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Original Contribution

Cross-National Comparisons of Time Trends in Overweight Inequality by Socioeconomic Status Among Women Using Repeated Cross-Sectional Surveys From 37 Developing Countries, 1989–2007

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Chronic diseases are now among the leading causes of morbidity and mortality in lower income countries. Although traditionally related to higher individual socioeconomic status (SES) in these contexts, the associations between SES and chronic disease may be actively changing. Furthermore, country-level contextual factors, such as economic development and income inequality, may influence the distribution of chronic disease by SES as well as how this distribution has changed over time. Using overweight status as a health indicator, the authors studied repeated cross-sectional data from women aged 18–49 years in 37 developing countries to assess within-country trends in overweight inequalities by SES between 1989 and 2007 ($n = 405{,}550$). Meta-regression was used to examine the associations between gross domestic product and disproportionate increases in overweight prevalence by SES, with additional testing for modification by country-level income inequality. In 27 of 37 countries, higher SES (vs. lower) was associated with higher gains in overweight prevalence; in the remaining 10 countries, lower SES (vs. higher) was associated with higher gains in overweight prevalence. Gross domestic product was positively related to faster increase in overweight prevalence among the lower wealth groups. Among countries with a higher gross domestic product, lower income inequality was associated with faster overweight growth among the poor.

developing countries; economic development; health status disparities; obesity; overweight; socioeconomic factors

Abbreviations: GDP, gross domestic product; SES, socioeconomic status; SII, slope index of inequality.

Overweight and obesity are major risk factors for diabetes, cardiovascular disease, and hypertension (1) and have increased dramatically in developing countries around the globe (2). In higher income countries, populations of a lower socioeconomic status (SES) suffer disproportionately from overweight and related comorbidities (3), and, traditionally, the opposite has been true in lower income countries (4). However, recent cross-sectional studies suggest the distribution of overweight by SES may have changed in some lower income countries, and that lower SES populations in some of these countries currently have a higher prevalence of overweight, mimicking long-standing associations between low SES and poor health in high-income countries (5–7). These recent studies are limited in that they capture only a single point in time and/or only a single country. Investigating changes in SES-specific overweight prevalence over time can determine whether new SES-based disparities in this health indicator are emerging in lower income countries.

Furthermore, country-level contextual features have previously been associated with the distribution of overweight by SES (4, 5, 8). For instance, higher country-level economic development has previously been associated cross-sectionally with an inverse relation between SES and overweight (4, 5). Stronger evidence for the role of economic development as a driving factor in the social patterning of obesity could be provided by examining whether within-country level of gross domestic product (GDP) and growth

Table 1. Age-standardized Overweight[a] Prevalence (SE) by Wealth Quintile and SII for Overweight[b] for Women in 37 Developing Countries[c], First and Final Survey Years, 1989–2007

