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ORIGINAL RESEARCH

Impact of the Economic Crisis on Body Mass Index in Spain: An Intersectional Multilevel Analysis Using a Socioeconomic and Regional Perspective

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Abstract

The Great Recession hit Spain deteriorating the living conditions of many Spanish people, increasing the prevalence of several chronic health issues, including obesity, and affecting health inequalities. We analyse the impact of this economic crisis on body mass index (BMI) disparities in Spain, from two perspectives: the socioeconomic and the territorial, through the application of an intersectional multilevel analysis of individual heterogeneity and discriminatory accuracy. We use data from the Spanish National Health Surveys of 2006/2007, 2011/2012 and 2016/2017 to build multilevel linear regression models and estimate BMI averages and components of variance. We find a greater increase in the overall average BMI and a widening of the socioeconomic disparities during the hardest years of the crisis. However, these differences decreased when the economic situation in the country began to improve. Both socioeconomic and geographical information contribute to mapping the distribution of BMI in the population. However, according to the ICC values, considering the regional perspective provides a better understanding of the distribution of the BMI, during the period of economic crisis, in the Spanish population. Therefore, regional policies can play an important role in counteracting obesity in times of crisis.

Keywords Obesity · Economic crisis · Socioeconomic and regional disparities · Multilevel analysis · Intersectionality theory

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Introduction

Economic Crisis and Health: Obesity

The year 2007 will be remembered as a turning point in the world economy. Gone were years of economic bonanza, as these gave way to a period of worldwide economic recession with the emergence of the financial crisis. In Spain it began in 2008, largely affecting the most disadvantaged groups (Karanikolos et al., 2013; Zapata Moya et al., 2015) and generating a worrying social, economic and political context characterized by high unemployment rates, significant precariousness of employment (Fernández, 2016) and an increase in income inequalities (Fernández, 2016; OECD, 2014).

Economic crises have been found to have health-related effects, mainly attributable to changes in the social determinants of health, such as unemployment (Bacigalupe & Escolar-Pujolar, 2014; Dávila Quintana & López-Valcárcel, 2009; Martin-Carrasco et al., 2016), which can have negative consequences on psychological factors, including stress and anxiety, and generate situations of instability and uncertainty affecting health indicators (Goeij et al., 2015; Martin-Carrasco et al., 2016). The impacts of crises vary according to the health outcome and the context considered, as well as the duration and intensity of the crises, and may generate procyclical or countercyclical effects (Catalano et al., 2011; Dávila Quintana & López-Valcárcel, 2009). Previous studies show increases in suicide rates due to economic crises (Ruhm, 2000; Suhrcke & Stuckler, 2012; Toffolutti & Suhrcke, 2014), which, however, have not been found in Spain during the crisis of 2007 (Regidor et al., 2014; Ruiz-Ramos et al., 2014). Nevertheless, this crisis did deteriorate the mental and nutritional health of Spaniards (Antentas & Vivas, 2014; Gili et al., 2014; Urbanos-Garrido & Lopez-Valcarcel, 2015). In addition, some studies note that economic recessions have widened socioeconomic inequalities in health in several countries, including Spain (Bacigalupe & Escolar-Pujolar, 2014; Escolar-Pujolar et al., 2014; Maynou & Saez, 2016), although one study shows a decrease in income-related health inequalities in Spain during this economic crisis (Coveney et al., 2016).

Regarding the effects of recessions on obesity prevalence and body mass index (BMI), for which the existence of socioeconomic gradients has been established (Ailshire & House, 2011; Costa-Font et al., 2014; Devaux & Sassi, 2013; García-Goñi & Hernández-Quevedo, 2012; Jongnam et al., 2019; Merino Ventosa & Urbanos-Garrido, 2016; OECD & EU., 2014; Raftopoulou, 2017; Rodriguez-Caro et al., 2016; WHO, 2000), some studies show that obesity prevalence decreases with economic recessions (procyclical variation) (Ruhm, 2000, 2005), while others show obesity prevalence and BMI increasing with economic crises (a countercyclical relationship) (Antentas & Vivas, 2014; Böckerman et al., 2007; Hernández-Yumar et al., 2019; Norte et al., 2019; OECD & EU., 2014; Radwan & Gil, 2014).

In Spain, the prevalence of obesity (Hernández-Yumar et al., 2019; Norte et al., 2019; Radwan & Gil, 2014) and the risk of obesity in low socioeconomic groups

(Norte et al., 2019) have increased alongside the economic and financial shocks, despite the implementation of several national public policies aimed at tackling the issue within the framework of the strategy for nutrition, physical activity and the prevention of obesity (NAOS Strategy) (Ballesteros Arribas et al., 2007).

The place of residence can also influence individual BMI, through so-called obesogenic environments (Davillas & Jones, 2020; Egger & Swinburn, 1997), generating disparities for example as found at different geographic levels in Spain (Costa-Font & Gil, 2008; Raftopoulou, 2017). During recent years, regional governments have also developed preventive actions against obesity (ASPCAT, 2019; CAIB, 2014; Gobierno-de-la-Rioja & Plan de Salud, 2009; ICCA, 2019; Pont Geis et al., 2009; SEPAD, 2019), implemented in parallel with austerity policies and regulations (especially since 2011), such as cutbacks in public spending on social items such as education, health and social protection (Conde-Ruiz et al., 2016), which have had negative effects on health inequalities (Maynou & Saez, 2016).

Despite the scientific evidence on BMI disparities among adults, there is no literature, to our knowledge, on the evolution of these disparities during the economic recession.

Intersectionality Theory and Multilevel Analysis of Individual Heterogeneity and Discriminatory Accuracy (MAIHDA)

Intersectionality theory began its development with Black feminism and has evolved based on the work of Crenshaw and others (Bowleg, 2012; Collins, 1990; Crenshaw, 1989; Hancock, 2016; Hankivsky, 2012; McCall, 2005; Seng et al., 2012). From the point of view of this theory (Bowleg, 2012; Collins, 1990; Crenshaw, 1989; Hancock, 2016; Hankivsky, 2012; McCall, 2005), variables or dimensions such as gender, race/ethnicity and social class are understood not to be separate but interlocked. Most intersectionality research is conducted using qualitative methods. Still, in quantitative research, an intersectional approach can be operationalized through the construction of intersectional strata, made up of combinations of such dimensions, consisting of interwoven societal contexts of oppression and privilege (Hankivsky, 2012) influencing the health of individuals and determining health disparities (Palència et al., 2014). That is, an intersectional perspective directs focus towards structural factors beyond behaviours and risk factors at the individual level (Kapilashrami et al., 2015).

