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Diversity of the food supply in urban environments of Chile: A comparative georeferenced study between Santiago and Antofagasta

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ABSTRACT

Introduction: The configuration of the food environment directly influences the eating habits and nutritional health of the population. In Chile, although research on these environments has increased in the Metropolitan Region, gaps still exist in other urban areas such as Antofagasta, making it difficult to understand territorial inequalities in access to healthy food.

Objective: Analyze the diversity of the food supply in the cities of Santiago and Antofagasta using georeferencing tools and ecological indices, characterizing territorial differences in food environments.

Materials and Methods: A descriptive-comparative analysis was conducted in two cities in Chile. Nutrition and Dietetics students collected data by recording food establishments within a four-block radius of their homes. The establishments were classified as healthy (SAL), unhealthy (NOSAL), mixed (MIX), and supermarkets (SUPER). The data were compiled in Excel spreadsheets, and absolute and relative frequencies were calculated. Food diversity was assessed using the Shannon and Simpson indices. The results were presented in tables, graphs, and thematic maps.

Results: A total of 323 establishments were identified: 165 in Santiago and 158 in Antofagasta. In both cities, unhealthy food options predominated, especially in districts like Lo Prado and Independencia. However, Antofagasta showed greater food diversity, with a more balanced distribution of establishment types, reflected in higher diversity indices (Shannon Index: 1.29 vs. 1.14; Simpson Index: 0.68 vs. 0.63).

Conclusions: Both cities exhibit food environments characterized by a greater availability of unhealthy foods and intra-urban inequalities. Georeferencing and ecological indices allow for a precise characterization of the urban food structure. These findings reinforce the need for urban and public health policies aimed at improving access to healthy food and reducing territorial inequities in Chile.

KEYWORDS

Urban food environment, food access, territorial inequalities, ecological indices, urban public health.

INTRODUCTION

The geographical distribution of food environments is a fundamental determinant of consumption patterns and, therefore, of the nutritional health of the population[1]. This is because physical, economic, and cultural access to food determines not only what is consumed, but also the quality and frequency of the diet. The food environment is defined as the set of physical, economic, and sociocultural spaces in which people acquire, prepare, and consume food, directly influencing their dietary choices and nutritional status[2]. Thus, not only the presence of supermarkets and open-air markets influences the diet, but also factors such as the cost of food, the availability of fresh products, advertising, and local food culture. In this context, georeferencing has become a key tool for analyzing the availability and accessibility of healthy and

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unhealthy foods, allowing the identification of the location and quantity of points of sale in different territories[2,3].

In relation to the above, several international studies have shown that the high concentration of fast-food outlets and businesses that sell ultra-processed products is associated with a higher prevalence of obesity, type 2 diabetes, and cardiovascular diseases[4,5]. These establishments promote consumption patterns based on foods high in calories, sugars, saturated fats, and sodium, while fresh foods are less accessible or more expensive. Conversely, the presence of open-air markets or local markets is linked to a higher consumption of fruits and vegetables, promoting more balanced and healthy diets, as well as access to fresh, high-quality food[6,7]. However, the unequal distribution of these establishments between urban and rural areas creates obesogenic food environments, which primarily affect the most vulnerable socioeconomic groups, increasing health and nutrition inequities[8-10].

In the Chilean context, research on food environments has become relevant in recent years, mainly in the Metropolitan Region, where population density and the diversity of establishments allow for more robust, but not necessarily existing, studies. However, in other regions, such as the Antofagasta Region (located in northern Chile) and in particular the city of Antofagasta, characterized by its desert geography, a high level of urbanization and a strong dependence on external food supplies, they have been little studied. These characteristics create a food environment with unique challenges, where access can be limited. For this reason, the scarcity of evidence limits our understanding of territorial inequalities in access to healthy food and their potential impact on the nutritional health of the population[11].

Given the scarce information on food diversity in other territories, this study aims to analyze the diversity of food supply in the cities of Santiago and Antofagasta using georeferencing tools and ecological indices, characterizing territorial differences in food environments and their potential impact on territorial nutritional equity. These indices (Simpson and Shannon) allow us to evaluate the diversity and predominance of types of establishments, providing a quantitative approach to the structure of the food environment.

This study provides evidence of educational, practical and methodological relevance, by integrating approaches from nutrition, health and georeferenced analysis. The results will allow progress in understanding the environmental factors that condition the population's food opportunities, contributing to the design of local policies aimed at promoting healthier and more equitable food environments.

