Social inequality in Health: Non-Communicable Diseases in Bolivia, determinants, and current challenges at the Municipal

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Abstract

Background: The social gradient of Non-Communicable Diseases (NCD) has been widely studied. However, little has been done to understand health inequality across populations within a country, such as between municipalities. We use Bolivian municipal data to analyze the social inequality in the incidence of NCDs and identify social determinants that contribute to this inequality.

Methods: First, we estimate curves and concentration indices (CI) of NCDs incidence, measuring the municipal socioeconomic status by the index of Unsatisfied Basic Needs. We rank municipalities from the poorest to the least poor. Then, we decompose the CI into some of its main social determinants using Wagstaff decomposition analysis. The information related to the incidence of NCDs is from the National Health Management Information System (HMI). Incidence rates are standardized by municipal demographics and availability of health services to control for these confounders during the analysis. Socioeconomic data at the municipal level for 2018 comes from the National Institute of Statistics, Sustainable Development Solutions Network - Bolivia, and projections.

Results: The CI for NCDs incidence is 0.20 (95% confidence interval: [0.06,0.34]), which shows that the population with NCDs concentrates in relatively less poor municipalities. Consistent with global patterns, hypertension and diabetes have the highest incidence and inequality. We separate the contribution of five social determinants to the inequality of hypertension and diabetes: (1) urbanization rate, (2) education, (3) indigenous people, (4) sanitation, and (5) the percentage of women with anemia. We find that the most relevant are the urbanization rate and education. The rate of urbanization contributes positively to inequality, while years of education contribute negatively.

Conclusion: There is an unequal distribution of NCDs that disadvantages municipalities of higher socioeconomic status. One of the main determinants is the urbanization rate. These results are consistent with the hypothesis that, in developing countries, rapid and unplanned urbanization tends to change people's way of life, potentially leading them to develop behavioral risk factors that contribute to the incidence of NCDs. Thus, policies on healthy urban environments and health education focused on municipalities with high incidence could help to curb the increase of NCDs in Bolivia.

Background

Low- and middle-income countries are in epidemiological transition. As countries develop, mortality due to infectious diseases has reduced while Non-Communicable Diseases (NCDs) mortality and disability have increased. Nowadays, premature deaths (between 30 and 69 years) from NCDs concentrate in low- and middle-income countries (85%) [1].

The rapid NCDs increase in developing countries is related to the population's socioeconomic status (SES) [2]. SES is strongly associated with the prevalence of NCDs. In high-income countries, NCDs prevalence tends to be higher for people with low SES [3]. Nonetheless, evidence from low- and middle-income countries is mixed. For example, risks of cancer and Cardiovascular Disease (CVD) and hypertension are higher among low SES groups, but diabetes and obesity risks tend to be lower [4–8]. Low SES groups have a significantly higher prevalence of tobacco and alcohol use and consume fewer vegetables, fish, and fiber. However, high SES groups are less physically active and consume more fats, salt, and processed foods [9–10].

Even less has been done to understand health inequality across populations within a country, such as between municipalities. For instance, in Argentina, cancer and CVD mortality follow a geographical pattern associated with poverty and urbanization: living in intermediate middle-sized cities or small cities and villages has a lower mortality risk than residing in big cities, even in conditions of greater poverty [11]. In addition, there is evidence of increasing risk-factors inequality (smoking, obesity, and high blood pressure) by education in urban areas of Argentina [12]. In Brazil, federal states of the last socioeconomic quintile have a healthy life expectancy (which factors in the absence of NCDs) 3 to 4 years higher than the first [13, 14]. Further evidence is required to understand the social distribution of NCDs within developing countries and their main contributors.

Like many low-middle income countries, Bolivia is also in epidemiological transition [15]. Eight out of ten deaths are due to NCDs. The age-standardized NCDs mortality rate is 571.5 (per 100,000 population), 35.26% of all NCDs deaths are premature deaths. The probability of dying between age 30 and exact age 70 from cardiovascular disease, cancer, diabetes, or chronic respiratory diseases is 17.88 for both sexes, 3.84 percentage points higher than the probability in the Americas [16].

According to the sustainable development index, Bolivia is ranked 79 out of 166 countries [17]. However, its development is unequal. The variation in the municipal development index is as high as the cross-country variation, with the highest-ranked municipalities close to the most developed countries and lowest-ranked close to the least developed [17]. This heterogeneity in development affects local living conditions, and thus NCDs evolution in the population. Understanding the underlying patterns could help identify better-targeted policies and reduce inter-municipality inequalities.

The purposes of this paper are to estimate the social inequality in the incidence of NCDs across Bolivia's municipalities (understood as in [18]) and identify social determinants that contribute to it [19, 20]. We focus on assessing social inequalities whose roots are closer to socioeconomic characteristics and not directly related to demographic factors or healthcare availability. Hence, we standardize the municipal incidence rates by these two variables, thus controlling for them when estimating social inequality. We use the index of Unsatisfied Basic Needs to approximate the municipal SES, ranking municipalities from the poorest to the least poor to calculate the inter-municipality Concentration Index (CI). Finally, the paper identifies social determinants contributing to this inequality through Wagstaff's decomposition analysis. Among the possible determinants, we consider urbanization, education, and ethnic composition, strong candidates for explaining inter-municipality health inequalities.