Most previous studies have applied traditional fixed-effects models to measure the socioeconomic gradients in obesity or BMI, considering the studied variables as separated demographical and socioeconomical risk factors, which disregards that the societal contexts conditioning individual health in general, and BMI in particular, are complex and multidimensional. Instead, a better approach to the study of socioeconomic inequalities in health can be obtained by considering demographical and socioeconomical identities as contextual dimensions that intersect with each other to define intersectional strata. The influence of these on individual health may be additive as well as interactive, when the contextual effect is larger than the simple additive effects of the specific dimensions that define the strata. Therefore, inspired on intersectionality theory, the so-called intersectional multilevel analysis of individual heterogeneity and discriminatory accuracy (MAIHDA), or intersectional MAIHDA, (Evans & Erickson, 2019; Evans et al., 2018; Merlo, 2018) conveys theoretical and methodological advantages that could make it the new "gold standard" in the research of health inequalities (Merlo, 2018). The application of Intersectional MAIHDA is rapidly increasing (Axelsson et al., 2018; Balloo et al., 2022; Evans & Erickson, 2019; Evans et al., 2018; Hernández Yumar et al., 2018; Mersky et al., 2021; Moreno-Agostino et al., 2023; Zubizarreta et al., 2022).

It is relevant to clary that MAIHDA is not a new methodology per se, but it may be viewed as a reorganization of existing multilevel modelling concepts. The MAIHDA approach stresses the relevance of performing a systematic analysis that simultaneously considers the differences between strata and the extent of individual variation around such averages. MAIHDA also maps and quantifies the sizes of such inequalities and provides information on the discriminatory accuracy of the sociodemographic and geographical information when predicting individual BMI. In this way, MAIHDA informs on the validity of the context studied for the outcome we are analysing. Compared with traditional analysis exclusively based on differences between group averages, the MAIHDA methodology provides an improved tool for auditing geographical and sociodemographic inequalities in health.

In MAIHDA, the fundamental statement is that individual and population health are not dislocated study objects. Rather, we need to consider the existence of a continuous distribution of individual heterogeneity that can be articulated at different levels of analysis. Observe that conceptually, MAIHDA can be applied using both traditional fixed model effects (Wemrell et al., 2019) or the more suitable random effects models (as those used in our paper) (Evans et al., 2020). This is because MAIHDA is a conceptual framework rather than statistical technique.

MAIHDA intrinsically adopts a multilevel approach that do not consider gender, income, and educational level as individual characteristics but rather as dimensions that define societal contexts that condition the distribution of resources and power and thereby lifestyle and health, which mitigate the risk of "blaming the victim", i.e. the societal context conditions the individual unhealthy lifestyle, but the society blames individuals for their unhealthy lifestyle. This is important due to weight stigma of people categorized as obese has harmful effects on their health and quality of life (Puhl & Heuer, 2010). In addition, an unwanted side effect in traditional epidemiology is the peril of stigmatization of the individual for pertaining to the groups with "bad" average health, as well as the peril of false expectations of the individuals included in the groups with "good" average health. This is so because we attribute the average group value to all individuals in the group (Merlo et al., 2017). However, by informing on the discriminatory accuracy of the groups (i.e. the variance partition coefficient (VPC) or the intra-class correlation coefficient (ICC)), MAIHDA indicates when the perils of stigmatization and false expectation could be accepted in benefit of public health. If the discriminatory accuracy of the strata is high, the pointed out specific groups are adequate. This idea is also relevant when planning targeted, universal or proportionate universal interventions (Fisher et al., 2021), where a high discriminatory accuracy indicated the suitability targeted interventions, while a low discriminatory accuracy suggests universal interventions.

Aims and Research Questions

Although previous research has investigated the impact of economic crises on health disparities, there is, as far as we know, no evidence on the potential effect of the crises on inequalities in BMI, despite the effects of BMI on health. So, given the increase of obesity in recent years and the deterioration of living conditions suffered by many Spanish people, our main aim is to analyse the impact of the post-2007 economic crisis on BMI disparities in Spain from intersectional socioeconomic and territorial perspectives. The two main research questions are the following:

1. What trends in BMI can be seen during the post-2007 economic crisis?
2. How did socioeconomic and geographical dimensions influence BMI before, during and after the economic crisis?

Methods

Population

This study is based on three cross-sectional surveys: the Spanish National Health Survey (SNHS) of 2006/2007 (INE, 2007a), 2011/2012 (INE, 2012a) and 2016/2017 (INE, 2017a), developed by the Spanish National Institute of Statistics and the Ministry of Health. These surveys were conducted through personal interviews with individuals aged 16 years or older (15 years or older for the 2011/2012 survey) residing in Spain, selected via a stratified three-stage sample (INE, 2007b, 2012b, 2017b). Our research focused on adults aged 18 years or older. This fact, together with number of missing values in the variables under study, led to final sample sizes of 23,026 (78% of the initial sample of the SNHS 2006/2007), 14,190 (68% of the initial sample of the SNHS 2011/2012) and 16,480 individuals (71% of the initial sample of the SNHS 2016/2017).

The survey of 2006/2007 corresponds with the pre-crisis period, 2011/2012 relates to the time of the economic crisis, and 2016/2017 represents the post-crisis period. It should be noted that although the economic context of this final period had improved compared to the previous one, the favourable conditions of the pre-crisis time were not achieved by that time.

Variables

Using an intersectional approach, we can analyse the BMI of the Spanish population by nesting the individuals within intersectional strata defined by a combination of demographic, social and economic variables (Merlo, 2018). In addition, given the importance of the place of residence as a determining factor of health (Macintyre et al., 1993, 2002; Matheson et al., 2008; Raftopoulou, 2017), our intersectional strata will be also defined by a geographic variable, referring, in our case, to each of the Spanish regions.

Our dependent continuous variable is self-reported $BMI\,(= weight(kg)/height(m^2))$, and the independent variables are the following.

Gender is categorized as female and male and we created three age groups to classify people as young adults (18–35 years), middle-aged (36–64 years) and older adults (≥ 65 years) (Martín Ruiz, 2005).

Income refers to the net monthly income of the household. We regrouped the income intervals in each survey to obtain intervals with income ranges that are as similar as possible. The six new income intervals (measured in euros) are (i) ≤ 600; (ii) 601–900; (iii) 901–1200; (iv) 1201–1800; (v) 1801–3600; (vi) ≥ 3601, for SNHS 2006/2007; (i) ≤ 550; (ii) 551–800; (iii) 801–1300; (iv) 1301–1850; (v) 1851–3450; (vi) > 3450, for SNHS 2011/2012; and (i) < 570; (ii) 570–799; (iii) 800–1299; (iv) 1300–1799; (v) 1800–3599; (vi) ≥ 3600, for SNHS 2016/2017. We estimated the mean total household income as the mid-point of each interval, assigning to the highest one in each survey the same amplitude as the respective preceding interval. We then divided the mean total household income by the total number of members in the household weighted by the OECD-modified scale (Hagenaars et al., 1994) to obtain the equivalent household income. Finally, we calculated income tertiles to classify individuals into three groups: low income (≤ 1st tertile), medium income (> 1st tertile to 2nd tertile) and high income (> 2nd tertile).

Regarding education, we grouped the educational levels of the surveys into three categories: low educational level (primary education or less), medium educational level (from 1st stage/cycle secondary education to higher professional education (SHNS 2006/2007)/advanced professional training or equivalent (SHNS 2011/2012 and 2016/2017)) and high educational level (university studies or the equivalent) (INE, 2007b, 2012b, 2017b). We assigned the highest educational achievements collected for the household to the selected adult because we assume that the socioeconomic context of the household can influence individual heterogeneity in BMI.

