; age

1. Introduction

The Chilean administrative system distinguishes at the subnational level three main types of territorial units: 16 regions, 56 provinces and 346 communes [1]. Although the first subnational level is preferred by national public agencies and international organizations to develop studies [2] and the second subnational level is used to monitor development programs and projects that public services created by law carry out in the province, we use the third subnational level to investigate whether local population pyramids coincide or present positive or negative biases compared to the national population pyramid. This decision is justified by the interest of anticipating medium- and long-term local problems that may result from heterogeneous population distribution and population imbalances, in order to help decision-makers identify what type of investments territories require according to their population composition.

The communal unit has important attributions when defining access to a series of state services that are organized and provided from this unit, such as health, education, housing and construction of green areas. These services are provided following central government guidelines, but in many cases they are complemented with resources or definitions that the communal authorities, represented by the mayors and a democratically defined council, resolve to provide basic services to the community.

However, with accelerated aging rates, it is essential to know where to encourage

the generation of this type of programs in the national territory. It is also necessary to consider the geography of the country and the vast distances between territories, to work on territorial differences in order to plan public policies in the long term and according to how the population pyramid evolves in each of these territorial subunits.

The hypothesis of this article is that despite the population transition processes experienced in Chile, population distribution is not homogeneous when considering the tertiary subunit. Hence, there are territories that concentrate an aging population, but others refer to different groups according to two variables: the productive vocation of the commune and the concentration of services to deploy family life projects. These population dynamics present some continuities and discontinuities in the national territory, which makes it possible to group the common ones into groups with similar characteristics.

In other words, by looking at the population pyramids in these territorial subunits, specific dynamics can be observed that, if considered, will better guide decision-making in the implementation of public policies.

2. Materials and methods

2.1. Source of information

We used microdata of people per commune from the 2017 Census database, available on the open data platform of the National Institute of Statistics [3]. We considered 346 subnational units of the third level, which corresponds to communes.

2.2. Population pyramid

A database was prepared with the five-yearly ages of the inhabitants of a commune between 0 and 80 years of age and over, divided by sex. For each commune under analysis, the standard deviation of the different age classes was compared with the national population pyramid. In this way it was possible to identify, for each five-year age, whether they fit the population value or have a positive bias (higher standard deviation with respect to the national population) or a negative bias (lower standard deviation with respect to the national population). The use of standard deviation made it possible to identify statistically significant differences in order to identify substantive changes between different territories.

2.3. Cluster analysis

Once the information for each commune was organized, identifying whether the standard deviation for each five-year age was greater than, less than or equal to the population pyramid, a cluster analysis was performed to group communes with similar population composition, regardless of whether they were territorially uncoupled.

The kmeans method was used (using Euclidean distances), which allows grouping data according to the similarity between them and separating those that are not similar and therefore belong to another cluster. The advantage of cluster analysis is that it makes it possible to form homogeneous groups that are not given a priori.

After several tests, it was possible to identify eight groups of communes similar to each other, but different from each other in terms of their population composition, considering the variation of means presented by each cluster. This process was carried

out using SPSS 25 statistical software.

2.4. Calculation of demographic indicators

In order to obtain a series of descriptive indicators of the demographic situation of each cluster, the following four indicators were calculated [4,5]: Masculinity index (Imasc). It expresses the ratio of men to women in a given territory, expressed as a percentage. It is usually greater than 100 in mining camps, in sites with temporary worker population and in areas with strong military presence: $(Imasc = ((Pt_{thombres} \times 100) / Pt_{women}))$.

Economic dependency ratio (EDR). Ratio of dependents (under 15 or over 64 years of age) over the working age population (between 15 and 64 years of age). The data are expressed as a percentage of the working-age population. As the rate increases, the burden on the productive part of the population to support the economically dependent part increases. Budget forecasts for education, health, pensions and other types of social spending must be adjusted as a result, in addition to changing their composition: $(Tde = ((Pt_{0-14} + Pt_{65 \text{ and over}}) / Pt_{15-64}) \times 100)$.

