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Intra-territorial inequalities in children's hospital admissions in the Metropolitan area of Santiago, Chile

Inégalités inter-territoriales dans les admissions hospitalières pour les enfants de l'agglomération métropolitaine de Santiago, Chili

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Resúmenes

English Français

This paper aims to unveil the behavior of inequalities in health among the children population according to socioeconomic groups living in the same territory. Main purpose of the research is to determine if hospital admissions for respiratory diseases present evidence of unequal effects on morbidity of the resident population in the municipalities of the Metropolitan Area of Santiago de Chile (MAS). Entropy index is used in order to present socio-spatial inequalities, proportional differences between mutually exclusive groups, and redistribution potential.

Observing simultaneously the spatial distribution of multiple socioeconomic groups within a territory provides a new lens for approaching the recent studies of inequality in the MAS, and allows to overcome an analysis based only on two antagonistic groups.

The main findings show inequality of health damage in residents of different municipalities in the Metropolitan Area of Santiago, Chile. The data shows how the place of residence influences the health inequalities experienced, finding the following configurations: territorial balance; territorial imbalance; territorial inequality; extreme territorial inequality. The differences found in the proportionality of hospital admissions, according to the socioeconomic group do not follow a uniform trend in favor of least vulnerable groups.

L'objectif de ce travail est de révéler le comportement des inégalités de santé sur la population infantile, ceci en fonction des groupes socio-économiques qui habitent sur le même territoire. L'objectif principal de la recherche est de déterminer si les admissions hospitalières pour des maladies respiratoires montrent des effets inégaux sur la morbidité de la population résidente dans les municipalités de la zone métropolitaine de Santiago du Chili (MAS). L'indice d'entropie a été utilisé pour présenter la distribution des inégalités socio-spatiales, les différences proportionnelles entre les groupes et le potentiel de distribution.

De même, nous avons observé simultanément la distribution spatiale de multiples groupes socio-économiques au sein d'un territoire, fourni une nouvelle perspective pour aborder les études récentes sur l'inégalité dans l'MAS, et ainsi pouvoir permettre de dépasser une analyse basée uniquement sur deux groupes antagonistes.

Les principaux résultats montrent l'inégalité existante par rapport aux dommages à la santé des résidents habitant différentes municipalités de la région métropolitaine de Santiago, au Chili. Les données montrent aussi comment le lieu de résidence influence sur les inégalités de santé expérimentés, trouvant les configurations suivantes: équilibre territorial; déséquilibre territorial; inégalité territoriale; Inégalité territoriale extrême. Les différences constatées dans la proportionnalité des hospitalisations, selon le groupe socio-économique, ne suivent pas une tendance uniforme en faveur des groupes les moins vulnérables.

Entradas del índice

Mots-clés : entropie, santé, inégalité sociale, inégalité spatiale, géographie de la santé
Keywords : entropy, health, social inequalities, spatial inequality, health geography

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Texto completo

Introduction

1 Since the 1970s, substantial evidence has demonstrated that socially disadvantaged groups are often exposed to physical environments that are potentially health-damaging (Richardson *et al.*: 2013; Bartley M., 2017). It has also been noted that many health outcomes vary geographically and, in particular, that more socially deprived communities have poorer health than less deprived areas; a gap that is widening in many countries (Pearce *et al.*: 2008; Padilla *et al.*: 2016).

2 There is a consensus that inequalities between people do not occur "naturally" but are created by the historical process and by the mode of production and organization of societies (Frohlich *et al.*: 2006). In fact, scientific evidence suggests that there is not only a link between individual socioeconomic circumstances and health but also between the socioeconomic environment, where individuals live their lives, and their health (Wolfson *et al.*: 1999). In general, the evidence points to a strong social gradient in the field of health of the population, invariably unfavorable for the socially underprivileged groups (Szwarcwald *et al.*: 2002).

3 As pointed out by Deguen and Zmirou-Navier (2010), evidence of social health inequalities is well established today in most industrialized countries: globally, socioeconomically disadvantaged populations are more strongly affected by various health problems – diabetes, cardiovascular diseases, some types of cancer, and the most severe forms of asthma (Cesaroni *et al.*: 2010) – than more advantaged populations.

4 It is important to mention that socioeconomic status (from now on referred to as SES) is one of the major determinants of health status and health disparities among different social and ethnic groups, and may serve as a health indicator that has predictive value in spatial epidemiologic assessment (Philips *et al.*: 2011). Indeed, Marmot debated two ways in which income could be causally related to health: through a direct effect on the material conditions necessary for biological survival, and through an effect on social participation and opportunity to control life circumstances (Marmot M., 2002).

Evidence from case studies

5 Several epidemiological studies attempt to identify and isolate factors that explain health inequalities in time and space, or between individuals. As Makdissia and Yazbeck (2010) point out, measuring health inequalities is essential for the implementation and the monitoring of health policies. Additionally, according to Arcaya *et al.* (2015), the operationalizing of a study of health inequalities involves social group health inequalities, in terms of group-level differences versus overall health distribution; defining groups in absolute versus relative social position; geographic health inequalities, as in place versus space; and generally tracking health inequalities over time.

6 Considering the importance of the environment in which the individual is embedded in an everyday context, it must be able to quantify the risk and unequal expression of impact on health, which different income strata potentially face in their respective territories. Therefore, it is possible to find many scientific contributions that enhance the use of relative risk (RR) and attributable risk in their research. Proof of this is set by Nilunger *et al.* (2004), who set a quantization parameter for Health Impact Assessment in Quebec (Canada), by analyzing the influence of different relative risks on disease burden for various socioeconomic groups. Similarly, Dalmau-Bueno *et al.* (2010), adjusted Poisson models to estimate relative risk of all-cause mortality, within the proposed methodology to analyze the evolution of socioeconomic inequalities in mortality in Barcelona (Spain), and more recently, Brunt *et al.* (2017), evaluated associations between air pollution, deprivation status and health outcomes in Wales (UK).

