Unhealthy Weight among Children and Adults: Urbanicity and the Cross-over in Underweight and Overweight in India

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ABSTRACT

Urbanization may drive the global rise of dual burdens of underweight and overweight in low- and middle-income countries. We assessed underweight and overweight by urban residence across the lifecourse in India using nationally representative, directly-measured height and weight data among ages 0 to 54 y (2004-2006; n= 236,040). Total unhealthy weight was comparable in urban and rural populations: 38% of the urban and 36% of the rural population, amounting to 378 million underweight or overweight individuals in 2011. Within urban settings, the unhealthy weight burden was largely composed of underweight in childhood and overweight in adulthood. Within rural settings, the unhealthy weight burden was largely composed of underweight at all ages. There was more overweight and less underweight in urban compared to rural areas at nearly all ages. In light of aging and urbanization projections, India's obesity advantage may be short-lived.

INTRODUCTION

Underweight and obesity are each potent contributors to negative health outcomes.[1–4] Globally, there is evidence that overweight is replacing underweight as the leading type of unhealthy weight in low-resource settings.[5,6] These patterns are in part attributed to macro-level changes related to urbanization, including economic growth, mechanization of labor and transport, sedentary living, and increased availability of processed and manufactured foods.[7–9] Many low- and middle-income countries are thus contending with a dual burden of disease, in which morbidity and mortality from infectious conditions such as tuberculosis and malaria are exacerbated by underweight, and morbidity and mortality from chronic conditions such as diabetes and heart disease are fueled by obesity.[9–11]

Many of the urbanization-related changes in lifestyle and living conditions anticipated to give rise to an impending obesity epidemic may indeed shift the balance of energy expenditure and intake to lower the risk of underweight. Despite interest in the role of urbanization in the global nutrition transition, the potential urbanization-related tradeoff between over- and under-nutrition in low-resource settings remains unclear. India, home to nearly one-fifth of the world's population and among the most rapidly urbanization nations and economies in the world, is known for its unrelenting high burden of underweight. Published reports of weight status of adult women suggest that India is among the countries that has not yet experienced a population-level transition from underweight to overweight,[5,12] although there is indication of a growing burden of overweight and obesity. [12–14] Nationally representative examination of weight status among adult men, children, and adolescents is more limited, and thus how contemporary unhealthy weight burdens compare between men and women and across age is unclear. To investigate how urbanicity relates to unhealthy weight from childhood through adulthood for both

sexes, we used nationally representative data to compare the burdens of underweight and overweight across urban and rural environments in India.

METHODS

Data

We combined two nationally representative surveys, the 2005-06 National Family Health Survey (NFHS) and the 2004-05 India Human Development Survey (IHDS), resulting in a sample of 236,040 respondents aged 0 to 54 years old.

The 2005-06 NFHS is the most recent and largest nationally representative survey providing directly measured anthropometric data. Implemented by local institutions with ORC Macro, the NFHS used a multi-stage cluster sample designed to be representative of urban and rural populations at the state- and national-level; detailed description of the study design and data collection protocols have been previously published.[15] A total of 74 369 men aged 15-54 years (response rate=87.1%), 12, 385 women aged 15-49 years (response rate=94.5%), and 46 655 children under 5 years of age were eligible for anthropometric assessments. For this analysis, we excluded individuals who had missing (n=20,841) or biologically implausible body mass index (BMI) values (beyond 5 SD from reference mean; n=125), and women who were pregnant (n=5,911), yielding 223,432 respondents.

The IHDS is the most recent nationally representative dataset that includes direct anthropometric measurements for children ages 8 to 11 years old, an age group not included in the NFHS. The IHDS interviewed 41,554 urban and rural households across India regarding health, education, employment, economic status, marriage, fertility, gender relations, and social capital.[16] Primary sampling units were villages and urban blocks. In urban areas, a random sample of

households was drawn; the rural sample consisted of a sample of households from the Human Development Profile of India 1993-1994 survey, freshened to ensure a nationally representative sample in 2004-05. The IHDS included data on 17 061 children ages 8 to 11 years old. After excluding children with missing (n=4274) or biologically implausible anthropometric values (n=179), 12,608 children between 8 and 11 y assessed in the IHDS were included in the analysis.

Weight status

Body mass index (BMI) was used for classifying weight status.[17–19] Mean BMI by age is shown in Supplemental Figure 1. Unhealthy weight status was classified as underweight, overweight or obese (referred to as "overweight" throughout), or obese following standard age-appropriate cut-offs.

For children under age 5 years, we used WHO-recommended classification,[3] defining underweight as a z-score ≥2 standard deviations below the sex-specific BMI-for-age according to the WHO Growth Standards [20], which have been endorsed by the Government of India.[21] While BMI-for-age is generally used to indicate wasting, we used it as a measure of underweight rather than the weight-for-age (the typical measure for underweight) to be consistent with the use of BMI in older age groups. Overweight and obesity were defined as z-scores ≥2 and 3 standard deviations above the sex-specific BMI-for-age, respectively.[20]

Weight status during late childhood (ages 8 to 11 y) and late adolescence (ages 15 to 18 y) was classified based on BMI for-age and sex z-scores relative to the WHO growth reference for school-aged children.[4] Classifications were as follows: z-score <-2 as underweight, z-score ≥1 as overweight, and z-score ≥ 2 as obese [22].