Marital status has been identified as a social determinant of BMI (Ortiz-Moncada, 2015), but we assume that the simple fact of living alone or not is a better predictor of BMI. We built a dichotomous variable from the sum of the number of adults and children declared in each household as a proxy of the household type: single-person household (living alone) or multi-person household (cohabitation).

Finally, we have also included the region of residence in the analysis. Although other studies have considered environments that are closer to individuals, such as neighbourhoods or cities, we have assumed that the characteristics of each region, in a context of a decentralized health system, also have an impact on health. Spain is divided into 17 autonomous communities (Andalusia, Aragon, Asturias, the Balearic Islands, the Canary Islands, Cantabria, Castilla y Leon, Castile-La Mancha, Catalonia, Community of Valencia, Extremadura, Galicia, Community of Madrid, Murcia, Navarra, the Basque Country and La Rioja) and 2 autonomous cities (Ceuta and Melilla), but our variable groups the two autonomous cities in a single region, in accordance with the categorization used in SNHS 2006/2007 (INE, 2007b).

The reference categories for the fixed-effects comparisons (see below) are males, young adults, high income, high educational level, multi-person household and the Community of Madrid, respectively.

Statistical Analysis

The statistical analysis is based on three approaches, which all include gender and age, as covariates, in addition to others described below. The *socioeconomic approach* (approach A) includes socioeconomic variables (income and education) together with the variable household type. The *regional approach* (approach B) takes only the region of residence into account. Finally, the *socioeconomic plus regional approach* (approach C) incorporates all variables included in both approaches A and B.

Depending on the approach (A, B or C), we combine the categories of variables (gender (g), age (a), income (i), education (e), household type (h) and region of residence (ac)) to build intersectional strata pertaining to each approach. Approach A contains $2(g) \times 3(a) \times 3(i) \times 3(e) \times 2(h) = 108$ strata. Of these, 108 (SNHS 2006/2007), 105 (SNHS 2011/2012) and 107 (SNHS 2016/2017) strata include observations. Approach B also has $2(g) \times 3(a) \times 18(ac) = 108$ strata, and in this case, all include observations. Finally, approach C contains $2(g) \times 3(a) \times 3(i) \times 3(e) \times 2(h) \times 18(ac) = 1944$ strata, of which 1589 (SNHS 2006/2007), 1459 (SNHS 2011/2012) and 1,557 strata (SNHS 2016/2017) include observations.

This analysis builds two multilevel linear regression models for each survey and each approach, with individuals at the first level and individuals nested within intersectional strata at the second level (Evans et al., 2018; Jones et al., 2016; Merlo, 2018).

The first model, or the *simple intersectional multilevel model,* contains a random intercept for the intersectional strata as well as variance components.

$$y_{ij} = \beta_0 + u_j + e_{ij} \tag{1}$$

where y_{ij} is the individual BMI, the subscript i corresponds with individuals ($i = 1,\ldots, n_j$), and the subscript j corresponds with the intersectional strata ($j = 1,\ldots, J$). The u_j is the stratum-level random effect (i.e. residual) and measures the difference between the average BMI of all the strata means (i.e. grand mean), β_0, and the mean BMI of each intersectional stratum. To avoid overinterpretation of extreme values, the strata residuals are shrunken, or precision weighted to a greater or lesser degree by an shrinkage factor so that shrinkage pulls the value of the small size strata towards the grand mean (as explained in Steele (2008)). The e_{ij}, the individual-level residual, measures the difference between the BMI of each individual and the average BMI of their corresponding intersectional stratum. Both u_j and e_{ij} follow a normal distribution with a mean of 0 and a respective variance of σ_u^2 and σ_e^2.

The second model, or the *intersectional interaction model,* includes, in addition to the random intercept and the variance components, the variables used to define the intersectional strata as fixed effects. By doing so, the u_j allows us to identify the possible existence of any two-way or higher interaction effects between the specific combination of variables that define the stratum. We can therefore measure whether the influence of a specific stratum is larger or smaller than the sum of the main effects of each social dimension (Merlo, 2018).

$$y_{ij} = \beta_0 + \beta_1 X_{1j} + \beta_2 X_{2j} + \beta_3 X_{3j} + \cdots + \beta_z X_{zj} + u_j + e_{ij} \tag{2}$$

where X_{zj} is a dummy variable for z ($z = 1, \ldots, Z$) categories of the explanatory variables, omitting the reference category, and β_0 denotes the predicted BMI of the stratum based on the main effects of the variables (i.e. 18- to 35 year-old males with high income and high education and who cohabit (Approach A); 18- to 35 year-old males living in the Community of Madrid (Approach B); and 18- to 35 year-old males with high income and high education and who cohabit in the Community of Madrid (Approach C)).

The choice of different reference categories would not affect the main results of our study. Although this would modify the values of the fixed effects, it does not alter the values of the eventual interaction of the effects' u_j s (Evans et al., 2018).

While the *simple intersectional model* measures the total or *ceiling* effect of intersectional strata (i.e. intersectional effects) and comprises the main effects (additive effects) as well as any interaction effects (interactive effects) of the variables, the *intersectional interaction model* isolates the interactive effects (Merlo, 2018).

The application of MAIHDA also enables us to analyse the components of variance, decomposing the individual heterogeneity into *within* and *between* intersectional group components. This allows us to estimate the share of the total variance pertaining to the intersectional level by calculating the VPC or ICC, which shows how the BMIs of two randomly selected individuals within the same stratum are correlated.

$$\mathrm{VPC} \equiv \mathrm{ICC} = \frac{\sigma_u^2}{(\sigma_u^2 + \sigma_e^2)}$$

This coefficient also provides information about the validity of intersectional strata as social group constructs (or of the intersectional effects) to predict the individual BMI. The higher the ICC, the more valid the intersectional strata for predicting the individual BMI are, as the correlation in BMI between individuals in each stratum (i.e. the clustering) is larger. In other words, the intersectional strata have stronger discriminatory accuracy (Merlo, 2018). On the other hand, the lower the ICC, the more heterogeneous individuals are within intersectional strata and the larger the overlap between strata, meaning that these strata have a limited capacity to inform about the BMI of the individuals who compose them. Correspondingly, the discriminatory accuracy of the strata is weaker (Merlo, 2018).

Additionally, an ICC equal to 0 in the *intersectional interaction model* means that the u_j in the *simple intersectional model* only expresses the additive effect of the variables composing the intersectional strata. Therefore, in the absence of interaction effects between these variables, all the u_j would be 0. However, if any interaction exists, some residual variation (σ_u^2) in the *intersectional interaction model* would be observed, and the ICC would differ from 0.

The statistical analyses were executed with the software Stata and MLwiN using the user-written runmlwin command (Leckie & Charlton, 2013). The models were estimated using the Markov chain Monte Carlo (MCMC) method (as explained in more depth in Leckie and Charlton (2013)). In addition, we calculated the Bayesian Deviance Information Criterion (DIC) to determine the goodness of fit of each model (Browne, 2017).

Results

Impact of the Economic Crisis on BMI

In Spain, the average BMI increased from 2006 to 2017, especially until 2012 (Tables 1, 2, 3, 4). A more detailed descriptive analysis is as follows:

Using socioeconomic and demographic variables, this trend is observed for almost all the categories analysed. During the period between 2006/2007 and 2011/2012, the groups most affected by increases in average BMIs are those with medium and low education (i.e. +2.3% and 2.1%, respectively) (Table 1).