7 On the other hand, in Chile, Hertel-Fernandez *et al.* (2007) estimated annual rates of infant mortality and relative risk by the mother's education and employment status, as well as the age for each cause of death. This is in order to measure socioeconomic inequalities and infant mortality attributable risk at national and regional levels from 1990-2005 and propose new policy targets. For its part, Vásquez *et al.* (2013), using the National Socioeconomic Characterization Surveys during the period 2000-2009, found that people in the lower income quintiles reported worse health status and more physical

limitations than those in the upper quintiles. Income, having higher education and private health insurance contribute to inequity in favor of higher income people in general, specialized and total consultations. Fuenzalida *et al.* (2016) in the Metropolitan Area of Santiago de Chile (MAS), calculated RR according to socioeconomic group residents in a municipality, finding that the risk differences of requiring hospitalization vary from 4 to 11 times more hospital admissions, among the poorest groups compared to those with the highest incomes.

8 As Aschan-Leygonie *et al.* (2013) state, there are different epistemological ways of studying the relationship between health and place. One of these ways focuses on health inequalities between different places and the resulting spatial patterns. The aim is to identify relationships between health status and spatial structure of the different social, economic and environmental characteristics, which can be applied both regionally and within a city. An alternative approach is to look at the individual level in order to assess the extent to which social, economic and ecological characteristics of a place affect the health of its residents. If individuals are grouped by common characteristics, it can be inquired how health inequality is reproduced within a place. For the purpose of this study, this second approach with the social stratification condition of grouping is used.

9 Given these premises, this paper seeks to expand the knowledge about the behavior of inequalities in health among socio-economic groups living in the same territory. The purpose of this research is to determine if hospital admissions for respiratory diseases present evidence of unequal effects on morbidity of the resident population in the municipalities of the Metropolitan Area of Santiago de Chile (MAS). If this happens, the assessment of health inequality will be the result of finding that some group(s) are proportionally impacted by higher rates of hospital admissions compared with the place of residence. Respiratory diseases have been selected since they are part of the group of "diseases of poverty", particularly because of the greater vulnerability of these populations to environmental conditions that affect health, such as pollution, overcrowding, and precariousness of basic sanitary conditions (Urriola R. 2011).

10 After justifying the use of entropy as a measure of socio-spatial inequality, the following section details the adopted methodology. The results of the use of measures of inequality and thematic mapping are then described, to conclude with a discussion section.

Entropy as a measure of socio-spatial inequality

11 The statistical formulation of entropy, proposed by Boltzmann and then Gibbs (Batty, 2010), demonstrates that thermodynamic laws can be obtained from statistical laws and points out that the maximum entropy of a system is directly proportional to the logarithm of the total number of configurations or states (k) possible in a particle system. Therefore, entropy would represent a measure of maximum dispersion of particles in a physical system and would be equivalent to the most probable micro-states.

12 As an example, we could transpose this concept to a social system, a city, composed of individuals categorized into three types of strata according to income levels (low, medium and high), which would configure a system with 3 possible states (k=3). Following the Boltzmann-Gibbs reasoning, we could thus obtain the maximum entropy (h) by calculating the logarithm of 3 and obtaining the macrostate of the system [1].

$$ln(k) = \ln 3 = 1.10 \qquad [1]$$

13 The entropy indicates the most probable configuration among multiple possible states (when probabilities are not known). In the used example, it would be represented by the probability of finding individuals of low, middle and high strata at a location in the study area, which would be p= 0.33 or 33.33%. It is therefore also interpreted in other application contexts as a measure of uncertainty.

14 Unlike the hypotheses of physics, and especially of the second principle of thermodynamics, in social systems, and especially in spatial systems, behavior turns out to be diametrically opposed. The existence of a sociocultural system; of an intelligence and autonomy of individuals; of the relations and capacities of communication, among other factors, shows that the most probable state of distribution in the territory of the events is far removed from a situation of uniformity or maximum entropy. The inhabitants of a community and the events that are related to them are grouped according to interests, hobbies, material possibilities, among other factors, leading the system to configure patterns of grouped distribution. Because of this, a large number of applications focus the analysis on socioeconomic segregation, seeking to know the degree of concentration of the different social categories, level of inequality and margin of action for a redistribution (Linares, 2013; Apparicio *et al.*: 2014).

15 Using entropy measures, Quillian & Lagrange (2016) compared socioeconomic segregation in metropolitan areas with a population of more than 1 million in France and the United States. They provide evidence that (1) high-income persons are the most segregated group in both countries; (2) that the shares of neighborhood income

differences that can be explained by neighborhood racial/ethnic composition are similar in France and the United States.

16 In Santiago de Chile, the relationship between inequality and residential segregation has been analyzed and discussed (Sabatini *et al.*: 2010; Ruiz-Tagle & López, 2014; Borsdorf *et al.*: 2016), but they have chosen to use the index of dissimilarity (or Duncan index) as one of its main analysis tools. The results show that high-income households are more isolated than poor households, with levels comparable to racial residential segregation in the United States, consolidating the eastern sector of the Metropolitan Area of Santiago de Chile (MAS) as the attractor of households of the richest decile within the city and expansions of the city on the western and southern periphery of the MAS as attractors of the poorest decile (Agostini *et al.*: 2016).

17 In this sense, the contribution of this research to the state of the art in Santiago will be the utilization of Entropy as a measure of socio-spatial inequality, seeking to measure the spatial distribution of multiple socioeconomic groups simultaneously within the same commune.

18 Despite the differences in the starting points of the concept of entropy, its practical application in the studies on inequalities in health is extremely useful, since the perfect distribution behavior, or uniformity, that the entropy exhibits is an optimal equality parameter. This allows us to contrast the empirical distributions of socio-economic conditions in an area of study, and from this, to evaluate the distance of an ideal situation of equality.

