Decomposing Socio-Economic Inequalities in Obesity: Evidence from Spain

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Abstract

The obesity epidemic stands as a major food related health concern hypothetically driven by a socio-economic vector though scant evidence has been reported on the existence of socio-economic inequalities in obesity. This paper makes use of survey evidence to empirically address the hypothesis of the existence of income-related inequalities in obesity in Spain using representative data from 2003. Besides quantifying inequalities, we take advantage of a concentration index methodology that allows a decomposition of the cross-section explanatory factors. Our findings provide suggestive evidence of significant socio-economic inequalities in the probability of being obese. In decomposing such inequalities we find that education attainment has a prominent influence compared to a so-called pure “income effect”. We conclude that socio-economic inequalities in obesity result from other confounding – both observed and unobserved– -effects .

Keywords: Health Information, Obesity, Education, Income Effects, Inequality Decomposition, Concentration Index.

JEL: H51, I12, I31

1. Introduction

Obesity stands as one of the major health risk in western societies both for its high prevalence and its preventable nature (WHO, 2002). Indeed, it is rising at alarming rates throughout Europe (EOTF & EASO, 2002; Rigby and James, 2003) and estimates indicate that is responsible for 9.1% of total US medical expenditure (Finkelstein *et al*, 2003) where obesity currently affect as much as 30% of the population (Flegal *et al.*, 2002). Similarly, obesity epidemic is also progressively becoming a primary health problem in southern European countries. According to the Spanish Ministry of Health, one out of every two individuals in Spain is overweight and 14.5% are obese.[1] After the United Kingdom, Spain is the EU country with the highest increases in obesity rates over the last decade (WHO, 2002); and appears to be one of the countries where the impact of obesity on avoidable mortality is the highest, being responsible for approximately 5.5% of total mortality and about 18,000 deaths yearly (Banegas *et al.*, 2003). The so-called 'obesity epidemic' has a marked effect on mortality rates in Spain, given the association between chronic diseases and obesity (Costa-Font and Gil, 2005). Cardiovascular diseases are the first cause of death (31% men and 41% women) and digestive system disorders account for 5% of total mortality in women and 10% in men (INE, 2002). Rough estimates by SEEDO in 2000 (Spanish Society for the Study of Obesity) show that obesity could be responsible for as much as 7% of total health expenditure (Aranceta *et al.*, 2003).

[1] Furthermore, recent estimates of the WHO Monica Project find that 16% of men and 25% of women suffer from obesity in Catalonia (Evans *et al.*, 2001).

A better understanding of the socio-economic forces that lie behind the expansion of obesity is fundamental for an adequate implementation of health and food policies to both control its emergence and reduce the effects on health and well-being. Among the main issues behind the determinants of obesity lies that of disentangling the extent to which obesity or body mass gain result from individual's income – in the form of its material conditions or budget restriction- . This is especially relevant in countries that exhibit comprehensive health care coverage through a public and universal health system However, the health system alone cannot be made responsible of all sources of health inequalities. This is more the case if risks to health largely depend on their underling feeding decisions and socio-environmental factors. Findings suggesting an empirical relationship between economic modernization and obesity (Wang *et al.*, 2002) indicate that despite some countries become richer, an expansion of economic affluence does not necessarily translate into better health outcomes. Indeed, economic modernisation coexists with an increasing 'obesogenic environment' that might explain the expansion of obesity through the industrialised world. Accordingly, some stream of the literature points towards the existence of socio-economic determinants of obesity explained by the interplay of a variety of factors, including remarkable economic and social changes (Phillips and Kubisch 1985) besides pure biological and genetic factors.

1.1 Socio-Economic Position and Obesity

The hypothesis of the existence and motivation of a socio-economic status (SES) vector in the prevalence of obesity is a highly controversial issue with ample public policy implications. In a classical review of around a hundred separate studies, Sobal and Stunkard (1989) find clear-cut evidence of an association between socio-economic status and obesity. More specifically, some studies find an inverse association between social class and obesity (Sobal, 1991). Some studies suggest evidence of a socio-economic pattern behind obesity (Swanton and Frost, 2006). Environmental effects also play a role: for instance, consumption of fatty foods might well be associated with a lower SES whilst obesity prevention is less a matter of concern to the least educated and poorer individuals. Yet, little is known about the potential socio-economic vector underlying the prevalence of obesity and, especially its determinants. While some authors argue that fat storage is linked to SES (Sundquist and Johansson, 1998) more recent studies argue that inequalities in obesity have to do with gender, age and ethnicity (Dreeben, 2001, Zhang and Wang, 2004). Indeed, in a study of obesity and SES using longitudinal data, Averett and Korenman (1996) question the direction of the relationship between obesity and income. Some relevant issues are summarised in Stunkard and Sorensen (1993). Since obesity and SES influence each other, before analysing the specific association between income and health that has been the subject of a large amount of research, we need to measure, and break down, the socio-economic related inequalities in obesity. The association between obesity and SES has significant policy implications in itself, and may indirectly reveal the existence of a level of health-related inequality that may not be observable when examining self-reported health status data.

One of the potential effects of SES is its influence on lifestyle choices that in turn have an effect on food intake (Chou *et al.*, 2004). Some ‘unhealthy’ lifestyles may well be more prevalent in socio-economic groups at the tail end of income distribution. For instance, the opportunity to save time to preparing meals (Cutler *et al.*, 2003) and the lower price of fatty foods (Lakdawalla and Philipson, 2002) has exerted a greater influence on lower income groups. If this is so, then pro-active policies might have to be implemented in order to promote healthier food intake in lower socio-economic groups. Potential income inequality may reveal some prior discrimination against obese population in the labour market. Income as a proxy for socio-economic position might indicate that individuals with lower income levels suffer from the 'hierarchy effect' in which they are less likely to obtain a high return for their work, a situation that causes first anxiety and then obesity. In fact, by using microlevel data from the Behavioural Risk Factor Surveillance System covering the period 1987-1995 in the US, Ruhm (2000) finds that body mass index and obesity are inversely related to state unemployment rates.

