OBESITY, SES, AND ECONOMIC DEVELOPMENT:

A TEST OF THE REVERSAL HYPOTHESIS *

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Abstract

Studies of individual countries suggest that socioeconomic status (SES) and weight are positively associated in lower-income countries but negatively associated in higher-income countries. However, this reversal in the direction of the SES-weight relationship and arguments about the underlying causes of the reversal need to be tested with comparable data for a large and diverse set of nations. This study systematically tests the reversal hypothesis using individual- and aggregate-level data for 67 nations representing all regions of the world. In support of the hypothesis, it finds not only that the body mass index, being overweight, and being obese rise with economic and social development but also that the effects of SES on these outcomes shift from positive to negative. These findings fit arguments about how health-related, SES-based resources, costs, and values change with economic development. Although economic and social development can improve health, it can also lead to increasing obesity and widening SES disparities in obesity.

1. Introduction

Already serious problems in the United States (Flegal, Carroll, Ogden, & Curtin, 2010) and other high-income nations (Roskam et al., 2010), excess weight and obesity are increasingly common in lower- and middle-income nations (Caballero, 2007; Popkin, 2009). In 2000, for the first time in history, the number of overfed people across the world, 1.1 billion in total, equaled the number of underfed people (Gardner & Halweil, 2000). In a study of 36 low- and middle-income countries, the number of overweight persons exceeded the number of underweight persons in well over half (Mendez, Monteiro, & Popkin, 2005). For example, sharp increases in obesity have occurred in Mexico, even among the poorest segments of the population (Monteverde, Noronha, Palloni, & Novak, 2010), and more than a fifth of the adult population is overweight in China, with levels rising particularly among the poor (Popkin, 2008). The global trend toward excess weight means that low- and middle-income countries face a dual health burden—they must grapple with acute and infectious diseases at the same time that chronic medical conditions associated with obesity such as diabetes, hypertension, metabolic syndrome, and disability are rising (Chopra, Galbraith, & Darnton-Hill, 2002; Kelishadi, 2007; Popkin, 2006).[1]

The classic review of Sobal & Stunkard (1989) and two recent updates (McLaren, 2007; Monteiro, Moura, Conde, & Popkin, 2004a) illustrate the changes in obesity that occur with social and economic development. Separate studies of individual nations show that high status persons tend to weigh more than others in poor countries but weigh less in rich countries. This apparent reversal in the effect of SES on weight with economic development highlights the importance of the national socioeconomic context of obesity.

2. Explanations of the Reversal

What might account for the changing influence of SES? Genetic predispositions, although related to individual weight, likely cannot explain differences in the direction of the SES gradient across regions, populations, and levels of economic development. Rather, the social environment is crucial (Caballero, 2007; Costa-Font, Fabbri, & Gi, 2010). One set of arguments focuses on how SES patterns of obesity, much like for cigarette smoking and other unhealthy behaviors (Cutler & Glaeser, 2009; Pampel, 2007), relate to the balance of the monetary costs of excess food with the health costs of excess weight for low and high SES groups in countries at different stages of economic development.

Consider first the monetary costs of excess food in poor countries. Low SES limits the resources available for excess food consumption and increases physically demanding labor, whereas high SES increases both access to excess food and avoidance of physically demanding work. These conditions limit weight gain among low SES groups and encourage weight gain among the affluent in developing countries. In rich countries with economies based largely on service and technology industries, however, most can afford high-calorie foods and avoid physical labor (Brownson, Boehmer, & Luke, 2005). Crucial to rising obesity in high-income countries, particularly among low SES groups, are 1) the changing production and price structure of calorically dense foods, stemming ultimately from technology that lowers cost per calorie (Bleich, Cutler, Murray, & Adam, 2008; Kumanyika, 2008), 2) the growth of restaurants with high-calorie selections (Chou, Grossman, & Saffer, 2004), and 3) reliance on easily prepared high calorie foods for home consumption (Cutler, Glaeser, & Shapiro, 2003).

High SES groups in high-income nations, however, counter the availability of excess food with concerns and motivations associated with the health costs of excess weight (Philipson

& Posner, 2008). Given the longevity advantages of high SES groups (Link and Phelan 1995), they arguably have more to lose from excess weight and benefit the most from healthy behavior. As monetary costs of obesity decrease for low SES groups, health costs of obesity increase for high SES groups. Although obesity rises overall with economic development, it should do so less among high SES groups (Molarius, Seidell, Sans, Tuomilehto, & Kuulasmaa, 2000; Roskam et al., 2010). In contrast, excess weight among high SES groups in low-income countries may come with fewer health costs than in high-income countries. Weak public health infrastructures, shortages of medical doctors, dangerous cities with poor air quality, and the persistence of infectious diseases may limit the survival prospects of even high SES individuals in low-income nations. Thus, while the balance of monetary and health costs leads to a direct association of SES and weight in poorer countries, it leads to an inverse association in richer countries.

Knowledge and cultural values may also play roles in the reversal. In poor countries with less developed educational systems and less scientific nutritional knowledge, the presence of malnutrition makes excess weight seem unimportant or even healthy across all groups. In rich countries, high SES groups have educational advantages for understanding the health value of proper weight, diet, and exercise (Bleich, Blendon, & Adams, 2007; Kan & Tsai, 2004) and in more effectively applying knowledge about health to everyday behavior (Mirowsky & Ross, 2003).