MATERIALS AND METHODS

Study Design

An observational, descriptive-comparative, and cross-sectional study was conducted. This classification reflects the fact that data collection took place at a single point in time, with the aim of simultaneously evaluating and comparing the diversity of food offerings in two urban centers in Chile: Santiago (central region) and Antofagasta (northern region). The analysis focused on classifying establishments according to the type of food they offered and on estimating ecological indices, providing a quantitative and spatial characterization of the food environment's structure at a specific moment. The collection of primary information was carried out over a period of three months, specifically between May and July 2025.

Classification of establishments

The food establishments were grouped into four categories defined by the research group:

- Healthy (SAL): Establishments whose main offering (at least 70% of the visible inventory) consists of fresh and minimally processed foods. Minimum criterion: Mandatory presence of fresh fruits and vegetables and absence or minimal offering of ultra-processed products. Examples: Fruit and vegetable shops.

- Unhealthy (NOSAL): Establishments where the selection of ultra-processed products, high in energy and with excessive amounts of critical nutrients, predominates. Minimum criteria: Absence of fresh foods (fruits/vegetables) and a predominance of packaged foods with warning labels, sugary drinks, and salty or sweet snacks. Examples: Small neighborhood stores, liquor stores that sell snacks, and convenience stores at gas stations.

- Mixed (MIX): Establishments that offer a balanced or hybrid selection of healthy and unhealthy products. Minimum criterion: Coexistence of at least one fresh food section (fruits, vegetables, or natural dairy products) with a significant selection of ultra-processed and packaged products. Example: Neighborhood stores that include a produce section.

- Supermarkets (SUPER): Large-scale establishments that offer a wide range of products in all the above categories. Minimum criterion: Points of sale with multiple aisles and checkout lanes, integrating both fresh food areas and a high density of ultra-processed products under the same commercial premises.

Data collection

The sampling frame was defined using convenience sampling based on the residential location of the data collectors. A total of 33 Nutrition and Dietetics students participated, 18 from the city of Santiago and 15 from Antofagasta. Each student surveyed a specific area using Google Maps to en-

sure the accuracy of the location and categorization of food retail outlets.

To ensure the comparability and robustness of the analysis, the study area was defined as a 400-meter radius from each collector's residence, extending north, south, west, and east. The choice of a 400-meter radius is based on a distance considered the threshold of effective walkability (approximately 5 minutes of walking at an average pace). This measurement allows for a precise evaluation of the local food environment, which exerts the greatest influence on purchasing decisions and daily eating habits of the population.

All visible street-level food establishments within a 400-meter radius to the north, south, west, and east were recorded. Informal street vendors and establishments exclusively for on-premises consumption (such as restaurants or cafes) were excluded, focusing solely on retail outlets for household consumption.

Only establishments operating at the time of the survey (between May and July 2025) were included. Temporarily closed establishments, those with metal shutters down during business hours, or those displaying "for rent/sale" signs were excluded to avoid bias in the actual availability of food.

Data processing and analysis

The collected data were consolidated into Excel spreadsheets for subsequent statistical analysis. During this process, a rigorous data cleaning stage was carried out by identifying duplicate addresses and verifying geographic coordinates in adjacent collector polygons, thus ensuring the elimination of redundant records and guaranteeing that each establishment was counted as a unique unit within the study.

The statistical analysis was structured at two levels:

1. Descriptive analysis: Absolute and relative frequencies of establishments were calculated according to their category (SAL, NOSAL, MIX, SUPER) at a global level by city.
2. Diversity Analysis: The diversity of the food supply was assessed using the Shannon and Simpson ecological indices, with the entire city as the unit of analysis. The indices were calculated in aggregate for Santiago and Antofagasta, allowing for a macro-urban comparison of the food environment structure between the two regional centers.
    - Shannon Index (H): Used to measure the fairness in the distribution of store categories; higher values indicate a more diversified supply and less concentration in a single type.
    - Simpson Index (D): Used to determine the probability that two randomly selected establishments belong to different categories, reflecting the heterogeneity of the environment.

Shannon Index Formula

$$H = -\sum_{i=1}^{n} p_i \cdot \ln(p_i)$$

Simpson Index Formula

$$D = 1 - \sum_{i=1}^{n} p_i^2$$

Where:

- Pi is the proportion of each type of store relative to the total.
- n is the number of categories (4 in this case: SAL, NOSAL, MIX, SUPER).