An alternative explanation points to the fact that an association between obesity and socio-economic position may be environmentally driven. Some studies also find that knowledge of the health risks associated with obesity also deters individuals from being overweight (Kan and Tsai, 2004). However, the transmission of information is costly and unequally distributed, and benefits highly educated individuals (Bundorf *et al.*, 2004), so one might expect lower skill and lower income (Cawley, 2004) to be associated with a higher prevalence of obesity and lower health status. Socio-environmental factors exert an influence on individual's behaviour which in turn might lead to the eating of calorie-dense, industrially produced foods[2]. Furthermore, obesity may to be subject to social stigma and may cause exclusion from certain jobs (Stunkard, 2000). Hence, in the light of previous discussion we believe that a relevant policy making question refer not only to the existence of socio-economic inequalities in obesity but the main underlying factors behind.

1.2 Study Objectives

This paper contributes to the literature by examining the hypothesis of income-related inequalities in the probability of obesity as well as its decomposition on its main underlying

[2] Actually, what some groups perceive as "normal feeding" behaviour may not be perceived as such by others; for instance, thinness can be a marker of social distinction and physical activity a commoditised product (e.g., fitness clubs), so that the chances of having the right weight are likely to be associated with socio-economic conditions.

factors. We use a measure of Body Mass Index (BMI) and we undertake the study in Spain, a Mediterranean country, whose population is exposed to the well known healthy "Mediterranean diet", or where such as diet can be arguably followed at a lower price compared to other non-Mediterranean countries. On the other hand, our study undertakes a decomposition to break down inequalities, and thus quantify and compare the underlying income-related effects of a variety of covariates. Our findings indicate that there are significant income-related inequalities in the probability of being obese which are largely avoidable which are explained mainly by education and to a lesser extent by demographics, and "pure income" effects. These results are robust to the econometric specification.

The paper is structured as follows. Section 2 presents the methodology for the measurement of obesity and income-related obesity inequalities. Section 3 discusses the microdata used to perform these calculations. Section 4 reports the empirical results and section 5 concludes.

2. Methods

2.1 Conceptual background

One can conceptually refer to the health production process on the basis of a health production function (h_i):

$$h_i = h(I_i, z_i) \qquad (1)$$

where I an individual's income and z captures characteristics of each one of *i* individuals. Thus, we hypothesise that individual's income will have a positive and significant effect.

However, unobserved heterogeneity might be argued to stand behind income related effects. For instance, a high level of stress –which remains unobservable to the researcher– might be on aggregate associated with higher socio-economic status, so that income in producing health is likely to have a non-linear effect. Similarly, other unobserved variables might be indirectly captured through the effect of certain well-known variables (e.g., education, age, gender, etc.) proxies effects of unobservable variables. Therefore, the examination of income related inequalities in health related outputs such as obesity is far from straight forward.

In the light of recent literature on health inequalities some authors argue that lower socio-economic groups are more likely to suffer from socially related anxiety (Wilkinson, 1997), which may lead to higher obesity in the lower deciles of income distribution. The socio-economic determinants of obesity might come from very different pathways. Empirical evidence is still relatively scarce and mostly aimed at explaining the causes of what is known as the 'obesogenic environment' (French *et al.*, 2001). This construct is the result of the economic effects of industrialisation and urbanisation due to economic growth that has led to an increasingly sedentary workforce and lifestyle. The reduction of energy expenditure is accompanied by a dietary shift towards the consumption of increasingly high-calorie diets with a high proportion of fats, saturated fats and sugars. From an evolutionary perspective, organisms behave so as to maximise the survival of their genes. Under conditions of natural selection and food scarcity, this leads to the reproduction of the fittest individuals. Assuming individual preferences are based on an environment of this kind and scarcity periods are rare, individuals would be expected to gain weight unless an increase in physical activity counteracts such effects (Logue, 1998). This imbalance may become structural due to the excess calorie intake, which is in turn reinforced by other unhealthy lifestyles.

Some studies examine a behavioural model of obesity to explain the determinants of calorie consumption, such as changes in relative prices and the density of fast food restaurants (Chou et al., 2002), reductions in the time costs of meals (Cutler *et al.*, 2003), and unemployment and job strenuousness (Ruhm, 2000). Using time series analysis of US states for 1972 to 1991, Ruhm (2000) found that obesity increases and physical activity declines during business cycle expansions. Lakdawalla and Philipson (2002) found evidence of a robust association between physical activity and obesity. From a theoretical perspective, having the 'proper weight' is envisaged as both an input of the health production function and as an 'intermediate output' (Kenkel, 1995). Recent data indicate that obesity affects not only current, but also future consumption of health services (Daviglus *et al.*, 2004).