Cultural values can reinforce SES differences in obesity across levels of development. Preferences for thinness in high-income nations show in the stigma and bias faced by the obese, particularly those of lower SES (Bourdieu, 1984; Puhl, Heuer, & Brownell, 2010). However, excess weight in poorer countries symbolizes high status, and among men, large size can indicate power and physical prowess (McLaren, 2007). Such values may contribute to a positive association between SES and weight in low income countries.

2.1 Alternative Arguments

Plausible alternative arguments counter claims about the reversal of SES disparities in obesity. Although early studies may have demonstrated differences across levels of development, the global environment of food production and consumption may have changed enough to weaken both the positive relationship between SES and obesity in lower-income countries and the inverse relationship in higher-income countries.

In low- and middle-income countries, even low SES groups may now have sufficient access to cheap, calorie-dense, and processed food to put on excess weight (Drewnowski, 2007; Monteverde et al., 2010). A nutrition transition in developing societies has increased worldwide consumption of highly processed foods through exports, advertising, and the globalization of the agri-food system (Hawkes, 2006; Popkin, 2006). Relying less on locally produced food, low SES residents of developing countries begin to adopt a diet more similar to low SES groups in richer nations and obesity rises. Conversely, through exposure to media, high SES groups in developing countries adopt Western ideals of thinness. These concurrent trends may considerably weaken the positive relationship between SES and obesity in low income countries.

In high-income countries, the obesity epidemic could be widespread enough to affect high as well as low SES groups. The obesogenic environment in the United States and other high-income nations (McLaren, 2007) makes it hard for any SES group to avoid obesity. Some support for this claim comes from findings that as weight has risen among all SES groups, inequality in obesity has declined in Sweden (Ljungvall & Gerdtham, 2010) and the United

States (Harper & Lynch, 2007; Zhang & Wang, 2004). The pervasive pressures toward excess weight may weaken the inverse relationship between SES and obesity in higher-income nations.

To evaluate the reversal and alternative hypotheses, we investigate global patterns of body weight with an underutilized data resource that has 1) comparable health measures, 2) representative samples of individuals, and 3) a large and diverse group of countries. This improves substantially on studies that compile findings from separate studies of individual countries (Ball & Crawford, 2005; McLaren, 2007; Monteiro et al., 2004a; Sobal & Stunkard, 1989), that examine national differences for a single region such as Europe (Roskam et al., 2010; van der Wilk & Jansen, 2005), that use data for cities rather than national populations (Molarius et al., 2000), or that investigate the SES weight relationship across diverse countries but for women only (Monteiro, Conde, Lu, & Popkin, 2004b).

3. Data and methods

3.1. Data

The data come from the World Health Survey (WHS), a World Health Organization (WHO) initiative aimed at collecting high-quality individual-level health data worldwide (Üstün, Chatterji, Mechbal, & Murray, 2003). The survey took place in 70 countries during the 2002 and 2003 survey period (WHO, 2010a). Of those, 67 countries have sufficiently high quality data on height and weight to use in the analysis.[2] Consistent question formats and interview techniques create a set of comparable health indicators for a range of countries at all levels of social and economic development and allow for combination of country-level contextual measures with individual-level health data.

The WHS uses a stratified multistage cluster sampling frame to select males and females age 18 and over living in households or institutions during the survey period. The WHS nations have response rates consistently over 80 percent across all regions and weights for most nations adjust for nonresponse as well as for oversampling (WHO, 2010a). However, 16 mostly high-income nations do not report weights, and older persons and females are overrepresented in Eastern Europe.

3.2. Measures

The body mass index (BMI) is computed from self-reported weight and height, but to prevent extremely small and large values from having undue influence, we recode all values below 10 (0.17 percent of the sample) as 10 and all values above 45 (0.72 percent of the sample) as 45. We also divide the BMI into four standard categories: underweight (<18.5), normal weight (18.5 to 24.9), overweight (25 to 29.9), and obese (30 or more). Of special concern is the potential misreporting of weight and height. If reporting tends to overstate weight (relative to height) in poorer countries and understate weight (relative to height) in richer countries, it will attenuate national differences. Lacking objectively measured weight and height, our main recourse to deal with this problem involves checks to ensure that relationships are meaningful and robust with respect to alternative specifications, measures, and outliers.

Besides gender, the sociodemographic control variables include age in decades, ranging from 1.8 to 9.0 and older, and an indicator of whether the individual is married or cohabiting versus the referent which includes never married, divorced, separated, and widowed. A residence measure indicates rural (the referent) or urban living.

Education equals years of schooling completed (range: 0 to 20). An additional categorical education measure classifies education by highest level of schooling but both measures give nearly identical results, and years of schooling avoids some problems of comparability across nations in meanings of the education categories.[3] We standardize years of schooling within each nation so that education is measured relative to those in the same nation rather than in absolute terms or in comparison to all other respondents across the world.

Occupation consists of dummy variables for no job, agricultural job, manual job, and nonmanual job. There are special challenges in collecting information on occupation in countries where subsistence living reigns: In some low-income WHS countries, as many as 70 percent of individuals report having no occupation. In addition, reports on occupation may differ so greatly across agricultural and industrial nations as to reduce the reliability of the classification. The measure has value but likely not as much as education.