For adult men and women aged 19 years and older, we used WHO international BMI cutoffs [2] for weight status classification as follows: BMI <18.5 as underweight, BMI≥25 as overweight, and BMI ≥ 30 as obese. Asian-specific cutoffs for overweight (BMI≥23) and obese (BMI≥25) were also applied and are reported in Supplemental Table 1.

Urban residence

The definition of urban was set by the 2001 Census of India and was used for sampling in the NFHS and IHDS datasets: (1) all statutory places with a municipality, corporation, cantonment board or notified town area committee, etc.; or (2) a place with minimum: population size of 5,000, proportion of male working population engaged in non-agricultural pursuits of 75%, and population density of 400 per sq. km. (1000 per sq. mile). All places not meeting these criteria were classified as rural.

Statistical Analysis

The sex- and age-specific prevalence and 95% confidence intervals of underweight, overweight, and obese were calculated as the proportion of individuals in each age group (0-4 y, 8-11 y, 15-18y, 19-54 [men] or 49 y [women]) falling within the respective weight category. Estimates were calculated separately for each sex and by area of residence.

We computed the prevalence ratio for underweight, overweight, and obesity comparing the prevalence for males versus females (reference) and the prevalence in urban versus rural areas (reference). Finally, we computed absolute burdens of unhealthy weight by multiplying the prevalence of underweight, overweight, and obesity for each age-sex-urbanicity group by its respective 2011 census population count. This method assumed that the age-sex-urbanicity specific prevalence of underweight and overweight in 2011 was the same as it was in 2004-06.

We also imputed the prevalence of unhealthy weight for ages 5 to 7 years and 12 to 14 by using the mean prevalence of adjacent age groups after stratifying on sex and urban residence and the prevalence of unhealthy weight among women ages 40-49 y for women ages 50-54 y to calculate the number of individuals with unhealthy weight in age groups lacking data for direct prevalence estimation.

All analyses used survey weights to generate nationally representative estimates separately for each age-sex stratum. Because we included respondents from mutually exclusive age groups from the two data sources and all reported estimates are age group-specific, weights from the respective datasets were used as provided. Unweighted sample sizes are reported throughout. Taylor-series linearization was used for variance estimation of point prevalence and prevalence ratios. Analyses were conducted using SAS 9.3 software (Cary, NC).

Role of the funding source

There was no funding for this study. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

RESULTS

Weight status over the lifecourse

Table 1 displays the prevalence of underweight, overweight (inclusive of obesity), and obesity by age and sex. Underweight prevalence was highest in the early adult ages of 19 to 29 y for men (34.0%) and women (38.3%). Overweight and obesity were highest in the oldest observed age groups: 50 to 54 y for men (16.4% and 2.3%, respectively) and 40 to 49 y for women (23.7% and 6.3%, respectively). For both sexes, in all age groups, underweight was greater than 10% while

obesity was less than 10%. Overweight was less than 10% for ages under 30 y and greater than 10% after.

The prevalence of unhealthy weight tended to be higher among boys compared to girls until age 18 but lower thereafter. Sex differences in underweight were most pronounced in the adolescent years of 15 to 18 y (prevalence ratio [PR] and 95% confidence interval 2.25, 2.09-2.42), while sex differences in overweight and obesity were largest in adults (overweight: 0.64, 0.60-0.68; obesity: 0.34, 0.29-0.40).

Underweight and overweight within urban and rural environments

Table 2 displays the prevalence of underweight and overweight (inclusive of obesity) and the ratio of underweight to overweight by urbanicity and sex. Underweight ranged from 14.5% to 30.0% in urban areas and 17.3% to 42.4% in rural areas, while overweight ranged from 2.4% to 41.9% in urban areas and 1.4% to 14.5% in rural areas. Within urban environments, underweight tended to be progressively lower with age and overweight tended to be progressively higher with age (Figure 1). Within rural environments, both underweight and overweight were generally higher with age.

The ratio of underweight to overweight was above one at ages younger than 29 y in urban India, however overweight exceeded underweight in the older ages. A cross-over from underweight to overweight as the predominant unhealthy weight in urban areas can be seen in Figure 1. In rural areas, underweight exceeded overweight at all ages (Table 2 and Figure 1).

Comparing underweight and overweight across urban and rural settings

Figure 2 displays prevalence ratios of underweight and overweight comparing urban and rural areas. For both sexes and nearly all age groups, underweight was lower in urban areas while overweight was higher in urban areas. For both underweight and overweight, the magnitude of urban-rural prevalence ratios were larger among adults than among children and adolescents.

Absolute burden of unhealthy weight in India

Table 3 shows the estimated number of individuals with unhealthy weight in 2011. Across India, we estimated that a total of 378 million individuals ages 0 to 54 y were of unhealthy weight in 2011. Considering the population distribution, the prevalence of any unhealthy weight, 38% in urban areas and 36% in rural areas, was comparable by urbanicity (data not shown). There were nearly three underweight individuals for every overweight individual. With respect to absolute numbers, the majority of individuals with unhealthy weight nationally were observed in rural settings (255.2 million) compared to urban (122.9 million). Roughly 76% of the nation's 277 million underweight individuals and 44% of the nation's 101 million overweight individuals were located in rural settings. While the total number of individuals with any type of unhealthy weight was comparable across sexes, there were more underweight males (145 million males compared to 132 million females) and more overweight females (55.2 million females compared to 45.8 million males). Across sex and urbanicity, the largest number of individuals with any unhealthy weight were in the 19 to 29 y age group (Supplemental Table 2).