Child and youth dependency ratio (CDR). Ratio to measure the potential need for social support of the child and youth population by the working population. It is the quotient between the population under 15 and the population between 15 and 64 years of age: $(T_{dij} = (Pt_{0-14} / Pt_{15-64}) \times 100)$.

Older Adult Dependency Ratio (OADR). Ratio to measure the potential need for social support of the older adult population by the working population. It is the ratio between the population aged 65 and over and the population aged 15-64: $(T_{dam} = (Pt_{65 \text{ and over}} / Pt_{15-64}) \times 100)$.

3. Results

Taking into account the 346 third-level subnational units that make up Chile, it is possible to affirm that the population structure by age and sex presents heterogeneous characteristics among them, which can be grouped into eight clusters. In general, these important nuances among them can be observed in **Figure 1**, from the superimposed pyramids. The distribution and spatial patterns in the communes of these clusters can be seen in **Figure 2**. The descriptive indicators of the demographic situation of each cluster are shown in **Table 1**.

Cluster number one (C1) is called 'aging population'. It is composed of 76 communes that are home to 749,265 people, with a population variability between 274 and 31,372 among the communes that comprise it. The characteristics that allowed such denomination are that both male and female population whose age structure is higher than the national standard in the five-year age group over 44 years old and more accentuated in the population over 60 years old. It is also relevant to mention that there are generational notches at the base of the pyramid, represented by lower proportions of children and young people, evidence of a low birth rate. This situation is evidenced by the fact that it is the cluster with the highest average value of the dependency rate of the elderly (Tdam), with 24.94. In terms of spatial distribution, they are located in mostly rural communes in the center and south of the country, highlighting those present in the regions of O'Higgins, Maule and Los Lagos. The fact that rural

communes are the main component of this cluster indicates that the loss of population in the most productive segments could be related to internal migration phenomena in search of labor sources.

Cluster number two (C2) is called ‘nest with active aging’. It is made up of 42 communes with 910,506 people, with a population variability between 3,829 and 51,917. It is characterized by an effective balance between male and female population with a higher proportion of children and young people in the five-year age group. Its average value of child and youth dependency ratio (T_{dij}) is the second highest of all the clusters, reaching 33.19. Also, there is a smaller population, compared to the national standard, in the five-year age group between 15 and 44 years, a symptom that these territories are unable to retain the younger economically active population that must leave the territory in search of job opportunities. This situation is evident in the average value reached by the economic dependency rate (T_{de}), which with its 54.20 reflects that it is the cluster with the highest proportion of dependent people over the working age population. Its spatial distribution is presented in areas made up of mostly urban communes belonging to the regions of Coquimbo, Bio = Bío, La Araucanía and Los Ríos. The location of the cluster’s communes and the strong dependency are signs of the work/family dislocation processes that have been experienced in recent years in specific areas of the country, such as mining.

Cluster number three (C3) is called ‘transition to aging’. It is composed of 40 communes that are home to 1,235,055 people, with a population variability between 3412 and 93,602. It is characterized by a relative balance between male and female population and a greater presence of population, compared to the national standard, over 50 years of age. The difference with C1 lies mainly in this balance between male and female population, in relation to a higher presence of male population in C1. There is also another difference related to the territories inhabited, which are more urban than rural, compared to C1. As in the case of C2, these territories are not able to retain the younger economically active population, who are less predominant in the cluster. This is not the case for the population of children between 0 and 9 years of age, which presents patterns quite similar to the national composition. In spatial terms, they are located in the center and south of Chile, highlighting communes that are mostly urban, present in the south of the Maule and Ñuble regions.

Cluster number four (C4) is called ‘adult population’. It is made up of 37 municipalities that bring together 5,413,419 people, with a population variability between 32,579 and 366,916, which makes this cluster the one with the greatest population weight, since it groups 30.8% of the country’s population. It is a conglomerate with a relative balance between men and women, with the exception of the segments over 70 years of age, where there is a more evident female preponderance in the population over 80 years of age, which results in a masculinity ratio of 96.40 for this group.