Rather than measure income, the WHS asks about the ownership of a list of goods. The 11 goods available for nearly all nations in the survey include items such as a bucket, bicycle, refrigerator, and computer. Following Filmer and Pritchett (2001), we create a scale based on the weights from the first dimension of a principal components factor analysis. The factor weights avoid summations that attribute equal importance to each item (e.g., a bucket and a refrigerator) and instead reflect the contribution of each item to a linear index of household goods ownership. Because the divergent meanings of the goods across countries make comparisons of absolute levels potentially misleading, the scales are centered to have a mean of zero and a standard deviation of one within each country.

The WHS does not include a current pregnancy item. Since pregnancy distorts usual standards for body weight and height and since countries vary widely in fertility levels, the lack of adjustment may bias effects at the macro level. We check on the potential bias by testing the hypotheses for women past childbearing ages.

Real gross domestic product per capita (GDP) measures the value of goods and services and is used to reflect social and economic development. GDP is associated with greater disposable income and changes in the affordability and health costs of food consumption. The measure, available from the Penn World Table (Heston, Summers, and Aten, 2009) for 2003, uses purchasing power parities to make national currencies comparable. It ranges from $358 for the Congo Republic to $61,861 for Luxembourg and is logged to reduce skew and focus on percentage differences.[4]

3.3. Missing Data

The descriptive statistics in Table 1 show considerable missing data, especially for the BMI, due to missing height or weight data. Five nations (Bangladesh, Ethiopia, Burkina Faso, Nepal, and Morocco) lack BMI data for more than half the sample, and 40 nations have missing BMI data for more than 10 percent of the sample. At the aggregate level, countries with higher GDPs and lower average levels of BMI have more missing data on the height and weight measures. At the individual level, younger, unmarried women in rural areas with low education and agricultural jobs are most likely to lack weight or height data. With more disadvantaged persons in low-income nations having less data and lower weight relative to height, the BMI scores are likely overstated in these nations which would attenuate differences with high-income nations.[5] Other measures, including occupation and household goods, have substantial missing data as well.

Table 1 About Here

Evidence from the relationships of missing data with aggregate and individual characteristics suggests the data are not missing completely at random (unconditional on the observed covariates), which makes typical approaches such as listwise deletion inappropriate (Allison, 2001). Because we cannot assume the missing data mechanism is ignorable, we use multiple imputation procedures (with the mi command in Stata 11) to estimate values for the missing data in the multivariate analyses. In the imputation phase, the procedures use a diverse set of predictors to estimate five sets of plausible values for each missing value. [6] The imputed values include a random component based on draws from the posterior predictive distribution of the missing data under a posited Bayesian model and, under the missing-at-random assumption (a more plausible assumption than is made by listwise deletion), provide unbiased estimates of variance (Allison, 2001).[7]

3.4. Estimation

Multilevel models treat level-1 individuals as nested within level-2 nations and allow level-1 effects to vary across nations. The estimates of random and fixed effects adjust for clustering by nation, different sample sizes for level-1 and level-2 units, heteroscedastic error terms, and varying numbers of cases within level-2 units – all problems that otherwise downwardly bias estimated standard errors (Raudenbush & Bryk, 2002). The linear regression estimates for the BMI and multinomial logistic regression estimates for the BMI categories come from HLM 6.08 (Raudenbush, Bryk, Cheong, & Congdon, 2004). Using the five data sets with imputed values, the multiple imputation procedure within HLM averages coefficient estimates and calculates appropriate standard errors and degrees of freedom.

4. Results

Table 2 first lists results for the individual-level determinants of the BMI for women. As shown by the coefficients for the age quadratic, body weight increases and declines, with the reversal occurring at about age 63.[8] Married women or who live in cities weigh more than their unmarried or rural counterparts. Increasing education and nonmanual work tend to lower the BMI, while BMI increases along with the household goods scale. However, based on the variance components, the effects of the SES variables vary significantly across nations.

Table 2 About Here

The next column uses the imputed data to re-estimate the model for the considerably larger sample. The results prove quite similar. The last columns in Table 2, based on multinomial logistic regression of the BMI categories for the imputed data, reveal much the same pattern of results as the linear multilevel regression. The models compare underweight, overweight, and obese categories relative to the base category of normal weight. Variables that increase the BMI in the linear model generally lower the logged odds of being underweight and raise the logged odds of being overweight and obese relative to the normal weight category. Conversely, variables that decrease the BMI generally raise the logged odds of being underweight and lower the logged odds of being overweight and obese. For example, the household goods measure does more than education or nonmanual work to reduce the logged odds of being underweight, but education and nonmanual work do more to reduce the logged odds of being overweight or obese.

The results for men in Table 3 (based on the raw and imputed data) differ in several ways from those for women. Urban residence and increasing education do less to reduce the BMI for men than women, while nonmanual work increases rather than decreases body weight for men. The effects of household goods are similar for men and women, but education and non-manual work do not reduce weight for men as they do for women. However, the effects of SES averaged across all nations may hide diverse nation-specific influences.

Table 3 About Here

At the aggregate level, higher national income is associated with higher BMI, and increases in the logged odds of being overweight or obese for both women and men. In Tables 2 and 3, logged GDP has positive effects on the BMI, being overweight, and being obese and negative effects on being underweight.

To more directly test for differences across nations in the effects of SES, Table 4 lists coefficients for interaction terms of education, nonmanual work, and household goods by either logged GDP or logged GDP and logged GDP-squared (we exclude the logged GDP-squared term when it is insignificant).[9] According to the reversal hypothesis, which posits increasing disparities at high levels of social and economic development, the slopes for SES should become more negative at higher levels of GDP.