RESULTS

The georeferenced survey identified a total of 323 operating food establishments in both urban centers, distributed as follows: 165 in Santiago and 158 in Antofagasta. Overall, the food supply was characterized by a marked predominance of establishments classified as unhealthy (NOSAL), representing 51.5% in Santiago and 43.7% in Antofagasta. In contrast, establishments offering predominantly healthy food (SAL) had the lowest relative presence in both cities, reaching only 4.2% in the capital and 5.1% in the northern city. Mixed-category (MIX) and supermarket (SUPER) establishments completed the food supply structure, representing 37.6% and 6.7% in Santiago, and 43.7% and 7.6% in Antofagasta, respectively.

When comparing regions, Antofagasta shows a more balanced configuration of unhealthy and mixed-type establishments, unlike Santiago, where the unhealthy offering is significantly higher than the other categories. This general distribution and the percentage differences between the two cities are represented graphically in Figure 1.

Regarding intra-urban distribution, the study revealed significant inequalities within each city. In Santiago, a high concentration of unhealthy food outlets was identified in the districts of Lo Prado and Independencia, with 26 and 25 establishments, respectively. Conversely, districts like Independencia showed greater heterogeneity, including a presence in all the analyzed categories, while areas like Talagante and La Pintana presented a very limited and undiversified offering. In Antofagasta, the sectoral analysis revealed that the northern zone has the highest commercial density, with a predominance of non-salary (NOSAL) and mixed (MIX) establishments, while the central sector stands out for its greater diversity and presence of salt (SAL) stores. Specific details of this municipal and sectoral distribution are presented in Tables 1 and 2.

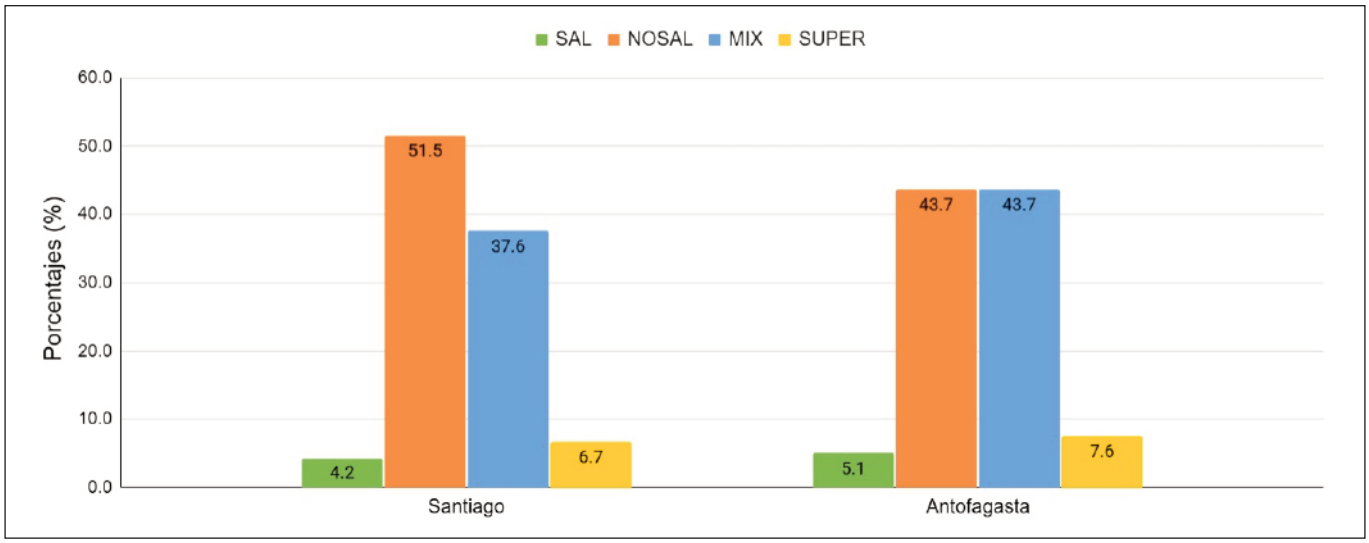

Figure 1. Food supply in the cities of Santiago and Antofagasta

Table 1. Food supply in the city of Santiago by commune

Commune	SAL	NOSAL	MIX	SUPER
El Bosque	0	4	7	2
Isla de Maipo	0	2	3	0
Cerro Navia	1	4	6	0
La Pintana	0	1	1	0
Peñalolén	1	2	2	0
Paine	1	2	2	0
Lo Prado	0	26	7	3
Buin	1	2	1	0
Independencia	1	25	14	3
Talagante	0	0	1	0
Estación Central	0	1	4	0
San Bernardo	1	4	3	2
Lampa	0	3	2	0
Puente Alto	1	9	9	1
Total	7	85	62	11
Percentage	4.2%	51.5%	37.6%	6.7%

* The values are presented as absolute and relative.