- The gap in BMI between the those with low vs. high education seems to increase by 17.7% (or+0.41 BMI units) between 2006/2007 and 2011/2012 (i.e. from 2.32 to 2.73 BMI units more in the group with low education compared to the highly educated group) and decreased 9.5% (or − 0.26 BMI units) between 2011/2012 and 2016/2017 (i.e. from 2.73 to 2.47 BMI units more in the group with low education compared to the highly educated group) (Table 1).
- Looking at the geographical aspect, all Spanish regions registered increases in average BMI between 2006/2007 and 2016/2017, except Castilla y Leon and Aragon, where the BMI decreased (Table 1). Among the regions with BMI increases, 11 of 16 reported the largest increase during the first years of the crisis (i.e. between 2006/2007 and 2011/2012).

Impact of the Economic Crisis on BMI Disparities

Additive Effects

All the models 2 (except those from approach B) show the existence of a socioeconomic gradient during the entire period: the groups with low income and education have a higher average BMI than the reference categories (high income and

Table 1 Individual characteristics, mean BMI and variation rates of BMI

Individual characteristics	SNHS 2006/2007		SNHS 2011/2012		ΔBMI 2011–2006*	SNHS 2016/2017		ΔBMI 2016–2011*	ΔBMI 2016–2006*
	Population (%)	Mean BMI (95% CI)	Population (%)	Mean BMI (95% CI)		Population (%)	Mean BMI (95% CI)		
Gender									
Overall	23,026 (100)	25.95 (25.89–26.00)	14,190 (100)	26.24 (26.17–26.32)	1,1	16,480 (100)	26.35 (26.27–26.42)	0,4	1,5
Males	9632 (41.83)	26.65 (26.57–26.73)	6821 (48.07)	26.89 (26.79–26.98)	0,9	7713 (46.8)	26.93 (26.84–27.03)	0,1	1,1
Females	13,394 (58.17)	25.44 (25.36–25.52)	7369 (51.93)	25.64 (25.53–25.76)	0,8	8767 (53.2)	25.83 (25.72–25.93)	0,7	1,5
Age									
≤ 35	5734 (24.90)	24.1 (23.99–24.2)	3078 (21.69)	24.37 (24.22–24.52)	1,1	2596 (15.75)	24.57 (24.39–24.74)	0,8	2,0
36–64	11,939 (51.85)	26.23 (26.15–26.31)	7386 (52.05)	26.41 (26.31–26.51)	0,7	8765 (53.19)	26.29 (26.19–26.38)	− 0,5	0,2
≥ 65	5353 (23.25)	27.3 (27.19–27.42)	3726 (26.26)	27.45 (27.32–27.59)	0,5	5119 (31.06)	27.35 (27.23–27.47)	− 0,4	0,2
Income									
Low	7957 (34.56)	26.66 (26.56–26.76)	4965 (34.99)	26.79 (26.65–26.92)	0,5	6452 (39.15)	27 (26.88–27.12)	0,8	1,3
Medium	7941 (34.49)	25.99 (25.89–26.08)	4750 (33.47)	26.43 (26.31–26.56)	1,7	4563 (27.69)	26.24 (26.1–26.37)	− 0,7	1,0
High	7128 (30.96)	25.10 (25.01–25.2)	4475 (31.54)	25.44 (25.32–25.56)	1,4	5465 (33.16)	25.66 (25.55–25.77)	0,9	2,2
Education									
Low	7171 (31.14)	27.18 (27.08–27.29)	2521 (17.77)	27.76 (27.58–27.93)	2,1	3914 (23.75)	27.6 (27.46–27.75)	− 0,6	1,5
Medium	9902 (43.00)	25.7 (25.62–25.79)	8268 (58.27)	26.28 (26.18–26.38)	2,3	8329 (50.54)	26.37 (26.27–26.47)	0,3	2,6
High	5953 (25.85)	24.86 (24.76–24.97)	3401 (23.97)	25.03 (24.89–25.16)	0,7	4237 (25.71)	25.13 (25.01–25.26)	0,4	1,1
Living alone									
No	19,395 (84.23)	25.87 (25.81–25.93)	10,971 (77.32)	26.2 (26.11–26.28)	1,3	12,223 (74.17)	26.32 (26.24–26.41)	0,5	1,7
Yes	3631 (15.77)	26.35 (26.21–26.5)	3219 (22.68)	26.39 (26.23–26.55)	0,2	4257 (25.83)	26.41 (26.27–26.55)	0,1	0,2
Region of residence									
Andalusia	2040 (8.86)	26.47 (26.28–26.67)	1947 (13.72)	26.74 (26.53–26.96)	1,0	2255 (13.68)	26.77 (26.56–26.97)	0,1	1,1
Aragon	2298 (9.98)	26.17 (25.99–26.35)	513 (3.62)	25.99 (25.61–26.37)	− 0,7	706 (4.28)	26.07 (25.74–26.41)	0,3	− 0,4

Table 1 (continued)

Individual characteristics	SNHS 2006/2007		SNHS 2011/2012		ΔBMI 2011–2006*	SNHS 2016/2017		ΔBMI 2016–2011*	ΔBMI 2016–2006*
	Population (%)	Mean BMI (95% CI)	Population (%)	Mean BMI (95% CI)		Population (%)	Mean BMI (95% CI)		
Asturias	822 (3.57)	25.95 (25.65–26.26)	599 (4.22)	26.72 (26.36–27.09)	3,0	657 (3.99)	26.77 (26.38–27.15)	0,2	3,2
Balearic Islands	1358 (5.9)	25.29 (25.05–25.52)	352 (2.48)	25.96 (25.5–26.42)	2,6	539 (3.27)	25.78 (25.4–26.15)	– 0,7	1,9
Canary Islands	1031 (4.48)	25.99 (25.71–26.28)	689 (4.86)	26.37 (26.02–26.72)	1,5	475 (2.88)	26.38 (25.92–26.83)	0,0	1,5
Cantabria	1452 (6.31)	25.95 (25.72–26.17)	393 (2.77)	26 (25.61–26.38)	0,2	266 (1.61)	26.59 (25.95–27.23)	2,3	2,5
Castilla y Leon	1000 (4.34)	25.9 (25.64–26.15)	919 (6.48)	25.82 (25.57–26.07)	– 0,3	1011 (6.13)	25.86 (25.61–26.12)	0,2	– 0,2
Castile-La Mancha	862 (3.74)	26.19 (25.88–26.49)	751 (5.29)	26.56 (26.21–26.91)	1,4	665 (4.04)	27.04 (26.67–27.41)	1,8	3,2
Catalonia	1336 (5.8)	25.57 (25.35–25.79)	1264 (8.91)	25.95 (25.7–26.2)	1,5	1523 (9.24)	25.96 (25.73–26.19)	0,0	1,5
C. of Valencia	1539 (6.68)	25.84 (25.61–26.06)	1388 (9.78)	26.15 (25.91–26.39)	1,2	1573 (9.54)	26.52 (26.28–26.76)	1,4	2,6
Extremadura	598 (2.6)	26.44 (26.05–26.82)	625 (4.4)	27.12 (26.76–27.48)	2,6	835 (5.07)	26.61 (26.31–26.91)	– 1,9	0,6
Galicia	2268 (9.85)	26.27 (26.08–26.45)	512 (3.61)	27.12 (26.69–27.54)	3,2	950 (5.76)	26.66 (26.38–26.94)	– 1,7	1,5
C. of Madrid	1626 (7.06)	25.29 (25.08–25.5)	1320 (9.3)	25.77 (25.53–26.02)	1,9	1359 (8.25)	26 (25.75–26.25)	0,9	2,8
Murcia	1602 (6.96)	26.32 (26.1–26.54)	616 (4.34)	26.47 (26.1–26.84)	0,6	960 (5.83)	26.51 (26.25–26.77)	0,2	0,7
Navarre	1392 (6.05)	25.57 (25.34–25.8)	692 (4.88)	25.49 (25.19–25.8)	– 0,3	589 (3.57)	26.27 (25.86–26.67)	3,1	2,7
Basque Country	800 (3.47)	25.66 (25.35–25.96)	811 (5.72)	26 (25.71–26.29)	1,3	1216 (7.38)	25.86 (25.6–26.11)	– 0,5	0,8
La Rioja	695 (3.02)	25.73 (25.44–26.02)	592 (4.17)	25.85 (25.51–26.2)	0,5	490 (2.97)	25.79 (25.39–26.19)	– 0,2	0,2
Ceuta-Melilla	307 (1.33)	26.38 (25.88–26.88)	207 (1.46)	26.43 (25.8–27.06)	0,2	411 (2.49)	26.92 (26.42–27.42)	1,9	2,0