Table 4 About Here

To summarize the results in Table 4, the interactions consistently confirm the reversal hypothesis. The slopes for education, being a nonmanual worker, and household goods become more negative at higher levels of development. For women, the negative coefficients for education by logged GDP in the equations for the BMI, being overweight, and being obese reflect an increasingly negative effect – or increasing disparities – in high-income nations. The same negative interaction terms show for nonmanual work and household goods. The effects for women are nearly all linear. For men, the same pattern of interaction emerges, but the pattern of SES effects is sometimes curvilinear.

To help make sense of the patterns described by the interaction coefficients, Figure 1 graphs how the *slopes* of the SES variables vary with logged GDP. Figure 1a shows that the slopes for education on the BMI shift linearly from positive to negative for women and become increasingly negative at the highest levels of logged GDP for men (after rising from low to moderate levels). For both females and males, the benefits of education for lower weight and the size of educational disparities in the BMI rise with GDP. The same shows in Figures 1b and 1c, which plot the logged odds coefficients for underweight, overweight, and obesity among females and then males. For females, the slopes for education on the logged odds of being overweight and obese shift from positive to negative. For males, the slopes on overweight and obesity shift from positive to negative after an initial rise. The graphs thus depict a clear reversal in the slopes of education on weight as GDP increases. Note, however, that the slopes for education are generally smaller for men than women.

Figure 1 About Here

Much the same patterns show for nonmanual work (Figures 1d-1f) and household goods (Figures 1g-1i). Females show near linear declines in the slopes of the SES variables on the BMI, overweight, and obesity, while males show either a decline or a rise and decline in the slopes. Again, the shifts are smaller for men than women, but both genders give support to the reversal hypothesis.

4.1. Robustness Checks

With only 67 nations, substantial missing data, and limited measures, the aggregate results reported in Table 4 might be highly sensitive to regional differences, age, and outlying nations. First, the diverse slopes of SES on weight across nations may stem from regional differences rather than economic development. Historical and cultural sources of body ideals may differ substantially across regions but remain largely stable with increases in economic and social development. If so, the interactive influence of GDP should disappear with regional controls. Since region and GDP are closely related, one would expect a reduction of GDP's influence with controls for correlated regional variables. But if the influence of GDP remains, it implies that GDP interacts with SES within as well as across regions and lends confidence to the findings.

Dividing the WHS nations into six regions based on the WHO (2010a) classification, creating dummy variables for five of the regions, and re-estimating the interaction models with the region controls produces the results in column 1 of Table 5. For women, the coefficients for the interaction of logged GDP with the SES variables are attenuated but remain significant with the region controls. For men, the interactions fall from significance for nonmanual work, but a linear interaction remains significant for education and a non-linear interaction remains significant for household goods. Thus, SES differences in body weight across levels of development stem partially from regional differences, but for the most part, the interactions hold within as well as across regions.

Table 5 About Here

Second, since propensities for overweight and obesity vary across the life course, age may also modify the impact of SES. Moreover, the lack of a measure of pregnancy status requires tests at ages where pregnancy is rare. Table 5 presents the coefficients for the interactions between SES and logged GDP from the BMI models for women and men ages 18 to 40 and 41 and over. For women in particular, the results show increases in the size of the interaction slopes from the younger to older age group. The tendency for the relationship between individual-level SES and weight to change direction with increasing GDP emerges as strongly, or more strongly, among older adults than among younger adults. That both age groups and genders show the reversal suggests that pregnancy among women does not greatly bias the results.

Third, the slopes of the level-2 logged GDP variable on both weight and the SES-weight slope might be sensitive to outlying nations. To check on this possibility, we saved the empirical Bayes estimates of the education slopes for each nation, and obtained dfbetas from regressing the estimates on logged GDP. For women, six nations, Kenya, Ghana, Malawi, Ethiopia, Congo, and Norway, had dfbeta values greater than the standard cutoff (the absolute value of $2/\sqrt{N_2}$ where N_2 equals 67). For men, six nations, Nepal, Congo, Chad, Zimbabwe, Malawi, and Norway, had dfbeta values greater than the cutoff. The influential nations are eliminated in Table 5 and results prove quite similar to those for all nations. For men, the curvilinear change in SES slopes with GDP proves weaker without the outlying nations, but the decline remains significant. Overall, influential nations do not distort the conclusions.

5. Discussion and conclusion

Increases in excess weight across the world may hinder improvements in the health of populations. Excess weight and especially obesity contribute to a host of chronic conditions and premature mortality in the developed world (Flegal et al., 2005) and threaten to do the same in the developing world (Popkin, 2009). This comes at a time when developing nations continue to suffer from morbidity and mortality risks from infectious diseases. Although economic and social development improves health, such progress can also create new concerns. As nations develop, problems of malnutrition are replaced by problems of over-consumption that differentially affect SES groups. Obesity disparities may widen, worsening health and mortality prospects most for the least advantaged.

A robust test of the reversal hypothesis among a diverse set of nations representing all regions of the world and using multiple measures of SES lends insight into the complex relationships between SES and excess weight. Our results show that higher SES (measured in several ways) has a positive relationship with BMI in low GDP nations, but the relationship becomes negative in high GDP nations. The patterns differed for men and women, with the shift from a positive to a negative relationship between SES and weight occurring more linearly for women than men, but both sexes showed widening SES disparities at higher levels of economic and social development.