Methods

Data

The study used secondary data at the municipal level for the year 2018 derived from the National Health Management Information System (HMI) and the Sustainable Development Solutions Network – Bolivia (SDSNB), with which we estimate Lorenz curves and CI of health variables with respect to the municipal SES, measured by the index of Unsatisfied Basic Needs (poverty levels).

Health data comes from the epidemiological surveillance records of the HMI. In 2018, Bolivia had 339 municipalities. Of those, 338 reported at least one new case of NCDs, and 169 reported at least one NCD death. This information is subject to underreporting problems since it depends on health services' coverage and duplicity problems since the records do not have a unique identifier per person. Standardizing health indicators by the availability of health services partially controls the underregistration problem, as explained below. To test if duplicity could bias our results, we contrast inequality estimates of epidemiological surveillance records with the primary health care Software System and the Statistical Clinical Information System. This data source has less coverage but is less likely to generate duplicates as identifiers are unique. We found no statistically significant differences between these two estimates (See Additional file 1: Annex 1 for details).

Definitions and measurement of variables

We measured the status of the NCDs using two indicators: the incidence rate and the mortality rate. The incidence rate shows the likelihood that an individual from the risk population will be affected by NCDs over a specific period; it is defined as the ratio of the number of new cases of NCDs to the risk population in 2018. In our case, the risk population is the municipality's population older than 14 years. The mortality rate is the ratio between the number of deaths from NCDs and the total municipal population. We estimate incidence and mortality rates for total NCDs and disaggregated by disease in all cases. The NCDs analyzed were cardiovascular diseases, diabetes, neoplasms (cancer), chronic respiratory diseases, arterial hypertension, rheumatic, endocrine, and renal diseases.

The primary socioeconomic indicator for the inequality analysis is the municipal Unsatisfied Basic Needs Index (UBN index), which measures poverty. This indicator calculates the percentage of families that do not have essential goods and services to meet basic needs: health care, education, housing, basic sanitation, and energy supplies. UBN index uses census data; therefore, we projected its value to 2018 using Bolivia's socioeconomic household survey (See Additional file 2: Annex 2 for details).

In addition to the index UBN, we use the following variables to decompose the factors related to the inequality of NCDs: (1) the rate of urbanization, (2) the average years of education of men of the municipality (projection to 2018), (3) the percentage of people who do not speak Spanish (projection to 2018), that approximates the percentage of indigenous people of the municipality, (4) the percentage of households with access to basic sanitation (projection to 2018), and (5) the percentage of women with anemia (2016), which approximates the nutritional status of the municipality. This information is from the Statistics National Institute (SNI) and the SDSNB.

Indirect standardization

After calculating the incidence and mortality rates, we standardize them by age group, sex, and availability of Health Services. We chose the indirect standardization method for the study, implemented through a linear regression analysis [21]. Details are in Additional file 1: Annex 1. Standardization allows a more refined analysis of inequality because we isolate the mentioned factors from the relationship between the health indicator and the socioeconomic level. Thus, inequality in NCDs could not be attributed to the demographic distribution of the population or the availability of health services. As we would treat municipalities as if they had an equal distribution of health services, we would be partially controlling for the underreporting bias usually present in HMIs of developing countries[22–24].

Lorenz Curve and Concentration Index

The concentration curve or Lorenz curve plots the cumulative percentage of the health variable (Y-axis) against the cumulative percentage of municipalities, classified according to their socioeconomic status, starting with the poorest and ending with the richest (x-axis). In other words, it plots the parts of the health variable against the quantiles of the socioeconomic status variable. The farther the Lorenz curves are from the 45° line, the greater the degree of inequality. If the Lorenz curve is above the 45° line, then the NCDs are concentrated in the poorest municipalities. On the other hand, if the Lorenz curve is below the 45° line, the opposite occurs [21].

Following Kakwani [25, 26], the Concentration Index (CI) can be computed as twice the covariance of the health variable and a municipalities rank in terms of socioeconomic status, divided by the mean of the health variable:

$$CI = \frac{2}{\mu} cov(y_i, R_i)$$

1

where y_i and R_i are respectively the health status of the ith municipality and the fractional rank of the ith municipality (in terms of the index of socioeconomic status); μ is the mean of the health and cov denotes the covariance.

The CI is negative when the Lorenz curve is above the 45° line and positive otherwise. Therefore, a positive value would indicate that the NCDs are concentrated in the wealthiest municipalities.

We weigh the CI by the size of the municipal population. In addition to the CI value, we estimate its robust standard error to test the null hypothesis that its value is zero, which means there is no inequality. Statistical significance was determined for p-values less than 10%.

Decomposition of the CI

Following Wagstaff et al. [27], suppose that the incidence or mortality rate from NCDs,y_i, is related to the socioeconomic variables, x_{ki}, by the following equation:

$$y_i = \alpha + \sum_k \beta_k x_{ki} + \epsilon_i$$

2

where $\beta_k$is the coefficient of the variable k and $\epsilon_i$is an error term.

Given the relationship between $y_i$and x_{ki} in Eq. (2), the CI for y_i can be written as:

$$CI = \sum\nolimits_k \frac{\beta_k \overline{x}_k}{\mu} C_k + \frac{GC_\epsilon}{\mu}$$

3

where μ is the mean of y_i, $\overline{x}_k$ is the mean of x_k, C_k is x_k's CI and in the last term GC_ϵ (residual) is the generalized CI for ϵ_i.