SNHS Spanish National Health Survey, *BMI* body mass index

*The variation in BMI between surveys was estimated in variation rates

Table 2 MCMC estimated parameters, ICC and DIC. SNHS 2006/2007

	A: Socioeconomic approach		B: Regional approach		C: Socioeconomic + regional approach	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
	Simple intersectional	Intersectional interaction	Simple intersectional	Intersectional interaction	Simple intersectional	Intersectional interaction
Measures of association						
Intercept	25.79 (25.44–26.10)	24.37 (23.95–24.82)	25.93 (25.68–26.19)	24.47 (23.95–24.99)	25.92 (25.81–26.03)	23.89 (23.56–24.19)
Gender						
Males		Ref		Ref		Ref
Females		− 0.25 (− 0.31 to − 0.20)		− 0.22 (− 0.27 to − 0.18)		− 0.25 (− 0.28 to − 0.23)
Age (years)						
≤ 35		Ref		Ref		Ref
36–64		2.07 (1.74–2.44)		2.15 (1.85–2.43)		2.07 (1.91–2.23)
≥ 65		2.59 (2.21–2.95)		3.13 (2.83–3.42)		2.6 (2.41–2.81)
Income						
Low		0.66 (0.31–1.02)				0.63 (0.45–0.80)
Medium		0.28 (− 0.06–0.63)				0.34 (0.18–0.51)
High		Ref				Ref
Education						
Low		1.39 (1.02–1.74)				1.38 (1.18–1.57)
Medium		0.54 (0.20–0.90)				0.65 (0.48–0.81)
High		Ref				Ref
Living alone						
No		Ref				Ref
Yes		− 0.46 (− 0.77 to − 0.14)				− 0.26 (− 0.45 to − 0.09)

Table 2 (continued)

	A: Socioeconomic approach		B: Regional approach		C: Socioeconomic + regional approach	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
	Simple intersectional	Intersectional interaction	Simple intersectional	Intersectional interaction	Simple intersectional	Intersectional interaction
Region of residence						
Andalusia				1.15 (0.50–1.78)		0.81 (0.46–1.16)
Aragon				0.49 (− 0.15–1.13)		0.36 (0.03–0.70)
Asturias				0.39 (− 0.28–1.11)		0.30 (− 0.1–0.7)
Balearic Islands				0.17 (− 0.50–0.83)		0.12 (− 0.25–0.48)
Canary Islands				0.57 (− 0.12–1.22)		0.47 (0.08–0.86)
Cantabria				0.46 (− 0.20–1.12)		0.31 (− 0.05–0.67)
Castilla y Leon				0.18 (− 0.49–0.84)		0.01 (− 0.37–0.41)
Castile-La Mancha				0.76 (0.08–1.43)		0.45 (0.05–0.84)
Catalonia				0.18 (− 0.49–0.83)		0.13 (− 0.23–0.48)
C. of Valencia				0.52 (− 0.15–1.17)		0.39 (0.04–0.75)
Extremadura				1.03 (0.33–1.74)		0.70 (0.24–1.15)
Galicia				0.71 (0.06–1.35)		0.54 (0.21–0.88)
C. of Madrid	Ref	Ref	Ref	Ref	Ref	Ref
Murcia				1.06 (0.38–1.69)		0.75 (0.40–1.1)
Navarre				0.18 (− 0.49–0.82)		0.12 (− 0.23–0.47)
Basque Country				0.20 (− 0.48–0.91)		0.26 (− 0.15–0.66)
La Rioja				0.16 (− 0.54–0.88)		0.05 (− 0.38–0.48)
Ceuta-Melilla				1.05 (0.28–1.84)		1 (0.45–1.55)
Measures of variance						
Variance level 2						
Intersectional strata	2.50 (1.84–3.37)	0.34 (0.22–0.52)	2.33 (1.76–3.07)	0.26 (0.16–0.40)	2.41 (2.12–2.73)	0.26 (0.19–0.35)

Table 2 (continued)

	A: Socioeconomic approach		B: Regional approach		C: Socioeconomic + regional approach	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
	Simple intersectional	Intersectional interaction	Simple intersectional	Intersectional interaction	Simple intersectional	Intersectional interaction
Variance level 1						
Individuals	17.26 (16.94–17.59)	17.26 (16.95–17.58)	17.71 (17.40–18.04)	17.71 (17.39–18.04)	17.25 (16.93–17.56)	17.25 (16.93–17.57)
ICC	12.6%	2.0%	11.6%	1.4%	12.3%	1.5%
DIC	131,026.12	130,997.38	131,628.97	131,614.43	131,699.06	131,159.99

In brackets, 95% confidence intervals (CI) are shown

ICC intra-class correlation coefficient, *DIC* Bayesian deviance information criterion

Table 3 MCMC estimated parameters, ICC and DIC. SNHS 2011/2012

	A: Socioeconomic approach		B: Regional approach		C: Socioeconomic + regional approach	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
	Simple intersectional	Intersectional interaction	Simple intersectional	Intersectional interaction	Simple intersectional	Intersectional interaction
Measures of association						
Intercept	26.03 (25.64–26.38)	25.14 (24.52–25.75)	26.1 (25.79–26.4)	25.93 (25.26–26.58)	26.18 (26.05–26.31)	25.25 (24.8–25.69)
Gender						
Males		Ref		Ref		Ref
Females		− 1.16 (− 1.46 to − 0.85)		− 1.25 (− 1.51 to − 0.99)		− 1.27 (− 1.45 to − 1.1)
Age (years)						
≤ 35		Ref		Ref		Ref
36–64		2.14 (1.77–2.54)		1.98 (1.66–2.3)		2.01 (1.79–2.22)
≥ 65		2.65 (2.23–3.07)		3.08 (2.73–3.4)		2.67 (2.42–2.93)
Income						
Low		0.74 (0.35–1.16)				0.65 (0.41–0.89)
Medium		0.33 (− 0.06–0.72)				0.27 (0.04–0.5)
High		Ref				Ref
Education						
Low		1.71 (1.27–2.15)				1.65 (1.35–1.95)
Medium		0.96 (0.59–1.33)				0.95 (0.73–1.16)
High		Ref				Ref
Living alone						
No		Ref				Ref