Investigating changes in social patterns of obesity has been logistically difficult because of a lack of consistent data collection across regions of the world. Collating the findings of diverse studies (McLaren, 2007; Monteiro et al., 2004a) and combining different data sets (Monteiro et al., 2004b) have worked well to identify differences in the influence of SES across levels of development. Yet, the WHS provides a unique resource to both confirm and improve on previous estimates by gathering height and weight data in near identical ways for representative samples, for both men and women, and in countries that represent all regions of the world.

Despite comparability of the WHS measures, these results should be interpreted with caution. The data face well documented biases in the use of self-reported weight and height (Deurenberg, Yap, & van Staveren, 1998). Any such biases may be exacerbated when making comparisons across nations with varied levels of national income and varied cultural ideals about weight. The difficulty of obtaining objective measures of weight and height in surveys of dozens of countries forces reliance on self-reports. A body of work documents that calculations based on self-reports may not be ideal, but they can be thought of as reliable (Spencer, Appleby, Davey, & Key, 2002; Denney, Krueger, Rogers, & Boardman, 2004). Self-reports are associated with overall and cause-specific mortality in ways that are similar to BMIs that come from objectively measured height and weight (Prospective Studies Collaboration, 2009; Rogers, Hummer, and Krueger, 2003), and studies have found similar results when using both self-reported and measured weight and height to make comparisons across nations at different levels of development (McLaren, 2007).

While misreporting is a well-documented problem, missing data on height and weight is an equally pressing concern. If understanding obesity on a global level is worthwhile, researchers are forced to deal with the problem of missing data using rigorous, though not flawless, techniques, such as multiple imputation. But the ultimate goal should be consistently collected and accurate data on weight across the globe, particularly for developing countries where current economic and nutritional transitions may both help and in some ways harm their populations. The WHS does well in the span of countries and consistency of data gathering. The challenge for organizations charged with data collection is, and will continue to be, finding innovative ways to obtain these data, within budgetary constraints.

Finally, the data do not allow for precise tests of the causes of the reversal, but several theoretical perspectives help make sense of our findings and drive policy considerations. In low-income nations, high SES may enable the consumption of high calorie foods, while allowing the avoidance of physically demanding tasks. In contrast, high SES individuals in high-income nations may have the most to lose from excess weight and may be most likely to eat healthily and exercise regularly. Knowledge about the health consequences of excess weight or how to manage one's weight may help drive the reversal, in part, because it is most prevalent among high SES individuals in high-income societies. In turn, low SES individuals in low-income countries may have low body mass not due to knowledge about the harms of excess weight, but because they cannot afford additional calories and have strenuous lives. Finally, if thinness is valued by high status individuals in high-income countries and plumpness is valued among high status individuals in low-income countries, cultural values may shape the reversal. Future research could examine the credibility of these arguments. Doing so would go a long way toward clarifying worldwide obesity scenarios and provide leverage for policy makers to meet the challenges of obesity head on, especially in low- and middle-income countries with large disadvantaged populations at risk of weight gain as their country experiences development.

ENDNOTES

[1] The relationship of obesity to mortality is the subject of some controversy – see Campos, Saguy, Ernsberger, Oliver, & Gaesser (2006) and Kim & Popkin (2006) for competing sides of the debate – but a conservative estimate is that obesity is associated with about 112,000 deaths a year in the United States alone (Flegal, Graubard, Williamson, & Gail, 2005).

[2] Turkey and Zambia lack data on most variables, and Mali has a mean BMI score of 36.4 that appears implausibly large – higher by a substantial amount than the next largest national mean of 24.5 – and likely has invalid data. All three nations are excluded from the analyses.

[3] Among cases with a score for the categorical measure of education, 10 percent lack the exact number of years of schooling. We use the categorical measure to estimate missing data for years of schooling, and checks show that using the estimated values do little to change the results.

[4] A second measure, the Human Development Index (HDI), comes from the United Nations (2005) and extends the focus on GDP to include measures of life expectancy and literacy. Analyses using the HDI give quite similar results to those using logged GDP.

[5] Missing data and the mis-reporting problems associated with self-reported height and weight calls for a comparison between the WHS and other available data across the world. Such an inquiry through the WHO Global Infobase (2010b) uncovered relatively scarce data with widely varying sampling procedures and quality. Nonetheless, a crude comparison of WHS data to all other sources combined found that the WHS data on height and weight are at least as good as these other sources (*r* exceeded 0.70 for men and women).

[6] For the variables with the most missing data (BMI, urban residence, occupation, and income), the predictors used in the imputation models (including measures at the individual and aggregate level) explain 20 to 30 percent of the variance.

[7] We also performed a multiple imputation analysis for the predictors but not the BMI outcome. The results differed little from those reported for the more extensive imputations that include the outcome variable—the approach that is often recommended in the statistical literature (Alison 2001).

[8] Cohort influences may be involved as well, but the rise and decline in weight with age appears less consistent with a cohort effect, which would tend to produce a steady rise in weight across generations. Although both age and cohort may be involved, a life course effect appears dominant.

[9] Rather than including all interactions together, the models add interactions involving one SES variable at a time. The table thus reports results, first for females and then for males, from a separate model with the education interactions, another model with nonmanual interactions, and a third model for the household goods interactions.