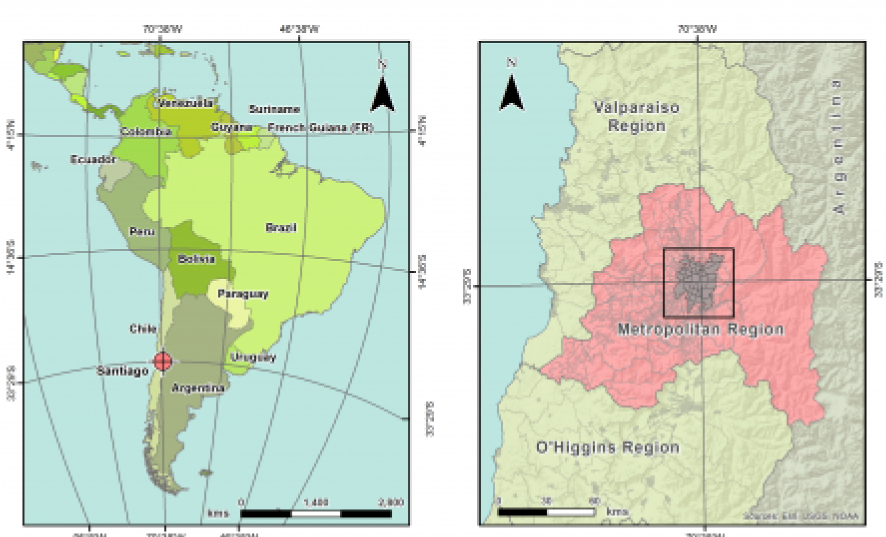
Materials and methods

Study area

19 The present case study is referred to the Metropolitan Area of Santiago de Chile (MAS) composed by 34 Administrative Units (AU) (See Map 1), distributed at an altitude ranging from 400 to 900 meters above the sea level, this being a highly contaminated area, with at least 5 million people exposed to an average annual concentration of Particulate Matter 10 ug/m3 (PM_{10}) exceeding the limit established in the Chilean standard (50 ug/m3) and the World Health Organization's standard (20 ug/m3). The units of measurement of PM_{10} are ug/m3, and contains particles with a diameter between 2.5 and 10 micrometers (µm) and micrograms per cubic meters.

20 Records consulted for the time series, taken from the National Information System Air Quality indicate the following average annual concentration: 2005: 66 ug/m3; 2006: 72 ug/m3; 2007: 69 ug/m3; 2008: 67 ug/m3 and, 2009: 66 ug/m3 (Fuenzalida *et al.*: 2016). Some of these pollutants are originated from natural sources such as soil or salt particles from nearby fields or the sea, but most of them originated from man-made sources such as vehicles, industrial plants, combustion and heating (Romero *et al.*, 2010). These anthropic dynamics exacerbate the natural factors of the territory, since, in general, Chilean cities are located into river basins that act as semi-orographic systems that impede air circulation and ventilation, or as directed especially along river corridors corresponding to fluvial axes (Román *et al.*, 2009).

Map 1: Study area location context.



Source: elaborated by the authors

21 The presence of an important set of hills around the MAS is a factor that limits the ventilation of the city and the evacuation of pollutants. Supplementary to this are other factors such as speed and wind direction (horizontal movement), as well as the existence of constraints on the vertical dispersion inversion effect that also hinder the distribution of

pollutants. Notably, the area also has remarkable differences in temperature between the different climatic seasons (Mott *et al.*, 1997). Therefore, evidence indicates that pollutants emitted during the day in the central and southwestern zones of the study area are transported to the northeast sector, while at night, the flow is reversed, with cleaner air descending from the foothills of the Andes, carrying the contaminated air into the central and western zone of the city.

Hospital admission data

22 Overall, this is a non-experimental study with a retrospective sense. For the analysis of health damage, hospital admissions (HA) is used corresponding to the total of intra-hospital care provided in the country, independent of the public or private character of the provider, for the treatment of diseases that have used one or more "bed-days" (hospitalization). These data are collected and validated by the Department of Health Information and Statistics of the Ministry of Health of Chile in its Annual Statistical Report of Hospital Discharges (IEEH acronym in Spanish).

23 Of the variables contained in the IEEH, age, diagnosis, place of residence, date, and health prognosis are analyzed. It is important to note that knowing the place of residence of the patient allows minimizing the problem of the unequal distribution of public and private hospital supply. Also, the MAS being within a radius less than 15 kilometers does not penalize mainly the interactions between the origins (patients) and the destination (hospital) considering center-periphery.

24 Selected morbidity diagnoses correspond to the scientific literature associated with air pollution by PM_{10}, including respiratory pathologies: pneumonia; bronchitis, emphysema, asthma and other chronic obstructive pulmonary diseases, classified according to ICD-10 codes (*Ministerio del Medio Ambiente*, 2011).

Population Study: children under five years old

25 The study examined the population under five years of age, as throughout their lives they demonstrate a lower territorial mobility, which guarantees that the events of health damage may be assigned or directly related to the levels of exposure to environmental pollution within their territories of residence. Furthermore, they are a group of people identified as being at risk of morbidity and mortality from these causes, as they are particularly susceptible to the effects of environmental pollution on health since they spend more time in outdoor spaces, have a higher respiratory rate, and inhale a larger volume of air in proportion to their body weight. Infants may be especially sensitive to the effects of environmental pollution because their immune, respiratory and their central nervous systems, which are not fully developed (Safaei J., 2007).

26 In Chile, health coverage system is differentiated by public and private, FONASA and ISAPRE, respectively, and based on contributions to social security by workers (7% of pay with a maximum of approximately 2,870 operating USD). FONASA (acronym in Spanish for National Health Fund) serves the majority of the population, especially the poor and elderly; ISAPRE (acronym in Spanish for Institutions of Healthcare) serves the younger, healthier, and higher-income patients (Urriola *et al.*: 2016). Thus, individuals are categorized based on the health systems they used, in order to generate groups based on whose household incomes are within predefined and mutually exclusive ranges, therefore are comparable to SES.