DISCUSSION

Across India, the prevalence of unhealthy weight among the Indian population aged 54 and younger was high: 38% in urban areas and 36% in rural areas in 2011. This amounted to 378 million individuals who experienced either underweight or overweight. The type of population-

level nutritional problem in each age group and sex differed by urbanicity. Although underweight continues to be the predominant type of unhealthy weight in rural India, the proportion overweight exceeded the proportion underweight within urban India at ages 30 and older. While underweight was lower at most ages in urban compared with rural areas, urban compared with rural residents were more likely to be overweight at all ages. The magnitude of the urban-rural PRs of overweight were larger than PRs of underweight. Informative for national health systems planning, we found that one-quarter of the national underweight burden and over one-half of the national overweight burden was located in urban areas. Considering underweight and overweight together, two-thirds of the national unhealthy weight burden was located in rural India.

We also found pronounced differences in the distribution of unhealthy weight by age and sex. Generally, levels of overweight were higher by age in both urban and rural areas, while levels of underweight were higher by age in rural areas only. The proportion of total unhealthy weight rose from roughly one-fifth among children under 5 to one-third among older children, and reached close to half for men and over half for women at ages 19 to 29 years. With respect to sex, the prevalence of any type of unhealthy weight tended to be higher for males during childhood and adolescence and higher for females thereafter. The most striking sex contrasts were in obesity, with adult men being half as likely to be obese compared with women. Considering underweight and overweight cumulatively from childhood to adulthood, there were more underweight males and more overweight females.

Urban women aged 40 to 49 y, toward the end of their reproductive years, were the most overweight and obese subgroup examined. Previous studies have also reported that Indian women were more likely to be overweight than Indian men,[23] and that urban women were more likely to be overweight compared to rural women.[12,24] Sex differences in overweight among women

may be exacerbated by biological factors, including childbearing, and sociocultural factors, including norms limiting female activity outside the home. Urban-rural differences are likely due to the labor-intensive agricultural economies, material deprivation, and lack of access to safe water and sanitation that hinder weight gain in rural settings. Given that being overweight is a risk factor for chronic conditions such as diabetes and heart disease, and that mothers may also pass these risks on to their children,[25] overweight in this group deserves attention from the maternal and child health community.

In contrast to over-nutrition, there is longstanding public health concern regarding under-nutrition due to under-investment in women and girls in India. Underweight was highest among women in their prime reproductive years of 19 to 39. Ample evidence links maternal weight status to birthweight, survival, subsequent child growth and development,[11] and risk of adult noncommunicable diseases,[26] suggesting intergenerational consequences of a high undernutrition burden at this critical stage in the lifecourse.

A limitation of this study was a lack of anthropometric data to characterize unhealthy weight at all ages. We were able to, however, estimate unhealthy weight across a broad range of life stages representing 70% of the 2011 Indian age distribution using the most recently available nationally representative data. There is no universally agreed upon method to classify overweight and obesity in children or adults (see for example, [2,4,27–29]), and there is debate regarding at which point "excess" weight becomes deleterious to health. [22,30,31] Because of the mixed evidence regarding the harm of excess weight in the Indian context, we chose to conservatively classify overweight for the main analysis by using the standard WHO overweight definition of BMI≥25 for adults rather than the Asian-specific overweight definition of BMI≥23.[2,29] If we

were to classify obesity as BMI≥23, these data indicate that urban Indian women are as obese as American women by age 40 y.[32]

In summary, while total unhealthy weight were comparable across urban and rural settings, under- and over-nutrition dramatically differed by urbanicity. Underweight continues to dominate the unhealthy weight burden in rural areas, whereas underweight and overweight are both prevalent at different stages of the lifecourse in urban India. Despite 70% of India's population being located in rural areas, over half of the absolute overweight burden existed in urban environments. The finding that the prevalence of overweight is higher than that of underweight in urban adults may be early indication of an epidemiologic cross-over from underweight to overweight in urban settings. Given projections for both aging and urbanization in India, these findings suggest that India's relative obesity advantage may be short-lived.