Country	Year	Age-standardized Prevalence of Overweight (SE) by Wealth Quintile					SII
		Quintile 1 (Lowest)	Quintile 2	Quintile 3	Quintile 4	Quintile 5 (Highest)	
Armenia	2005	49.0 (3.7)	46.6 (3.8)	47.0 (4.2)	45.0 (3.7)	42.4 (5.8)	7.3
Armenia	2000	42.0 (2.1)	42.0 (2.7)	45.1 (3.2)	49.0 (2.9)	39.1 (2.7)	−0.6
Bangladesh	2007	2.3 (0.5)	3.1 (0.8)	5.5 (1.0)	13.8 (1.5)	31.4 (1.8)	−34.8
Bangladesh	1996	0.7 (0.3)	0.5 (0.2)	1.2 (0.7)	1.6 (0.5)	12.8 (2.4)	−11.4
Benin	2006	6.8 (0.7)	10.1 (0.8)	13.4 (0.9)	23.7 (1.3)	38.9 (1.4)	−39.3
Benin	1996	7.1 (2.1)	9.5 (2.5)	6.8 (1.8)	13.5 (3.0)	27.5 (3.6)	−18.5
Bolivia	2003	34.9 (1.6)	44.6 (1.9)	57.4 (1.6)	59.9 (1.9)	58.4 (1.8)	−30.6
Bolivia	1994	22.2 (2.4)	31.0 (3.2)	50.9 (2.4)	45.8 (4.1)	46.2 (3.6)	−33.9
Burkina Faso	2003	2.1 (0.5)	2.9 (0.5)	3.6 (0.6)	6.4 (0.9)	31.2 (2.1)	−30
Burkina Faso	1992	3.6 (1.0)	2.6 (0.7)	5.8 (1.4)	7.0 (1.0)	19.9 (1.7)	−17.9
Cambodia	2005	3.7 (0.7)	6.5 (1.3)	5.6 (1.1)	12.5 (1.5)	21.6 (2.2)	−21.8
Cambodia	2000	2.9 (0.7)	3.8 (0.8)	4.7 (0.9)	7.2 (1.3)	15.3 (2.3)	−13
Cameroon	2004	12.4 (1.5)	16.5 (1.9)	31.4 (2.6)	42.4 (2.4)	54.4 (3.0)	−55.3
Cameroon	1998	8.2 (1.6)	12.2 (2.2)	26.7 (4.6)	34.6 (3.2)	38.6 (3.1)	−42.5
Chad	2004	4.1 (1.2)	5.3 (1.7)	4.7 (1.8)	8.0 (1.7)	24.3 (2.1)	−20.1
Chad	1996	2.4 (0.7)	3.1 (1.0)	2.1 (0.8)	5.5 (1.7)	15.4 (1.7)	−13.4
China	2006	15.7 (2.6)	18.2 (1.9)	21.7 (1.7)	19.2 (1.7)	17.8 (2.5)	−0.4
China	1989	10.8 (3.7)	8.4 (1.1)	14.6 (2.1)	12.7 (1.7)	11.4 (1.3)	−4.5
Colombia	2005	40.8 (1.1)	48.2 (1.1)	49.2 (1.2)	49.2 (1.3)	46.3 (1.7)	−6.2
Colombia	1995	34.9 (2.2)	55.2 (2.0)	47.2 (2.6)	45.8 (5.0)	53.3 (2.2)	−13
Cote d’Ivoire	1998	4.4 (1.4)	11.9 (2.6)	19.8 (3.7)	32.9 (3.3)	40.7 (2.7)	−47.4
Cote d’Ivoire	1994	5.4 (1.1)	9.2 (2.8)	12.9 (2.7)	23.1 (2.9)	39.6 (4.0)	−38
Egypt, Arab Republic	2005	62.4 (0.3)	73.9 (0.4)	78.1 (0.1)	83.4 (0.1)	85.8(1.6)	−27.9
Egypt, Arab Republic	1995	32.5 (1.8)	47.0 (2.1)	56.2 (1.9)	63.4 (3.0)	74.6 (2.0)	−51
Ethiopia	2005	2.1 (0.9)	2.9 (0.9)	1.5 (0.6)	1.6 (0.7)	10.6 (2.2)	−7.5
Ethiopia	2000	1.8 (0.7)	1.2 (0.4)	1.4 (0.6)	1.3 (0.5)	7.5 (0.9)	−5.5
Ghana	2003	8.6 (1.2)	13.6 (1.7)	20.8 (2.0)	33.4 (2.4)	57.7 (2.5)	−58.3
Ghana	1993	6.3 (1.6)	3.9 (0.8)	10.9 (2.2)	19.6 (3.7)	33.4 (3.2)	−33.1
Guatemala	1998	27.5 (2.7)	39.8 (3.3)	48.2 (3.9)	57.4 (5.7)	75.1 (2.8)	−56.5
Guatemala	1995	23.0 (1.6)	26.8 (1.9)	38.0 (1.7)	48.2 (2.8)	52.7 (2.3)	−39.8
Guinea	2005	6.8 (1.1)	7.8 (1.4)	9.2 (1.3)	17.2 (2.1)	32.1 (2.2)	−29.5
Guinea	1999	4.7 (1.0)	6.6 (1.1)	9.6 (1.3)	13.4 (1.6)	35.6 (2.8)	−31.8
Haiti	2005	9.8 (1.8)	14.5 (2.0)	19.2 (2.3)	28.3 (2.3)	45.2 (3.5)	−43.4
Haiti	1994	3.6 (1.5)	7.0 (1.9)	7.9 (1.6)	16.6 (2.9)	32.9 (3.1)	−30.7
Indonesia	2007	28.8 (2.2)	28.2 (2.8)	32.3 (2.7)	34.4 (3.5)	26.8 (3.3)	−1.9
Indonesia	1997	19.2 (2.8)	21.3 (2.9)	19.8 (4.0)	16.9 (2.8)	21.4 (3.4)	0.1
Jordan	2007	58.8 (2.7)	59.8 (4.0)	62.6 (3.0)	54.8 (3.1)	55.5 (3.9)	4.6
Jordan	1997	59.8 (2.5)	64.9 (2.1)	66.5 (2.1)	70.9 (1.9)	66.2 (2.1)	−9.9
Kazakhstan	1999	31.0 (4.8)	29.4 (4.0)	30.8 (5.6)	33.9 (5.0)	42.6 (3.3)	−11.3
Kazakhstan	1995	35.4 (2.6)	37.6 (3.5)	39.5 (3.7)	39.2 (4.2)	43.2 (2.9)	−8.1

Table continues

in GDP are associated with a shift in the burden of overweight toward lower SES groups over time. Additionally, country-level income inequality has been shown to modify the association between economic development and level of inequality in overweight by SES (9) and might also modify any relation between economic development and disproportionate gains in overweight prevalence among the lower SES populations. Investigating these associations is