27 Along these lines, the beneficiaries of the public system are classified into 4 groups depending on the level of monthly taxable income of the insured. Group A (FONASA A), lacking in resources; Group B (FONASA B), less than or equal income to 370 USD; Group C (FONASA C), more than 370 USD and less than or equal to 542 USD income; and Group D (FONASA D), more than 542 USD. Private system users are not classified by income bracket, but based on studying the behavior of the total fees paid by affiliated ISAPRE for a month in the country, the average salary of individuals in this group is approximately 1,978 USD.

28 To estimate the total population exposed to environmental pollution by SES, the study uses the allocation percentage of the beneficiary population's participation per forecasting system utilized, income bracket, and municipality (annual statistics calculated by FONASA) according to the value of the projection of the population under age of six that DEIS calculates annually using Taucher population projection method.

29 For analysis purposes, the SES classification is grouped into 5 categories of interest, these being SES 1= FONASA A; SES 2= FONASA B; SES 3= FONASA C; SES 4= FONASA D; SES 5= ISAPRE. Identifying these groups allows assessing the presence of inequality in the magnitude of the risk of illness and requiring hospital care.

Statistical techniques

30 Data sources discussed in this study are based on total numbers of HA, that is, the census of health events that required hospital treatment for recovery. This advantage allows the direct and non-probabilistic identification of the health damage present in the population under study. This provides a set of indicators capable of diagnosing and assessing the magnitude of the risk faced by human health, with the statistical characteristic of being replicable over time and in other municipalities in the country. Evidence of inequalities in health requires different techniques of measurement, between two or more groups, of different social categories or forms of grouping. First, we calculate the specific rate for hospital admissions per 1,000 inhabitants belonging to an SES (RHA*i*) [2].

31 Rate per hospital admissions per 1000 population (RHA):

$$\mathrm{RHA}_i = \frac{\mathrm{HA}_{\mathrm{SESi}}}{\mathrm{P}_{\mathrm{SESi}}} * 1000 \qquad [2]$$

Where:

RHA_i: specific rate of hospital care that occurred in the period 2005-2009, in children under 5 years of age belonging to the categories $\mathrm{SES_i}$, with *i*=1..5.

SES_i: corresponds to the population under 5 years of age belonging to one of the 5 groups of SES (*i*:1..5), defined as:

- *i*=1→ SES1: FONASA A
- *i*=2→ SES2: FONASA B
- *i*=3→ SES3: FONASA C
- *i*=4→ SES4: FONASA D
- *i*=5→ SES5: ISAPRE

HA_{SESi}: total number of hospitalizations occurring to children under 5 years of age, in the $\mathrm{SES_i}$, with *i*:1..5.

P_{SESi}: total population estimated to 2007, according to the groups $\mathrm{SES_i}$, with i:1..5.

32 Secondly, in order to measure equity in health damage, an adaptation of the classical Entropy Index *h* will be used [3]. Proposed by Shannon (1948), measures the spatial distribution of multiple groups simultaneously. It can obtain values between zero and *ln*(*k*), where within this range the low values indicate that the groups within the spatial units have an inequitable representation. That is, they would be expressing inequalities with respect to the health damage, while at the opposite end, with high values close to *ln*(*k*), we would find a situation where the spatial units express maximum entropy, that is, maximum equity. This index is formulated as follows (Forrest, 2005):

$$h_i = -\sum_{j=1}^{k} p_{ij} \ln(p_{ij}) \qquad [3]$$

Where *k* is the number of groups, p_{ij} the proportion of the group *j* in the spatial unit *i* ($\mathrm{n_{ij}/n_i}$), n_{ij} = number of population group *j* in the spatial unit *i,* and n_i the total population in the spatial unit *i*.

33 Finally, a quotient between empirical and theoretical entropy is calculated [4], which allows the classification of values on cartographically interpretable scales. The values will be taken to a measurement range ranging from 0 to 1 according to the formula presented below:

$$H_i = \frac{h_i}{\ln(k)} \qquad [4]$$

Where H_i is the entropy quotient of the spatial unit *i*; h_i is the calculated entropy in the spatial unit *i,* and *ln(k)* is the theoretical maximum entropy.

34 $H_i = 1$ would indicate perfect equity while $H_i = 0$ would represent extreme concentration. On the other hand, it is possible to apply the property called "entropy equivalence" to deepen interpretations on this indicator (Bacallao *et al.:* 2002).

35 As Table 1 shows, as the value of H_i decreases, the distribution becomes more unequal and the potential for redistribution increases (See table 1). As an example, it can be said that a value of H_i = 0.90 on a system of 5 categories (k = 5) would indicate a potential redistribution (reallocation of cases to other spatial units) of 25% if maximum equity is desired.