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Table 1. Descriptive Statistics: WHS Females and Males

	Females		Males		Min	Max
	N	Mean	N	Mean	Value	Value
BMI	125319	24.26	105177	24.17	10	45
Underweight	125319	0.09	105177	0.07	0	1
Normal	125319	0.55	105177	0.56	0	1
Overweight	125319	0.24	105177	0.27	0	1
Obese	125319	0.12	105177	0.09	0	1
Age	169455	4.03	132091	3.93	1.8	9
Married	168754	0.64	131441	0.66	0	1
Urban	160035	0.55	125356	0.53	0	1
Education	169238	-0.04	131779	0.17	-4.78	5.05
Not Working	163670	0.62	127152	0.28	0	1
Agriculture	163670	0.09	127152	0.22	0	1
Manual	163670	0.09	127152	0.27	0	1
Nonmanual	163670	0.20	127152	0.24	0	1
HH Goods	163980	0.06	127715	0.09	-6.54	10.40
GDP	169698	112.03	132243	106.30	3.58	618.61
Listwise N	110657		93876			

Table 2. Individual- and Nation-Level Effects (b listed above t value) for Multilevel Models of the BMI and BMI Categories: WHS Females

Predictors	Raw Data Linear BMI	Raw Data Variance Components [a]	Imputed Data Linear BMI	Imputed Data Multinomial Logit of BMI Categories [b] Under	Over	Obese
Constant	24.36	2.80***	24.35	-2.06	-0.77	-1.67
Age	2.13***		1.71***	-0.37***	0.60***	0.94***
	10.03		10.76	-5.76	9.70	11.39
Age 2	-0.17***		-0.12***	0.03***	-0.04***	-0.07***
	-7.16		-7.19	4.44	-6.17	-8.03
Married	0.60***		0.65***	-0.29***	0.27***	0.20***
	8.94		10.65	-8.97	9.25	6.54
Urban	0.39***		0.37***	-0.08	0.15***	0.18**
	4.71		5.71	-1.91	4.68	3.47
Education	-0.24***	0.36***	-0.20***	-0.04	-0.11***	-0.16***
	-3.68		-3.85	-1.71	-5.05	-4.96
Agriculture	-0.67***		-0.67***	0.06	-0.25**	-0.41***
	-4.09		-5.72	1.01	-3.33	-3.76
Manual	0.26**		0.33***	-0.17*	0.09*	0.09
	2.96		4.12	-2.65	2.53	1.76
Nonmanual	-0.33**	0.85***	-0.32***	-0.17*	-0.12**	-0.27***
	-3.53		-4.02	-2.47	-3.31	-4.87
HH Goods	0.17**	0.29***	0.16**	-0.09***	0.05**	0.07*
	2.76		3.18	-5.27	2.97	1.98
Logged GDP	0.38**		0.44**	-0.31***	0.11*	0.23**
	2.85		3.29	-4.38	2.62	3.15
N Level 1	110657		169632	169632		
N Level 2	63		67	67		

* p < .05 ** p < .01 *** p < .001

[a] Without logged GDP [b] Base category = normal weight

Table 3. Individual- and Nation-Level Effects (b listed above t value) for Multilevel Models of the BMI and BMI Categories: WHS Males

Predictors	Raw Data Linear BMI	Raw Data Variance Components [a]	Imputed Data Linear BMI	Imputed Data Multinomial Logit of BMI Categories [b] Under	Over	Obese
Constant	24.42	3.15***	24.47	-2.74	-0.70	-2.01
Age	1.71***		1.45 ***	-0.41 ***	0.62***	1.02***
	13.35		13.42	-5.11	10.61	10.85
Age 2	-0.15***		-0.12	0.04 ***	-0.05***	-0.08***
	-12.15		-11.95 ***	5.14	-9.23	-9.04
Married	0.59***		0.64	-0.22 **	0.31***	0.41***
	11.27		11.98 ***	-3.38	7.54	9.49
Urban	0.05		0.03	0.02	0.07	0.02
	0.43		0.39	0.41	1.88	0.32
Education	-0.02	0.18***	-0.02	-0.09 **	-0.03	-0.08*
	-0.50		-0.70	-3.23	-1.80	-2.46
Agriculture	-0.28*		-0.23 *	-0.17 **	-0.07	-0.31***
	-2.24		-2.29	-3.01	-1.29	-4.39
Manual	0.13		0.26 **	-0.29 ***	0.14***	0.05
	1.49		3.34	-4.29	4.43	0.95
Nonmanual	0.22*	0.50***	0.31 ***	-0.33 ***	0.21***	0.04
	2.53		4.19	-5.26	5.09	0.66
HH Goods	0.29***	0.20***	0.29 ***	-0.15 ***	0.13***	0.16***
	6.62		8.01	-4.28	8.18	6.03
Logged GDP	0.92***		0.87 ***	-0.57 ***	0.34***	0.49***
	6.48		6.21	-6.43	6.13	5.54
N Level 1	93876		132203	132203	132203	132203
N Level 2	63		67	67	67	67

* p < .05 ** p < .01 *** p < .001
[a] Without logged GDP
[b] Base category = normal weight

Table 4. Individual- and Nation-Level Interaction Effects (b listed above t value) for Multilevel Models of the BMI and BMI Categories: WHS Females and Males [a]