At the same time, a pyramidal profile with a narrow base stands out, referring to a low birth rate, where the evidence points to sustained deficits with respect to the national standard in children under 19 years of age. If large age groups are considered, this subset is dominated by the young adult and adult population, related to productive population groups. In spatial terms, they are mainly located in consolidated urban or metropolitan areas, highlighting the case of several communes in the Metropolitan

Region, in the consolidated urban area of the country's capital, which concentrates the largest number of jobs, especially in the areas of commerce and services.

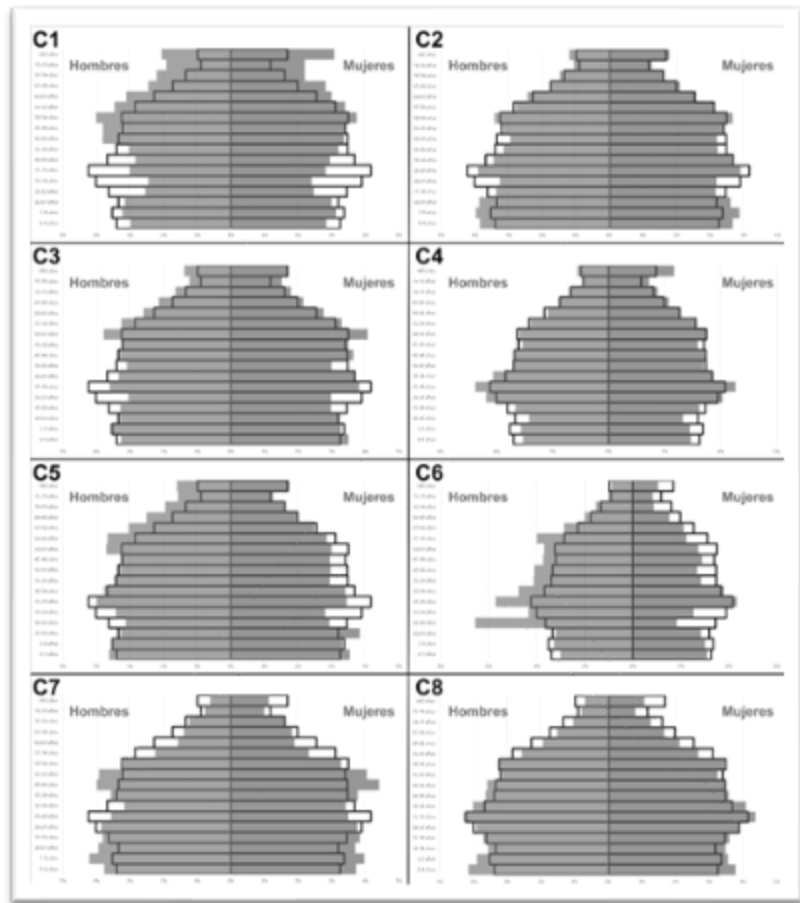


Figure 1. Population pyramids for each cluster (gray bars) superimposed on the national population pyramid.

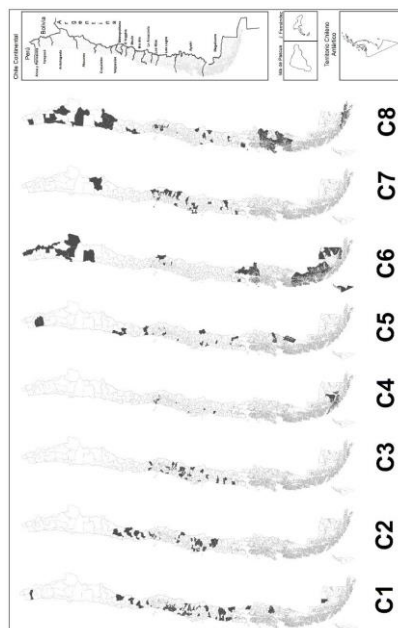


Figure 2. Distribution and territorial patterns for each cluster.

