Non-communicable diseases mortality rate and prevalence of high BMI by income and income inequality across countries: Associations and methodological considerations, an ecological analysis

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ABSTRACT

INTRODUCTION Today, non-communicable diseases (NCDs) represent the highest morbidity and mortality burden worldwide, with high body mass index (BMI) as one of the main risk factors. NCDs mortality rate and prevalence of high BMI have a clear relationship with wealth but not with other economic indicators such as income inequality. There are well-known theories in dispute – social integration and neo-material – trying to reveal this relationship.

METHODS In this ecological study, utilizing open datasets from World Bank (WB) and Global Health Observatory, we explore the associations between countries' economic indicators (income and income inequality) and relevant health outcomes (NCDs mortality rate and prevalence of high BMI) using bivariate correlations. To investigate the impact of inequality on health among similar-wealth nations, countries were grouped by the WB's income classification method.

RESULTS Multiple correlation analyses were conducted, revealing significant associations between the health variables and economic indicators, but more robust with income than inequality. Specifically, high BMI was positively correlated with income ($r=0.46$, $p<0.05$) and negatively correlated with inequality ($r= -0.17$, $p<0.05$). NCDs mortality rate showed a negative correlation with income ($r= -0.54$, $p<0.05$) and a positive correlation with inequality ($r=0.20$, $p<0.05$). At the income level groups, most associations were no longer observable, remaining a few in the higher income groups without a clear pattern.

CONCLUSIONS Globally, while income inequality may be related to worse health outcomes, this association is significant only once poverty has been largely overcome, compatible with both theories in dispute. Whether these associations observed at a general level are maintained at the grouped level will depend on the health outcomes studied, the construction of the wealth indicator, and the methodological limitations of country-income grouped analysis. These characteristics, typical of ecological studies on health inequity, could explain the literature's mixed results in this regard.

INTRODUCTION

Non-communicable diseases (NCDs) represent the highest burden of morbidity and mortality worldwide[1,2], causing 71% of all deaths and 57% of premature deaths in 2016[3].

The Global Burden of Diseases Study[4] shows that NCDs are also the main determinant of disability-adjusted life years (DALYs) and concludes that high BMI (≥25 kg/m^2), diet, or both would be the true driver for other DALYs' primary risk factors such as arterial hypertension (HT) and hyperglycemia (HG). It has been evidenced that a high BMI leads to higher total mortality and increased risks of illness or death from diabetes, some forms of cancer, chronic kidney disease, osteoarthritis, ischemic heart disease, and ischemic stroke[5]. Thus, a strong relationship is observed between a high BMI and the development of comorbidities that currently cause the highest mortality rate and DALYs globally.

During the 21st century, the increasing rates of overweight and obesity, and associated comorbidities, could even lead to

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a decrease in life expectancy in high-income countries. Based on the impact of high BMI on the global burden of morbidity and mortality, some researchers today propose the fifth stage of epidemiological transition, the era of obesity and inactivity, where demographic and socioeconomic patterns of being overweight or obese can be identified according to the development level of a country[6]. High-income countries have been the first to experience epidemiological transitions throughout history. Therefore, understanding the demographic and socioeconomic patterns of being overweight or obese is essential to prevent nations of lower incomes from following the upward trend of prevalence of high BMI, which is observed in the transition to middle and high-income countries.

While malnutrition is a problem in some low-income countries, the prevalence of being overweight or obese is driven by economic growth, industrialization, mechanized transport, urbanization, an increasingly sedentary lifestyle, and a nutritional transition to processed food and high-calorie diets. Paradoxically, as countries increase their economic development, high BMI is increasingly concentrated in the poorest population group[7], while the most privileged stratum have characteristics that reduce the prevalence of being overweight or obese, such as greater access to health and healthy foods, higher education level, and sociocultural norms like healthism and a more positive value placed on being slim[8].