Equation (3) has two components: (1) a deterministic or explained component and (2) an unexplained component. The first component consists of each k regressor's elasticity and CI product. Elasticity ($\frac{\beta_k \overline{x}_k}{\mu}$) indicates the impact of each determinant on the desired health outcome, i.e., how much change in the dependent variable is associated with one unit of change in the explanatory variable. The CI indicates the extent of unequal distribution of each determinant across economic groups. The second component, the unexplained portion, is the part of the inequality that cannot be explained by systematic variation in the contributors (determinants) across economic groups.

The steps to estimate Eq. (3) are the following. First, the coefficients (β_k) of the explanatory variables are calculated. To do this, we need to conduct regression analysis using an appropriate regression model. In the second step, the means of the health variable (μ) and each determinant ($\overline{x}_k$) are calculated. Thirdly, by multiplying the mean of each determinant by the corresponding coefficients and dividing the result by the mean of the health variable, we can calculate the elasticity of each determinant. In the fourth step, CIs for the health variable (C), determinants (C_k) and the generalized CI of the error term (GC_ϵ) are calculated. C_k can be calculated by Eq. (1).

Now that all the variables in Eq. (3) have been calculated, we can reveal the contribution of each determinant to inequality by multiplying the elasticity of each determinant by its concentration index ($\frac{\beta_k \overline{x}_k}{\mu}$)$C_k$. This is the absolute contribution of each determinant to the measured inequality. Taking the absolute contribution, one can note that the contribution to inequality is the result of two factors: (1) a marginal effect of each determinant on the health variable and (2) the distribution of the determinant based on socioeconomic status. The percentage contribution is the absolute contribution of each determinant divided by the CI of the health variable $(\frac{\beta_k \bar{x}_k}{\mu}) C_k / C$.

Results

Incidence of NCDs

In 2018, the average standardized incidence rate of NCDs was 11.08%. This rate varies significantly between municipalities, with the lowest rate being 0% and the highest being 44.66%. In Fig. 1, we can visualize the incidence of NCDs per municipality.

The municipal standardized incidence rates pattern is significantly correlated with geographical and social factors. For example, the incidence of NCDs tends to be higher in the country's eastern region. In contrast, the incidence in the west of the country is considerably lower, in which 56 municipalities have an estimated incidence rate of 0%. The correlation between the disease and the socioeconomic distributions is even more critical.

The incidence of NCDs is also positively correlated with the socioeconomic status of the municipality. We can see this correlation by contrasting the incidence of NCDs and the percentage of inhabitants with Satisfied Basic Needs (SBN). The latter is on the right side of Fig. 1, graduated on a scale of green colors ranging from dark to light. Dark green illustrates high percentages of SBN and light green low percentages of SBN. We found that many municipalities with high percentages of SBN also have a higher incidence of NCDs.

The relationship between the percentage of SBN and the incidence of NCDs can be observed nationally and by region. In the center and southwest of the country, we can see that the incidence is relatively higher in the metropolitan regions of the center and southwest department capitals (See La Paz, Cochabamba, Potosí, and Sucre in the map). At the same time, it tends to be zero in historically poor and rural regions, such as Corque, Carangas, Chacarilla, Papelpampa, San Pedro, and Pocoata (See Fig. 1). Similarly, in the north and east of the country, we can observe that the incidence of NCDs is higher in metropolitan regions (see Santa Cruz, Cobija, and Trinidad on the map) and relatively more prosperous municipalities.

Inequalities in NCDs

Figure 2 shows the concentration curve that plots the accumulated proportion of new NCDs cases considering all the municipalities of Bolivia in 2018 ordered by the UBN index, from the poorest to the least poor. Consistent with the pattern shown in the municipal maps, the concentration curve is below the 45 ° line, which indicates that NCDs concentrate in municipalities with higher socioeconomic status (less poor).

In the first column of Table 1, we can observe the standardized incidence rates of NCDs disaggregated by disease. The highest incidence rates correspond to arterial hypertension, diabetes mellitus, and rheumatoid arthritis. These three diseases account for about 78% of the aggregated incidence rate; two, arterial hypertension and diabetes mellitus, have positive concentration indices, significant and similar to the general CI (see Column 2, Table 1). As shown in Fig. 2, a positive CI indicates that the incidence of these diseases concentrates in municipalities with a higher socioeconomic status. Kidney, Neoplasms, and Respiratory diseases with lower incidence rates also have positive CI. On the contrary, rheumatoid arthritis has a negative and significant index, which would indicate that this disease is more concentrated in poor municipalities.