Table 3 (continued)

	A: Socioeconomic approach		B: Regional approach		C: Socioeconomic + regional approach	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
	Simple intersectional	Intersectional interaction	Simple intersectional	Intersectional interaction	Simple intersectional	Intersectional interaction
Yes		− 0.6 (− 0.94 to − 0.26)				− 0.43 (− 0.63 to − 0.23)
Region of residence						
Andalusia				1.02 (0.35–1.68)		0.61 (0.22–1.01)
Aragon				0.05 (− 0.73–0.82)		− 0.1 (− 0.63–0.4)
Asturias				0.63 (− 0.12–1.4)		0.49 (0.01–0.97)
Balearic Islands				0.07 (− 0.74–0.87)		− 0.28 (− 0.84–0.27)
Canary Islands				0.58 (− 0.19–1.32)		0.2 (− 0.27–0.68)
Cantabria				0.04 (− 0.75–0.83)		− 0.14 (− 0.69–0.42)
Castilla y Leon				− 0.22 (− 0.94–0.5)		− 0.44 (− 0.87–0)
Castile-La Mancha				0.77 (0.02–1.5)		0.3 (− 0.16–0.77)
Catalonia				0.1 (− 0.6–0.78)		− 0.05 (− 0.47–0.38)
C. of Valencia				0.28 (− 0.42–0.97)		0.08 (− 0.33–0.49)
Extremadura				1.1 (0.34–1.85)		0.67 (0.18–1.15)
Galicia				1.04 (0.25–1.81)		0.71 (0.21–1.23)
C. of Madrid	Ref	Ref	Ref	Ref	Ref	Ref
Murcia				0.75 (0.01–1.49)		0.3 (− 0.19–0.79)
Navarre				− 0.43 (− 1.18–0.3)		− 0.46 (− 0.92–0.01)
Basque Country				0.04 (− 0.67–0.78)		− 0.08 (− 0.52–0.37)
La Rioja				− 0.09 (− 0.84–0.64)		− 0.24 (− 0.71–0.25)
Ceuta-Melilla				0.65 (− 0.22–1.56)		0.28 (− 0.41–0.96)

Table 3 (continued)

	A: Socioeconomic approach		B: Regional approach		C: Socioeconomic + regional approach	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
	Simple intersectional	Intersectional interaction	Simple intersectional	Intersectional interaction	Simple intersectional	Intersectional interaction
Measures of variance						
Variance level 2						
Intersectional strata	2.63 (1.89–3.58)	0.33 (0.2–0.52)	2.31 (1.72–3.07)	0.29 (0.17–0.45)	2.65 (2.29–3.05)	0.38 (0.24–0.53)
Variance level 1:						
Individuals	18.14 (17.73–18.58)	18.13 (17.72–18.57)	18.48 (18.07–18.91)	18.48 (18.05–18.93)	17.95 (17.52–18.40)	17.96 (17.54–18.39)
ICC	12.6%	1.8%	11.1%	1.6%	12.9%	2.1%
DIC	81,483.48	81,446.37	81,756.02	81,732.52	81,879.41	81,472.00

In brackets, 95% confidence intervals (CI) are shown

ICC intra-class correlation coefficient, *DIC* Bayesian deviance information criterion

Table 4 MCMC estimated parameters, ICC and DIC. SNHS 2016/2017

	A: Socioeconomic approach		B: Regional approach		C: Socioeconomic + regional approach	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
	Simple intersectional	Intersectional interaction	Simple intersectional	Intersectional interaction	Simple intersectional	Intersectional interaction
Measures of association						
Intercept	26.10 (25.84–26.39)	25.62 (25.05–26.2)	26.13 (25.85–26.40)	25.92 (25.31–26.54)	26.26 (26.14–26.37)	25.42 (24.97–25.86)
Gender						
Males		Ref		Ref		Ref
Females		− 1.19 (− 1.47 to − 0.90)		− 1.14 (− 1.39 to − 0.90)		− 1.19 (− 1.36 to − 1.03)
Age (years)						
≤ 35		Ref		Ref		Ref
36–64		1.83 (1.46–2.19)		1.73 (1.41–2.03)		1.72 (1.50–1.95)
≥ 65		2.39 (1.99–2.76)		2.82 (2.49–3.13)		2.38 (2.12–2.64)
Income						
Low		0.52 (0.17–0.88)				0.53 (0.31–0.75)
Medium		0.19 (− 0.14–0.53)				0.22 (− 0.01–0.44)
High		Ref				Ref
Education						
Low		1.57 (1.17–1.96)				1.58 (1.31–1.84)
Medium		0.82 (0.47–1.16)				0.96 (0.76–1.16)
High		Ref				Ref
Living alone						
No		Ref				Ref

Table 4 (continued)

	A: Socioeconomic approach		B: Regional approach		C: Socioeconomic + regional approach	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
	Simple intersectional	Intersectional interaction	Simple intersectional	Intersectional interaction	Simple intersectional	Intersectional interaction
Yes		− 0.56 (− 0.86 to − 0.26)				− 0.45 (− 0.63 to − 0.26)
Region of residence						
Andalusia				0.88 (0.25–1.47)		0.40 (0.01–0.78)
Aragon				− 0.01 (− 0.73–0.69)		− 0.18 (− 0.64–0.29)
Asturias				0.73 (0.03–1.43)		0.53 (0.04–1.01)
Balearic Islands				− 0.12 (− 0.85–0.61)		− 0.41 (− 0.92–0.10)
Canary Islands				0.53 (− 0.22–1.27)		0.13 (− 0.40–0.68)
Cantabria				0.44 (− 0.38–1.27)		− 0.03 (− 0.69–0.62)
Castilla y Leon				− 0.20 (− 0.87–0.48)		− 0.50 (− 0.93 to − 0.07)
Castile-La Mancha				0.88 (0.16–1.57)		0.56 (0.06–1.04)
Catalonia				− 0.10 (− 0.76–0.54)		− 0.23 (− 0.64–0.18)
C. of Valencia				0.59 (− 0.06–1.23)		0.27 (− 0.14–0.68)
Extremadura				0.53 (− 0.16–1.21)		0.21 (− 0.27–0.68)
Galicia				0.51 (− 0.19–1.19)		0.21 (− 0.24–0.66)
C. of Madrid	Ref	Ref	Ref	Ref	Ref	Ref
Murcia				0.70 (0.03–1.36)		0.35 (− 0.11–0.8)
Navarre				0.33 (− 0.41–1.04)		0.15 (− 0.36–0.63)
Basque Country				− 0.07 (− 0.74–0.60)		− 0.27 (− 0.69–0.16)
La Rioja				− 0.04 (− 0.80–0.68)		− 0.28 (− 0.81–0.24)
Ceuta-Melilla				1.25 (0.54–2.00)		0.93 (0.37–1.49)