Although exposure to many NCDs risk factors (high BMI, HT, HG, consumption of red meat, sugary drinks, cigarettes, and alcohol) increases with socioeconomic development[4], low- and middle-income countries are disproportionately affected, with almost three quarters of all NCDs deaths and 82% of premature deaths[1]. Due to the challenge that NCDs represent in the 21st century, reducing premature mortality from NCDs by a third is considered one of the United Nations Sustainable Development Goals for 2030. To achieve this goal, understanding the socioeconomic distribution of NCDs mortality and its triggers across different countries is essential. As stated above, the relationship between wealth and the prevalence of high BMI and NCDs mortality rate is clear; however, there is no consensus on the influence of other economic indicators, particularly income inequality. This is mainly because studies that relate income distribution to health tend to use general mortality as an indicator of the population's health, which can mask the differences in the causes of death between countries or regions, and how income inequality has contributed to these differences[9]. Furthermore, the results of previous international empirical research about the effect of income inequality on population health are mixed[10]. In 2006, a review by Wilkinson and Pickett[11] showed that 78% of the studies fully or partially supported the positive relationship between income inequality and worse health. However, in a study from the same period, Lynch et al.[12] concluded that there is little evidence of a direct effect of income inequality on poor health outcomes.

Heterogeneity bias and internationally unmatched data on income inequality are commonly identified limitations in studies on inequality and health[13]. Even for health results typically analyzed in ecological studies, such as life expectancy at birth and infant mortality rate, for which there is consensus that wealth and equity lead to better indicators[10,14], there are also mixed results regarding the impact of income and inequality according to the level of development of nations.

In addition to the causal effect on the population's health, the action mechanism of income inequality is also controversial. The social integration theory by Wilkinson and Pickett[11,15] postulates that psychosocial factors such as status comparisons connect inequality with poor health outcomes. Based on factors such as consumption, individuals easily discern their relative status, integrating inequality in the form of stress, depression, shame, and anxiety, and thereby affecting behaviors related to health. Furthermore, this discerning process would damage social cohesion, increasing individualism and distrust, and thus leading to adverse health consequences. In turn, Lynch et al.[12] in the neo-material theory, minimize psychosocial pathways and propose that material resources explain the negative relationship between inequality and health. Income inequality would be the result of historical, cultural, and political-economic processes that influence people's access to resources and shape the availability of public goods that support health (e.g. health services, education, environmental regulation, welfare states, etc.). The consequences of underinvestment in public goods, disproportionately impact the poor in countries with high income inequality, which worsens population health.

While the social integration theory suggests that inequality would have more damaging effects in rich countries – where status comparisons are more salient – the neo-material theory proposes that the damage would be more significant in lower income nations due to their inadequate health infrastructure[10].

Since income inequality is usually more accentuated in the poorest countries[16], clarifying the fundamental cause of a higher mortality burden in the most vulnerable countries is challenging: income or inequality? The general objective of this study is to explore associations between economic variables (income and inequality) and two health outcomes (prevalence of high BMI and NCDs mortality rate) among countries, both at a general level and grouped by income. The latter with the aim to identify whether inequity impacts the population's health more in rich or poor countries. Additionally, we analyze the characteristics of ecological studies on health inequity and how they could explain the literature's mixed results allowing highly different theories.

METHODS

Design

This is an ecological study of multiple groups of countries examining associations between economic variables and health outcomes. We will explore these associations between countries at the general level and also among countries with similar income levels. For this purpose, we will group countries according to their wealth using the World Bank (WB) income groups.

Selection of cases

Countries considered for the study were taken from the UN country members list.

The selection criteria for countries to be included was that information about economic and health variables was available. Health data from 2016 were chosen after determining that it was the most recent year with the largest number of countries with complete health data. For economic variables, GNI (gross national income) per capita corresponds to data from 2016. We accepted to include the most recent Gini coefficients between 2011 and 2016 due to the significant variability of the information available.