Table 1
Incidence rate of NCDs and Concentration Index by disease

Disease	**Incidence rate (1)**	**Concentration Index (2)**
General (all)	11.08	0.20***
		(0.07)
Arterial hypertension	4.67	0.25**
		(0.11)
Diabetes mellitus	2.48	0.26***
		(0.10)
Rheumatoid arthritis	1.49	-0.21***
		(0.04)
Obesity	1.37	-0.05
		(0.13)
Kidney disease	0.71	0.31**
		(0.15)
Other cardiovascular diseases	0.77	0.28
		(0.18)
Respiratory diseases	0.36	0.29*
		(0.15)
Neoplasms	0.31	0.34***
		(0.09)

Note: Column (1) contains the incidence rate, and column (2) the concentration Index. Incidence rates are expressed in percentage. These rates are standardized by age groups (15–19, 20–29,40–49,50–59, 60 and more), sex, and availability of health services (1st, 2nd, and 3rd level health facilities per 10000 inhabitants). Robust standard errors in parentheses, * p < 0.1; ** p < 0.05; *** p < 0.01. N = 339. Source: Own elaboration based on HMI (2018), NIS (2018), and SDSNB (2020)

Table 2presents the standardized rates and concentration indices of mortality caused by NCDs, disaggregated by disease. As we can see, the table results are consistent with incidence rates concentration indices. Like the incidence, mortality from NCDs concentrates in municipalities of higher socioeconomic levels. Besides, diabetes mellitus and cardiovascular diseases (arterial hypertension is one of them) account for 64.2% of deaths from Non-Communicable Diseases.

Table 2
Mortality Rate from NCDs and concentration rates by cause of death

Disease	**Rate (x 10000) (1)**	**CI (2)**
Total	6.81	0.20***
		(0.05)
Diabetes mellitus	2.64	0.27**
		(0.11)
Neoplasms	1.75	0.20***
		(0.05)
Cardiovascular diseases	1.73	0.17***
		(0.04)
Respiratory diseases	0.74	-0.06
		(0.14)

Note: Column (1) contains mortality rates and column (2) mortality Concentration Indexes. Mortality rates are expressed in deaths per 10000 inhabitants. These rates are standardized by age groups (0–15, 15–39, 40–59, 60 and more), sex and availability of health services (1st, 2nd, and 3rd level health facilities per 10000 inhabitants). Robust standard errors in parentheses, * p < 0.1; ** p < 0.05; *** p < 0.01. N = 339

Source: Own elaboration based on HMI (2018), NIS (2018), and SDSNB (2020)

Decomposing inequalities by social determinants

To better understand the relationship between the municipal socioeconomic status and the incidence of NCDs, we decompose the CI into five social determinants. The factors selected are: (1) the rate of urbanization, (2) men’s average years of education, (3) the percentage of people who do not speak Spanish (approximates the percentage of indigenous people), (4) the percentage of households with access to basic sanitation, and (5) the percentage of women with anemia (approximates the nutritional status). For this analysis, we focus on the two diseases with the highest incidence rate: arterial hypertension and diabetes.

Figure 3 shows the Wagstaff decomposition of arterial hypertension and diabetes mellitus. Each bar shows the percentage of the CI explained by that variable. As we can see, the rate of urbanization, the percentage of the indigenous population, and the percentage of women with anemia contribute positively to the inequality of NCDs. Of these three factors, the most relevant is the rate of urbanization, which explains 84% of the observed hypertension CI and 80% of the observed diabetes mellitus CI. On the other hand, education and sanitation contribute negatively to NCDs inequality, i.e., they reduce inequality. The former explains a more significant percentage of the observed CIs than the latter.

Table 3 shows Wagstaff decomposition details. The contribution of each socioeconomic factor to the CI is the multiplication of the factor’s CI (Column 1) and the incidence rate-factor elasticity (Columns 2 and 3). As we can see, the incidence of hypertension and diabetes increases with urbanization (elasticities 0.74), which concentrates in municipalities with high socioeconomic status (CI 0.28). Thus, we can explain why urbanization contributes positively to hypertension and diabetes inequality. Analogously, we observe that education and sanitation reduce the incidence rates of hypertension (elasticities -1.78 and -0.56, respectively). More educated and higher sanitation populations are concentrated in municipalities with high socioeconomic status (CI 0.09 and 0.11, respectively), thus reducing hypertension and diabetes inequality. Finally, having a higher percentage of the indigenous population in a municipality reduces hypertension and diabetes mellitus incidence rates. However, these populations concentrate more in poorer municipalities (CI -0.42), which explains why this variable contributes positively to the observed CIs.

Table 2
Concentration Index decomposition coefficients by social determinant and disease

Socioeconomic factor	**CI (1)**	**Elasticity**	
		Arterial Hypertension (2)	**Diabetes Mellitus (3)**
Urbanization (%)	0.28***	0.74***	0.74***
	(0.04)	(0.22)	(0.20)
Education (years)	0.09***	-1.78*	-0.96
	(0.02)	(0.98)	(0.83)
Indigenous (%)	-0.42***	-0.33***	-0.24***
	(0.07)	(0.08)	(0.06)
Sanitation (%)	0.11**	-0.56**	-0.63***
	(0.05)	(0.27)	(0.24)
With anemia (%)	-0.03	-1.59***	-1.22***
	(0.02)	(0.29)	(0.29)

Note: Incidence rates are standardized by age groups (15–19, 20–29,40–49,50–59, 60, and more), sex and availability of health services (1st, 2nd and 3rd level health facilities per 10,000 inhabitants). Column (1) contains the concentration index of the socioeconomic factor. Columns (2) and (3) contain the elasticity of the incidence rate of the disease (arterial hypertension or diabetes) with respect to the socioeconomic factor. The contribution of each factor to the CI of the disease is the product of column (1) and column (2) or (3), depending on the disease. Robust standard errors in parentheses, * p < 0.1; ** p < 0.05; *** p < 0.01. N = 339.
Source: Own elaboration based on HMI (2018), NIS (2018), and SDSNB (2020)

Discussion

We estimate incidence and mortality rates and standardize them by age group, sex, and availability of health services. Using the standardized rates, we analyze the social distribution of NCDs, finding that the NCDs are concentrated in municipalities with higher socioeconomic levels, indicating that higher levels of socioeconomic development do not necessarily lead to better health in Bolivia.