In addition to the economic determinants of obesity, its socio-cultural contexts are recognised as key factors explaining the development of an individual's weight. Given that obesity is household-produced, individuals' self-image and social interactions are likely to play a role in explaining their weight. Indeed, there is evidence to suggest that individuals' social interactions are not significantly independent of their body mass production (Costa-Font and Gil, 2004). At the same time, eating and physical activity patterns in industrialised nations are likely to be, to some extent, culturally driven behaviours. Wansink (2004) finds that the eating environment (that is, the environmental factors associated with food intake) is associated with the amount of food eaten. Recently, Kan and Tsai (2004) found evidence using quantile regression that knowledge of obesity risk factors affects individuals' obesity and that this affect differs for males and females. Another variable connected with health knowledge is schooling, which potentially increases the efficiency of health production (Kenkel, 2000; Grossman, 2003), and, according to the health capital theory, is likely to influence obesity by contributing to individuals' income. Finally, the effect of schooling on obesity can be explained by time preferences (Fuchs, 1982). Indeed, individuals' consumption level depends on the rate at which future health benefits are discounted in their consumption decisions, and their fitness is negatively associated with a high rate of time preference measured using country-based aggregate data (Komlos *et al.*, 2004).

2.2 Measurement of obesity

As in previous work, our measure of obesity is derived from respondents' reports of their height and weight and from the calculation of the widely accepted BMI or "body mass index" indicator (i.e., weight in kilograms divided by the square of height in metres, kg/m^2). The World Health Organisation classification defines a BMI of 25 to 29.9 kg/m^2 as overweight and a BMI of $\geq$ 30 kg/m^2 as obese.[3] Measuring BMI using self-reported rather than observational data may result in some underestimation of the prevalence of obesity, although of a modest magnitude (e.g. Quiles-Izquierdo and Vioque, 1996, Costa-Font and Gil, 2005 and 2006). Our procedure for measuring obesity involves transforming a dichotomous obesity measure (y_i) into a continuous variable by using a probit model as follows:

$$y_i = \alpha + \sum_k \beta_k x_{k,i} + \varepsilon_i \qquad (2)$$

where y_i =1 (if individual i is obese), ε_i is the random error term, x_k is a set of exogenous determinants of obesity and β_k the associated marginal effects estimates (including the constant term). From this econometric specification we derive the following measure of the probability of being obese,

$$P(y_i = 1) = \alpha + \sum_k \beta_k x_{k,i} \qquad (3)$$

[3] Although this is the most widely used measure of obesity, it poses several problems. For instance, the BMI does not take into consideration body composition (adiposity vs. lean weight) or body fat distribution. This means it may fail to predict obesity among very muscular individuals and the elderly (Kopelman, 2000).

No significant differences were found when employing a linear probability model (LPM) consistently with previous evidence (cf. Van Doorslaer and Koolman, 2004, Van Doorslaer *et al.*, 2004 and García-Gómez and López, 2004a,b Jones, 2001). Moreover, in examining the determinants of obesity we should bear in mind that certain determinants such as gender and age are unavoidable. Indeed, women have much more peripheral body fat in the legs and hips than men, and obesity is found to be higher in middle age groups (Costa-Font and Gil, 2004).

The regression model just outlined should be not seen as a structural model of obesity and the results interpreted under a "causal" relationship. But as a reduced form model whose estimates provide an indication of how exogenous changes in obesity covariates can affect the role of socio-economic inequality in obesity.

2.3 Measurement of inequality

As is common practice in the literature, we use the obesity concentration index as our measure of income-related inequalities with regard to obesity (Van Doorslaer and Koolman, 2004). The concentration index (CI) of the probability of obesity on income, can be adequately estimated, from individual level data, following the covariance approach (Jenkins, 1988) as follows:

$$CI = \left(\frac{2}{\bar{y}}\right)\text{cov}(y_i, R_i) \qquad (4)$$

where $\bar{y}$ is the average obesity rate of the sample, R_i is the income fractional rank of the ith individual (the cumulative proportion of the population ranked by income up to the ith individual) and $\text{cov}(\cdot)$ denotes the covariance. This index ranges between a minimum value of −1 up to a maximum of +1 and this occurs when all the population's obesity is concentrated in the hands of the richest and poorest person respectively. A value of zero would mean that every member has the same obesity measure or, in other words, that obesity is equally distributed over income in the sense that the *pth* percentage of the population ranked by income has exactly the *pth* percentage of total obesity for any *p*.

According to Wagstaff *et al.* (2003) there is a direct way to decompose the above mentioned degree of SES inequality into the determinants of the obesity condition. This requires first estimating the elasticity of a set of x_k exogenous covariates on the probability of obesity as described by equation (2), so that the CI can be expressed as:

$$CI = \sum_k \left(\beta_k \frac{\overline{x_k}}{\overline{y}} \right) C_k \qquad (5)$$

where $\overline{x_k}$ is the average value of x_k and C_k denotes the concentration index of x_k against income (i.e., how income is distributed over each explanatory variable of obesity). The term in brackets in equation (5) expresses the elasticity of the probability of *y* (obesity) with respect to x_k (evaluated at the population mean). Thus, if we define this estimated elasticity with respect to a specific *k* as follows:

$$\hat{\eta}_k \equiv \frac{\hat{\beta}_k \overline{x}_k}{\overline{y}} \qquad (6)$$

then we can interpret the CI of the probability of obesity on income as a weighted sum of the inequality in each of its determinants, with the weights being the elasticities of each one of the determinants,

$$\hat{CI} = \sum_k \hat{\eta}_k \hat{C}_k \qquad (7)$$

This decomposition, as pointed out by Van Doorslaer and Koolman (2004), has the advantage of clarifying how each correlate of obesity contributes to total income-related obesity inequality in two parts: (i) its impact on obesity, as measured by the obesity elasticity (η_k) along with (ii) the extent of unequal income distribution, measured by the concentration index (C_k). Following Kakwani *et al.* (1997), total inequality with regard to obesity can be usefully broken down into "potentially avoidable" and "unavoidable" or intrinsic inequality. The latter can be attributed, for instance, to differences in the age and gender composition of the population by income. Hence, it is possible to (indirectly) standardise the estimated CI of equation (7) by calculating the age-gender expected inequality (CI*) and then subtract its influence (i.e., partial effects of age and gender on obesity) from the total CI in order to obtain an estimate of the so-called potentially avoidable inequality (I*=CI−CI*).