Cluster number five (C5) is called ‘men of terminal productive age’. It is composed of 23 communes that are home to 279,464 people, with a population variability between 625 and 33,985. It is characterized by a tenuous imbalance in favor of the male population, in the ages from 30 to 80 years and older. This situation is supported by the average value of the Imasc, which with a value of 108.78 reflects that it is the second cluster with the highest proportion of men over women. It is also noteworthy that this cluster is composed mainly of adult men. The spatial distribution of the communes is quite diverse, i.e., representative territories of the cluster are found in the north, center, south and southern part of the country, typical of mostly rural communes, but where the main productive activities of the country are concentrated: mining, aquaculture and agricultural industries, among others.

Cluster number six (C6) is called ‘men in initial productive age’. It is made up of 30 municipalities with 598,916 people, with a population variability between 138 and 404,495. It is characterized by a clear imbalance of male population in relation to female population, mainly in the segments of 15 to 19, 20 to 24 and 55 to 59 years of age. There is a deficit of women in the early fertile age (15 to 24 years), but not in the right productive quinquennial groups (25 to 34 years). This could be an explanation for the low birth rate, which gives room for the narrowness of the pyramidal base, as this is a consequence of a population dedicated mainly to specialized productive activities and not to core-family activities, which is fundamental evidence of the family/residence decoupling processes that have been occurring recently in the country and are known as labor commutation [6]. It is the cluster with the lowest average Tdam value of 11.42. The spatial distribution is concentrated in communes in the north of the country, the commune of Santiago (seat of the presidential government), Patagonia and the Chilean Antarctic territory.

Cluster number seven (C7) is called the ‘expanding nest’. It is composed of 49 communes that are home to 4,069,398 people, with a population variability between 7273 and 568,106. It is the third cluster in terms of population concentration, with 23.2% of the country’s population. It presents a balance between male and female population, together with an absence of adult population over 55 years of age and elderly population over 65 years of age. Its pyramidal base represents a birth rate that exceeds the parameters of the national pyramid by finding a population surplus in the strata under 19 years of age, being one of the clusters with the largest youth population. In addition, the population segment between 35 and 59 years of age is representatively relevant for men and women, which confers its marked age trend to children and young people, together with adults of mature age. In this way, this cluster shows the presence of families that are starting their formation, with a marked number of children.

Table 1. Descriptive indicators of the demographic situation of each cluster.

C1		C2	C3	C4	C5	C6	C7	C8
Total communes		42						
Total population	749.265	910.506	1.235.055	5.413.419	279.464	598.916	4.069.398	4.317.300
Communal population	9.858 (274–31.372)	21.679 (3829–51.917)	30.876 (3412–93.602)	146.309 (32.579–366.916)	12.151 (625–33.985)	19.964 (138–404.495)	83.049 (7273–568.106)	88.108 (523–361.873)

	50.94	49.04	49.06	48.24	51.99	63.42	49.25	50.4
% Men	(48.18–69.71)	(47.78–49.97)	(44.98–50.72)	(45.82–49.96)	(49.23–59.84)	(50.11–91.3)	(47.18–53.76)	(47.88–57.93)
	49.05	50.96	50.94	51.76	48.00	36.58	50.75	49.59
% Women	(30.29–51.82)	(50.03–52.22)	(49.28–55.02)	(50.04–54.18)	(40.16–50.77)	(8.7–49.89)	(46.24–52.82)	(42.07–52.12)
	104.71	96.24	96.40	93.32	108.78	232.66	97.12	102
Imasc	(93–230)	(91–100)	(82–103)	(85–100)	(97–149)	100–1050)	(89–116)	(92–138)
	52.87	54.20	51.06	45.44	52.67	31.1	47.21	47.73
Tde	(38.38–63.64)	(49.07–60.29)	(45.80–57.31)	(38.43–50.81)	(39.82–61.63)	(4.58–46.68)	(37.58–53.53)	(39.3–57.61)
	27.93	33.19	30.09	26.53	32.56	19.68	31.71	33.9
Tdi	(21.32–31.86)	(29.27–36.95)	(26.54–32.43)	(17.39–31.02)	(28.93–36.07)	(2.28–30.51)	(27.12–37.39)	(29.66–45.5)
	24.94	21.01	20.97	18.91	20.11	11.42	15.5	13.82
Tdam	(14.64–34.33)	(16.92–26.41)	(16.71–27.53)	(15.19–22.58)	(9.62–26.53)	(0–20.53)	(7.58–19.43)	(4.39–19.75)

