Appendix 1. METHODS AND DATA

With our first set of data sources, the Demographic and Health Surveys (DHS), we developed an understanding of the typology of double burden households at the nationally representative level. For all years these countries collected anthropometry on women of childbearing age and preschoolers. We linked these data with gross domestic product (GDP) per capita to examine the relationship at the country level between the double burden and 1 measure of national income. With our second set of data sources we created measures of the double burden for all nations, but for the most recent period of available data with age-specific under- and overnutrition measures these are only estimates.

COUNTRY ESTIMATES OF THE DOUBLE BURDEN

Country-level anthropometry

We used data from the Institute for Health Metrics and Evaluation recently published in *Lancet*.[1] These publicly available data include anthropometric measures of weight and height to estimate age-specific prevalences of wasting, stunting, and overweight in all age groups. The only measure they exclude is thinness (body mass index [BMI] < 18.5) for women 19 and older.[1] We added adult thinness in our analysis. The countries and their regions, populations, and anthropometric levels for the measures noted above are in Supplemental Table S1.

The DBM at the country level was defined as having a high prevalence of both undernutrition and overweight/obesity in at least one population group. We examined which countries had DBM [DBM; prevalence wasting >15% or stunting > 30% or women's thinness (prevalence >20%)]and adult or child overweight(prevalence >20, 30, 40%). The cutoffs for undernutrition are defined as wasting (WHZ<-2) or stunting (HAZ<-2) for children age 0-4. and thinness (BMI<18.5) for adult women. For overweight (BMI Z >+2 in children under age 18 and BMI>25 for adults [2]) exceeds 20%, 30%, or 40% prevalence (Figure 1 and Supplemental Tables S1 and S2). We use a combination of overweight and obesity because extensive epidemiological research associates BMI of 25 or even lower to the risks of noncommunicable diseases (NCDs) across LMICs.[3-9]

MEASURES FOR HOUSEHOLD AND GLOBAL ANALYSES

Global estimates for all ages for anthropometry

For children ages 6–18 and adults we used estimates for all low- and middle-income countries (LMIC) from a recent study NCD-RisC group[1] In many cases this group used complex statistical algorithms to estimate the levels of stunting and overweight/obesity. The only data missing are the distributions of stunting in adults for each country. For children ages 0–5 we used a data set developed by the joint UNICEF-WHO-The World Bank group.[10] These preschooler data are based on the WHO Child Growth Standards of -2 standard deviations (SDs) from the standard for wasting and stunting and +2 SDs for overweight and obesity. We collected these data from disparate surveys and estimates that cover all countries, like the adult and child data. The only LMIC missing is South Sudan, so we used Sudanese data for both Sudan and South Sudan.

For the earlier period there are no data in the 1990's for many countries. UNICEF data provided the aged 0-4 data for the most recent decade but had much missing data for the 1990's so we utilized data from DHS as much as possible for the anthropometry in the 1990's for ages 0-4.

Household and national estimates

All the surveys we used had standardized protocols to measure weight and height.[11] We calculated BMI as weight in kilograms divided by height in meters squared (kg/m^2). We defined thinness and overweight according to the WHO recommendations, thinness at BMI < 18.5 kg/m^2 and overweight at BMI ≥ 25 kg/m^2.[12,13] We adjusted BMI for women ages 15.0–17.9 according to the International Obesity Task Force definitions.

We assessed children's anthropometric statuses by comparing data with the WHO Child Growth Standards. We used the WHO igrowup macro to calculate z-scores and excluded children with invalid z-scores for ages 0-4. We excluded 2 countries, Benin and Pakistan, from this study entirely due to their high percentages of invalid z-scores. For iron status we followed WHO cutoffs for children and women.[14]

We calculated the annualized change in prevalence by dividing the absolute change in levels by the number of years between surveys to provide a comparable measure of positive or negative change for all measures of malnutrition in countries for which we have 2 years of data. For a detailed presentation of the observed heterogeneity, we selected a set of countries for which we had pre-1997 and post-2011 data and time spans from 16 to 24 years as examples.