	Females				Males			
	Linear	Multinomial Logit of BMI Categories [b]			Linear	Multinomial Logit of BMI Categories [b]		
	BMI	Under	Over	Obese	BMI	Under	Over	Obese
Education	-0.23***	-0.02	-0.11***	-0.13***	-0.07*	-0.12*	-0.03	-0.05
	-4.75	-0.76	-4.75	-4.37	-2.03	-2.64	-1.35	-1.65
Education x	-0.33***	0.02	-0.13***	-0.20***	0.57***	0.04	0.35**	0.43**
Logged GDP	-8.11	0.90	-8.13	-7.75	4.05	0.24	3.36	2.70
Education x					-0.09***	0.00	-0.05***	-0.07**
Logged GDP ^{2}					-5.51	-0.21	-4.25	-3.74
Nonmanual	-0.13	-0.20**	-0.06	-0.08	0.27**	-0.36***	0.22***	0.05
	-1.35	-3.34	-1.32	-1.27	3.62	-4.22	5.40	0.85
Nonmanual x	-0.48***	-0.13*	-0.15***	-0.37***	-0.22**	-0.02	-0.09*	-0.16**
Logged GDP	-6.59	-2.15	-4.41	-6.77	-3.16	-0.34	-2.58	-2.82
HH Goods	0.12**	-0.08**	0.05*	0.09**	0.23***	-0.14***	0.13***	0.18***
	3.21	-3.55	2.53	3.29	6.60	-4.04	7.08	5.61
HH Goods x	-0.28***	-0.01	-0.11***	-0.17***	0.41*	0.06	0.24*	0.31*
Logged GDP	-9.18	-0.43	-7.27	-6.76	2.31	0.36	2.63	2.29
HH Goods x					-0.07**	-0.01	-0.04**	-0.05**
Logged GDP ^{2}					-3.29	-0.35	-3.55	-3.24

* $p < .05$ ** $p < .01$ *** $p < .001$

[a] Interactions of education, nonmanual work, and household goods are added separately to the models

[b] Base category = normal weight

Table 5. Robustness Checks on Individual- and Nation-Level Interaction Effects (b listed above t value) for Multilevel Models of the BMI and BMI Categories: WHS Females and Males [a]

Females	Region Controls		Ages [b] 18-40		Ages [b] 41+		Omit 6 Nations	
Education	-0.23	***	-0.26	***	-0.08		-0.27	***
	-4.88		-5.26		-1.28		-5.47	
Education x Logged GDP	-0.18	**	-0.19	***	-0.46	***	-0.32	***
	-2.91		-4.46		-8.75		-7.90	
Nonmanual	-0.14		-0.01		-0.03		-0.19	
	-1.51		-0.11		-0.24		-1.99	
Nonmanual x Logged GDP	-0.33	**	-0.21	*	-0.86	***	-0.47	***
	-2.74		-2.27		-7.17		-5.43	
HH Goods	0.12	**	0.04		0.34	***	0.09	*
	3.06		1.09		6.23		2.23	
HH Goods x Logged GDP	-0.18	*	-0.22	***	-0.36	***	-0.28	***
	-2.54		-7.50		-7.05		-8.93	
N	169632		93436		75953		156822	

Males	Region Controls		Ages 18-40		Ages 41+		Omit 6 Nations	
Education	-0.08	*	-0.09	*	-0.05		-0.06	
	-2.07		-2.53		-0.94		-1.61	
Education x Logged GDP	0.53	**	0.44	**	0.63	**	0.52	*
	2.85		2.79		3.26		2.21	
Education x Logged GDP ^{2}	-0.08	**	-0.06	**	-0.10	***	-0.09	**
	-3.39		-3.43		-4.42		-3.39	
Nonmanual	0.26	**	0.44	***	0.07		0.27	**
	3.70		5.43		0.58		3.65	
Nonmanual x Logged GDP	-0.03		-0.13		-0.31	**	-0.30	***
	-0.28		-1.54		-2.76		-4.24	