TABLE 1. Equivalence between entropy and potential redistribution to eliminate inequity

Hi Index	Proportional representation according to k(5)					Potential redistribution (%)
1.00	20%	20%	20%	20%	20%	0
0.94	37%	15%	15%	11%	22%	19

0.90	45%	16%	14%	10%	14%	24
0.83	53%	14%	11%	8%	14%	33
0.73	63%	10%	9%	7%	11%	42
0.66	68%	7%	8%	6%	11%	47
0.32	8%	3%	0%	3%	87%	66
0.00	100%	0%	0%	0%	0%	80

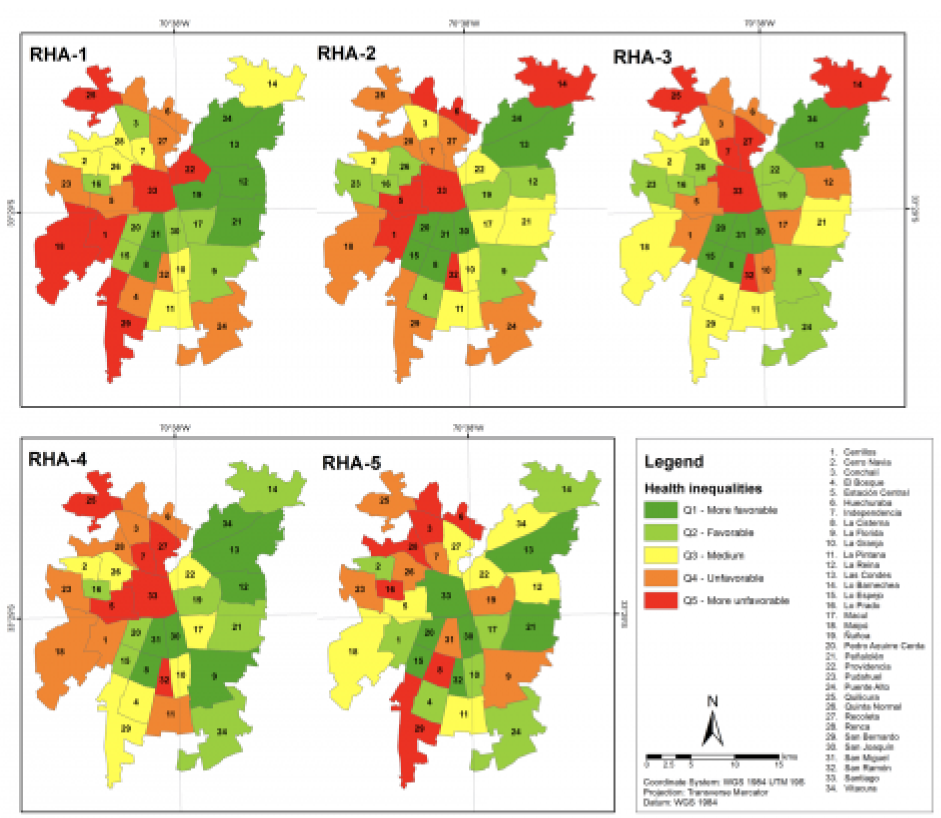
Source: elaborated by authors.

Results

Health inequalities

36 To represent the spatial distribution of each socio-spatial group and their respective hospital admission rate, quantile maps will be used, with 5 intervals (See Map 2), which is why the analysis of results will refer to quintiles (Qx), with Q1 being more favorable and Q5 being more unfavorable. The data for each of the municipalities of the MAS can be consulted in Annex 1.

Map 2: Rate for Hospital Admissions per 1,000 inhabitants belonging to a SES in the Metropolitan Area of Santiago.



Source: elaborated by the authors

37 In relation to the magnitudes of inequality in health, it is possible to verify certain facts. RHA-1 (Min: 91.37; Max: 689.56; Rg: 598.19) shows a group of 5 municipalities with more favorable hospital admission values concentrated in the East Zone of the MAS, while in the West Zone are 3 municipalities with unfavorable values. Important to notice is that *Vitacura* (n°34) and *Providencia* (n°22), minimum and maximum respectively, despite the similar socioeconomic structure and spatial nearness of the territories, they show opposites conditions of health inequalities. RHA-1 shows the highest range between the maximum and minimum of 598.19.

38 Relative to RHA-2, (Min: 13.28; Max: 163.42; Rg: 150.14) there is a grouping of 5 municipalities in the South Zone of the MAS with more favorable values of hospital admission. Similar context shows the RHA-3 (Min: 0.00; Max: 235.94; Rg: 235.94) of groups of more favorable conditions. In both maps, the dichotomy between *Lo Barnechea* (n°14) and *Vitacura* (n°34) and *Las Condes* (n°13) is exacerbated.

39 The RHA-4 (Min: 17.29; Max: 177.00; Rg: 159.71) shows a center-east axis of more favorable conditions. *Santiago* (n°33) persists as a territory with more unfavorable conditions. Nevertheless, the RHA-5 (Min: 22.66; Max: 77.82; Rg: 55.16) shows an important difference. It is significant to mention that *Santiago* is an emblematic territory since is the political-administrative center of the country and the region. In the map, *San*

Ramón (n°32) and *Huechuraba* (n°14) are shown with favorable conditions. RHA-5 shows the lowest range between the maximum and minimum of 55.16.

Socio-spatial inequality

40 Understanding that the optimum of entropy is in a standard far from reality, given the unique characteristics of each territory, the population groups – in the case of this study, the child population – behaves unevenly with respect to hospital admissions according to their respective socioeconomic status.

41 It should be remembered that *H* values close to 1 would indicate perfect equity while close to 0 would represent an extreme concentration. In that matter, the whole 34 administrative units are above 0.60 in the *H* index (See Table 2). However, the municipalities with greater differences between groups (children population) in the same territory, under or equal to H=0.75, are *Providencia* (0.62), *San Joaquín* (0.70), *Vitacura* (0.70) and *Quilicura* (0.75). On the other hand, municipalities with lower differences between groups inside of territories boundaries, over or equal to H=0.90, are *Ñuñoa* (0.90), *Peñalolén* (0.90), *Macul* (0.91) and *La Reina* (0.93).

42 Highlighted in Table 2 is the equivalence between "entropy" and "potential redistribution" to eliminate inequality in health damage (See Table 2). To answer the question of what percentage of redistribution can be considered sufficient to represent intervals between inequalities, we apply the following criteria, based on the coefficient of variation interpretation:

1. Up to 25%, territorial balance. The inequalities found do not represent relevant differences between *SES* groups;
2. Up to 33%, territorial imbalance. The inequalities found represent incipient concentration for the lower income groups.
3. Up to 50%, territorial inequality. The inequalities found represent a big concentration for the lower income groups.
4. Greater than 50%, extreme territorial inequality. The inequalities found represent an excessive concentration for the most unfavorable social group.