3. Data and variable definitions

The data used in this paper were taken from the Spanish National Health Survey (SNHS) 2003 (INE, 2005). This is a biannual, cross-sectional nationally representative survey and is designed for the purpose of gathering data on aspects such as self-perceived health state of the population, primary and specialised health care utilisation, consumption of medicines, perceived mortality, life habits, conducts related to risk factors, anthropometrical characteristics, preventive practices and also socioeconomic characteristics of individuals. The SNHS-2003 follows a stratified multi stage sampling procedure where primary strata are Autonomous Communities. Then sub-strata are defined according to residence area population size. Within sub-strata, municipalities and sections (primary and secondary sampling units, respectively) are selected following a proportional random sampling scheme. Finally, individuals are randomly selected from the sections. The survey provides weighting factors to elevate estimations to the national level.

Our investigation is based on the adult questionnaire of the SNHS-2003 which was administered to 21,650 individuals from all Spanish regions aged 16-99. We dropped 472 individuals with missing values for their weight and/or height and 5,250 additional individuals with missing information on household income, a variable of interest in the investigation.. Importantly, we found that the characteristics of those individuals with missing values on income were very similar to those included in the final sample. Hence, no influence on potential sample selection was found and then the estimated sample contained 15,928 adults.

We used household income (the ranking variable) as our measure of SES. Although other variables can proxy the SES of each household (e.g., education or occupational status), our decomposition method needs a continuous measure of SES. In particular, the concept of income employed referred to the total net monthly household income. However, household earnings are measured from a categorical variable with 8 income categories or intervals. Instead of simply taking the midpoint of each income bracket, we employed an interval regression model based on information of the head of the household (age, gender, education, socioeconomic status and region of residence) to obtain a continuous household income variable (see the Appendix). Once net monthly household income was predicted we divided it by an equivalence factor (equal to the number of household members elevated to 0.5), to adjust for differences in household size. This gives us more information on individual's income to undertake our decomposition.

The explanatory variables used to estimate our regression model are explained in Table 1 and classified as follows. First, we use the logarithm of equivalent household income. Second, eight age-sex categories corresponding to groups 16-29, 30-44, 45-64, 65+ for men and women (the omitted category corresponded to women older than 65). These demographic variables constitute what can be considered as the determinants of unavoidable inequalities. Third, three education level categories (the category omitted is low education) to measure alternative effects associated with the generation of health knowledge (Kenkel, 1991). On the other hand, since obesity is essentially an imbalance between calorie intake and expenditure, we include data on physical activity, namely the frequency of physical activity both at work and during spare time. This is found to be relevant in some studies, which suggest that post-industrial societies tend to be relatively sedentary and utilise fewer calories on a daily basis (Grueber and Frakes, 2005). Indeed, it is well established that physical activity leads to weight loss because it increases the body metabolism and energy expenditure. Furthermore, we also consider as an additional obesity determinant ~~v)~~ the number of hours slept per day.

[Insert Table 1 about here]

Following previous studies revealing that smokers exhibit higher metabolic rates than non-smokers and tend to consume fewer calories (Chou *et al.*, 2004), we include as a covariate smoking habits of the adult population. However, this a potentially controversial issue given that recent evidence suggests that the fall in smoking does not necessarily contribute to rising obesity rates in the US (Gruber and Frakes, 2005). Similarly, there is still evidence of a resistance to quit smoking especially among women, especially due to a fear of weight gain. Factors associated with dietary habits are important (Boumtje *et al.*, 2005) and our data contains a set of them such as the frequency of consumption of certain foods (e.g., meat, fish, vegetables or sweets). Finally, given that Spain is a regionally heterogeneous country, we need to control for differences associated with cultural eating patterns in different areas; we therefore ~~viii)~~ include dummy variables for the eighteen Autonomous Communities or regional variables (the category omitted is Andalucia). Table 1 reports the definition, mean and standard error of the mean of the variables employed in the regression analysis.

4. Results

Our database suggests that the overall prevalence of obesity for a sample of Spanish adults aged 16-99 in 2003 was 13.95% (Table 1). This figure should be interpreted with some caution given that it is a slightly lower to the 14.5% obtained from observational measurement procedures of height and weight in Spain (Aranceta *et al.* 2003). Interestingly, Table 2 exhibits the distribution of obesity among income deciles. The data unambiguously reveal that obesity declines with an increase in economic status: while 19.3% of respondents in the lowest income decile are obese, this figure falls to 8% in the top income decile. However, in addition to the overall decline in obesity with increasing income, this pattern is monotonic across all income deciles. Similarly, Figure 1 plots the distribution of obesity among different income deciles by gender. Interestingly, we find that whilst for men there is a moderate declining pattern of obesity across income deciles, this pattern is even more pronounced among women. Effectively, while the women's obesity rate in the lowest income decile is as high as 23.53%, this figure strongly declines to 5.26% in the top income decile. Therefore, we (tentatively) conclude that there is some evidence of an income gradient underlying the prevalence of obesity.