Table 1. Continued

Country	Year	Age-standardized Prevalence of Overweight (SE) by Wealth Quintile					SII
		Quintile 1 (Lowest)	Quintile 2	Quintile 3	Quintile 4	Quintile 5 (Highest)	
Kenya	2003	9.8 (1.7)	15.6 (1.9)	21.3 (2.1)	29.1 (2.6)	48.9 (2.5)	−47.4
Kenya	1993	9.2 (1.6)	8.3 (1.3)	13.5 (2.7)	19.5 (2.7)	34.9 (4.2)	−30.7
Madagascar	2003	3.5 (0.8)	3.1 (1.1)	4.0 (0.8)	6.7 (1.1)	16.3 (1.7)	−14.6
Madagascar	1997	3.0 (0.8)	2.7 (0.9)	2.9 (0.9)	2.7 (0.7)	12.6 (2.3)	−7
Malawi	2004	9.8 (1.2)	8.7 (1.0)	12.1 (1.2)	16.4 (1.3)	29.9 (1.9)	−24.1
Malawi	1992	5.0 (1.3)	7.4 (1.6)	9.1 (1.8)	9.6 (2.0)	21.2 (2.9)	−16.5
Mali	2006	8.6 (1.0)	9.6 (1.0)	15.0 (1.4)	21.5 (1.7)	41.8 (1.5)	−40.9
Mali	1995	4.4 (0.9)	4.1 (0.8)	6.7 (1.4)	7.0 (1.1)	28.8 (3.1)	−24
Morocco	2003	28.6 (1.7)	38.2 (1.6)	43.5 (1.6)	49.9 (1.6)	53.4 (1.5)	−30.6
Morocco	1992	18.0 (1.4)	21.1 (2.2)	35.8 (2.8)	50.6 (2.6)	52.4 (3.1)	−48.9
Mozambique	2003	6.0 (0.8)	6.2 (1.0)	8.8 (1.1)	19.2 (1.7)	38.3 (1.9)	−39.7
Mozambique	1997	4.7 (1.2)	2.2 (0.8)	8.7 (2.6)	13.8 (2.9)	31.0 (3.6)	−29.9
Namibia	2006	12.3 (1.4)	22.5 (1.6)	33.8 (1.8)	41.2 (1.8)	53.2 (3.4)	−49.2
Namibia	1992	8.5 (1.5)	9.8 (1.8)	14.3 (2.4)	32.9 (3.7)	48.6 (2.3)	−53.3
Nepal	2006	3.1 (0.9)	2.1 (0.6)	3.7 (0.7)	8.4 (1.4)	26.7 (2.2)	−25.9
Nepal	1996	1.0 (0.4)	0.5 (0.4)	1.4 (0.6)	0.9 (0.5)	8.3 (3.4)	-−5.8
Nicaragua	2001	36.0 (1.5)	47.9 (1.6)	57.1 (1.8)	64.3 (1.7)	64.1 (2.0)	−35.7
Nicaragua	1997	31.3 (1.3)	41.7 (1.6)	52.9 (1.5)	53.6 (1.7)	56.1 (1.7)	−30.6
Niger	2006	5.2 (1.2)	6.1 (1.4)	8.4 (1.3)	13.6 (1.7)	39.7 (2.0)	−39.5
Niger	1998	3.7 (1.4)	2.9 (0.7)	3.5 (1.0)	5.2 (1.0)	31.8 (3.0)	−27.3
Peru	2000	32.6 (1.2)	45.6 (1.2)	59.3 (1.2)	62.9 (1.3)	57.4 (1.7)	−33.7
Peru	1992	29.5 (1.6)	42.5 (2.0)	46.8 (2.6)	57.8 (1.7)	48.3 (2.8)	−30.5
Rwanda	2005	8.7 (1.3)	6.8 (1.2)	10.5 (1.7)	10.5 (1.4)	23.6 (1.9)	−16.5
Rwanda	2000	9.7 (1.5)	12.1 (1.2)	9.3 (1.1)	10.1 (1.0)	25.7 (1.6)	−15.9
Tanzania	2004	9.0 (1.5)	9.4 (1.3)	14.4 (1.2)	17.5 (1.5)	42.8 (2.1)	−39.7
Tanzania	1996	7.3 (1.1)	8.8 (1.3)	9.9 (1.4)	12.7 (1.6)	30.3 (2.0)	−24.9
Turkey	2003	54.4 (2.9)	64.4 (2.3)	67.5 (2.5)	68.1 (2.3)	53.6 (3.6)	−2.1
Turkey	1993	40.6 (3.9)	45.3 (2.8)	63.2 (1.9)	63.2 (2.8)	52.2 (5.3)	−21.2
Uganda	2006	5.3 (1.6)	8.5 (2.0)	15.1 (2.6)	20.5 (2.7)	35.7 (3.5)	−37.6
Uganda	1995	5.5 (1.8)	6.8 (1.5)	8.4 (2.0)	7.9 (1.5)	20.0 (2.3)	−14.7
Zambia	2007	9.0 (1.2)	10.9 (1.3)	13.5 (1.4)	26.9 (1.7)	48.0 (1.9)	−47.6
Zambia	1996	7.4 (1.1)	11.0 (2.3)	14.5 (1.9)	17.5 (1.8)	29.8 (3.1)	−26.2
Zimbabwe	2005	15.6 (1.5)	19.1 (1.6)	20.8 (1.9)	36.3 (1.9)	52.5 (2.1)	−47.1
Zimbabwe	1994	17.2 (2.7)	16.9 (3.1)	25.4 (4.2)	31.8 (3.9)	38.7 (3.3)	−28.6

Abbreviations: SE, standard error; SII, slope index of inequality.

[a] Overweight is defined as body mass index ≥25 kg/m^2 (15).

[b] The SII for overweight is a summary measure of the level of inequality in overweight prevalence by wealth group. It is obtained by regressing the age-standardized overweight prevalence for each socioeconomic status group (shown in this table) on the rank of each wealth quintile in the social hierarchy, ranked by ridit score (the cumulative proportion of the population with a higher wealth level than the average person in each wealth quintile; range: 0–1) from highest to lowest. Essentially, the SII shown here represents the slope of the regression line through the wealth quintiles, moving from the highest wealth group (0) to the lowest (1). A negative SII indicates lower levels of overweight in the lower wealth groups; a positive SII indicates lower levels of overweight in the higher wealth groups.

[c] Data for all countries expect China and Indonesia are publically available and were derived from the Demographic and Health Surveys (10). The China Health and Nutrition Survey (12) and the Indonesian Family Life Survey (11) provided the data for China and Indonesia, respectively.

critically important to providing information about the contextual circumstances in which lower SES becomes a risk factor for overweight.

Using nationally representative, repeated cross-sectional measurements among women in 37 lower income countries, we investigated changes in the relation between overweight and individual SES over time. We tested whether GDP was related to differential rates of increase in overweight prevalence by SES, hypothesizing that higher GDP in developing countries would be associated with higher rates of overweight prevalence gains in lower (compared with higher) SES populations. Additionally, we tested whether this relation varied by country-level income inequality.