Variables

Independent variables

GNI Per Capita: The gross national income represents a country's income and is used by the WB to estimate the size of the economies using the Atlas method. For this study, we obtained the GNI per capita from the World Development Indicators (WDI) by the WB[17].

Gini Index: The Gini coefficient or index is a measure of statistical dispersion to describe the inequality of income of countries or determined demographic or economic groups[18]. We obtained Gini coefficients for each country from the Standardized World Income Inequality (SWIID) database in its 9th version[19] and used income inequality data after taxes and payments. We used the SWIID data since it increases international and temporal comparability due to its inclusion of samples from different sources and years.

Dependent variables

Health variables: The prevalence of high BMI (overweight and obesity) is defined as the percentage of the population presenting a BMI ≥25 kg/m². The NCDs mortality rate represents the proportion of the population – in a given place and period – that dies due to NCDs. We used age-adjusted data from 2016 from the Global Health Observatory[20,21].

Statistical analysis

Descriptive statistics were used to describe the economic and health variables. Variables were analyzed for normality using descriptive statistics, P-P and Q-Q plots, and the Shapiro-Wilk test. The income variable GNI per capita was log-transformed.

Due to the non-normality of the prevalence of high BMI and the income variable – which persisted after the logarithmic transformation – and the relatively small sample, associations between economic and health indicators were carried out using a non-parametric test. Kendall's tau rank correlation test was selected over Spearman's coefficient due to a small sample.

We grouped countries by wealth, following the WB's income groups. The groups are based on the GNI per capita. We selected this classification as it is one of the most commonly used in public policy and health. Data were analyzed using IBM SPSS version 28.

RESULTS

Descriptives

Of the 193 eligible countries, 153 (79%) met the inclusion criteria for the study.

Grouping of countries by income level resulted in four groups divided as follows: Low, 20 (13%); Lower Middle, 48 (31%); Upper Middle, 38 (25%); and High, 47 (31%). Ranges of income are shown in Table 1.

Preliminary analyses showed non-normality of the income variable (Skewness=1.92; Kurtosis=3.09; W=0.71, $p<0.001$). Log transformation was carried out. However, the variable did not reach the desired normality (Skewness=0.07; Kurtosis = -0.90; W=0.06, $p=0.007$). We kept the variable log-transformed but used non-parametric testing.

Table 1. Descriptive statistics of economic variables by World Bank income classification, ecological study of countries, 2016 (N=153)

Countries	n (%)	Raw GNI per capita (thousands of US$)			Log GNI per capita			Gini coefficient		
		Range	Mean	SD	Range	Mean	SD	Range	Mean	SD
All	153 (100)	0.27–82.11	13.14	17.97	2.43–4.91	3.73	0.62	23.0–66.0	39.0	7.84
By group										
Low	20 (13.1)	0.27–0.97	0.61	0.17	2.43–2.99	2.77	0.13	32.1–54.2	42.5	5.24
Lower middle	48 (31.4)	1.07–3.93	2.29	0.97	3.03–3.59	3.32	0.19	26.7–55.9	41.6	6.15
Upper middle	38 (24.8)	4.08–12.12	6.97	2.24	3.61–4.09	3.82	0.14	23.0–66.0	41.0	8.30
High	47 (30.7)	12.38–82.11	34.65	19.26	4.09–4.91	4.47	0.25	23.6–51.2	33.1	6.84

Table 2. Non-parametric correlations between economic and health variables, ecological study of countries, 2016 (N=153)

Variables	Mean	SD	1	2
Economic				
1. Log GNI per capita	3.7	0.6		
2. Gini	39.0	7.9	**-0.34***	
Health				
3. NCDs mortality rate	543.2	157.6	**-0.54***	**0.20***
4. Prevalence of high BMI	47.7	16.2	**0.46***	**-0.17***

*p<0.05.