Several factors could explain our results. One likely explanation is that the living and working conditions can lead to harmful lifestyles, leading to NCDs [28]. For instance, urban areas in developing countries have generally experienced an increase in NCDs due to the adverse effects of globalization. Thus, a considerable proportion of global marketing promotes tobacco, junk food, and alcohol consumption. Similarly, rapid and unplanned urbanization changes people's way of life through increased exposure to shared risk factors, such as unhealthy diets, sedentarism, air pollutants (including tobacco smoke), and harmful alcohol use [28].

In Bolivia, the NCDs with the highest incidence are hypertension and diabetes. Following the aggregated pattern, these diseases are concentrated in municipalities with higher socioeconomic status. As we describe below, hypertension and diabetes are contingent on behavioral risk factors such as unhealthy diets and sedentary lifestyles, more likely adopted in urban settings.

Hypertension originates from genetic and environmental factors. Although the genetic predisposition to hypertension is not modifiable, this disease is highly preventable due to the strong influence of environmental risk factors and lifestyle, among which are: excessive weight gain (which leads to overweight and obesity), unhealthy diet, excessive consumption of sodium, and insufficient consumption of potassium, high-stress levels, insufficient physical activity, and excessive alcohol consumption [29, 30].

Changing people's environment and lifestyles can prevent Diabetes Mellitus. In particular, the probability of getting sick with Type 2 diabetes, which corresponds to 90% of cases worldwide, is strongly associated with overweight and obesity. The most relevant risk factors are excess adipose tissue, high body mass index, abdominal and visceral fat [31]. So, regular physical activity [32, 33] and diets low in saturated fat or trans-fat can reduce the incidence of this disease [31, 34]. In some cases, adopting these lifestyles may be more effective than pharmacological solutions; the difficulty lies in making these behavioral changes permanent and effective in vulnerable populations [30].

Furthermore, hypertension, diabetes, and obesity are among the main risk factors for other cardiovascular diseases - ischemic arrest, hemorrhagic arrest, ischemic heart disease, heart failure, peripheral arterial disease, and Chronic Kidney Diseases [35–37]. Also, some risk factors, including a diet high in saturated fats, affect the likelihood of getting breast and prostate cancer [38–42], two of the most common cancers in Bolivia. Consistent with the idea that diseases sensitive to harmful lifestyles explain the inequality of NCDs, we also found positive concentration indices in cancer, other cardiovascular diseases, and Chronic Kidney Diseases (column 2, Table 1).

Wagstaff decomposition analysis showed that urbanization contributes to the concentration of hypertension and diabetes in municipalities with high socioeconomic status. Higher levels of urbanization come with improvements in socioeconomic conditions, but they also increase access to processed or ultra-processed foods (convenience stores) and reduce access to recreational spaces (parks) [28]. In this way, urbanization favors adopting unhealthy lifestyles, which would increase hypertension [43] and diabetes [44]. In addition, several studies find that an improvement in socioeconomic status can reduce the incidence of NCDs. However, if this increase reaches the point of allowing families to transition to a diet with higher calorie content, it can produce the opposite effect [45].

The presented evidence suggests that poor municipalities with indigenous populations and nutritional deficits (anemia) are not likely to suffer from hypertension or diabetes (See Table 3). Poor municipalities may be in an earlier phase of the epidemiological transition, where infectious diseases are still more prevalent than NCDs. For example, some infectious diseases related to soil-transmitted helminths increase iron deficiency anemia, which is more common in lesser developed countries [46]. Alternatively, we can interpret the contribution of the percentage of the indigenous population to hypertension and diabetes inequality as evidence of horizontal inequalities, i.e., inequalities between culturally defined groups. In this case, indigenous populations' culturally specific economic conditions or behavior may reduce the chances of developing these diseases [47].

On the other hand, we observe that education reverses the inequality of hypertension and diabetes, being particularly relevant for the first disease (See Fig. 3). Municipalities, where higher educational levels accompany a higher socioeconomic status, do not concentrate incidences of hypertension or diabetes as high as municipalities of similar socioeconomic status but with lower educational levels. For example, evidence from other countries shows that education reduces hypertension [43] and sedentary lifestyle [48], one of the main risk factors for diabetes. In addition, policies that create physical spaces and times to perform exercises in neighborhoods, educational units, and workplaces are more effective if accompanied by health education, support groups, and counseling [48]. Similarly, although its effect is minor, access to basic sanitation also reverses the concentration rate, probably due to its association with the quality of the urban environment.