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TABLES

Table 1. The prevalence of underweight and overweight in India by age and sex

Age group	Prevalence, % (95% CI) Male	Female	Prevalence Ratio (95% CI) (ref=females)
	Underweight		
0 to 4 y	16.7 (15.9-17.4)	16.9 (16.1-17.6)	0.99 (0.93-1.05)
8 to 11 y	26.1 (24.1-28.0)	22.2 (20.6-23.8)	1.18 (1.08-1.28)
15 to 18 y	25.5 (24.3-26.7)	11.3 (10.7-12.0)	2.25 (2.09-2.42)
19 to 29 y	34.0 (33.0-35.0)	38.3 (37.5-39.1)	0.89 (0.86-0.92)
30 to 39 y	25.6 (24.5-26.6)	31.1 (30.1-32.0)	0.82 (0.79-0.86)
40 to 49 y	26.3 (25.1-27.5)	26.5 (25.5-27.6)	0.99 (0.94-1.04)
50 to 54 y	26.1 (24.1-28.2)	n/a	n/a
	Overweight		
0 to 4 y	2.1 (1.9-2.4)	1.6 (1.4-1.9)	1.29 (1.09-1.53)
8 to 11 y	9.3 (8.1-10.6)	7.9 (6.9-8.9)	1.18 (1.01-1.38)
15 to 18 y	2.3 (1.9-2.7)	2.9 (2.6-3.2)	0.80 (0.66-0.97)
19 to 29 y	6.2 (5.8-6.7)	7.8 (7.3-8.2)	0.80 (0.74-0.87)
30 to 39 y	13.0 (12.2-13.8)	17.3 (16.5-18.1)	0.75 (0.71-0.80)
40 to 49 y	15.1 (14.1-16.0)	23.7 (22.6-24.7)	0.64 (0.60-0.68)
50 to 54 y	16.4 (14.8-18.0)	n/a	
	Obesity		
0 to 4 y	0.6 (0.5-0.8)	0.5 (0.3-0.6)	1.32 (0.96-1.83)
8 to 11 y	4.3 (3.2-5.3)	2.8 (2.2-3.4)	1.52 (1.14-2.03)
15 to 18 y	0.4 (0.2-0.5)	0.3 (0.2-0.4)	1.20 (0.75-1.92)
19 to 29 y	0.7 (0.5-0.8)	1.3 (1.1-1.4)	0.53 (0.42-0.66)
30 to 39 y	1.7 (1.5-2.0)	3.8 (3.5-4.2)	0.45 (0.39-0.53)
40 to 49 y	2.1 (1.8-2.5)	6.3 (5.8-6.8)	0.34 (0.29-0.40)
50 to 54 y	2.3 (1.8-2.9)	n/a	n/a

Estimates based on IHDS (2004-05) data for 8 to 11 y; all other estimates based on NFHS (2005-06) data. Sample sizes for males were: 21,421 for 0-4 y, 6 527 for 8-11 y, 10,004 for 15-18 y, 23 949 for 19-29 y, 17 588 for 30-39 y, 13 370 for 40-49 y, 4,239 for 50-54 y. Sample sizes for females were: 19 844 for 0-4 y, 6,081 for 8-11 y, 17 967 for 15-18 y, 41 391 for 19-29 y, 31 779 for 30-39 y, and 21 880 for 40-49 y. Underweight defined as BMI-for-age z-score <-2 for 0 to 4 y; BMI-for-age z-score < -2 for 8 to 18 y; and BMI < 18.5 for 19+ y. Overweight defined as

weight-for-age z-score ≥ 2 for 0 to 4 y; BMI-for-age z-score ≥ 1 for 8 to 18 y; and BMI ≥ 25 for 19+ y. Obesity defined as BMI-for-age z-score ≥3 for 0 to 4 y; BMI-for-age z-score ≥ 2 for 8 to 18 y; and BMI ≥ 30 for 19+ y.

Table 2. Prevalence of underweight, overweight, and their ratio in urban and rural settings in India

	Urban males (n=44,469)			Urban females (n=60,070)		
	Underweight	Overweight	Underweight/ Overweight	Underweight	Overweight	Underweight/ Overweight
0 to 4 y	14.7 (13.4-15.9)	3.2 (2.5-3.9)	4.59	14.5 (13.2-15.8)	2.4 (1.9-3.0)	6.04
8 to 11 y	23.7 (21.4-26.1)	13.3 (11.4-15.3)	1.78	20.7 (18.3-23.1)	10.5 (8.8-12.1)	1.97
15 to 18 y	24.5 (22.6-26.4)	4.7 (3.8-5.6)	5.21	13.2 (11.9-14.4)	5.8 (5.0-6.6)	2.28
19 to 29 y	28.7 (27.3-30.0)	10.2 (9.3-11.1)	2.81	30.0 (28.8-31.1)	14.4 (13.5-15.4)	2.08
30 to 39 y	15.9 (14.6-17.1)	22.4 (21.0-23.8)	0.71	16.9 (15.7-18.0)	31.9 (30.5-33.4)	0.53
40 to 49 y	14.9 (13.5-16.2)	26.7 (24.9-28.5)	0.56	12.5 (11.3-13.6)	41.9 (40.1-43.6)	0.30
50 to 54 y	14.0 (11.6-16.3)	28.7 (25.6-31.9)	0.49	n/a	n/a	n/a

	Rural males (n=52,629)			Rural females (n=78,872)		
	Underweight	Overweight	Underweight/ Overweight	Underweight	Overweight	Underweight/ Overweight
0 to 4 y	17.3 (16.4-18.3)	1.8 (1.5-2.0)	9.61	17.6 (16.7-18.5)	1.4 (1.1-1.6)	12.57
8 to 11 y	26.8 (24.3-29.2)	8.2 (6.6-9.7)	3.27	22.6 (20.6-24.6)	7.2 (6.0-8.3)	3.14
15 to 18 y	26.0 (24.5-27.6)	1.0 (0.7-1.4)	26.00	10.6 (9.8-11.3)	1.7 (1.4-1.9)	6.24
19 to 29 y	37.1 (35.7-38.5)	3.9 (3.4-4.4)	9.51	42.4 (41.4-43.4)	4.5 (4.1-4.9)	9.42
30 to 39 y	30.8 (29.4-32.1)	8.0 (7.2-8.7)	3.85	38.0 (36.9-39.1)	10.1 (9.5-10.8)	3.76
40 to 49 y	32.4 (30.8-33.9)	9.0 (8.1-9.8)	3.60	33.6 (32.3-34.8)	14.5 (13.5-15.5)	2.32
50 to 54 y	32.6 (29.9-35.3)	9.9 (8.4-11.4)	3.29	n/a	n/a	n/a

Estimates based on IHDS (2004-05) data for 8 to 11 y; all other estimates based on NFHS (2005-06) data. Underweight defined as weight-for-age z-score <-2 for 0 to 4 y; BMI-for-age z-score < -2 for 8 to 18 y; and BMI < 18.5 for 19+ y. Overweight defined as BMI-for-age z-score ≥2 for 0 to 4 y; BMI-for-age z-score ≥ 1 for 8 to 18 y; and BMI ≥ 25 for 19+ y. Obesity defined as BMI-for-age z-score ≥3 for 0 to 4 y; BMI-for-age z-score ≥ 2 for 8 to 18 y; and BMI ≥ 30 for 19+ y.