Country-level burden of malnutrition

For the severity of the double burden in children at the country level we used the recent WHO/UNICEF guidelines for high levels of overweight/obesity, wasting, and stunting.[10] The prevalence levels we used to designate a country's population as high in wasting, overweight, or stunting are ≥15%, ≥ 15%, and ≥ 30%, respectively. Meeting any of these criteria meant a country faced undernutrition according to anthropometric status.

For women there is no clear cutoff for overweight and obesity. Thus, we present data based on 40%, 30%, and 30% cutoffs for overweight prevalence in the population. We designated ≥ 20% as the underweight cutoff for thinness prevalence. There is no global agreement on what constitutes a country with excessive overweight and obesity or thinness, so we selected these based on distribution and where we found major breaks and excessively high burdens. The countries who fit these criteria for the double burden spelled out above are found in Supplemental tables S1 and S2.

Measures of undernutrition included wasting (WHZ<-2) and stunting (HAZ<-2) for children age 0-4 and thinness (BMI<18.5) for adult women. Cutoffs for overweight/obesity were BMI Z >+2 in children under age 18 and BMI>25 for adults.[2]

Some might argue from a high-income perspective that we should consider only obesity in the DBM definition. However, extensive epidemiological research significantly associates body mass indexes (BMIs) of 22 or 23 with the risks of noncommunicable diseases (NCDs) and the risk of becoming overweight (BMI ≥ 25 kilograms per square meter (kg/m^2) World Health Organization (WHO) across LMICs.[3-9] We also acknowledge the role of poor dietary quality as a common determinant of the DBM and potentially an element contributing to other dimensions of poor health, independently of the anthropometric variables. However, these dimensions will not be covered by this series.

HOUSEHOLD-LEVEL ANALYSIS

Data sources

Most of our data are from the DHS, a series of nationally representative surveys typically conducted every 5 years (available at http://www.measuredhs.com). Details of the DHS sampling methodology are described elsewhere.[15] Additional data are from the 1993 and 2014 Indonesian Family Life Survey (representative of 83% of the Indonesian population),[16,17] the 1991 and 2015 China Health and Nutrition Survey (representative of 56% of the Chinese population),[18] the 2013 Brazil National Health Survey (1996 data from the DHS),[19,20] the 1988 and 2012 Mexico National Survey of Health and Nutrition (ENSANUT, nationally representative),[21-24] and the 1992 and 2002 Vietnam Living Standards Surveys. [25] For Mexico we eliminated the small ENSANUT 2016, which was collected in a different season than the other surveys.

The sample data for the earliest and the most recent surveys available for each country are in Supplemental Table S3. The supplemental tables include the data discussed below—population size, GDP per capita based on purchasing power parity (GDP [PPP]), and sample size.

Study population and sample size

We restricted all analyses to nonpregnant women ages 15–49 and children ages 0–4. Pregnancy status was available for all countries. The countries for which data were available and the sample sizes are in Supplemental Table S1. Our arrangement of countries into regions follows the World Bank's.[26] For countries with only 1 survey, we included that single survey (Supplemental Table S1). For countries with more than 3 surveys, we included only the oldest and the most recent. The overall total sample size was 469,564 households with at least 1 child age 0–4 and 816,469 households with a nonpregnant woman age 15–49. Additionally, 438,877 households had both a child age 0–4 and a woman age 15–49. In total the analyses included 1,098,378 women 15–49 and 664,547 children 0–4.