Rheumatoid arthritis escapes the pattern described above as it concentrates in poor municipalities. Furthermore, the relationship between behavioral risk factors and the incidence of this disease is not as clear. Rheumatoid arthritis is an autoimmune disease of chronic inflammation that destroys joints and bones, causing disability and early mortality. The most mentioned risk factors are genetic, hormonal, dietary, sex, infectious agents, and smoking [49]. Recently, the disease has been linked to abdominal obesity and environmental factors associated with people's occupation [49, 50], among them, stress, moisture, vibration, asbestos, fertilizers, crops and foliage, and mineral dust (silica) [51–54]. People living in rural areas of the country, usually poor, tend to be exposed to some of these environmental factors, possibly explaining rheumatoid arthritis' negative CI. The higher incidence of rheumatoid arthritis in poor municipalities could lead to poverty traps in which the disease, when not treated on time, generates disability, which generates greater poverty [55].

Finally, the heterogeneity of NCDs incidence in Bolivia suggests implementing policies that prioritize municipalities with high incidence rates. Most of the diseases included in the study concentrate in municipalities with high socioeconomic status, and they share common risk factors. Likely, actions aimed at reducing the inequality of highest-incidence diseases will affect most of the other diseases. The main risk factors for these diseases coincide with the modifiable factors prioritized by the WHO [56].

Hence, its strategy to reduce the prevalence of NCDs could be a reasonable starting point for designing municipal policies in Bolivia.

Limitations

Despite our data processing and estimation efforts, the quality and availability of data limit the study results. We use epidemiologic surveillance records from the HMI in Bolivia, whose validity relies on health services' accessibility and correct identification. Therefore, NCD’s incidence rate could be either under or overestimated depending on local health services conditions. We standardized the incidence rates by health service availability to reduce this bias in the inequality analysis. Nevertheless, it remains a concern for the aggregated estimates where we cannot control for the overall performance of the HMI. In addition, it also concerns the disease-specific rates as data quality could vary by disease.

On the other hand, we had no information at the municipal level of social determinants directly related to the incidence of NCDs, such as access to processed food, recreational spaces, variables of environmental contamination. Hence, we focused on more general social determinants, limiting our capacity to understand the underlying mechanisms of NCD’s inequality.

Conclusions

Analyzing Bolivia’s 2018 municipal data, we find a statistically significant CI of 0.20, implying that NCDs' incidence concentrates in municipalities with higher socioeconomic status. Concentration indices are positive and significant for hypertension, diabetes, cancer, cardiovascular diseases, and chronic kidney diseases but negative for rheumatoid arthritis. Most of these diseases develop because of the adoption of behavioral risk factors.

We focus on the two diseases with the highest incidence, hypertension and diabetes, and use Wagstaff’s decomposition to identify critical determinants. Results show the rate of urbanization contributes positively to NCD’s social inequality while years of education contribute negatively; that is, more urban municipalities are at greater risk; however, the municipality’s level of education can help reverse this situation.

Because of these findings, we conjecture that NCDs’ concentration in municipalities with higher socioeconomic status could be related to unintended effects of economic development and rapid and unplanned urbanization processes. Such processes may increase NCDs incidence by facilitating the adoption of unhealthy lifestyles, e.g., consumption of junk food, insufficient physical activity, exposure to air pollutants, excessive alcohol use [26].

Interventions focused on reducing social inequalities in health could help curb the increasing incidence of NCDs in developing countries. Knowing the social distribution of NCDs, it is possible to prioritize municipalities with the highest incidence and design policies based on their social determinants. So far, our findings favor adopting two types of policies: (1) creating healthier urban environments and (2) preventing risk factors through education and health information. Such policies call for thinking about cross-sectoral actions, in which, for example, the urban planning sector, the food production, marketing sector, and the education sector work in coordination.

Abbreviations

NCDs: Non-Communicable Diseases; SDGs: Sustainable Development Goals; HMI: National Health Management Information System; SDSNB: Sustainable Development Solutions Network – Bolivia; UBN: Unsatisfied Basic Needs; SNI: Statistics National Institute; CI: Concentration index; SBN: Satisfied Basic Needs WHO: World Health Organization.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Availability of data and materials

The data that support the findings of this study are available from the National Health Management Information System (HMI)) of Bolivia, https://estadisticas.minsalud.gob.bo/Reportes_Dinamicos/Menu_rep_dinamicos.aspx, and the Sustainable Development Solutions Network - Bolivia (SDSNB), https://www.sdsnbolivia.org/en/Atlas.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

SRE conceptualized the study and performed the decomposition analysis of the Concentration Index. PCO systematized the data on NCDs and performed the calculation of the Concentration Indices. SRE and PCO analyzed the data, wrote, revised, and approved the manuscript.