Table 4 (continued)

	A: Socioeconomic approach		B: Regional approach		C: Socioeconomic + regional approach	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
	Simple intersectional	Intersectional interaction	Simple intersectional	Intersectional interaction	Simple intersectional	Intersectional interaction
Measures of variance						
Variance level 2:						
Intersectional strata	2.28 (1.65–3.12)	0.29 (0.17–0.45)	1.89 (1.39–2.53)	0.23 (0.13–0.37)	2.06 (1.74–2.41)	0.39 (0.21–0.58)
Variance level 1:						
Individuals	20.10 (19.67–20.55)	20.10 (19.68–20.53)	20.50 (20.08–20.95)	20.50 (20.05–20.95)	19.95 (19.51–20.40)	19.88 (19.43–20.34)
ICC	10.2%	1.4%	8.5%	1.1%	9.4%	1.9%
DIC	96,307.70	96,275.89	96,642.63	96,613.27	96,703.18	96,278.01

In brackets, 95% confidence intervals (CI) are shown

ICC intra-class correlation coefficient, *DIC* Bayesian deviance information criterion

high education, respectively). These disparities are more pronounced in 2011/2012 (the years of economic crisis) than in other years and are larger between educational groups (Tables 2, 3, 4). Regarding the differences in BMI between Spanish regions, for the years of the economic crisis (2011/2012), those living in four of the 17 regions (Andalusia, Asturias, Extremadura and Galicia) show a higher BMI compared to Madrid (the reference region). For 2006/2007 and 2016/2017, the number of regions with statistically significant differences increased to 9 and 5, respectively (all of them, again, with positive differences, with the exception of Castilla y León that shows a lower BMI compared to Madrid in 2016/2017). Andalusia is the only region in which the BMI remained above that of Madrid throughout the entire period.

Analysis of the Variance Components

The analysis of the variance components, pursued through the calculation of the ICC in the *simple intersectional model* (model 1), indicates the relevance of socioeconomic variables during the pre- and post-crisis period as the *socioeconomic approach* (approach A) shows the greatest ICC values in 2006/2007 and 2016/2017 (i.e. 12.6% and 10.2%, respectively (Tables 2 and 4). However, in 2011/2012, the predominant approach is the *socioeconomic plus regional approach* (approach C), with an ICC of 12.9% (Table 3), suggesting the importance of considering not only the socioeconomic status, but also the region of residence in these years.

Regarding the *intersectional interaction model* (model 2), which provides information only about the effects of interaction between the variables that construct each intersectional stratum, approach A again presents the greatest ICC value in 2006/2007 (i.e. ICC (A) = 2% (Table 2)). However, in this case, approach C leads the ranking in both 2011/2012 and 2016/2017 (i.e. ICC values of 2.1% and 1.9%, respectively (Tables 3 and 4)). According to the previous explanations, as all the ICC values diverge from zero regarding all three surveys and approaches, there is evidence of interactions between these variables.

Analysis of the Strata BMI Average Values

Finally, we have analysed the estimated strata BMI average values collected in Online Resources. They show the difference between the average BMI of each stratum and the estimated BMI of the Spanish population. Therefore, a stratum with a negative average value will have a lower mean BMI than the grand mean BMI of all the strata averages, while a stratum with a positive average value will have a higher mean BMI than the average BMI of all the strata averages.

When comparing the evolution of the conclusive strata BMI average values of model 1 in approaches A and C (Online Resource 1 and 2), we can observe that from 2006 to 2011/2012, both negative and positive strata BMI average values increased their difference from the grand mean BMI of all the strata averages in both approaches (for example, strata 8 and 85 went from − 2.4 and 1.4 to − 3.1 and 2.2, respectively (Online Resource 1)), but between 2011/12 and 2017, in approach A, such differences decreased (for example, strata 3 and 103 went from − 3.3 and 2.5 to − 2.7 and 1.9, respectively (Online Resource 1)). However, approach C shows that while differences pertaining to negative strata BMI average values increased (for example, in stratum 14, from − 3.7 to − 4.1 (Online Resource 2)), the differences of the positive values were reduced to a greater extent (for example, in stratum 1585, from 2.9 to 1.5 (Online Resource 2)).

Discussion

The rising prevalence of obesity and the existence of a socioeconomic gradient related to this issue represents a challenge for public organizations due to the risks of negative effects on health and its inequalities.

Our results show that BMI increased substantially over the first years of the economic crisis, which is in line with the findings of previous studies (Norte et al., 2019; Radwan & Gil, 2014), and that this increase was more notable among people with medium and low educational attainment, like in other countries (OECD, 2017). Looking at the geographical regions, we observe that this increase in BMI during the first years of the crisis was present in all of them, with the exception of Castilla y Leon and Aragon, the only two (of 18) where BMI decreased. The socioeconomic gradient is present during the entire period under study, confirming previous findings (Ailshire & House, 2011; Costa-Font et al., 2014; Devaux & Sassi, 2013; García-Goñi & Hernández-Quevedo, 2012; Jongnam et al., 2019; Merino Ventosa & Urbanos-Garrido, 2016; OECD & EU, 2014; Raftopoulou, 2017; Rodriguez-Caro et al., 2016; WHO, 2000). In general, people with the highest BMIs in our sample have low income and low educational attainment, and the individuals with the lowest BMIs present medium/high income and a high educational level (Online Resource 1 and 2). Our results therefore show an inverse association between BMI and income, and an even more pronounced inverse association between BMI and educational attainment. Although the crisis presented an opportunity to improve the educational level of the Spanish population (the percentage of people with low education decreased in 2016/2017, compared to 2006/2007, moving to the medium education group (Table 1)), this did not translate into a reduction in BMI despite the strong link between educational attainment and obesity. With respect to the territorial dimension, we find evidence of regional inequalities in BMI along the period analysed, although these reduced during the first years of the economic crisis (2011/2012).

We can observe a widening of socioeconomic disparities in BMI over the first years of the economic crisis. The increase in the difference with respect to the grand mean of all the strata averages, with both negative and positive shrunken stratum effect values, between 2006 and 2012 (Online Resource 1 and 2) suggests that people who had a BMI lower than the grand mean in 2006/2007 had an even lower BMI in 2011/2012, while people who had a BMI higher than the grand mean in 2006/2007 had an even greater BMI in 2011/2012. Therefore, the difference between the intersectional strata located at the extreme ends of the spectrum increased from 2006 to 2012. If we consider the inverse association between socioeconomic variables and BMI, the widening of the socioeconomic gradient is clear. This is in line with another study showing an increase in the probability of being obese for the more disadvantaged social groups in 2012 (year of crisis) compared to 2006 (pre-crisis year) (Norte et al., 2019). On the other hand, the difference between the strata at the ends decreases over the period in which the crisis disappears (2011/2012–2017), which reduces the socioeconomic disparities in BMI.