[Insert Table 2 and Figure 1 about here]

In Table 3 we present the estimation of the maximum-likelihood marginal effects of different probit model specifications. Indeed, we have adjusted three equations adding gradually new covariates to better understand their impact on the obesity rate. As previously mentioned, these estimates are then used to calculate and decompose the CI of the probability of obesity (Van Doorslaer *et al.*, 2004). The Wald test confirms the joint significance of the coefficients of all independent variables and the Variance Inflation Factors (VIF) suggest no evidence of multicollinearity. Other diagnostic tests were computed including a Ramsey RESET test to confirm that no specification problems were present and a Hausman test suggesting that income can be treated as an exogenous variable. Finally, it is worth noting that we identified a small correlation between income and education which suggest no severe coliniarity concerns in using both of them in the same specification.

As expected, regardless of the adopted regression approach, (log) net equivalent income exerted a negative and statistically significant effect on the prevalence of obesity in equations 1 and 2, though this effect is not different from zero in equation 3. Interestingly, the prevalence of obesity increases with age. That is, younger cohorts of men and women have lower probabilities of having obesity compared to older generations, although there seems to be an inverted U-shape during the last stages of life in case of women. Effectively, compared to the reference category women aged 45-64 have higher probabilities to be obese than those aged 65 and more, as shown in equations 2 and 3 of the probit model. Furthermore, even when our 2003 database is not representative of the immigrant population, including a dummy control for migrant did not appear significant.

[Insert Table 3 about here]

Not surprisingly, higher levels of education were significantly associated with a lower weight to height ratio, in concordance with previous studies that indicate that obesity declines with knowledge of the risk involved (Kan and Tsai, 2004). The estimations reveal that individuals that have completed university degree exhibit much lower obesity prevalence (8-10%) compared to less educated people. It is also worth noting that carrying out physical activity either at work or during spare time has a statistically significant inverse effect on obesity. Similarly, smoking exerts a negative influence on the prevalence of obesity (i.e., it reduces the obesity rate between 1.8-2.2%), indicating that non-smoking might lead to an increase in an individual' body mass (Chou *et al.*, 2004). On the other hand, food consumption variables were not statistically significant with the exception of consumption of sweets. Strikingly, the consumption of this item (between 3 times per week or more to daily basis) has a negative impact on the obesity prevalence rate. Finally, Table 3 also points towards the existence of a clear-cut regional pattern (cf. Aranceta *et al.*, 2003), with comparatively low prevalence rates in Northern Spain (Asturias, Cantabria, The Basque Country and Castilla-Leon) and in Catalonia and Madrid. Other reports have also suggested that inequalities in health follow north-south patterns and, in the case of Spain, are not associated with the institutional organisation of the health system (Costa-Font, 2005).

Table 4 shows the obesity elasticity estimates (η_k) with respect each covariate and the concentration index of each explanatory variable on income.[4] The elasticity of the prevalence of obesity with respect to income, evaluated at the mean sample, is negative and significant, although the exact magnitude of the income effects might well be overestimated (Cawley, 2004).[5] That is, 1% increase in (log) household equivalent income leads approximately to 0.13-0.15 percentage points decline in the prevalence of obesity. Other significant elasticities are those of education −more importantly in case of completed intermediate education− and

[4] Given that the components of equation (7) are non-linear functions of the data with complex sampling distributions, we opted to use bootstrapping methods to derive standard errors of the concentration indices. The number of replications has been set to 100.

[5] Given than income (or education) is the key variable, we have dropped equation 3 in Table 4 since the estimated parameter of (log) equivalent income is not significantly different from zero (Table 3).

physical activity during spare-time which is responsible for a reduction in the obesity rate. Moreover, the concentration index of the log of income (0.0461) exhibits an unequal income distribution in favour of the richest shares of population, shown to be statistically significant by bootstrapped standard errors. As for the effect of age and gender we find a lower concentration of obesity among the younger and high-income groups, though this condition is more prevalent among men. Finally the more educated adults are the more strongly concentrated is health (absence of obesity) amongst the richest, while the opposite is true for low educated individuals.[6]

[Insert Table 4 about here]

Next, in Table 5 we report the estimates of income-related inequality indexes of obesity and its decomposition. As expected, the CI of the probability of being obese on income is negative and statistically significant (--0.08), indicating that there is a pro-rich income inequalities in obesity in Spain.[7] In other words, SES as measured by income is negatively related to obesity (i.e., obesity is concentrated in low income groups). This pattern of obesity inequality is much higher than that found in the US adult population (-0.055 as estimated by Zhang and Wang, 2004) though Spain's obesity rate is clearly lower.[8] Furthermore, Table 5 displays a significant estimate of probability of obesity inequality not fully explained by age and gender (I*=CI-CI*), pointing towards the existence of "potentially avoidable inequality". The resulting figure, between -0.068 and -0.075 suggests that only a modest share of income-related inequality in the probability of obesity is due to differences in the population age-

[6] These features have been observed in the EU context, for instance, by Van Doorslaer and Koolman (2004).
[7] These inequalities are roughly similar to those obtained by Costa-Font and Gil (2006a, 2008) for other chronic conditions.
[8] Notwithstanding this, our sample is not totally comparable to the one of Zhang and Wang (2004) because their dataset comprise younger cohorts (adults aged 18-60 years old) and several ethnicity groups.

gender structure. In other words, this result indicates that the largest share of existing inequalities in obesity is indeed avoidable