Table 3. Non-parametric correlations between economic and health variables by World Bank income classification, ecological study of countries, 2016 (N=153)

Variables	Mean	SD	Log GNI	Gini
Low (N=20)				
Log GNI per capita	2.8	0.1		
Gini	42.5	5.2	0.15	
NCDs mortality rate	677.1	120.0	0.02	-0.24
Prevalence of high BMI	26.9	7.3	0.17	0.28
Lower middle (N=48)				
Log GNI per capita	3.3	0.2		
Gini	41.6	6.2	-0.02	
NCDs mortality rate	637.3	119.7	-0.14	-0.19
Prevalence of high BMI	40.0	15.6	**0.26****	-0.08
Upper middle (N=38)				
Log GNI per capita	3.8	0.1		
Gini	41.0	8.3	-0.06	
NCDs mortality rate	552.8	107.5	-0.16	**-0.23***
Prevalence of high BMI	55.5	11.5	-0.04	-0.14
High (N=47)				
Log GNI per capita	4.5	0.3		
Gini	33.1	6.8	**-0.20***	
NCDs mortality rate	382.3	93.0	**-0.44****	0.12
Prevalence of high BMI	58.1	9.2	-0.03	**0.27****

*p<0.05, **p<0.01.

The Gini coefficient considers a normal distribution. Our analysis of normality showed that considering our sample of countries, normality persisted (Skewness=0.32, Kurtosis=0.49, W=0.98, p=0.05). Table 1 shows descriptive Log GNI per capita and Gini index results for each income level.

Regarding the health variables, the NCDs mortality rate showed a normal distribution (Skewness=0.14, Kurtosis= -0.64, W=0.98, p=0.055.), while the prevalence of high BMI did not (Skewness= -0.35, Kurtosis= -1.35, W=0.89, p<0.011).

Associations

General associations

The correlation analyses revealed associations between the mortality rate of NCDs and prevalence of high BMI with economic variables. Specifically, the NCDs mortality rate showed a moderate negative correlation with Log GNI per capita, (r[151]= -0.54, p<0.05). Conversely, a weak correlation was observed between the NCDs mortality rate and the Gini coefficient (r[151]=0.20, p<0.05). In terms of prevalence of high BMI, a moderate positive correlation was found with Log GNI per capita (r[151]=0.46, p<0.05). In contrast, a small negative correlation was observed with the Gini coefficient (r[151]= -0.17, p<0.05). Results are shown in Table 2.

Associations by income groups

The significance of the association between Log GNI per capita and the Gini coefficient was evident solely within the highest income group. Within the same group, Log GNI per capita exhibited a weak negative association with the Gini coefficient (r[45]= -0.20, p<0.05) and a moderate and negative correlation with the NCDs mortality rate (r[45]= -0.44, p<0.01). However, Log GNI per capita did not show a significant association with the prevalence of high BMI (r[45]= -0.03, p>0.05). Additionally, whithin the highest income group, the Gini coefficient showed a weak negative association with the prevalence of high BMI (r[45]= -0.27, p<0.05).

In the Upper Middle group, a single significant association was observed. The NCDs mortality rate showed a weak negative correlation with the Gini coefficient (r[38]= -0.23, p<0.05). Similarly, in the Lower Middle group, only one significant association was identified: a weak positive correlation between the prevalence of high BMI and Log GNI per capita (r[48]= -0.26, p<0.01).

The correlation analyses revealed no significant associations between the health outcomes and the economic variables in the Low income group, as shown in Table 3.

DISCUSSION

Our results showed that, at a general level, the health variables studied are significantly associated with economic indicators, particularly income. However, whether these associations can be observed at the grouped level will depend on the health variable studied and the action of grouping itself. We believe this is central to the controversy regarding when and how economic indicators explain the different health outcomes between countries. Poverty and inequality are not two isolated phenomena; instead, they occur together. Therefore, the discussion regarding the importance of one over the other could be limited if we consider that the associations will be determined primarily by the method chosen for grouping. It is necessary to reflect on two key aspects: 1) the methodology used and the effects of grouping analysis, and 2) the characteristics of the chosen health variables.