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Figures

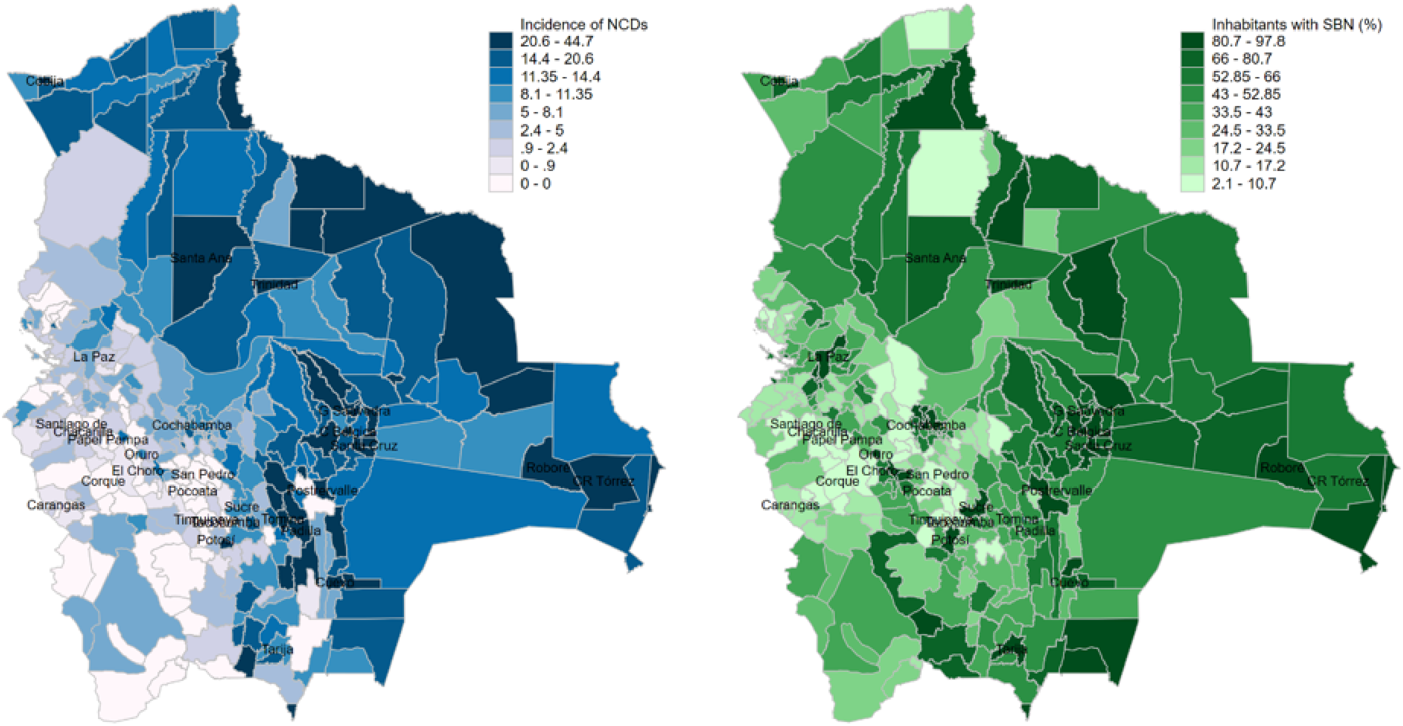

Figure 1

Municipal maps of incidence of NCDs and SBN, 2018

Note: Left figure contains the municipal incidence rate of NCDs (in percentage). Right figure contains the percentage of inhabitants with satisfied basic needs in a municipality. Incidence rates are standardized by age groups (15-19, 20-29,40-49,50-59, 60 and more), sex, and availability of health services (1^{st}, 2^{nd}, and 3^{rd} level health facilities per 10000 inhabitants). The population of interest for the computation of incidence rates is older than 14 years. The maps contain information from 339 municipalities.

Source: Own elaboration based on HMI (2018), NIS (2018), and SDSNB (2020)

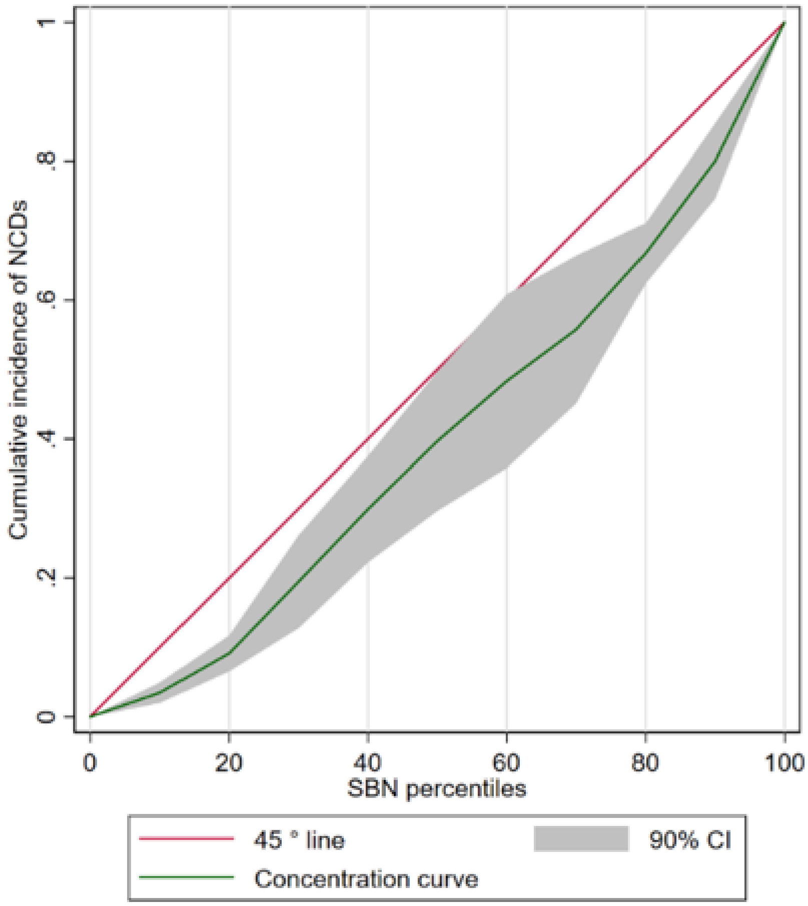

Figure 2

Concentration curve for NCDs (CI=0.20, 90% Confidence Interval)

Note: The concentration curve is estimated with data from 339 municipalities. Observations are weighted by their population size. The population of interest for the computation of incidence rates is older than 14 years. Incidence rates are standardized by age groups (15-19, 20-29,40-49,50-59, 60 and more), sex, and availability of health services (1^{st}, $2^{nd,}$ and 3^{rd} level health facilities per 10000 inhabitants).