One of the main causes of the economic shock lies in the housing boom (Coveney et al., 2016), which is related to the economic construction sector, in which many employees, at the time of economic expansion, were middle-aged men with low and medium education (notably, basic general education (EBG) or compulsory secondary education (ESO)) (Aparicio, 2010). Many young men abandoned their studies to enter a labour market offering high salaries, such as the construction sector (Aparicio, 2010). When the housing bubble burst, this sector was the most affected in terms of unemployment, resulting in large income losses, especially among young people (Coveney et al., 2016; OECD, 2014). This crisis caused the young to be at the greatest risk of poverty, rather than the elderly, which was common in the pre-crisis period (Fernández, 2016; OECD, 2014).

. Although men were quite affected by unemployment, especially in the first years of the crisis (INE, 2020), women also suffered from the growth of unemployment in the economic depression period and show the highest unemployment rates (INE, 2020).

This economic crisis also generated a reduction of the mean income of Spanish households (INE, 2020). This reduction has hindered access to a healthy and balanced diet (Antentas & Vivas, 2014; FEN, 2013) and generated unhealthy dietary patterns that are highly associated with low adherence to the mediterranean diet (MD). High adherence to this diet is related to a lower prevalence of high BMI and obesity (Buckland et al., 2008; Panagiotakos et al., 2006; Schröder et al., 2004). Interestingly, Bonaccio et al., (2014) observed a decrease in adherence to the MD in an Italian region in later years, possibly under the influence of the economic crisis.

The identified BMI trend motivates the question of whether policies focused on tackling obesity have been directed towards the correct targets and whether they have taken adequate account of socioeconomic and regional circumstances. This aligns with the concept of *proportionate universalism* developed by Marmot, i.e. the "attempt to marry the obvious need to work hardest on behalf of those in greatest need while preserving the universalist nature of social interventions" [97, p. 280]. The intersectional MAIHDA provides a suitable quantitative tool for aiding such attempts. According to the ICC values of model 1, socioeconomic variables had a greater influence on BMI than regional variables in non-crisis periods, while the regional variable played an important role, together with socioeconomic variables, during the economic crisis. These ICCs also show that the intersectional strata are relatively meaningful contexts with some influence on BMI and that this influence is mainly due to additive rather than interactive effects. However, the ICC values are not sufficiently high to motivate policies focused only on certain groups, but they show the relevance of regional authorities in the implementation of general interventions aiming to reduce BMI in a time of crisis. In fact, a previous study, focused on children, shows a significant inverse association between average regional public health spending and overweight/obesity rates in Spain (Carmona-Rosado & Zapata-Moya, 2022). Nevertheless, future research focused on the adult population is needed. Thus, public regional and national institutions should launch strategies aimed towards the general population while directing special attention to the strata with the greatest BMI. In addition, *proportionate universalism* fits well to address socioeconomic gradients in health, such as that observed in BMI (Fisher et al., 2021).

Our results may be prone to underestimation because the survey data are self-reported. Although people tend to undervalue their weight and overvalue their height (Gil & Mora, 2011; Livingstone & Black, 2003; Nyholm et al., 2007; Spencer et al., 2002), this bias does not largely affect the results of socioeconomic inequalities in obesity, such as income-related inequalities (Costa-Font et al., 2014). In addition, studies have found a strong correlation between self-reported BMI and measured BMI (Basterra-Gortari et al., 2008; Bes-Rastrollo et al., 2005; Savane et al., 2013). Furthermore, the surveys have the limitation that they include pregnant women who could not be identified and whose BMI may be higher due to their pregnancy.

A high number of missing values in the income variable (41%, 61% and 68% of the total missing in the SNHS 2006–2007, 2011–2012 and 2016–2017, respectively) was found in the databases, which is common for this type of health surveys. Thus, the consideration of this variable in the models, as a determinant of BMI, has led to the exclusion of a non-negligible proportion of individuals from our analysis, which could generate a selection bias if this set of missing data does not follow a random pattern. Given this concern, we have tested for potential selection bias by performing an imputation of the income variable for those individuals with missing data, as suggested by one of the reviewers, finding no evidence of selection bias in the three samples and confirming the robustness of our results.

The constructed intersectional strata are based on the available survey information as well as a theoretical basis. We are aware that a larger number of categories in the explanatory variables might have been desirable, but we are limited by the size of the samples. The larger the number of categories, the larger the number of strata and, therefore, the larger the number of strata with very few or no observations. The quantitative analysis requires that the sample be well distributed among the strata to avoid this situation. However, although strata with few individuals are observed in our study, the application of the intrinsic shrinkage factor provides reliability weighted estimations and allows for their consideration in the analysis. Further, it should be noted that another combination of variables that creates new intersectional strata could alter our results as approximately 89% of the total variability of BMI is attributable to other factors not considered in this study. Additionally, comparing many strata using 95% CI bears the risk of finding false conclusive differences. Despite this, the application of an intersectional MAIHDA has extended our knowledge of socioeconomic and regional disparities in BMI in Spain in the context of the Great Recession.

Conclusion

This is the first study addressing the impact of the post-2007 economic crisis on BMI and its inequalities in Spain. Previous research has analysed the impact on obesity (BMI $\geq$ 30 kg/m^2), with one also focusing on its effects on inequalities, but only among obese people. However, none of this previous research considered the characteristics as social contexts but as independent determinants.

In response to our first research question, we conclude that the BMI increased between 2006/2007 and 2016/2017, but especially until 2011/2012. In addition, an expansion of socioeconomic disparities in average BMI is observed during 2006–2012, corresponding with the worst years of the Great Recession, while these inequalities seem to be reduced in the post-crisis period. On the contrary, regional disparities decreased during the years of economic crisis. Future analysis of regional inequalities in BMI is needed.

Regarding the second research question, in general terms, socioeconomic variables have a great influence on BMI. However, the introduction of the regional perspective in the analyses allows for a better mapping of the distribution of BMI in the Spanish population during periods of economic recession.

The values of ICC (or VPC) for both socioeconomic and or geographical strata suggest that in spite of the differences between strata BMI averages, there is a considerable overlapping between strata in their individual distribution of BMI. Therefore, as discussed elsewhere (Merlo et al., 2019), the results of our study are in line with the notion of *proportionate universalism* (Fisher et al., 2021; Marmot, 2015), suggesting that interventions aiming to address BMI should focus on those in greatest need while maintaining the universalist nature of social interventions. The implementation of interventions to reduce obesity by public organizations should be accompanied by policies aiming to protect population from the consequences of economic crises, such as high unemployment rates, to avoid the widening of BMI inequalities. Such policies must be developed within national and regional frameworks. Particularly, according to our results, regional policies can become especially important during the periods of economic crisis.

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Data Availability Data are available from the Ministry of Health, Social Services and Equality website (https://www.mscbs.gob.es/en/estadisticas/microdatos.do) and from the Spanish National Institute of Statistics website (http://www.ine.es/dyngs/INEbase/en/operacion.htm?c=Estadistica_C&cid=1254736176783&menu=resultados&secc=1254736195295&idp=1254735573175).

Code Availability Not applicable.

Declarations

Conflict of interest Authors declare that there exists no conflict of interest or competing interests.

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