Methodological considerations

Several studies[1,3,11,12,22,23] have discussed the relationship of income and inequality with health variables in determined groups accounting for wealth or development, namely 'high income', 'developing', or 'the 30 wealthier', among other classifications. However, much of the results will be determined by the grouping criteria and the variables considered to describe 'wealth' and 'development'.

To determine how rich or developed a country is, researchers and economists often rely on national indicators such as the GNI in its per capita variation to get an idea of the income of its citizens. The WB income classification used in this study is the most frequent tool to group countries across research and public policy[24]. Nevertheless, some authors have criticized such classifications. Nielsen[25] has argued that the WB, International Monetary Fund, and United Nations Development Program (UNDP) categorizations lack clarity in their 'underlying rationale' and that there is a need for a new classification system based on transparent methodology instead of *ad hoc* rules and criteria. Furthermore, Kaplan[26] argues that the WB classification provides a distorted picture of reality, ignoring key aspects of development such as inequality, human development, social exclusion, and governance, which undoubtedly affect health indicators.

Perhaps one of the most relevant issues regarding the use of GNI per capita alone is the lack of a component that accounts for the dispersion of wealth within a country – especially relevant for Latin America and Asia. As we did in this study, several authors have proposed to include the Gini Index when exploring relationships between development and health[12,27]. However, even when inequality is considered, there are concerns that income is not a good indicator enough, and some have proposed that a multidimensional approach should be proffered, such as the Human Development Index by the UNDP[22]. Lynch et al.[28] indicate that some authors have also used arbitrary cut-off points to suggest associations between income or development and health.

Literature indicates that even well-established and widely used instruments, such as the division proposed by the WB, present essential imperfections. We believe that a new and different method to describe the development of nations is required for its use in health research.

In addition to the variables used to construct economic indicators, which influence when and how wealth explains diverse health outcomes among countries, we identify methodological issues commonly found in ecological studies. These issues can also impact the statistical associations between economic indicators and health outcomes, contributing in part to inconclusive results. Studies on disparities and population health often look for associations with countries stratified by wealth. By having a small number of cases (countries), this method leads to small groups of countries with similar income indicators, reducing the data's variability and diminishing the power of associations observable at a general level.

Characteristics of the health variables

As Linden and Ray[16] stated, our results also show that the wealthiest countries are less inequitable and have better health outcomes. The prevalence of high BMI was the exception, being higher in the wealthiest nations. As reported by the Global Burden of Disease Study 2016[4], this NCDs risk factor increases with socioeconomic development. Despite this fact, as stated by Bennett et al.[3], those with the highest risks of death from NCDs – based on the NCDs mortality rate – were the low- and middle-income countries (LMICs).

Prevalence of high BMI

High BMI is a remarkably complex variable to analyze. It presents a distribution pattern marked by socioeconomic and cultural covariates, and may even be the opposite between countries of different levels of development[8,22].

In developing countries, inhabitants face food shortages and a predominance of manual labor. Low caloric intake and high energy expenditure would explain the low prevalence of being overweight or obese in these nations. The absence of significant associations with the economic variables, at least by the WB grouping, may be due to the division according to income (developed in the previous section) in which the narrow range in the variable of GNI per capita (<US$1005) is the lowest within the four income levels. The middle-income countries show a relation between high BMI and income much less clearly. Industrialization, urbanization, and nutritional transition are commonly postulated as drivers of being overweight or obese with increasing wealth in the country. This was also observed at the grouped level, where prevalence of high BMI increases exponentially along with economic development.