Some further suggestive results emerge from the preceding decomposition analysis and in particular the contributions of the explanatory variables to the degree of income-related inequalities in the probability of suffering obesity (Table 5). The most remarkable result is that education accounts for the most sizeable contribution to overall income related inequality, roughly 70% consistently with the view that knowledge might stand behind individuals' body mass above the obesity threshold. Secondly, demographics contribute between 14-20% to the obesity inequality index, whilst income alone barely explains approximately a remaining 7-8%. This means that had income been equally distributed or had income elasticity been zero, inequalities in obesity would largely remain. Finally, other factors exhibit a comparative minor contribution. In particular, those factors classified as "food habits" do not seem to convey a significant independent influence in explaining socio-economic inequalities in obesity, which implies that their effect in explaining income related inequalities, is not independent from that of income and education, or other controls.[9]

[9] As an additional piece of evidence, if we dropped education from the analysis it is found that the CI of the probability of obesity obviously decline (approximately to ~~-0.06 in the LPM and~~ -0.045 in the probit equation.); but in this new specification the key contributor to obesity inequalities becomes the demographic variable (between 66-74% in Equation 1 and 50-58% en Equation 2) an not the income.

5. Discussion

This paper has addressed an increasingly apparent food policy concern, namely the expansion of obesity in Spain, a Mediterranean country where 14% of its population is already obese. Unlike previous studies (García-Gómez and López, 2004b, Costa-Font and Gil, 2006), here we attempt to contribute both to the understanding of processes behind the development of obesity as well as to the literature on preventable or behavioural (food related) inequalities in health. Our findings suggest evidence of income related inequalities in obesity regardless of the empirical specification employed. Interestingly, roughly 70% of inequalities in obesity are explained by differences in education, thus, the acquisition of formal educational level seems to capture a large share of the income related inequality. Yet, explanations for this are contentious and could well be channelled through environmental factors, namely people who finished college spent at least 8 more years in educational system and are put in the situation to be mostly surrounded in their work environment with people like themselves. Other competing explanations point towards the role of unobserved variables such as knowledge and knowledge acquisition skills. In both cases, government actions to reduce an income gradient in obesity should coordinate several policy areas including food and health related risk communication. Our findings suggest that these policies would be even more efficient that income transfers attempting to track down inequalities.

Our results also speak to food related fiscal policy analysts as for the introduction of incentives to healthy diets through market and regulatory mechanisms. Although some research indicates that body mass is negatively associated with the real price of groceries (Cawley, 1999), other evidence (see Leicester and Windmeijer, 2005) questions possible effects of new taxes on the quantity of fat in food products. However, promoting or subsidising knowledge on healthy lifestyles (e.g., physical activity and good eating and sleeping habits) tackling especially low income individuals may well change low-income groups behaviour arguably more oriented to the consumption of junk food.[10]

Some potential caveats refer to the fact that available data on obesity is typically self-reported which could convey some underestimation bias. However, studies comparing observational and self-reported data report a significantly high correlation between the two measures (Chou *et al.*, 2004). ON the other hand, inequality estimates would not be affected, unless there is a reason for most affluent individuals not to report their true weight and height biasing the results. Another caveat worth mentioning refers to the cross-section nature of the data. Indeed, by controlling for time specific effects it is possible to incorporate som unobserved heterogeneity, though at the time of the study no suitable database was available.

[10] Some evidence from the US (McCrory *et al.*, 1999) demonstrate a positive association between the frequency of consuming restaurant food (fried chicken, pizza, hamburgers, fried fish…) an increased body fatness in adults.

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Table 1. Descriptive statistics and variable definition. SNHS-2003 (N=15,928)

Variable	Definition	Mean	s.e.
Dependent Variable:			
Obesity	Dummy variable: 1 obese; 0 otherwise	0.1395	0.0027
Explanatory Variables:			
Log. Income	Logarithm of total monthly net equivalent income	6.5187	0.0044
Intermediate education	Dummy variable: 1. completed secondary education; 0. otherwise	0.4071	0.0039
University education	Dummy variable: 1. completed university education; 0. otherwise	0.1454	0.0028
Moderate job	Dummy variable: 1. job which requires walking, carrying some weight, frequent journeys ; 0. otherwise	0.4808	0.0040
Hard job	Dummy variable: 1. hard job which requires considerable physical effort; 0. otherwise	0.1783	0.0030
Physical exercise (at leisure)	Dummy variable: 1. if the individual does physical activity during leisure time; 0. otherwise	0.4055	0.0039
Sleep	Number of hours usually slept per day	7.433	0.0117
Smoking	Dummy variable: 1. if the individual smokes; 0. otherwise	0.3032	0.0036
Meat	Dummy variable: 1. if eating frequency ranges from 3 o more times a week to daily basis; 0. otherwise	0.6898	0.0037
Fish	Dummy variable: 1. if eating frequency ranges from 3 o more times a week to daily basis; 0. otherwise	0.4396	0.0039
Green vegetables	Dummy variable: 1. if eating frequency ranges from 3 or more times a Week to daily basis; 0. otherwise	0.7145	0.0036
Sweets	Dummy variable: 1. if eating frequency ranges from 3 or more times a week to daily basis; 0. otherwise (e.g., biscuits, jams, etc.)	0.4563	0.0039
M16-29	Dummy variable: 1. male aged 16-29; 0. otherwise	0.1161	0.0025
M30-44	Dummy variable: 1. male aged 30-44; 0. otherwise	0.1517	0.0028
M45-64	Dummy variable: 1. male aged 45-64; 0. otherwise	0.1298	0.0027
M65+	Dummy variable: 1. male aged 65 and over; 0. otherwise	0.0875	0.0022
F16-29	Dummy variable: 1. female aged 16-29; 0. otherwise	0.1191	0.0026
F30-44	Dummy variable: 1. female aged 30-44; 0. otherwise	0.1456	0.0028
F45-64	Dummy variable: 1. female aged 45-64; 0. otherwise	0.1313	0.0027
Region 2	Dummy variable: 1 if resident in Aragon; 0 otherwise	0.0179	0.0010
Region 3	Dummy variable: 1 if resident in Asturias; 0 otherwise	0.0327	0.0014
Region 4	Dummy variable: 1 if resident in Balear, Is. ; 0 otherwise	0.0258	0.0013
Region 5	Dummy variable: 1 if resident in Canarias, Is. ; 0 otherwise	0.0591	0.0019
Region 6	Dummy variable: 1 if resident in Cantabria; 0 otherwise	0.0164	0.0010
Region 7	Dummy variable: 1 if resident in Castilla-Leon; 0 otherwise	0.0584	0.0019
Region 8	Dummy variable: 1 if resident in Castilla-La Mancha; 0 otherwise	0.0505	0.0017
Region 9	Dummy variable: 1 if resident in Catalonia; 0 otherwise	0.1086	0.0025
Region 10	Dummy variable: 1 if resident in Valencia; 0 otherwise	0.1016	0.0024
Region 11	Dummy variable: 1 if resident in Extremadura; 0 otherwise	0.0283	0.0013
Region 12	Dummy variable: 1 if resident in Galicia; 0 otherwise	0.0851	0.0022
Region 13	Dummy variable: 1 if resident in Madrid; 0 otherwise	0.0898	0.0023
Region 14	Dummy variable: 1 if resident in Murcia; 0 otherwise	0.0277	0.0013
Region 15	Dummy variable: 1 if resident in Navarre; 0 otherwise	0.0164	0.0010
Region 16	Dummy variable: 1 if resident in the Basc Country.; 0 otherwise	0.0633	0.0019
Region 17	Dummy variable: 1 if resident in Ceuta; 0. otherwise	0.0022	0.0004
Region 18	Dummy variable: 1 if resident in Melilla; 0. otherwise	0.0029	0.0004