TABLE 2. Equivalence between entropy and potential redistribution to eliminate inequality in health damage

H Index	Equivalent proportional representation according to k(5)					Potential Redistribution (%)
	pRHA1	pRHA2	pRHA3	pRHA4	pRHA5	
1,00	20%	20%	20%	20%	20%	0
0,93	37%	14%	25%	12%	12%	22
0,91	40%	15%	23%	14%	9%	23
0,90	44%	11%	20%	12%	14%	24
0,88	45%	11%	20%	16%	8%	25
0,87	48%	14%	14%	11%	13%	28
0,86	43%	18%	25%	8%	6%	28
0,85	51%	12%	14%	10%	13%	31
0,84	52%	12%	15%	11%	10%	32
0,83	52%	7%	13%	12%	15%	32
0,82	53%	15%	14%	12%	6%	33
0,81	55%	8%	15%	12%	9%	35
0,80	55%	10%	13%	14%	7%	35
0,79	57%	11%	14%	11%	7%	37
0,78	58%	10%	15%	11%	6%	38
0,77	59%	9%	12%	12%	9%	39
0,76	59%	8%	13%	14%	6%	39
0,75	60%	9%	14%	11%	6%	40
0,70	65%	6%	12%	9%	8%	45

0,62	71%	7%	10%	7%	5%	51
0,00	100%	0%	0%	0%	0%	80

Source: elaborated by authors.

43 In that order, the AU of *Providencia* (0.62), according to its *H* index, presents an "extreme territorial inequality" with a 51% of potential redistribution. Eleven municipalities have "territorial inequality": *San Joaquín* and *Vitacura* both (0.70) 45%, *Quilicura* (0.75) 40%, *Lo Espejo* (0.76) 39%, *Puente Alto* (0.76) 39%, *Pudahuel* (0.77) 39%, *El Bosque* (0.78) 38%, *Maipú* (0.79) 37%, *Pedro Aguirre Cerda* (0.80) 35%, *San Bernardo* (0.80) 35% and *Quinta Normal* (0.81) 35% (See Map 3).

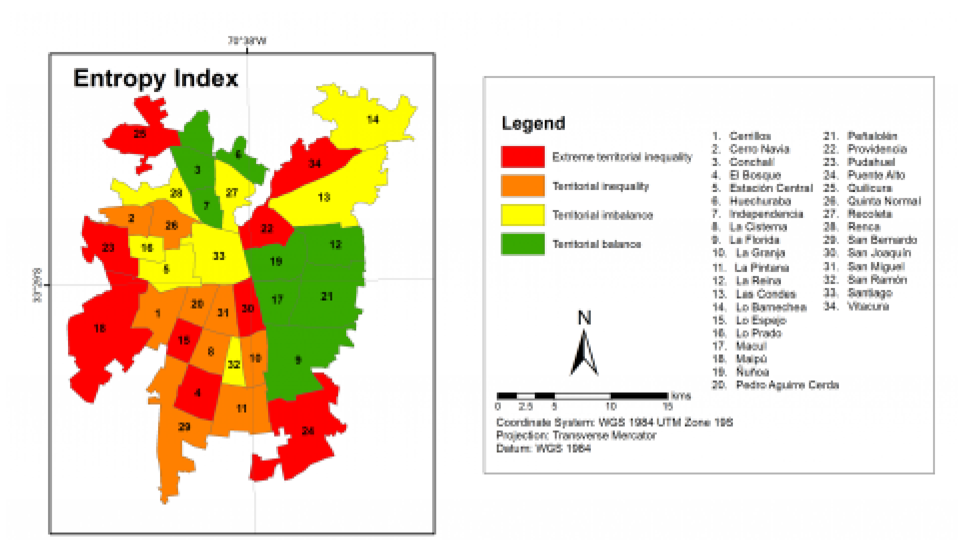
44 The entropy theory establishes an optimal distribution of 20% for each equivalent proportional representation according to five classes. Said optimum leaves an obvious 0% of "potential redistribution", since the phenomena are equally distributed. Nevertheless, in terms to exemplify, *Providencia*, an AU that shows an *H* Index of 0.62 (See Table 3), presents 51% of potential redistribution. The interpretation of that percentage should be addressed regarding the different classes of the municipality:

TABLE 2.1. Extract of Table 2; example of H Index 0.62

H Index	Equivalent proportional representation according to k(5)					Potential Redistribution (%)
	pRHA1	pRHA2	pRHA3	pRHA4	pRHA5	
0,62	71%	7%	10%	7%	5%	51

45 Class RHA-1 holds the 71% of hospital admissions. In order to achieve an optimal distribution, the potential redistribution percentage indicates the complement value that should be redistributed to achieve the optimum distribution between classes. In the case of Providencia, RHA-2 should absorb 13%, RHA-3 10%, RHA-4 13% and RHA-5 15%, adding 51% as a result (potential redistribution).

Map 3: MAS municipalities according to entropy index H and rate per hospital admissions per 1000 population.



Source: elaborated by authors.

46 Among the municipalities that are in a "territorial imbalance", can be found 16: *Cerrillos* (0.82) 33%, *La Cisterna*, *La Granja*, *La Pintana*, *San Miguel* and *Cerro Navia* with (0.83) 32%, *Estación Central*, *Recoleta*, *Santiago*, *San Ramón*, *Renca* and *Las Condes* (0.84) with the same 32%, *Lo Prado* (0.85) 31%, *Lo Barnechea* (0.86) 28% and *Huechuraba* and *La Florida* with (0.87) 28% of potential redistribution percentage. Finally, six municipalities present a "territorial balance". These are *Conchalí* and *Independencia* both (0.88) with 25%, *Ñuñoa* and *Peñalolén* both (0.90) with 24%, *Macul* (0.91) 23% and *La Reina* (0.93) 22% of potential redistribution (See Table 3). Spatially speaking, it can be said that balanced territories are concentrated in the east and north zones of the MAS.