Imasc: masculinity index. Tde: economic dependency ratio. Tdij: child and youth dependency ratio. Tdam: elderly dependency ratio.

The spatial distribution is concentrated in mostly urban districts in the center-south of the country. which present conditions for family habitability (greater number of real estate projects or lower land prices. greater supply of health and education services. greater concentration of service and commercial jobs. among others).

Cluster number eight (C8) is called the ‘consolidated nest’. It is made up of 49 communes with 4.317.300 people. with a population variability ranging from 7523 to 361.873. It is the second cluster in terms of population concentration. with 24.6%. The characteristics that allowed its denomination are a balance between sexes. a birth rate above the national average and a strong child and adult component. The spatial distribution is representative of the capitals of the subnational region. plus territories associated with the economic dynamics of mining and salmon farming.

4. Discussion

The results obtained allow us to affirm that the population structure by age and sex at the subnational communal level presents heterogeneous characteristics and. in specific places. population imbalance. The analysis of territorial patterns identifies eight different clusters: aging population (C1). active aging nest (C2). transition to aging (C3). adult population (C4). men in terminal productive age (C5). men in initial age (C6). expanding nest (C7) and consolidated nest (C8). Each of these clusters presents diverse population characteristics that must be carefully considered in order to establish a public policy agenda in accordance with the types of aging present in the territories. the productive sources and the concentration of family groups in the national territory.

4.1. Considerations on the aging of the population

For clusters C1. C3. C4 and C5 the process of population aging is a reality. According to the evidence reported by Peládez and Minoldo [7]. here it is plausible to

find higher demands in two punctual services of social protection of old age: long-term care services and pension systems.

In the case of care services, home care is an important gap [8] that falls mainly on extended nuclear families and mainly on women. Therefore, generating policies to support care is essential especially considering that the territories in which the aging population is located present particular characteristics of low urbanization and impoverishment that could increase the comparative disadvantages of these segments in relation to the rest of the population [9].

With regard to pensions, it is clear that the current conditions of the system have impoverished older adults, who retire under the operating conditions of an individual system based on private savings and retire with lower incomes than those received, given the longer life expectancy. But the challenge is greater when considering the acceleration of aging in the sectors and the decrease in the productive base of labor operating in the territories, which increases the negative effects of the lack of resources.

Hence, the policy necessarily has to consider that there is a target group of communities for the promotion of healthy aging and satisfactory old age, overcoming the pitfalls of care and pensions. The challenge is not minor, given the demonstration that older adults perceive barriers to daily life, difficulties in accessing public services, limited recreational options, economic problems and social indiscipline in general [10].

Also, the distinction between rural and urban communities will be necessary given that, worldwide, the main determinant of access to services for older adults in rural areas is the lack of availability of services, while for urban dwellers, financial barriers are the main obstacle to access [11]. As evidenced by Coy [12], this is aggravated in the context of lack of wealth distribution and the deepening of the neoliberal model that has led to increasing vulnerability of broad sectors of society, making their ways of life more precarious, with greater informality and social insecurity.

Finally, it is necessary to observe the consequences in terms of health since, as Fuenzalida and Carvajal [13] point out, adults and older adults worsen their health situation from a complex interaction of individual and structural risk factors, including sedentary lifestyles, lack of physical activity, increased availability of processed foods, and worsening environmental quality of the place of residence.

Therefore, older adults in C1 and C5, who are concentrated in rural areas, should be a priority when it comes to health prevention.