MATERIALS AND METHODS

Data sources

The majority of the data were derived from Demographic and Health Surveys, nationally representative, repeated cross-sectional household surveys administered primarily in lower- and middle-income countries approximately every 5 years and standardized to enable cross-country comparisons (10). We identified 35 countries that had repeated Demographic and Health Surveys containing prospectively collected individual anthropometric and SES data. Additionally, we used the Indonesian Family Life Surveys (11) and the China Health and Nutrition Survey (12). Each data source used a single or multistage cluster sample design. The countries included and the first and last survey years are listed in Table 1. The average number of years between the first and last surveys was 8.8 (standard deviation, 3.2); changes over time were annualized to account for differences in the number of years included in each country.

For the majority of our sample, anthropometric measurements were available only for those women less than age 50 years, so we limited our analyses to adult nonpregnant women aged 18–49 years in all countries. Earlier years of the Demographic and Health Survey collected anthropometrics on only those women who had children aged 0–5 years; we limited our main analyses to this subgroup to keep the repeated cross-sections over time comparable. For the 506,839 women who met eligibility criteria, covariate information was complete for 405,550 of them (80%).

Key variables

Individual-level variables. Height and weight were measured by trained technicians using standard techniques (11, 12). Body mass index (weight (kg)/height (m)^2) was used to classify people as obese or overweight according to World Health Organization guidelines (13). For each country and survey wave, prevalence of overweight (body mass index $\geq$25) according to SES was calculated. We used the body mass index cutpoint that combines overweight and obesity since body mass index above this level is associated with a substantial increase in cardio-metabolic problems (14). Although lower body mass index thresholds demonstrate disease risk in some populations, the World Health Organization recommends the body mass index cutpoint of $\geq$25 for international comparisons of overweight (15).

Individual SES was represented by a wealth index derived from household assets. Wealth was chosen to represent SES because, in lower income countries, assets-based wealth indices are considered a superior measure of financial resources compared with income; income can be highly fluctuating and come from multiple sources, and items are often bartered, which can make it difficult to translate into income (16). We chose to utilize wealth rather than education since the distribution of education was quite different among the countries we studied, with some countries having too few people completing tertiary school to enable stable estimates. The Demographic and Health Survey data include a constructed wealth index comprising queried household assets; principal components analysis was used to generate a total wealth score for each family in each country in each survey wave (16). The Indonesia Family Life Surveys and the China Health and Nutrition Survey also collected information regarding household assets, and we constructed a wealth index comparable to the Demographic and Health Survey index for each of these countries. The wealth index represents a relative measure. For the analyses, the country- and survey-year-specific quintiles of wealth score were used to create a categorical variable for wealth status.

Age was controlled for by direct standardization. We used each country's age-specific overweight rates and the World Health Organization world standard population age structure (17) to better enable comparisons across countries.

Country-level variables. We used GDP per capita adjusted for purchasing power parity and inflated to the 2005 international dollar value (referred to henceforth as GDP) to represent country-level economic development (18). The baseline survey year GDP for each country was used in the regression analyses. The annualized percentage change in GDP per capita (purchasing power parity) over the survey period represented change in GDP. Country-level average Gini coefficient represented country-level income inequality (19). Values were obtained from the World Bank Indicators Database (20).

Statistical analyses

Slope index of inequality (SII). To summarize the level of inequality in overweight prevalence by wealth group, we estimated the SII (21). The SII is recommended for quantifying the absolute level of inequality in a health outcome for within-country time trends and cross-country comparisons (21, 22). It accounts for the mean level of health by socioeconomic group as well as the proportion of the population in each group (21). Since our analyses used quintiles of wealth to also ensure that the proportion of the population in each wealth group was similar across years and countries, the main advantage of using the SII is that it considers information from all wealth quintiles.

This regression-based measure is obtained by regressing the mean health status of each SES group on the rank of each SES group in the social hierarchy (19, 21), ranked from highest to lowest, represented by the ridit score. The ridit score is the proportion of the population with a higher wealth score than the average person in each wealth group (19). Specifically, we regressed the age-standardized overweight prevalence for each wealth group on the ridit score for each wealth quintile: (Age-standardized overweight prevalence|country, year)$_j$ = $\alpha + \beta_1$(ridit scores for wealth)$_j + \epsilon$, where j denotes wealth quintile. The regression is weighted by the number of individuals in each SES group (19, 21). The resulting regression coefficient β_1 is the SII and represents the difference in overweight prevalence moving from the highest