Among the groups divided by income according to the WB, the range of the GNI per capita variable is increasing, allowing for more significant income differences between countries; and, presumably, greater class differences also within each. Despite the poorest countries being the most inequitable, the highest income group showed the most significant income differences. Concordantly, it was the only income group where the Gini index and GNI per capita showed a significant association. As the level of development increased, the demarcation of social classes is accompanied by signs of distinction[29], in which obesity is increasingly associated with poverty and intertwines with other sociocultural variables such as gender and education level. Although the measurement of the latter variables is beyond the scope of this study, it is essential not to forget the aforementioned high BMI paradoxical distribution pattern in order to avoid an ecological fallacy. Concordantly, our results showed that high BMI was significantly associated with the Gini index only in the high-income group, where the income range is far broader.

Social, economic, and cultural variables can act as protective or risk factors for a prevalence of high BMI, depending on the level of socio-economic development of the country and the subgroup to which people belong. This could explain that, at the grouped level, no significant association was observed between high BMI and economic variables. It demonstrates the importance of analyzing the prevalence of high BMI within specific population subgroups, defined by the social, economic, and cultural variables above. Our study coincides with the review by McLaren[22], where no significant associations between income and high BMI in the wealthiest countries were found. Other economic indicators should be considered in the study of the association between socioeconomic status (SES) and prevalence of high BMI in wealthier nations. The author identifies other SES indicators (education level, living area, or occupation) associated with a high BMI. This could be due to the ability of these indicators to translate distal effects of inequity in nations where income inequality is lower.

NCDs mortality rate

The WHO highlights four groups of diseases within the NCDs that account for over 80% of deaths: cardiovascular diseases, cancer, chronic respiratory diseases, and diabetes[30]. The probability of dying from any of these diseases shows significant heterogeneity within each income group; for example, in the lowest income group, this probability is 15% in Ethiopia, while in Afghanistan it is over 30%. Similarly, in the highest income group, the likelihood is under 10% in countries such as Israel, Japan, or Italy, and over 20% in Latvia or Lithuania[30]. The search for significant relationships between economic indicators and NCDs mortality is particularly complex when carried out on many diseases that only share non-transmissibility but differ widely in their etiology, development, and consequences.

Although our results show a significant association between economic indicators and the mortality rate from NCDs at a general level, we believe this is due to the general relationship between health and economic development, and not to particular conditions of these diseases. A good approximation could be the four main groups proposed by the WHO, which would show an association not only with economic indicators but also with geographical ones.

Income versus inequality

We agree with Pickett and Wilkinson[27] that larger income differences increase social inequality and, therefore, differences between social classes. The neo-material theory would not be sufficient to explain the differences in health among rich countries, whereas the social integration theory could become relevant. Nevertheless, there are few rich countries. Wilkinson and Pickett[11] propose that while nations join the group of developed economies – GNI per capita equal to or US$ >25000 – additional income increases become less relevant, and only through more equality health outcomes would improve.

We believe it is essential to reflect on this point since only 26 countries (17%) have reached this threshold. Many studies that support the social integration theory – and that show a positive correlation between health results and lower inequality – have been done precisely on high-income or European countries[8,31,32].

Similar to Lynch et al.[28] who also recognize the negative psychosocial consequences of income inequality, we argue that the interpretation of links between income inequality and health must begin from the structural causes of disparities and not only focus on the perceptions of those disparities. In these wealthy countries, perceptions of inequality could also become more relevant precisely because the structural causes of inequalities are not significant.

Inequality necessarily implies an essential share of poverty. We believe that inequality matters because a lower economic capacity involves low investment in human capital, education, healthcare services, and other social infrastructures. It is not due to inequality itself but to the share of the population that does not have the necessary economic resources and is systematically excluded from essential social services.

Income inequality is a manifestation of neo-material conditions that affect health. Associations would depend on the level and distribution of other social resources. Low-income populations living in high-income countries with high levels of inequality enjoy healthcare services, education, and nutrition above their counterparts in the low- and middle-income countries[10]. Furthermore, although gradients in health exist even in high-income countries with high levels of inequality, their public services are less concentrated in the wealthier population than in the lower income countries with high inequality.