Source: Own elaboration based on HMI (2018), NIS (2018), and SDSNB (2020)

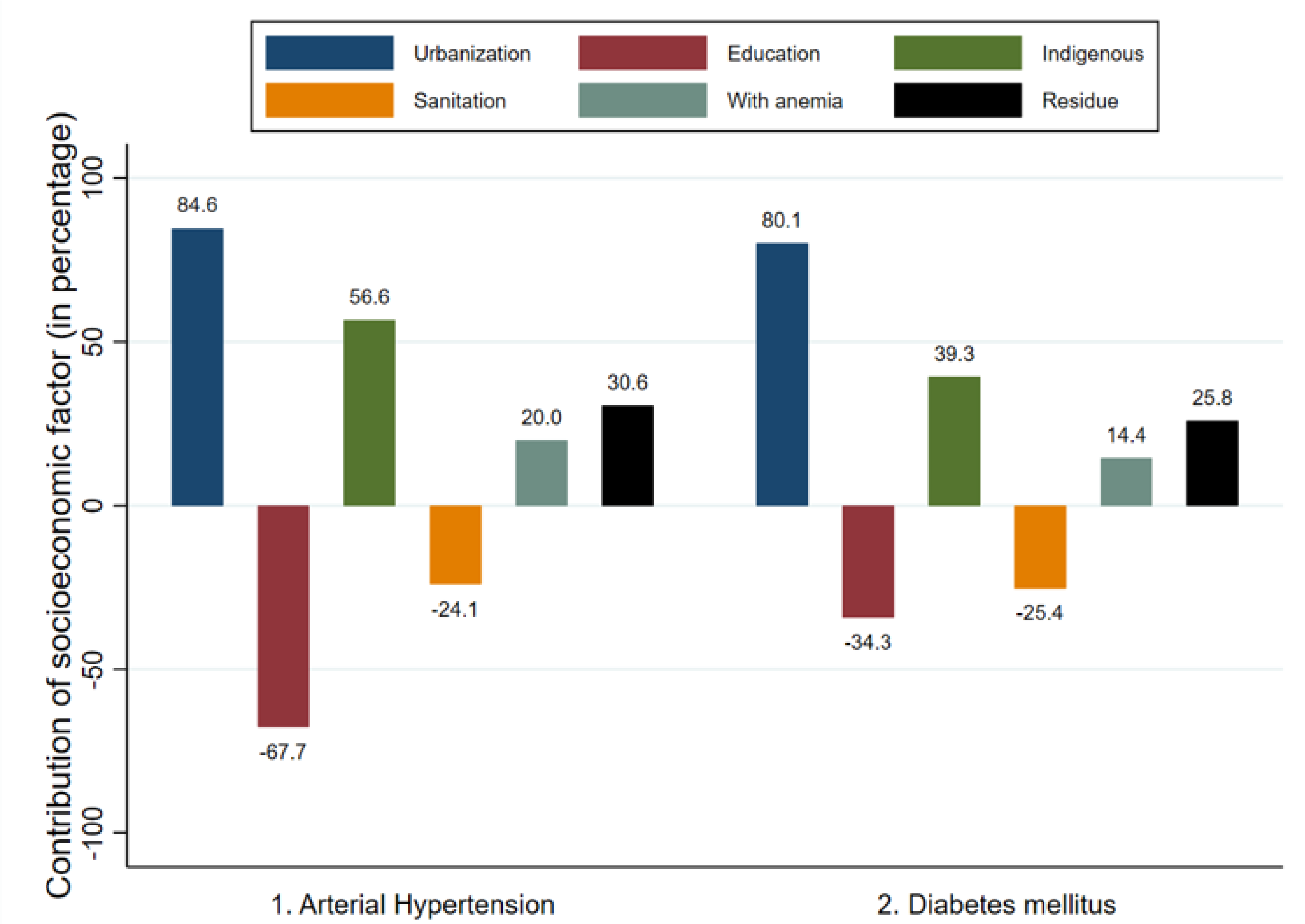

Figure 3

Decomposition of the Concentration Index of NCDs by social determinant

Note: Arterial Hypertension's bars (first 6 bars) are the product of columns (1) and (2) of Table 2, divided by the CI of Arterial Hypertension. Diabetes Mellitus bars (second 6 bars) are the product of columns (1) and (3) of Table 3, divided by the CI of Diabetes Mellitus. The 6 bars of each disease sum to 100%.

Source: Own elaboration based on HMI (2018), NIS (2018), and SDSNB (2020)

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