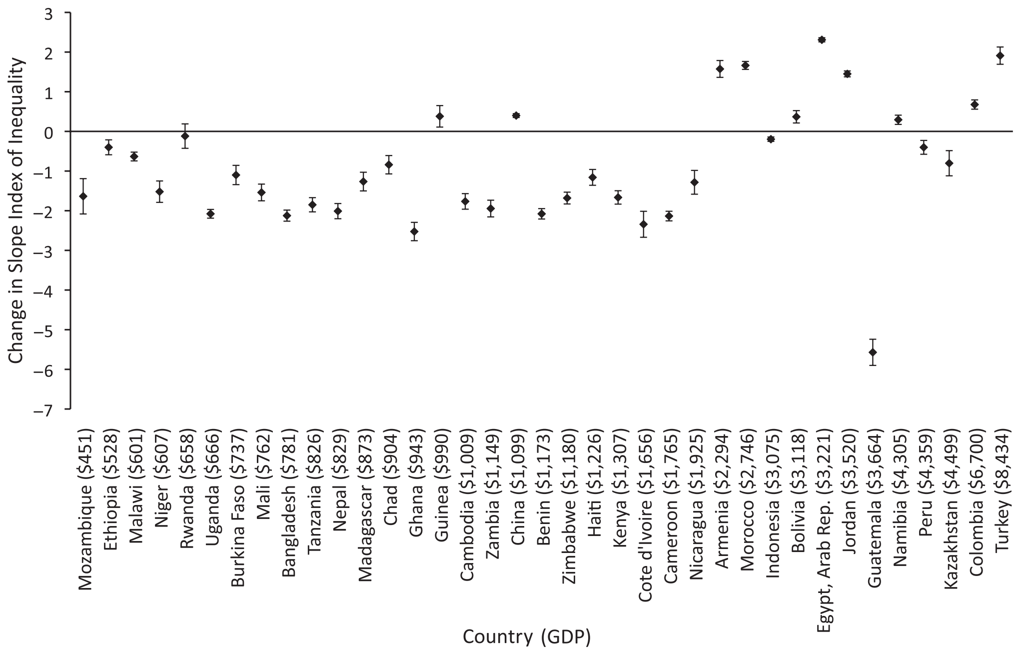

Figure 1. Annualized change in slope index of inequality for overweight between the first and last survey years, with 95% confidence intervals, for women in 37 developing countries in 1989–2007, ordered according to first-year gross domestic product (GDP). GDP is per capita adjusted by the purchasing power parity method and is adjusted for inflation using the 2005 international dollar value as a base. Positive values for annualized change in slope index of inequality indicate faster overweight prevalence increase among lower wealth groups (vs. higher); negative values indicate faster overweight prevalence increase among higher wealth groups (vs. lower). Rep, Republic.

(0) to the lowest (1) group. Accordingly, a negative SII would indicate higher overweight prevalence in the higher wealth groups, whereas a positive SII would mean higher levels of overweight prevalence in the lower wealth groups. The SII was calculated for each country in each survey year.

Change in SII. We estimated the change in SII between the first and the last survey years for each country by adding indicator variables for survey year and interaction terms for the survey year variables and the ridit score to the model of SII described above. The change in the SII between the first and last survey years is represented in the interaction between ridit score and last survey year. Change in SII was then annualized to account for the different number of years between surveys in different countries. The subsequent statistical analyses used change in the SII between the first and last survey years and its confidence interval obtained from this model.

The change in the SII is the difference in the magnitude of inequality in overweight levels. For our purposes, it also is indicative of the differential rate of increase in overweight prevalence between the higher and lower wealth groups since it is calculated within countries, and, by using wealth quintiles, we constrained the amount of change that could be due to change in proportion in each wealth group. This is illustrated in Web Figure 1, which is posted on the *Journal*'s Web site (http://aje.oupjournals.org/). A negative change in SII would indicate an increase in the magnitude of overweight inequality by SES brought about by a faster increase in overweight prevalence for the higher wealth groups compared with the lower wealth groups. A positive change in the overweight inequality indicates a decrease in the magnitude of the overweight inequality by SES, brought about by a faster increase in overweight among the lower wealth groups compared with the higher wealth groups.

Meta-regression of change in SII. Change in the annualized SII was used to represent the differential growth rates in overweight prevalence between the low- and high-SES groups as the outcome in a country-level meta-regression. We estimated the crude associations between change in the SII and GDP as well as percentage change in GDP using random-effects meta-regression (23). We then tested whether the effects of GDP varied by percentage change in GDP by interacting these 2 variables. Based on residual diagnostics, continuous GDP was log-transformed for the analyses, and change in GDP was left in its continuous form.

We assessed whether the association between GDP and the change in SII varied by country-level income inequality. To do so, we tested the interaction using the continuous form of the variables as well as with tertiles of GDP and a dichotomized version of the Gini coefficient.

Sensitivity analyses. For sensitivity analyses, we calculated the difference in the growth rates of overweight prevalence for the lowest and the highest wealth quintiles. We conducted linear regression analyses with this measure as an outcome instead of the change in the SII to ensure that they produced approximately the same results.

Analyses of overweight prevalence and SII accounted for the complex survey design and utilized the sampling weights provided by the Demographic and Health Survey and Indonesia Family Life Surveys (10, 24). The sampling weights account for differential probability of selection and response;

Table 2. Country-level Meta-regressions of Change in Slope Index of Inequality for Overweight on GDP[a] and Annualized Percentage Change in GDP Among Women in 37 Developing Countries, 1989–2007

Model	Beta Coefficient	95% Confidence Interval	Percentage of Between-study Variance Explained	No.
Model 1: baseline GDP (logged $1,000s)	0.84	0.22, 1.46	15.7	37
Model 2: annualized percentage change in GDP	0.08	−0.05, 0.22	1.9	37
Model 3				
Baseline GDP (logged $1,000s)	0.89	0.28, 1.49		
Annualized change in GDP	0.10	−0.02, 0.22	20.3	37

Abbreviation: GDP, gross domestic product.

[a] GDP is per capita adjusted by the purchasing power parity method and adjusted for inflation using the 2005 international dollar value as a base.

details can be found elsewhere (10, 24). Alpha was set at 0.05 for all main effects and at 0.20 for all interactions. The alpha for the interaction was intentionally set liberally since we had relatively few observations and were substantively interested in detecting any interactions that exist (25). All analyses were performed with Stata software (version 11, 2009, Stata Corporation, College Station, Texas).

RESULTS

Table 1 displays age-standardized overweight prevalence by wealth as well as the estimated SII for overweight for each country in its first and final survey years. Additional descriptive characteristics are provided in Web Table 1, also posted on the *Journal*'s Web site (http://aje.oupjournals.org/). Mean absolute inequality level for overweight prevalence (SII) was −23.3. At this level, the lowest SES group would have an overweight prevalence approximately 23 points lower than that of the highest SES group. Mean SII values by GDP tertile in the first and last survey years, respectively, were −17.6 and −30.6 for the lowest GDP tertile, −28.9 and −37.9 for the middle GDP tertile, and −26.2 and −21.0 for the highest GDP tertile. On average, the amount of inequality in overweight levels by wealth increased (more negative) for countries in the 2 lowest GDP tertiles and decreased (less negative) for countries in the highest GDP tertile. Mean annualized change in SII was −1.0 (range: −5.6 to 1.9), indicating that, on average, the higher wealth groups experienced higher overweight prevalence gains compared with the lower wealth groups.