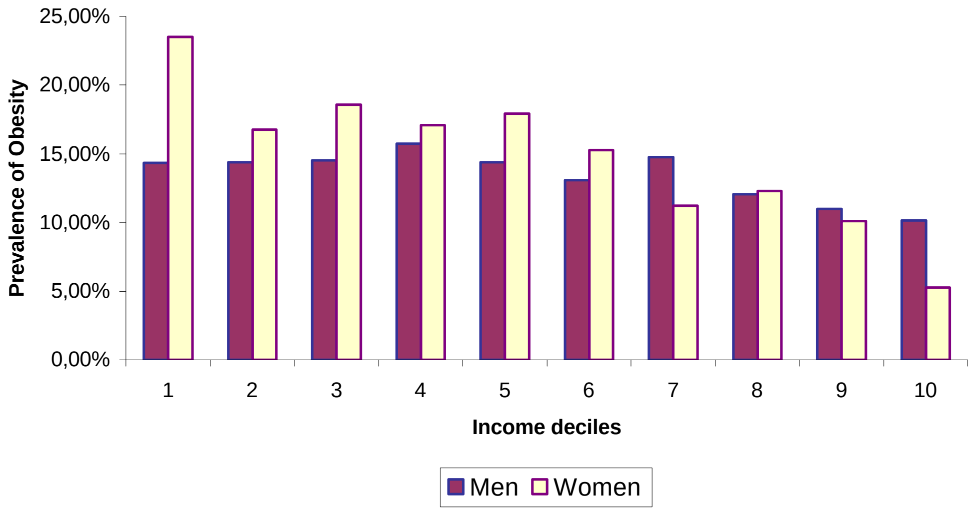
Note: Statistics calculated using sampling weights. Omitted categories: women aged 65 and more, with low education, a sedentary job (i.e., seated the majority of the working day or standing up most of the working day without carrying out large journeys or efforts) and from Region 1 or Andalucia. *Source*: SNHS− Spanish National Health Survey 2003 (INE, 2005).

Table 2. Distribution of obesity by income deciles

Income deciles	N	Mean
1	1,593	19.31%
2	1,593	15.59%
3	1,594	17.13%
4	1,592	16.43%
5	1,592	16.27%
6	1,593	14.16%
7	1,593	12.92%
8	1,593	12.18%
9	1,593	10.54%
10	1,592	7.81%
Total	15,928	13.95%

Note: (Log) equivalent income was employed as the measure to compute income deciles. *Source*: Spanish National Health Survey 2003 (INE, 2005).

Figure 1. Distribution of obesity by income deciles and gender



Note: (Log) equivalent income was employed as the measure to compute income deciles *Source:* Spanish National Health Survey 2003 (INE, 2005).

Table 3. Estimation of the obesity determinants.