Table 3. Estimated number, in millions, (% of national total) of underweight and overweight individuals ages 0 to 54 y urbanicity in 2011

	Males			Females			Males and Females		
	Underweight	Overweight	Any unhealthy weight	Under-weight	Over-weight	Any unhealthy weight	Under-weight	Over-weight	Any unhealthy weight
Urban	35.84	25.19	61.03	30.32	31.55	61.87	66.16	56.74	122.90
Rural	109.19	20.60	129.79	101.76	23.67	125.42	210.94	44.27	255.21
Urban and rural	145.02	45.79	190.82	132.07	55.22	187.29	277.10	101.01	378.11

Numbers were estimated by multiplying the prevalence of unhealthy weight in each age-sex-urbanicity group by the number of individuals in that group. Population counts for each age-sex-residence group were from the Census of India, 2011. The prevalence of unhealthy weight for ages 5 to 7 y and 12 to 14 y were imputed based on the mean prevalence of adjacent age groups after stratifying on sex and urban residence, and the prevalence unhealthy weight for women ages 40-49 y was used for women ages 50-54 y.

FIGURES

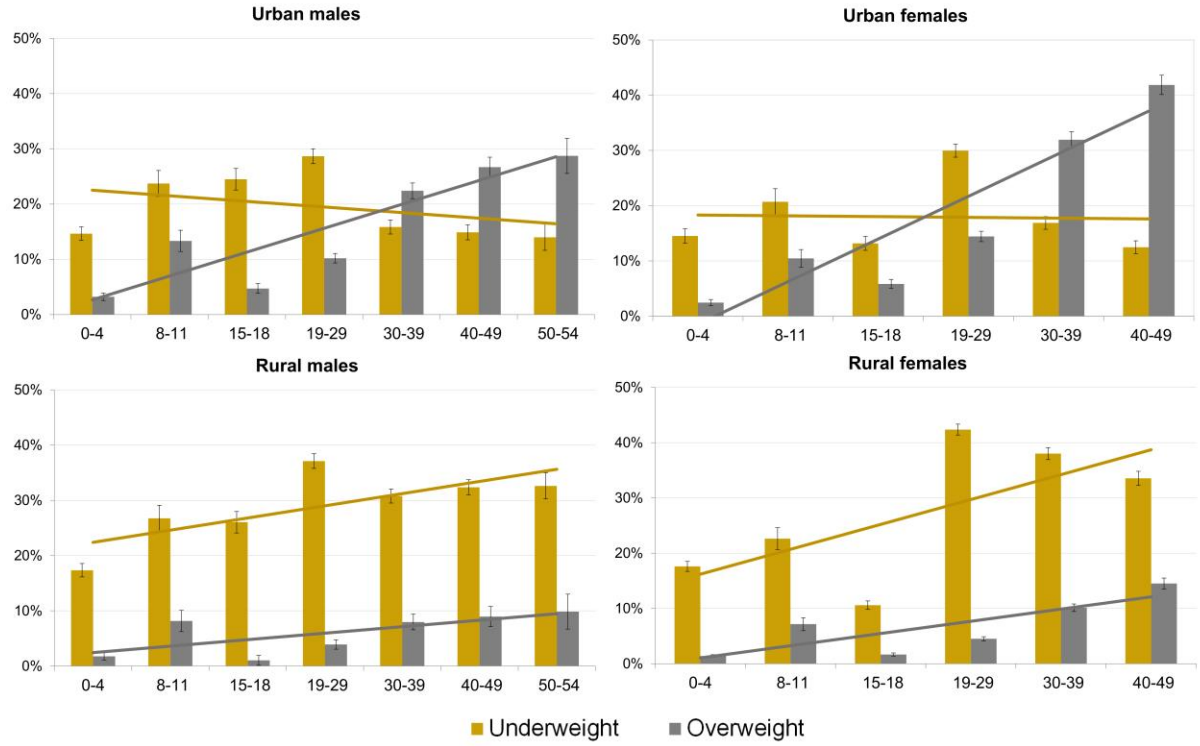


Figure 1. Prevalence (%, vertical axis) of underweight and overweight (inclusive of obesity) by age (years, horizontal axis) within urban and rural areas. Error bars display the bounds of the 95% confidence limits for the prevalence. Estimates based on IHDS (2004-05) data for 8 to 11 y; all other estimates based on NFHS (2005-06) data.