Figure 1 displays the annualized change in the overweight inequality and its 95% confidence interval over the survey period for each country, listed in order of baseline GDP. Ten of 37 countries had a positive change in the overweight inequality, indicating a faster overweight prevalence increase among the lower wealth groups (vs. high); the remaining 27 countries had a negative change in SII, indicating a faster overweight prevalence increase among the higher wealth groups.

Higher change in the inequality in overweight prevalence was significantly associated with higher baseline GDP levels (Table 2, model 1), indicating that higher GDP was associated with a relatively faster rate of increase in overweight prevalence among lower wealth groups. A 1-unit increase in log GDP was associated with an increase of 0.84 units (95% confidence interval: 0.22, 1.46) in overweight inequality change score.

The relation between annualized percentage change in GDP and change in overweight inequality over the survey period was positive but was not statistically significant (Table 2, model 2) in the crude model. When both baseline GDP and percentage change in GDP were included in the model, baseline GDP remained significantly associated and percentage change in GDP was marginally significantly related to level of change in overweight inequality (Table 2, model 3). We found no significant interaction between baseline GDP and level of change in GDP ($P = 0.60$). Country-level GDP alone accounted for 15.7% of the between-country variance in the change in SII; the addition of change in GDP increased the variance explained to 20.3%.

The interaction between economic development (GDP tertile) and income inequality (dichotomous Gini coefficient) was statistically significant ($P = 0.05$). The proportion of the between-country variance explained in the model that interacted GDP and the Gini coefficient was 32.2%. We interpret these results conservatively since the interaction was not robust to specification in its continuous form; however, because theory and prior research suggest a rationale for an interaction, we probed the interaction further and tested by categories. Among countries in the highest GDP tertile, a lower country-level income inequality was associated with a predicted annual change in overweight inequality of 1.13 (95% confidence interval: 0.11, 2.15), indicating a faster increase in overweight prevalence for the lower wealth groups compared with the wealthier groups (Figure 2). Conversely, for countries in the highest GDP tertile but with high income inequality, the predicted annual change in the overweight inequality was −0.91 (95% confidence interval: −2.12, 0.29), indicating slower overweight prevalence growth among the lower wealth groups in comparison to wealthier groups ($P = 0.01$). Among countries in the 2 lowest GDP tertiles, the predicted change in overweight inequality was not significantly different according to level of income inequality (Figure 2).

Sensitivity analyses

The analyses using the difference in prevalence rate gains between the highest and lowest wealth quintiles as the outcome instead of change in SII produced similar results. Baseline GDP was positively associated with higher overweight prevalence growth in the least wealthy compared with the wealthiest, and the interaction between GDP and income inequality was significant (data not shown). This finding supports our use of change in SII as an indicator of disproportionate change in overweight prevalence among wealth categories.