	Probit Model (Marginal Effects)		
	Equation 1	**Equation 2**	**Equation 3**
Constant	------	------	------
Log. Income	**-0.0201**	**-0.0182**	-0.0105
M16-29	**-0.1046**	**-0.0902**	**-0.0940**
M30-44	**-0.0265**	-0.0081	-0.0132
M45-64	-0.0146	-0.0006	-0.0043
M65+	-0.0187	-0.0091	-0.0107
F16-29	**-0.0964**	**-0.0883**	**-0.0906**
F30-44	**-0.0656**	**-0.0563**	**-0.0594**
F45-64	0.0156	**0.0255**	**0.0231**
Intermediate education	**-0.0592**	**-0.0561**	**-0.0543**
University education	**-0.0855**	**-0.0871**	**-0.0860**
Moderate job		**-0.0185**	**-0.0217**
Hard job		**-0.0382**	**-0.0373**
Physical exercise		**-0.0366**	**-0.0343**
Sleep		-0.0038	-0.0039
Smoking		**-0.0186**	**-0.0181**
Meat		0.0024	0.0055
Fish		-0.0057	-0.0059
Green vegetables		0.0058	0.0058
Sweets		**-0.0248**	**-0.0241**
Region 2			-0.0153
Region 3			**-0.0292**
Region 4			-0.0226
Region 5			-0.0115
Region 6			**-0.0362**
Region 7			**-0.0302**
Region 8			0.0153
Region 9			**-0.0316**
Region 10			-0.0118
Region 11			0.0177
Region 12			-0.0184
Region 13			**-0.0370**
Region 14			-0.0122
Region 15			-0.0027
Region 16			**-0.0383**
Region 17			-0.0411
Region 18			-0.0272
N. of obs.	15,928	15,928	15,928
Wald test	488.08	562.76	596.28
Pseudo R^2	0.0708	0.0796	0.083

Note: Regression equations estimated using sampling weights. Marginal effects, that replace the coefficients of the probit model, allow a quantitative interpretation. Omitted categories: women aged 65 and more, with low education, a sedentary job (i.e., seated the majority of the working day or standing up most of the working day without carrying out large journeys or efforts) and from Region 1 or Andalucia. Coefficients differing significantly from zero (at P<0.05) are in bold typeface. *Source*: SNHS− Spanish National Health Survey 2003 (INE, 2005).

Table 4. Obesity elasticity and concentration index of obesity determinants

	Probit Model (Marginal Effects)		
	Obesity Elasticity Equation 1	**Obesity Elasticity Equation 2**	C_k
Log. Income	-0.1444	-0.1304	**0.0461**
M16-29	-0.0871	-0.0751	**0.0605**
M30-44	-0.0288	-0.0088	**0.1231**
M45-64	-0.0136	-0.0006	**0.1082**
M65+	-0.0117	-0.0057	**-0.2401**
F16-29	-0.0823	-0.0755	**0.0283**
F30-44	-0.0685	-0.0588	**0.1193**
F45-64	0.0147	0.0240	**0.0459**
Intermediate education	-0.1728	-0.1636	**0.1070**
University education	-0.0892	-0.0908	**0.4848**
Moderate job		-0.0637	**-0.0499**
Hard job		-0.0489	0.0036
Physical exercise		-0.1063	**0.0815**
Sleep		-0.2051	**-0.0029**
Smoking		-0.0404	**0.0563**
Meat		0.0120	**0.0383**
Fish		-0.0180	**0.0153**
Green vegetables		0.0299	**0.0196**
Sweets		-0.0812	**0.0107**

Note: C_k is the concentration index of the obesity determinants against income. Omitted categories: women aged 65 and more, with low education, a sedentary job (i.e., seated the majority of the working day or standing up most of the working day without carrying out large journeys or efforts). Statistical inference on the coefficients of C_k has been based on bootstrapping methods. When these coefficients differ significantly from zero (at P<0.05) are in bold typeface.

Table 5. Income related inequalities in obesity and its decomposition

	Probit Model (Marginal Effects)	
	Equation 1	**Equation 2**
Income-related inequalities		
CI of the probability of obesity	-0.0857	-0.0873
Avoidable inequality of obesity (I* = CI-CI*)	-0.0684	-0.0750
Decomposition		
Income	7.76%	6.87%
Demographics	20.19%	14.16%
Education	72.05%	70.44%
Physical exercise(*)		5.80%
Smoke		2.60%
Food habits		0.12%

Note: The covariate 'Sleep' is included under category Physical exercise.

Appendix. Interval regression estimation for household income. SNHS-2003

Variables	Coefficient	Std. Error	Z
Constant	-883.6364	110.9828	-7.96
Male	160.6173	23.8116	6.75
Age	53.02414	3.7612	14.1
Age square	-0.4311044	0.0347	-12.41
Primary education	172.4092	21.1725	8.14
Secondary education	519.4873	35.5059	14.63
University education	1252.239	52.2106	23.98
Employed	429.0424	34.6649	12.38
Unemployed	-112.5732	45.2676	-2.49
Region_2	-82.9182	37.6970	-2.2
Region_3	96.05939	39.0249	2.46
Region_4	349.094	55.0739	6.34
Region_5	-260.7394	34.8475	-7.48
Region_6	38.05388	49.9869	0.76
Regioin_7	-81.25286	29.7532	-2.73
Regioin_8	-97.5909	37.0973	-2.63
Regioin_9	307.2174	46.5770	6.6
Regioin_10	-91.28319	32.4263	-2.82
Regioin_11	-134.1226	40.2807	-3.33
Regioin_12	95.2971	38.0882	2.5
Regioin_13	260.3253	46.7449	5.57
Regioin_14	-189.3494	36.5480	-5.18
Regioin_15	211.6827	48.5453	4.36
Regioin_16	237.9882	45.9604	5.18
Regioin_17	-63.01413	70.7058	-0.89
Regioin_18	131.9195	58.6115	2.25
N	15,928		
Wald Test	2,394.04		
Sigma (σ)	742.740	16.905	
McFadden's Adj. R^2	0.094		

Note: Independent variables refer to the head of the household. Estimation performed using sampling weights. Inference based on robust standard errors. Reference category: female, unschooled or illiterate, inactive and residing in Andalucia. *Source*: SNHS− Spanish National Health Survey 2003 (INE, 2005).