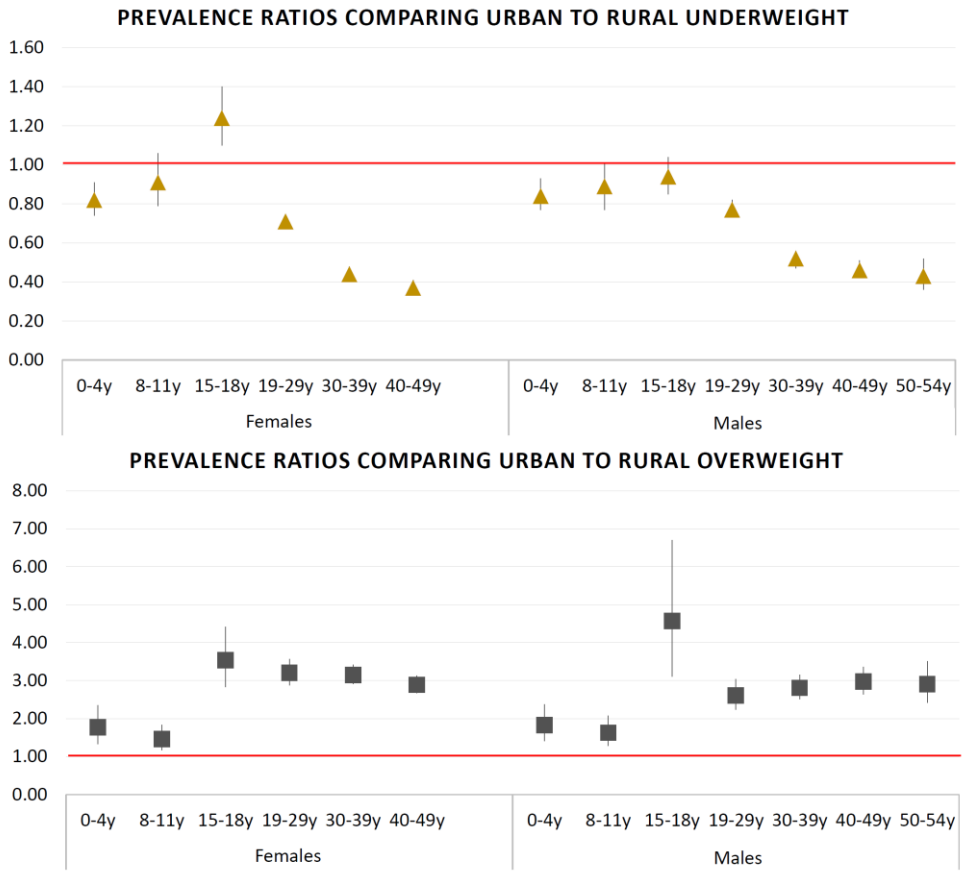


Figure 2. Comparison (prevalence ratios [PR]) of underweight and overweight (inclusive of obesity) by urbancity (ref=rural) for each age group and sex. Error bars display the bounds of the 95% confidence limits for the PR. The red horizontal line marks the null value. Estimates based on IHDS (2004-05) data for 8 to 11 y; all other estimates based on NFHS (2005-06) data.

SUPPLEMENTAL TABLES AND FIGURES

Supplemental Table 1. Prevalence of unhealthy weight in urban and rural areas in India