47 Regardless *Providencia*, the administrative units of *San Joaquín,* and *Quinta Normal* display territorial inequality surrounded by municipalities that possess territorial imbalance. Such dynamics represent a particular interest; because the two identified administrative units have greater intergroup inequality within their territory compared to adjacent territories. (See Map 3)

Discussion

48 In Latin America, the scarcity of social resources by some population groups generates an exposure to greater health risks compared to other population groups. This problem,

historically known as the "old inequalities in Latin America", is that the socioeconomic disparities of the different groups have been creating cultural and health access gaps that increasingly widen, which translate into obstacles to the well-being of the less-favored sectors. In that sense, this region has been considered by the United Nations Development Program (UNDP) as the most unequal region in the world (Juarez-Ramirez, C. *et al.*: 2014).

49 There is a modern understanding that health inequalities are a topic of great scientific and public relevance, and it is predicted that they will continue to be, so long as there are considerable differences in damage to health status of the population groups according to their unequal discriminatory factors, in correlation to the inherent diversity of the present society (Fuenzalida, M. *et al.*: 2016). Evidence suggests that, globally, socio-economically disadvantaged populations are more strongly affected by various health problems (e.g. diabetes, cardiovascular disease, some cancers, severe forms of asthma, among others) than the richest populations (Deguen, S. *et al.*: 2010).

50 In this regard, cities present specific challenges for the approach to health and the environment. Reflecting on the urban environmental perspective necessarily leads us to understand the relational dynamics of a complex system assigned by socio-cultural determinations, where the human being, in a process of technological adaptation, regulates the equilibrium of the new systems that it builds (Vargas, S. *et al.*: 2008).

51 The constant interest of the scientific community to address issues of inequality is fostered by the intense dynamism with which 21st century public policy is confronted by a sustained detriment of the environment and the quality of life of the population, affecting mainly those disadvantaged groups (Fuenzalida, M. *et al.*: 2015). In the context of air pollution, it is a reality that causes serious damage to the health of millions of people around the world, especially those with respiratory and cardiovascular diseases (Carneseca, E. *et al.*: 2012). Similarly, socio-economic factors could accentuate the relationship between air pollution and health outcomes, i.e. if disadvantaged communities are exposed to high levels of air pollution, and subsequently, due to the additional material deprivation situation and psychosocial stress, it is plausible to consider that they are more susceptible to the effects of such contamination on their health levels (Forastiere, F. *et al.*: 2007; Cesaroni, G. *et al.*: 2010).

52 The results obtained in the present investigation evidenced that health problems do not appear uniformly in the population, both for the proportionality between multiple socioeconomic groups and for the potential redistribution. On the contrary, they exhibit a behavior of inequality in health, the groups most affected being those belonging to lower socioeconomic strata compared to those characterized by better conditions of access to health and belonging to the elderly social segments economic resources. These results are consistent with those reported by research that indicates that the impact of social and economic inequalities within the same territory is enormous and is currently considered one of the main risk factors for illness (Salgado-Barreira, A. *et al.*: 2014).

53 In relation to the apparent acquired susceptibility of the lower SES, it should be mentioned here that this would depend, among other factors, on the sanitary level protection of the population, their poverty condition, education and availability of health services (Prieto, MJ *et al.*: 2007).

54 In methodological terms, working with data on hospitalization over other levels of health care falls into two relevant facts for this study. On the one hand, the quality of the continuous registry, being the only system of collection of health history that is validated at a national level and that includes all the hospital care provided by both the public and private sector. On the other, it guarantees homogeneity in the review of health damage: the occurrence of a case is mainly due to the fact that only the most severe ones require hospitalization (Antunes, F. *et al.*: 2013; Nascimento, L. *et al.*: 2012), over optional access to medical consultation. In order to reduce the availability bias of beds or other factors unrelated to population morbidity, work has been done on the care provided during the five-year period since 2005-2009.

55 Finally, it is important to highlight the fact that the use of entropy as a measure of inequality, observing simultaneously the spatial distribution of multiple socioeconomic groups within a territory, provides a new lens for approaching the recent studies of inequality in the MAS (Sabatini *et al.*: 2010; Ruiz-Tagle & López, 2014; Borsdorf *et al.*: 2016), and allows to overcome an analysis based only on two antagonistic groups. In this sense, the differences found in the proportionality of hospital admissions, according to the socioeconomic group do not follow a uniform trend in favor of least vulnerable groups.

56 This allows the suggestion that the place of residence should be an important factor to incorporate into studies of inequality, as it delivers a contextual framework to the territory as a category of analysis and not only as a container of information or display of results. Thus, the solution is to distribute the resources among the different areas in proportion to their needs and adequately respond to the health care needs of the different social groups (Borrell & Malmusi, 2010).

Conclusions

57 It is imperative to pay attention to inequalities between social groups living within the same territory, as these inequalities affect the opportunities and achievements of people. From the academic sphere, and recently from a political sphere, voices have emerged showing the importance of making those differences visible, detecting the territories that should be a priority in singular efforts (public policies, tools or focused solutions) to bring them closer together and place them at the same level as those that show more favorable situations. It is tried in this way, to seek equality of opportunities against development, which for the particular interest of this text, is referred to a better health.

58 Based on the results of the present investigation, it is possible to identify the territories where the damage to health is concentrated, along with information on proportion and redistribution among socioeconomic groups. The data shows how the place of residence influences the health inequalities experienced, finding the following configurations: territorial balance; territorial imbalance; territorial inequality; extreme territorial inequality. Undoubtedly the last two categories require supplementing the information with the existence of resources and health equipment that allow assessing whether such differences are unfair or avoidable.