It may seem paradoxical that it is in the countries with the highest income where the relationship between inequality and health results is more significant than in the lowest income countries. As we stated above, this might be due to the limitations of the grouped analysis present in ecological studies, particularly associated with the broader income range present in the high-income category, allowing a more significant association between inequality and income. Additionally, the literature shows that high-income countries do not necessarily share similar welfare states, which would also impact the effect of inequity within these countries. Chung and Muntaner[33] identified that the difference between high-income countries and health indicators such as infant mortality and low birth weight were associated with a comprehensive welfare state. This has also been described by Navarro et al.[34], who examined health indicators from OECD countries for 50 years and their relationship with political, economic, and social variables.

The considerable amplitude of the GNI per capita among high-income countries (US$ 20000–82000) means significant differences in development exist among them. This could produce a gradient, not only social but also a health one. Therefore, the intervention of the welfare state to neutralize the health gradient among high-income countries could have an exceptionally high impact.

Precisely, rich countries with the worst health results are those whose welfare state has significant access barriers to health based on ethnicity, race, and nationality. Among Gulf countries – Saudi Arabia, Qatar, and Bahrein, among others – some healthcare services are restricted to nationals. In contrast, others are designated for foreigners, in the circumstances where labor conditions for immigrants have been described as 'modern slavey'[35]. Saudi Arabia presents significant differences in healthcare access due to the concentration and development of high complexity services in rich and urban zones, segregating the rural and disadvantaged populations.

Something similar happens in the United States, where a healthcare system increases social inequalities, including health results. While income inequalities have increased, chronic health conditions follow a predictable increase in prevalence as income decreases[36].

We believe that the difference in health results – both for rich and for lower income countries – is due to the fact that a generous welfare state allows for better healthcare accessible to all, regardless of income or location. The social integration and neo-material theories can coexist, but we must remember that most countries are not rich. Inequality is always crucial – for rich and poor – but a generous welfare state requires, first and foremost, material resources before these can be distributed.

Limitations

An inherent limitation of ecological studies is that the results obtained at the aggregated level may not necessarily represent what occurs at the individual level. However, although it has been suggested that individual studies should be prioritized when assessing the effect of income distribution on health indicators, we consider that ecological studies can also be valuable as a first step in providing guidance for global policymaking.

CONCLUSIONS

NCDs mortality rate and prevalence of high BMI result from the demographic and epidemiological profile nowadays, and represent a challenge for public health as they act differently from traditionally studied health indicators.

On the one hand, the prevalence of high BMI is strongly determined by social, cultural, and economic variables that can work as protectors or risk factors according to the country's development and social status. On the other hand, the NCDs mortality rate covers several diseases that differ in etiology, development, and consequences, their incidence dissimilar even among countries with similar economic development.

Those who investigate the differences in health must carefully consider how groups are defined, as data from income and inequality in health can only be interpreted considering the group composition. In this regard, significant associations between economic and health variables are expected to be no longer observable if these are explored in subgroups already stratified by income or wealth.

Therefore, associations concerning economic variables must be read with caution, as they cannot reflect the complex multidimensional relationship.

Because of the unique distribution pattern shown by the main burden of diseases, questioning the study method becomes crucial. Although the social gradient remains evident, it is vital to find comprehensive indicators of development that could weigh the different variables influencing health results, such as income, education level, gender, and location.

Despite the considerable economic development of the last 50 years, in all countries to a greater or less extent, there are groups living in systematically disadvantageous positions, leading to an increase in their morbidity. We consider our results evidence that while income inequality could be associated with worse health results, this association is relevant only when poverty has been largely overcome. Thus, there is a need to consider the structural social determinants of health that can allow the development of welfare states to be functional enough to neutralize arbitrary, unfair, and avoidable differences in health.

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AUTHORS' CONTRIBUTIONS
JT conceived the research idea, developed the theoretical framework, and collected the ecological data. DU processed the data and performed the statistical analysis. Both JT and DU contributed to the interpretation of the results and discussion writing. All authors reviewed the results, and read and approved the final version of the manuscript.

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