Table 2. Food supply in the city of Antofagasta by sector

Sector	SAL	NOSAL	MIX	SUPER
North	0	15	3	2
North	1	5	4	0
North	1	2	5	1
North	0	4	4	0
North	1	4	8	2
North	3	4	6	1
North	0	1	3	0
City center	0	5	7	0
City center	1	3	8	0
City center	1	8	5	1
South	0	2	2	3
South	0	1	6	0
South	0	1	3	0
South	0	5	2	1
South	0	6	2	1
Total	8	69	69	12
Percentage	5.1%	43.7%	43.7%	7.6%

* The values are presented as absolute and relative.

Finally, the assessment of food diversity using ecological indices confirmed structural differences between the two environments. Antofagasta exhibited higher levels of diversity than Santiago in both indicators analyzed, obtaining a Shannon Index of 1.29 compared to 1.14, and a Simpson Index of 0.68 compared to 0.63 for the Metropolitan Region. These values, summarized in Table 3, suggest that the food environment of Antofagasta has a more equitable distribution among the various types of stores, reflecting a less concentrated and potentially more varied supply than that observed in Santiago.

Table 3. Food diversity indices in the cities of Santiago and Antofagasta

City	Shannon Index	Simpson Index
Santiago	1.14	0.63
Antofagasta	1.29	0.68

DISCUSSION

The study results show a clear predominance of establishments offering unhealthy food (NOSAL) in both contexts analyzed (Santiago and Antofagasta), with a low representation of establishments offering predominantly healthy food (SAL). This pattern revealed food environments with a strong presence of ultra-processed options and lower accessibility to healthy foods, which aligns with recent findings on the concentration of obesogenic environments in Latin American urban areas and with emerging evidence on the relationship between the availability of unhealthy establishments and adverse population health outcomes[12].

Regarding territorial differences, the greater diversity observed in Antofagasta (measured by ecological indices) indicates a more balanced distribution among establishment categories compared to Santiago. We interpret this finding in light of the territorial differences found in terms of urban structure, commercial density, and supply chains. Cities with less commercial centrality or with differentiated supply patterns (for example, a greater role for mixed chains or supermarkets) may show greater equity in the representation of types of commerce, even though the absolute availability of healthy supply remains limited[12-14].

Furthermore, the concentration of NOSAL points in specific districts of Santiago (such as Lo Prado and Independencia) reflects an unequal distribution of food supply. This situation contributes to the creation of unhealthy food environments. Healthy food environments are a key determinant for ensuring adequate access to food security[1,15]. This is consistent with socio-spatial analyses that document greater exposure to unhealthy businesses in lower socioeconomic status neighborhoods in Chilean urban areas. The concentration of businesses offering unhealthy products around homes and schools can influence consumption patterns and increase the risk of chronic diseases in vulnerable groups[4,5,16].

From a public policy perspective, the results highlight the need to implement intersectoral interventions that consider not only the presence or absence of supermarkets/open-air markets, but also the qualitative composition of the commercial supply. The Chilean experience in implementing nutritional labeling and advertising restrictions on ultra-processed foods that exceed established limits for critical nutrients (calories, sodium, saturated fatty acids, and sugars) has shown that policies can modify purchasing decisions as well as product formulation. However, these measures must be complemented by focused urban planning strategies, support for local markets (such as farmers' markets), and actions that improve both the accessibility and affordability of fresh food in neighborhoods with limited healthy options[17].

Regarding methodology, the application of ecological diversity indices (Shannon, Simpson) offers advantages for characterizing food supply beyond simple counts. These measurements allow for the identification of food diversity within the supply. However, recent studies propose combining potential accessibility analyses with mobility and consumption data to obtain a more complete picture of food access[18].

Finally, the findings of this study should be interpreted within the context of its limitations, including the non-probability sampling method and the data collection focus on students' homes, which could introduce selection bias and limit representativeness. We recommend that future studies incorporate more representative sampling, inventory verification, and quantitative measures of price and quality. Lastly, the study does not include consumption data or population health indicators; to infer health effects, it will be necessary to link these sources with epidemiological data[19-21].

CONCLUSIONS

In conclusion, the results presented show a predominance of environments with unhealthy food options in both cities analyzed, as well as communal inequalities, which could contribute to gaps in food opportunities and health outcomes. The combination of georeferenced analysis and the diversity index is useful for characterizing the structure of the food environment. Further studies integrating actual accessibility, consumption data, and policy evaluations are needed to design effective responses aimed at nutritional equity in Chilean urban contexts.

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