59 Within the limitations of this study, it is possible to mention the fact of showing the inequality through a classic indicator of social stratification (weighing of economic income), above one of social class. Considering that the latter has incorporated different factors with a potential impact on health, which also allows to deepen the results and discussions with the true causes of the inequalities observed in the health area (Rocha, K. *et al.*: 2013). At the expense of the above, it was a privilege to work with official data of free disposition and easy management that allow its wide use by the municipal, governmental and related entities, for the quantification of the risk and damage in health according to identified SES.

60 The importance of this work relies on the use of information of type of beneficiary and health prevision as an indicator that allows to evaluate the inequality in health, associating the sections of monetary income of each category, and based on this, to infer concentrated socioeconomic groups as mutually exclusive. It is also advantageous to locate these groups according to residence, which allows the obtaining of specific rates comparable both internally and intra-territories

61 The detection of SESs in defined geographical areas with local administration (municipalities), lends itself as an information input that would facilitate the design and implementation of targeted interventions for human health and inequality issues.

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Anexo

TABLE 3. Territorial distribution of inequality among social groups resident in the Metropolitan Area of Santiago

ZONE	MUNICIPALITY	RHA 1	RHA 2	RHA 3	RHA 4	RHA 5	*p*RHA1	*p*RHA 2	*p*RHA 3	*p*RHA 4	*p*RHA 5	H=h/ln(k)
N	Conchalí	316.94	74.89	125.68	96.3	72.93	0.46	0.11	0.18	0.14	0.11	0.88
N	Estación Central	384.7	94.31	119.44	97.26	50.9	0.52	0.13	0.16	0.13	0.07	0.84
N	Huechuraba	368.98	107	113.64	96.86	77.82	0.48	0.14	0.15	0.13	0.1	0.87
N	Independencia	333.33	84.33	149.85	119.05	59.9	0.45	0.11	0.2	0.16	0.08	0.88
N	Quinta Normal	355.1	54.3	94.04	78.47	60.5	0.55	0.08	0.15	0.12	0.09	0.81
N	Recoleta	379.73	84.57	128.25	99.02	55.82	0.51	0.11	0.17	0.13	0.07	0.84
N	Santiago	544.62	163.42	235.94	177	37.53	0.47	0.14	0.2	0.15	0.03	0.84
S	El Bosque	376.44	66.09	95.37	74.11	42.36	0.58	0.1	0.15	0.11	0.06	0.78
S	La Cisterna	182.13	26.9	38.52	37.34	75.89	0.5	0.07	0.11	0.1	0.21	0.83

S	La Florida	219.27	63.02	62.1	50.11	60.2	0.48	0.14	0.14	0.11	0.13	0.87
S	La Granja	329.87	66.77	112.43	78.74	45.93	0.52	0.11	0.18	0.12	0.07	0.83
S	La Pintana	357	81.37	105.42	88.36	52.28	0.52	0.12	0.15	0.13	0.08	0.83
S	Lo Espejo	259.88	36.82	56.92	60.36	27.66	0.59	0.08	0.13	0.14	0.06	0.76
S	Lo Prado	276.48	66.67	75.35	54.4	72.91	0.51	0.12	0.14	0.1	0.13	0.85
S	Macul	213.67	77.91	122.33	74.45	45.91	0.4	0.15	0.23	0.14	0.09	0.91
S	Pedro Aguirre Cerda	261.84	48.57	61.65	67.19	34.8	0.55	0.1	0.13	0.14	0.07	0.8
S	Puente Alto	364.97	81.82	67.29	54.45	43.45	0.6	0.13	0.11	0.09	0.07	0.76
S	San Bernardo	433.36	91.81	104.96	77.46	69.8	0.56	0.12	0.14	0.1	0.09	0.8
S	San Joaquín	292.24	26.33	52.14	42.06	37.98	0.65	0.06	0.12	0.09	0.08	0.7
S	San Miguel	209.56	28.91	54.51	49.05	62.45	0.52	0.07	0.13	0.12	0.15	0.83
S	San Ramón	364.82	120.57	169.58	118.69	22.66	0.46	0.15	0.21	0.15	0.03	0.84
W	Cerrillos	411.43	113.86	107.66	96.15	45.71	0.53	0.15	0.14	0.12	0.06	0.82
W	Cerro Navia	321.01	67.16	104.25	77.86	46.02	0.52	0.11	0.17	0.13	0.07	0.83
W	Maipú	431.65	84.17	106.07	80.81	54.59	0.57	0.11	0.14	0.11	0.07	0.79
W	Pudahuel	386.09	60.23	75.81	79.6	56.43	0.59	0.09	0.12	0.12	0.09	0.77
W	Quilicura	606.1	92.98	137.89	109.18	56.61	0.6	0.09	0.14	0.11	0.06	0.75
W	Renca	364.17	86.27	105.9	79.65	67.97	0.52	0.12	0.15	0.11	0.1	0.84
E	La Reina	159.51	61.83	106.54	51.63	50.99	0.37	0.14	0.25	0.12	0.12	0.93
E	Las Condes	175	31.92	58.24	37.11	39.67	0.51	0.09	0.17	0.11	0.12	0.84
E	Lo Barnechea	317.78	134.06	182.28	60.76	42.18	0.43	0.18	0.25	0.08	0.06	0.86
E	Ñuñoa	194.48	49.25	86.9	53.67	60.1	0.44	0.11	0.2	0.12	0.14	0.9
E	Peñalolén	209.05	73.64	104.85	69.43	37.7	0.42	0.15	0.21	0.14	0.08	0.9
E	Providencia	689.56	70.89	92.84	71.64	50.14	0.71	0.07	0.1	0.07	0.05	0.62
E	Vitacura	91.37	13.28	0	17.29	48.37	0.54	0.08	0	0.1	0.28	0.7

Source: elaborated by authors.

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