We conducted direct measurements of the data sets available to us so we could apply the same measures noted below to all and the same cutoffs for erroneous measurements and weigh the data to be nationally representative (except China, which is representative of 56% of the population). Lacking adequate population coverage to present regional averages, we focused on country results and selected countries in which the most recent survey was after 2011 and the earliest survey was before 1997 (yielding intervals of 16–24 years) to give some sense of the heterogeneity of long-term trends (Supplemental Figure 6). The UNICEF-WHO-The World Bank Joint Child Malnutrition Estimates are the best recent regional estimates.[27]

GDP per capita based on purchasing power parity

GDP (PPP) is a measure of GDP divided by the midyear population (GDP/capita) for each country.[26] For our GDP (PPP) measures we used World Bank data, which evaluate the cost of a given basket of goods to equalize exchange rates and ascertain exact values in purchasing terms for each country.[28]

Statistical analysis

We used STATA version 14.2 (StataCorp, College Station, Texas) for all statistical analyses. All results are nationally weighted to be representative of the country. We adjusted age to the world age structure and felt that it did not significantly impact the results, so we present only the nationally representative weighted results. We weighted regional results by each country's 2010 population for the most recent period and by its 1990 population for the earlier period.

For the regression results we used ordinary least squares with controls for population size and for the GDP/capita relationship. For each outcome we tested linear, quadratic (second-degree polynomial), and cubic polynomial (third-degree polynomial) versions of GDP/capita. We kept the most appropriate relationship in terms of statistical significance.

Equity: Does overweight differ by socioeconomic status?

We followed a method that our group published earlier.[29] Our outcomes of interest were (1) overweight prevalence difference defined by the difference in overweight prevalence between the lowest and the highest wealth or education quintiles for each survey wave and (2) the annualized difference in the rate of overweight prevalence growth for the lowest and highest wealth or education quintiles between the first and last survey waves. We calculated overweight prevalence difference in each survey wave in each country for wealth quintiles by $\text{Overweight Prevalence}_{\text{lowest quintile}} - \text{Overweight Prevalence}_{\text{highest quintile}}$. A positive overweight prevalence difference indicates that the lower wealth quintile had a higher prevalence of overweight compared to the higher wealth quintile. To obtain the annualized difference in overweight prevalence growth rates between wealth quintiles, we took the difference between the change in overweight prevalence in the lowest group over the survey period and the change in the highest group over the survey period: (Overweight lowest,last wave – Overweight lowest,first wave) – (Overweight highest,last wave – Overweight highest,first wave). We annualized this result for each country. A positive difference in prevalence growth rates indicates that the lowest wealth quintile had a higher prevalence growth rate than did the highest quintile, and this gap is growing.

Euromonitor data: Country-level sales of sugar-sweetened beverages and nonessential or junk foods

Comparable data on sales of sugar-sweetened beverages (SSBs) are available for hundreds of countries from Euromonitor International Passport.[30] In a new database Euromonitor collected caloric information for most beverages on a country by country basis. With these data we estimated kilocalorie/capita/day trends in sales for a limited number of years (2009–2014). We were the beta tester of the new Euromonitor data, which are now publicly available to subscribers. Longer-term trends from 2000 are available for volume in milliliters (ml). In both cases we combined sales of what Euromonitor terms off-trade volume (i.e., supermarkets, retailers) and on-trade volume (i.e., restaurants, cafeterias). All volume data are reported in ml/capita/day. We suspect these Euromonitor data omit many small local bottlers, but no rigorous study has evaluated the completeness of the data. We define SSBs as regular cola carbonates, noncola carbonates (e.g., lemon/lime and orange carbonates, ginger ale, mixers), liquid and powder concentrates, juice drinks (up to 24% juice), nectars (25–99% juice), ready-to-drink coffees and teas, sports and energy drinks, and Asian specialty drinks.

Nonessential or “junk” foods include cakes, pastries, chocolate and sugar confectioneries, chilled and shelf-stable desserts, frozen baked goods, frozen desserts, ice cream, sweet biscuits, snack bars, processed fruit snacks, salty snacks, savory biscuits, popcorn, pretzels, and other savory snacks. Clearly, these are aggregate measures, and we omit many items and likely include some that would be termed healthful foods and not ultraprocessed junk foods.

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