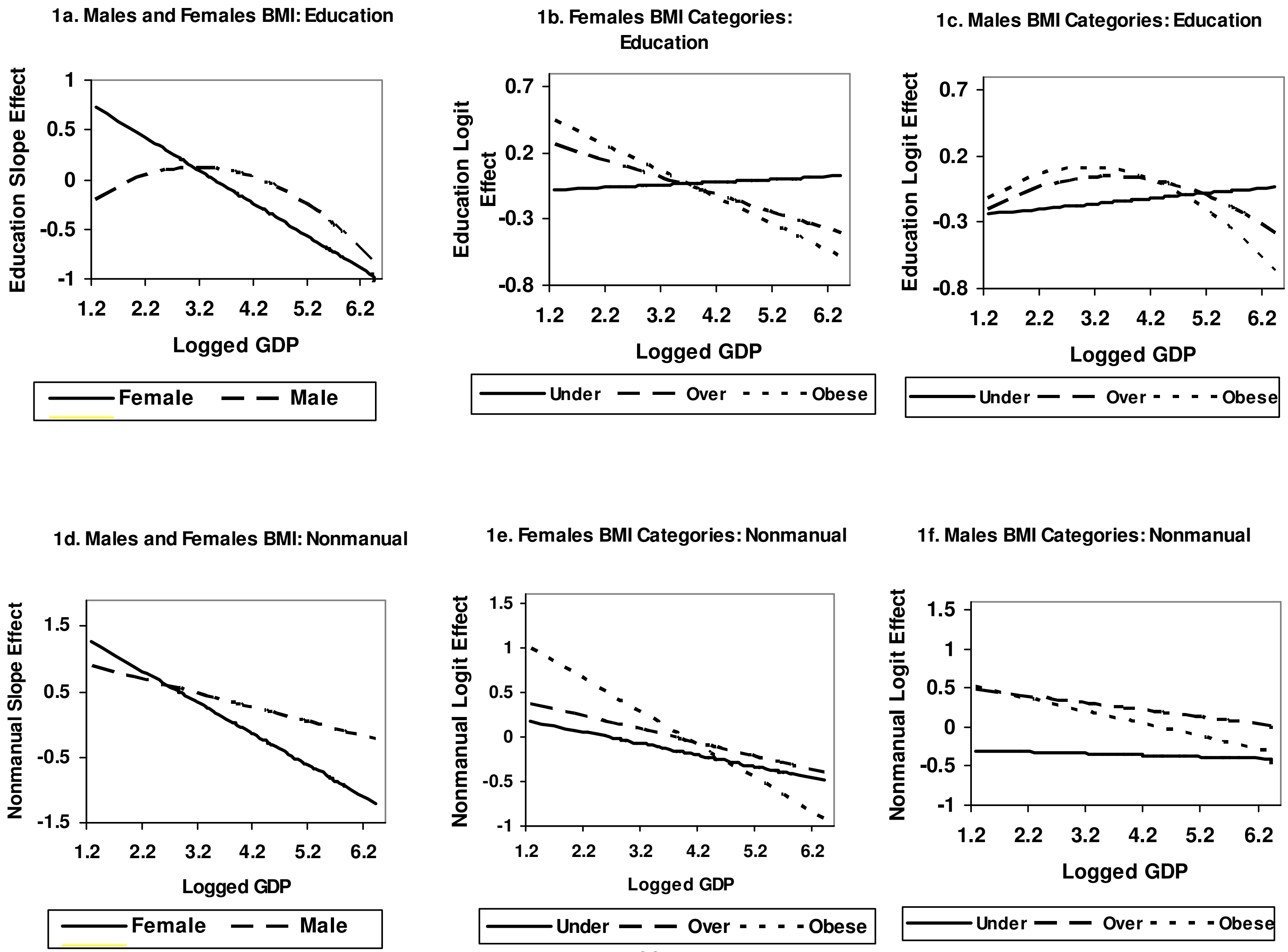
HH Goods	0.23	***	0.24	***	0.33	***	0.23	***
	6.44		6.50		5.51		6.11	
HH Goods x Logged GDP	0.36		0.25		0.48		0.40	
	1.51		1.29		1.94		1.49	
HH Goods x Logged GDP ^{2}	-0.06	*	-0.04		-0.08	**	-0.07	*
	-2.11		-1.75		-2.84		-2.31	
N	132203		70728		61323		120322	

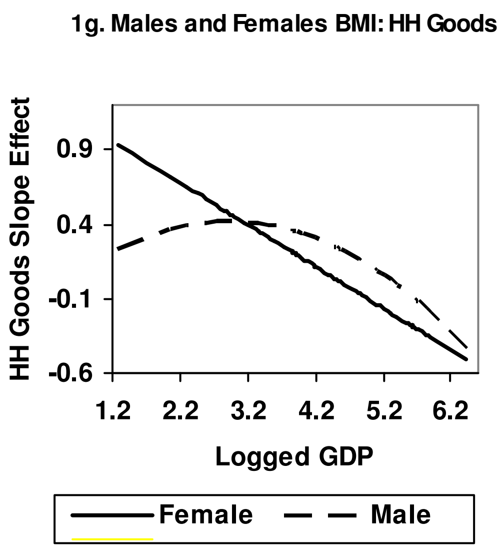
* p < .05 ** p < .01 *** p < .001

[a] Interactions of education, nonmanual work, and household goods are added separately to the models

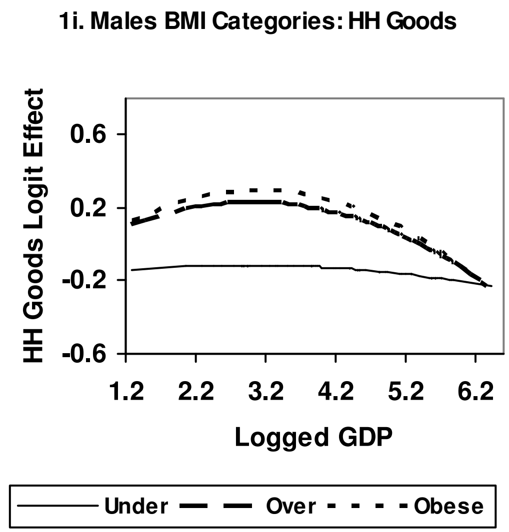
[b] Age groups based on reported rather than imputed age

Figure 1. SES Effects on the BMI and BMI Categories by Logged GDP




1g. Males and Females BMI: HH Goods
HH Goods Slope Effect
0.9
0.4
-0.1
-0.6
1.2
2.2
3.2
4.2
5.2
6.2
Logged GDP
Female
Male


1h. Females BMI Categories: HH Goods
HH Goods Logit Effect
0.6
0.2
-0.2
-0.6
1.2
2.2
3.2
4.2
5.2
6.2
Logged GDP
Under
Over
Obese


1i. Males BMI Categories: HH Goods
HH Goods Logit Effect
0.6
0.2
-0.2
-0.6
1.2
2.2
3.2
4.2
5.2
6.2
Logged GDP
Under
Over
Obese