	Prevalence, % (95% CI)		Prevalence Ratio	Prevalence, % (95% CI)		Prevalence Ratio (95% CI)
	Urban	Rural	(ref=rural)	Urban	Rural	
Age group	(n=44 469)	(n=52 629)	(95% CI)	(n=60 070)	(n=78 872)	(ref=rural)
	Male Underweight			Female underweight		
0 to 4 y	14.7 (13.4-15.9)	17.3 (16.4-18.3)	0.84 (0.77-0.93)	14.5 (13.2-15.8)	17.6 (16.7-18.5)	0.82 (0.74-0.91)
8 to 11 y	23.7 (21.4-26.1)	26.8 (24.3-29.2)	0.89 (0.77-1.01)	20.7 (18.3-23.1)	22.6 (20.6-24.6)	0.91 (0.79-1.06)
15 to 18 y	24.5 (22.6-26.4)	26.0 (24.5-27.6)	0.94 (0.85-1.04)	13.2 (11.9-14.4)	10.6 (9.8-11.3)	1.24 (1.10-1.40)
19 to 29 y	28.7 (27.3-30.0)	37.1 (35.7-38.5)	0.77 (0.73-0.82)	30.0 (28.8-31.1)	42.4 (41.4-43.4)	0.71 (0.68-0.74)
30 to 39 y	15.9 (14.6-17.1)	30.8 (29.4-32.1)	0.52 (0.47-0.56)	16.9 (15.7-18.0)	38.0 (36.9-39.1)	0.44 (0.41-0.48)
40 to 49 y	14.9 (13.5-16.2)	32.4 (30.8-33.9)	0.46 (0.42-0.51)	12.5 (11.3-13.6)	33.6 (32.3-34.8)	0.37 (0.34-0.41)
50 to 54 y	14.0 (11.6-16.3)	32.6 (29.9-35.3)	0.43 (0.36-0.52)	n/a	n/a	n/a
	Male overweight			Female overweight		
0 to 4 y	3.2 (2.5-3.9)	1.8 (1.5-2.0)	1.83 (1.41-2.37)	2.4 (1.9-3.0)	1.4 (1.1-1.6)	1.77 (1.33-2.35)
8 to 11 y	13.3 (11.4-15.3)	8.2 (6.6-9.7)	1.63 (1.29-2.07)	10.5 (8.8-12.1)	7.2 (6.0-8.3)	1.46 (1.17-1.83)
15 to 18 y	4.7 (3.8-5.6)	1.0 (0.7-1.4)	4.57 (3.11-6.70)	5.8 (5.0-6.6)	1.7 (1.4-1.9)	3.54 (2.83-4.42)
19 to 29 y	10.2 (9.3-11.1)	3.9 (3.4-4.4)	2.61 (2.24-3.04)	14.4 (13.5-15.4)	4.5 (4.1-4.9)	3.21 (2.88-3.57)
30 to 39 y	22.4 (21.0-23.8)	8.0 (7.2-8.7)	2.81 (2.51-3.15)	31.9 (30.5-33.4)	10.1 (9.5-10.8)	3.15 (2.91-3.42)
40 to 49 y	26.7 (24.9-28.5)	9.0 (8.1-9.8)	2.98 (2.64-3.36)	41.9 (40.1-43.6)	14.5 (13.5-15.5)	2.89 (2.67-3.13)
50 to 54 y	28.7 (25.6-31.9)	9.9 (8.4-11.4)	2.91 (2.42-3.51)	n/a	n/a	n/a
	Male Obesity			Female obesity		
0 to 4 y	1.0 (0.6-1.4)	0.5 (0.3-0.6)	2.17 (1.33-3.54)	0.7 (0.4-1.0)	0.4 (0.3-0.5)	1.78 (1.06-3.01)
8 to 11 y	5.9 (4.7-7.1)	3.8 (2.5-5.1)	1.55 (1.05-2.29)	3.3 (2.4-4.3)	2.6 (1.9-3.4)	1.27 (0.85-1.90)
15 to 18 y	0.9 (0.5-1.3)	0.1 (0.0-0.2)	7.53 (3.09-18.37)	1.0 (0.6-1.3)	0.1 (0.0-0.1)	15.20 (7.27-31.79)
19 to 29 y	1.2 (1.0-1.5)	0.4 (0.2-0.5)	3.47 (2.15-5.59)	2.8 (2.4-3.2)	0.6 (0.4-0.7)	5.05 (3.91-6.53)
30 to 39 y	3.3 (2.7-3.9)	0.9 (0.7-1.1)	3.80 (2.80-5.16)	8.2 (7.4-9.0)	1.7 (1.4-1.9)	4.92 (4.15-5.84)
40 to 49 y	4.4 (3.6-5.2)	0.9 (0.7-1.2)	4.68 (3.34-6.54)	13.0 (11.9-14.1)	2.9 (2.5-3.3)	4.46 (3.80-5.24)
50 to 54 y	4.4 (3.1-5.6)	1.2 (0.7-1.8)	3.50 (2.10-5.81)			

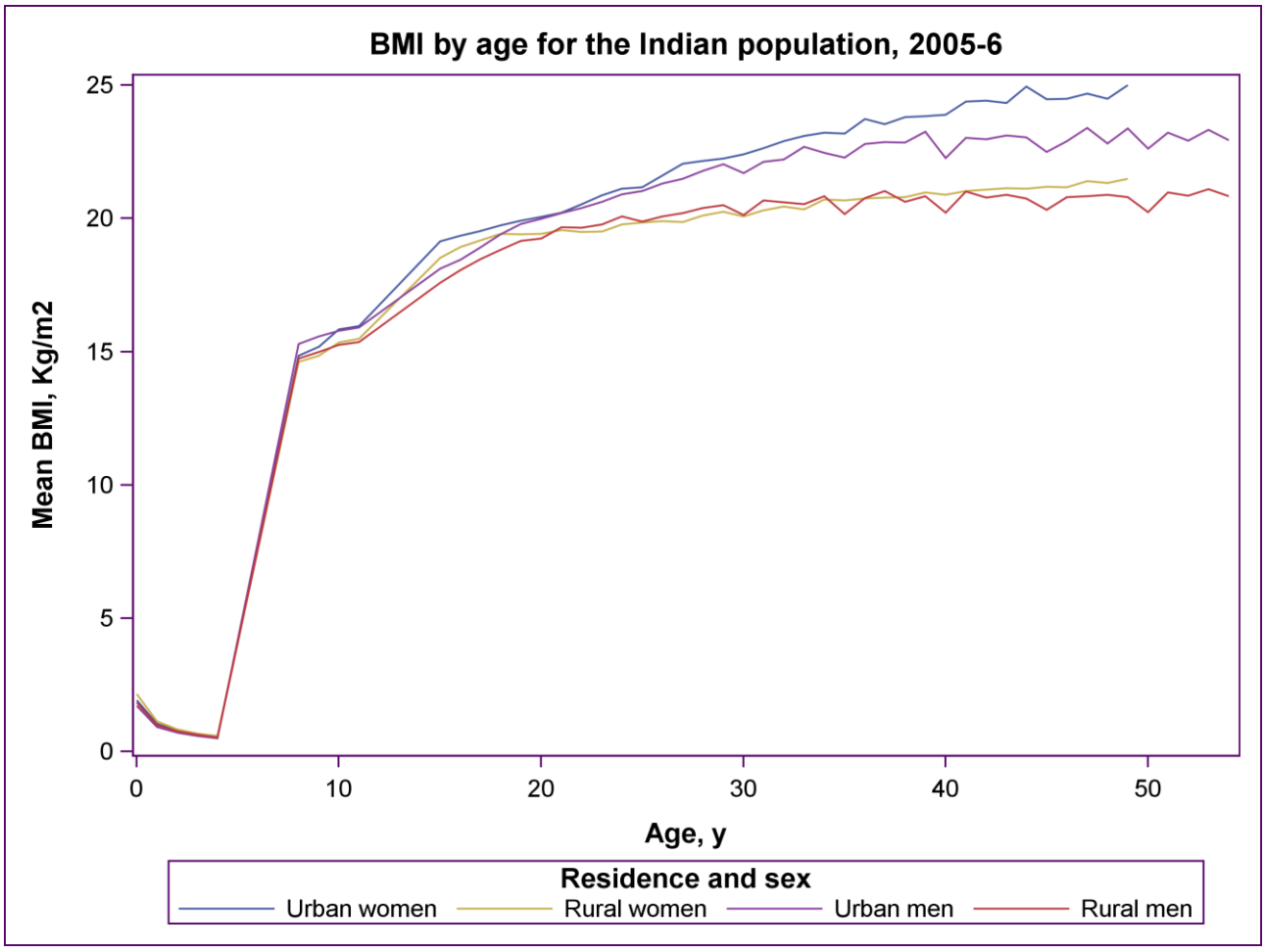
Estimates based on IHDS (2004-05) data for 8 to 11 y; all other estimates based on NFHS (2005-06) data. Underweight defined as weight-for-age z-score <-2 for 0 to 4 y; BMI-for-age z-score < -2 for 8 to 18 y; and BMI < 18.5 for 19+ y. Overweight defined as BMI-for-age z-score ≥2 for 0 to 4 y; BMI-for-age z-score ≥ 1 for 8 to 18 y; and BMI ≥ 25 for 19+ y. Obesity defined as BMI-for-age z-score ≥3 for 0 to 4 y; BMI-for-age z-score ≥ 2 for 8 to 18 y; and BMI ≥ 30 for 19+ y.