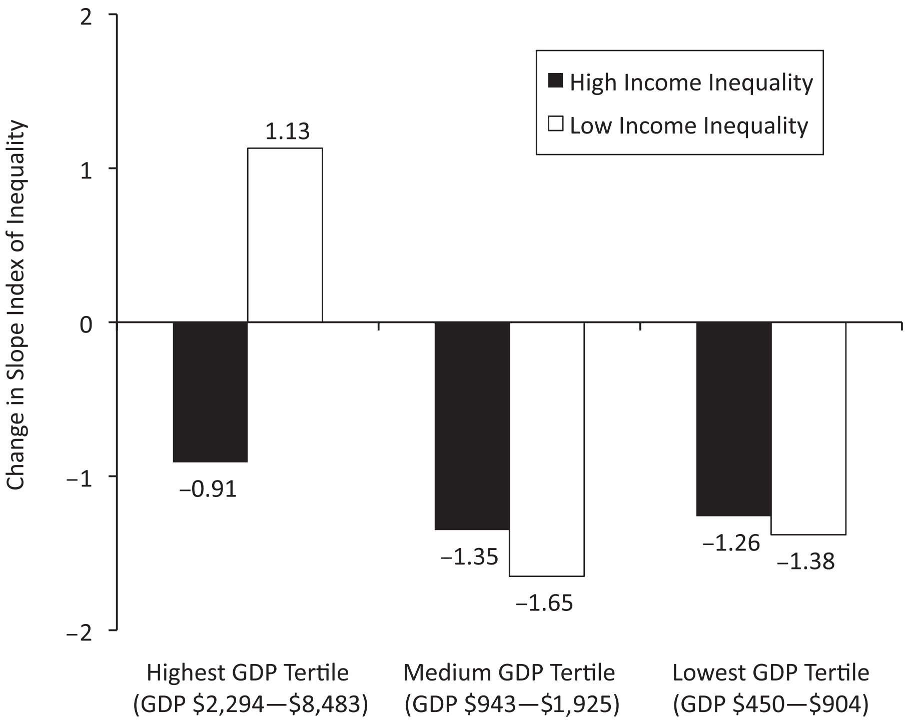

Figure 2. Predicted change in slope index of inequality in overweight by country-level gross domestic product (GDP) and country level of income inequality among women in 37 developing countries, 1989–2007. Positive values for annualized change in slope index of inequality indicate faster overweight prevalence increase among lower wealth groups (vs. higher); negative values indicate faster overweight prevalence increase among higher wealth groups (vs. lower). Estimate for highest GDP tertile and high-income-inequality countries is significantly different from the estimate for highest GDP tertile and low-income-inequality countries. Income inequality was represented by the Gini coefficient and was dichotomized; low income inequality range: 29.8–42.1 and high income inequality range: 42.2–74.3. GDP is per capita adjusted by the purchasing power parity method and adjusted for inflation using the 2005 international dollar value as a base. Baseline GDP was used to create GDP tertiles. Sample countries in the 6 categories: highest GDP tertile/high income inequality: Bolivia, Colombia, Guatemala, Namibia, Peru; highest GDP tertile/low income inequality: Armenia, Arab Republic of Egypt, Indonesia, Jordan, Morocco, Turkey, Kazahkstan; middle GDP tertile/high income inequality: Cameroon, Guinea, Haiti, Kenya, Nicaragua, Zambia, Zimbabwe; middle GDP tertile/low income inequality: Benin, Cambodia, China, Cote d'Ivoire, Ghana; lowest GDP tertile/high income inequality: Burkina Faso, Madagascar, Malawi, Mozambique, Nepal, Rwanda, Uganda; lowest GDP tertile/low income inequality: Bangladesh, Chad, Ethiopia, Mali, Tanzania, Niger.

DISCUSSION

This research among women from 37 developing countries suggests that economic development is significantly related to faster increase in overweight prevalence for lower SES groups compared with higher SES groups and that this relation varies by income inequality. Specifically, the country-level combination of high GDP and lower income inequality was associated with the greatest likelihood of disproportionately faster increases in overweight prevalence for the lower wealth groups compared with higher wealth groups.

Economic development

Among developing countries, we found that higher GDP was associated with a relatively faster increase in overweight prevalence among women of lower wealth. Our work is consistent with previous work relating higher GDP to an inverse relation between obesity and SES (5, 26), and it adds to this body of work by investigating the SES-specific overweight prevalence accrual process over time.

Change in GDP was positively associated with higher overweight prevalence increases in the lower wealth groups, but the result was marginally statistically significant ($P = 0.09$). The lack of a statistical significance between GDP change and SES-specific overweight prevalence growth could be due to the limited range of GDP change or our small sample size ($n = 37$). Alternatively, it is possible that the relation between GDP and faster increases in overweight prevalence among the poor is spurious rather than causal; however, theory and previous research suggest that national wealth plays a role in SES-specific overweight prevalence (4). Faster overweight prevalence increases could stem from a contextual change felt disproportionately by lower income groups, such as occupational change with changing economies. Alternatively, it could stem from a different response to the same environment.

Income inequality

We found some evidence that the association between country-level GDP and SES-specific increases in overweight prevalence growth varies by country level of income inequality. Among countries in the highest GDP tertile, having high income inequality (i.e., Bolivia, Peru, Guatemala, Namibia, and Colombia) was associated with a significantly higher increase in overweight prevalence among the higher-wealth individuals. Being in the highest GDP tertile but having lower income inequality (i.e., Armenia, Egypt, Indonesia, Jordan, Morocco, Turkey, and Kazahkstan) was associated with a higher increase in the overweight prevalence rate among the lower-wealth individuals. These findings may suggest that the increased resources that most likely accompany wealth do not have a universal effect on overweight risk, even at the same level of economic development.

We interpret these results conservatively since the significance of the interaction between GDP and income inequality was not apparent when the variables were entered in their continuous form. The different findings with different model specifications may be due to Guatemala acting as an influential point. When we ran the model without Guatemala, the interaction remained significant and the high-GDP/high-inequality countries still had lower predicted rates of increase in overweight prevalence for the lower wealth groups compared with those of high-GDP/low-inequality countries; however, the predicted rates in the high-GDP/high-inequality countries were positive rather than negative.

Although not directly comparable, these results differ from those of a recent study that examined the relation between level of inequality in overweight prevalence between SES groups and country-level income inequality at a single point in time among adolescents in Europe and North America (8). Of the middle-income countries in that study (comparable to higher income countries in our study), those with higher income inequality had a lower magnitude of inequality in overweight compared with those with lower income inequality (8). When we examined only the most recent survey wave among our higher income countries, we found that countries with higher income inequality had a higher magnitude of inequality in overweight levels (mean SII = −35.3) compared with those with lower income inequality (mean SII = −8.9). Differences could be due to the age of the populations studied or the fact that the highest income countries in our sample still had a higher overweight prevalence in the higher SES groups.

Limitations

Limitations should be noted. First, we used an assets-based wealth index to represent SES, which covers only one realm of SES and is an imperfect measure of financial resources; however, it is commonly used and believed to be superior to income in lower income countries (16). Second, our country-level GDP per capita and Gini coefficient were also approximations of economic development and income inequality, but these indicators are commonly used in the field and enable comparisons across studies. The SII assumes a linear relation between mean health status and the SES categories; visual examination of the plotted data reveals that this assumption is reasonable. Finally, to keep the sample comparable over time, we limited the analysis to only those women with children less than age 5 years; this is the subsample of women for whom the Demographic and Health Survey has consistently obtained anthropometrics. In the more recent Demographic and Health Surveys, procedure has changed and anthropometric measurements are being obtained for all women in the household. Our sample is representative of only women between the ages of 18 and 49 years with young children in these countries; however, in previous work, we found that the differences in prevalence growth rates between higher and lower SES women from the fuller sample were similar to the results from the more restricted sample of women with young children.

We did not have data to examine equivalent research questions among males. Nevertheless, we would expect the result to be different for men because of a generally lower prevalence of overweight (27) and different associations between SES and overweight (28).