4.2. Policy considerations related to labor commutation processes

Cluster C6 is a special case, due to the clear imbalance of male population. According to the findings of Manzano [14] the gender factor becomes relevant according to the productive structure of each geographic area and, therefore, the particularity of the occupational structure of certain localities, generates the possibilities for the male workforce to achieve full employment, while the female workforce does not have the same luck. One aspect that derives from this is related to the labor commutation present in C5 and C6. This has important consequences on the structure, dynamics and magnitude of the population, both in the place of origin and destination [15].

Hence, advances in transportation, specialization in work shifts, and the productive vocation of some territories favor the conditions for long-distance interregional labor commutation [16], which has consequences on the functioning of the housing, health, and transportation markets, among others.

The demand for these services changes between the place of work and the place of residence, taking advantage of the privileges of commuting to work in relation to higher incomes, but which are repaid in regions of residence that provide better living conditions. Hence, territorial planning has to consider amenities, housing services, health and access to education, among others, that prevail in the places of residence and not in the territory where work is done, but considering these communes in the critical infrastructure necessary to develop the productive processes: special health equipment, single-person or temporary housing solutions for the transfer of personnel to these areas, critical transportation infrastructure that allows displacements between territories, among others.

4.3. Policy considerations associated with the concentration of household groups

The concentration of family groups in the territory occurs mainly in clusters C7 and C8, which are also located in the central areas of the country, where labor centers and relevant services for people of different ages are concentrated. Considering that there are few territories in the stage of population growth, the territories belonging to these clusters will require permanent monitoring, given that it will be an increasingly infrequent expression in a country and Latin American context. According to the Demographic Observatory of Latin America and the Caribbean, while in the five-year period 1950–1955 the crude birth rate per thousand inhabitants was 42.5 in the five-year period 2015–2020 it is 16.5 and the projection indicates that in the five-year period 2095–2100 it will be 8.9 (ECLAC, 2020). Additionally, in C2, which concentrates a population of children and adolescents, it will also be relevant to monitor its particular population characteristics.

Given that the base of the pyramid represents one of the largest markets in the world [17], it is to be expected to find in these communes a greater facility alternatives for users and/or consumers in terms of health, education, leisure and residence, given the international evidence for Latin America [18].

However, the housing strategies of low-income and middle-income families are different and, according to Di Virgilio and Gil [19], involve different practices, decisions and objectives related to access to housing and/or land, property tenure, improvement of habitat conditions, housing equipment, access to and payment of services. In this sense, access to the socialization of the benefits of living in urban territories, which is predominant in these clusters, is affected by land use market dynamics, which result in the effects that real estate developers have on the urban dynamics of access to residential land, conditioning the way in which individuals access the city and the socialization of the city's own amenities [20].

Building more equitable territories in terms of socialization and access to services is central in these territories, which have complex population dynamics, as they represent the different segments of the population pyramid.

4.4. Limitations. scope and projections

Considering the exploratory nature of the research. it is necessary. in the future. to delve deeper into the labor market and migration. the main drivers of change in the population structure by age and sex [9]. Understanding these dynamics will make it possible to anticipate territorial demands of the communes and better meet the specific needs of the different groups. such as requirements in health (pediatric/adult/geriatric). education (compulsory/university/training). labor. access to goods and/or services. all depending on the threshold of demand and possibilities of provision from a public or private point of view.

Within the projections of the research. a consolidating edge is related to understanding how these eight different groups meet their health care needs. The life course approach [21] and the accumulation of positive and negative effects on health and well-being throughout the life cycle (pre-natal. early years. adolescence. productive age. family formation and older ages) will be an appropriate contextual framework for analysis.

It is expected that the results of the research will become a frame of reference when trying to explain the local heterogeneous characteristics of specific age groups at the subnational level. In a broader research context. this will allow in the medium term to calculate age-standardized morbidity rates at the communal scale. and to compare their behavior between different geographic areas. which is essential for making public policy decisions.

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