Supplemental Table 2. Estimated number (in milliions) of underweight and overweight individuals by age, sex, and urbanicity in 2011

	Urban males			Urban females			Urban total		
Age group	Underweight	Overweight	Any unhealthy weight	Underweight	Overweight	Any unhealthy weight	Underweight	Overweight	Any unhealthy weight
0 to 4 y	2.29	0.50	2.79	2.06	0.35	2.41	4.35	0.85	5.20
5 to 7 y	2.03	0.88	2.90	1.67	0.61	2.28	3.70	1.49	5.18
8 to 11 y	3.50	1.96	5.46	2.71	1.37	4.08	6.21	3.33	9.54
12 to 14 y	2.68	1.00	3.68	1.70	0.82	2.52	4.38	1.82	6.20
15 to 18 y	3.86	0.74	4.60	1.83	0.81	2.64	5.69	1.55	7.24
19 to 29 y	11.78	4.19	15.97	11.64	5.61	17.24	23.41	9.80	33.21
30 to 39 y	4.84	6.84	11.68	4.93	9.34	14.27	9.77	16.18	25.95
40 to 49 y	3.61	6.47	10.08	2.78	9.31	12.08	6.39	15.78	22.16
50 to 54 y	1.27	2.60	3.87	1.00	3.34	4.34	2.26	5.94	8.21
0 to 54 y	35.84	25.19	61.03	30.32	31.55	61.87	66.16	56.74	122.90

	Rural males			Rural females			Rural total		
Age group	Underweight	Overweight	Any unhealthy weight	Underweight	Overweight	Any unhealthy weight	Underweight	Overweight	Any unhealthy weight
0 to 4 y	7.46	0.76	8.22	7.03	0.55	7.59	14.50	1.31	15.81
5 to 7 y	6.49	1.46	7.95	5.44	1.15	6.59	11.93	2.62	14.54
8 to 11 y	10.86	3.31	14.17	8.43	2.66	11.09	19.29	5.98	25.27
12 to 14 y	7.72	1.35	9.07	4.48	1.19	5.67	12.20	2.53	14.74
15 to 18 y	9.73	0.39	10.12	3.45	0.54	3.99	13.18	0.92	14.11
19 to 29 y	29.19	3.07	32.26	31.80	3.38	35.18	60.99	6.45	67.44
30 to 39 y	17.56	4.55	22.11	21.64	5.77	27.41	39.20	10.31	49.51
40 to 49 y	14.70	4.07	18.76	14.37	6.21	20.58	29.07	10.28	39.35
50 to 54 y	5.47	1.65	7.13	5.11	2.21	7.32	10.59	3.86	14.45
0 to 54 y	109.19	20.60	129.79	101.76	23.67	125.42	210.94	44.27	255.21
Urban and rural, 0 to 54 y	145.02	45.79	190.82	132.07	55.22	187.29	277.10	101.01	378.11

Prevalence estimates based on IHDS (2004-05) data for 8 to 11 y; all other estimates based on NFHS (2005-06) data; population counts for each age-sex-residence group were from the Census of India, 2011. The prevalence of underweight, overweight, and obese for ages 5 to 7 y and 12 to 14 y were imputed based on the mean prevalence of adjacent age groups after stratifying on sex and urban residence



Supplemental Figure 1. Means based on IHDS (2004-05) data for 8 to 11 y; all other estimates based on NFHS (2005-06) data. No data were available for ages 5 to 7 y and 12 to 14 y.