Conclusions

Using a multiregional sample of women in 37 countries over time, we found that country-level GDP was associated with a decreased level of overweight inequality. However, this decrease in inequality was brought about by a disproportionately faster increase in overweight prevalence among the lower wealth groups in comparison to the higher wealth groups. These results highlight an increased disease burden for the poor in association with higher economic development contexts, particularly when combined with lower income inequality.

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REFERENCES

1. Mokdad AH, Ford ES, Bowman BA, et al. Prevalence of obesity, diabetes, and obesity-related health risk factors, 2001. *JAMA*. 2003;289(1):76–79.
2. Popkin BM. The world is fat. *Sci Am*. 2007;297(3):88–95.

3. Kaplan GA, Keil JE. Socioeconomic factors and cardiovascular disease: a review of the literature. *Circulation*. 1993; 88(4 pt 1):1973–1998.
4. Sobal J, Stunkard AJ. Socioeconomic status and obesity: a review of the literature. *Psychol Bull*. 1989;105(2):260–275.
5. Monteiro CA, Conde WL, Lu B, et al. Obesity and inequities in health in the developing world. *Int J Obes Relat Metab Disord*. 2004;28(9):1181–1186.
6. Monteiro CA, Conde WL, Popkin BM. Income-specific trends in obesity in Brazil: 1975–2003. *Am J Public Health*. 2007; 97(10):1808–1812.
7. Popkin BM. Will China's nutrition transition overwhelm its health care system and slow economic growth? *Health Aff (Millwood)*. 2008;27(4):1064–1076.
8. Due P, Damsgaard MT, Rasmussen M, et al. Socioeconomic position, macroeconomic environment and overweight among adolescents in 35 countries. *Int J Obes (Lond)*. 2009;33(10): 1084–1093.
9. Banks J, Marmot M, Oldfield Z, et al. Disease and disadvantage in the United States and in England. *JAMA*. 2006; 295(17):2037–2045.
10. Measure Demographic and Health Surveys. *Guide to DHS Statistics*. Calverton, MD: ORC Macro; 2006. (DHS publication no. DHSG1).
11. Family life surveys: a RAND labor and population program. *Indonesian family life surveys*. Santa Monica, CA: RAND Corporation. (http://www.rand.org/labor/FLS/IFLS/hh.html). (Accessed October 11, 2010).
12. China Health and Nutrition Survey. Project description. Chapel Hill, NC: The University of North Carolina at Chapel Hill. (http://www.cpc.unc.edu/projects/china/proj_desc/). (Accessed December 12, 2009).
13. WHO/FAO. *Expert Consultation on Diet, Nutrition and the Prevention of Chronic Diseases Report of the Joint WHO/FAO Expert Consultation*. Geneva, Switzerland: World Health Organization; 2003.
14. Zimmet PZ, McCarty DJ, de Courten MP. The global epidemiology of non-insulin-dependent diabetes mellitus and the metabolic syndrome. *J Diabetes Complications*. 1997;11(2):60–68.
15. WHO Expert Consultation. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. *Lancet*. 2004;363(9403):157–163.
16. Measure Demographic and Health Surveys. *The DHS Wealth Index*. Calverton, MD: ORC Macro; 2004. (DHS publication no. CR6).
17. Ahmad O, Boschi-Pinto C, Lopez A, et al. *Age Standardization of Rates: a New WHO Standard*. Geneva, Switzerland: World Health Organization; 1999. (GPE discussion paper series, no. 31).
18. EdStat indicators. Washington, DC: The World Bank. (http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTEDUCATION/EXTDATASTATISTICS/EXTEDSTATS/0, contentMDK:21272698~menuPK:4323930~pagePK:64168445~piPK:64168309~theSitePK:3232764,00.html). (Accessed January 22, 2010).
19. Harper S, Lynch J. Measuring health inequalities. In: Oakes J, Kaufman J, eds. *Methods in Social Epidemiology*. San Francisco, CA: Jossey-Bass; 2006:134–168.
20. World development indicators and global development finance. Washington, DC: The World Bank. (http://ddp-ext.worldbank.org/ext/DDPQQ/member.do?method=getMembers&userid=1&queryId=6). (Accessed on January 22, 2010).
21. Wagstaff A, Paci P, van Doorslaer E. On the measurement of inequalities in health. *Soc Sci Med*. 1991;33(5): 545–557.
22. Kunst AE, Geurts JJ, van den Berg J. International variation in socioeconomic inequalities in self reported health. *J Epidemiol Community Health*. 1995;49(2):117–123.
23. Morton S, Adams J, Suttorp M, et al. *Meta-Regression Approaches: What, Why, When, and How?* Rockville, IN: Southern California—RAND Evidence-based Practice Center; 2004. (RAND publication no. technical review 8).
24. Frankenberg E, Karoly L, Gertler P, et al. *The 1993 Indonesian Family Life Survey: Overview and Field Report*. Santa Monica, CA: RAND & Demographic Institute, University of Indonesia; 1995. (Rand publication no. DRU 1195).
25. Jewell NP. *Statistics for Epidemiology*. Boca Raton, FL: Chapman & Hall/CRC; 2004.
26. Ezzati M, Vander Hoorn S, Lawes CMM, et al. Rethinking the ''diseases of affluence'' paradigm: global patterns of nutritional risks in relation to economic development. *PLoS Med*. 2005;2(5):406–412.
27. WHO global infobase. Geneva, Switzerland: World Health Organization. (https://apps.who.int/infobase/). (Accessed October 11, 2010).
28. Monteiro CA, Moura EC, Conde WL, et al. Socioeconomic status and obesity in adult populations of developing countries: a review. *Bull World Health Organ*. 2004;82(12): 940–946.