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Understanding Geographic Variations in BMI in India

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The university-wide Livable Lives Initiative investigates what social conditions and policy supports can make life with a low or moderate income stable, secure, satisfying, and successful. The aim is to build a large body of work that informs local programs as well as state and federal policies in economic security, employment, public health, education, housing, and other key areas.

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Understanding Geographic Variations in BMI in India

Comparison of Body Mass Index is a useful marker for energy imbalance and associated variations across populations. High BMI is associated with cardiovascular and metabolic diseases, whereas low BMI is associated with increased mortality. BMI comparisons across geographical locations may give us indication as to which direction the public health policies should head and what could be the corrective approach towards a more balanced and healthier energy level. The current study uses Indian National Family Health Survey (NFHS-3) data for women from 2005-06 to develop state-specific models of BMI and do inter-state comparisons. We also examined the individual versus contextual predictors of these variations. Of the total sample (N = 118,734), 29% had a BMI lower than 18.5, and were classified as underweight, with Uttar Pradesh having the highest number of underweight women, followed by Maharashtra, West Bengal and Karnataka. North-eastern states of Arunachal Pradesh, Nagaland, Manipur, and Mizoram, collectively had lowest percentage of underweight residents. Female respondents who had higher levels of education, were married, and were employed, had a lower prevalence of being underweight (p<0.000). Women who smoked and consumed alcohol were also more likely to be underweight. But addition of such individual level variables like income and wealth variables, educational and demographic variables, and health behaviors alter the odds of having a low BMI in some states (such as Punjab, Kerala, Goa & Delhi), but not in others (such as Bihar, Jharkhand, Arunachal Pradesh, Nagaland, Madhya Pradesh & Manipur). In former types of states where individual level variables change the odds of having low BMI, continued investments in education, health education targeted toward health-adverse behaviors, and access to public health resources may show improvement in levels of BMI. On the other hand, states where individual level variables did not influence the odds of having low BMI in our analysis might have different genotypical characteristics of the female respondents. It is also possible that these states might need intervention not only at individual level, but also at the level of macroeconomic and developmental factors such as food security, or to health-related factors such as the availability, accessibility, and quality of health care services, particularly those directed toward women. The current study shows the need for two-pronged policy interventions to alter the BMI imbalance in India.

Key words: *BMI, food security, India, women, health, geographic variation, determinants*

Background

Ensuring food security is a growing public health challenge in developing countries. Quantification of food adequacy is most commonly accomplished through measurement of the Body Mass Index (BMI), although there are several other measures such as the free fat index (Bhat et al., 2005; Khongsdier, 2002). Dividing the weight of an individual in kilograms by the square of the height in meters provides a (usually) two-digit number, which can be directly compared across individuals. The World Health Organisation suggests a normal BMI of between 18.5 and 23 in Asians (WHO, 2000, 2002). These cut-offs are not without controversy. Scholars have suggested that, since northern Indians have higher body fat, optimum levels of cut-off for overweight should be 19 kg/m2 for females and 21.5kg/m2 for males (Dudeja et al., 2001). Higher body fat has been attributed to the "thrifty genotype/ phenotype" and adiposity even in thinner adults and children in

India, and increases the risk of illnesses (Glumer, Vistisen, Borch-Johnson, & Colagiuri, 2006; Ramachandran et al., 2002; Vikram et al., 2003; Yajnik, 2004).

Irrespective of these controversies, it is clear that the BMI is a useful marker for energy imbalance. While most studies have focused on under-nourished populations with low levels of BMI and chronic energy deficiency, studies in the past decade have reported a growing trend of high BMI in a sizeable proportion among the wealthy in urban areas. Such elevated levels of BMI is also associated with clustering of cardiovascular disease risk and metabolic syndrome (Mohan et al., 2000; Ramachandran, Mary, Yamuna, Murugesan, & Snehalatha, 2008; Snehalatha, Sivasankari, Satyavani, Vijay, & Ramachandran, 1999).

There are several factors that are associated with BMI. Increased BMI scores have been identified among individuals of young and middle age, female gender, higher income and education, and individuals living in urban areas. Lower BMI is more commonly seen among the elderly, people with low incomes, people with little formal education, those living in rural areas, and users of tobacco (Pednekar, Gupta, Hebert & Hakama, 2007; Pednekar, Gupta, Shukla, & Hebert, 2006; Shukla, Gupta, Mehta, & Hebert 2002). With increasing rural development, the past few years have seen rising BMIs in rural areas, with increasing incidence of overweight and obesity, and with increases in related non-communicable illnesses (Ramachandran et al., 2004). Most of these studies are epidemiological, and establish prevalence of BMI patterns, while a few studies have tried to understand the reasons behind these patterns (Griffiths & Bentley, 2005).

The majority of the studies in India are either city specific (Mohan et al., 2000; Pednekar, Hakama, Hebert, & Gupta, 2008; Shukla, Gupta, Mehta, & Hebert, 2002), state specific (Griffiths & Bentley, 2001, 2005; Khongsdier, 2002; Sauvaget et al., 2008), region specific (Dudeja et al., 2001), or ethnicity specific (Bose & Chakraborty, 2005), with few studies looking at multi-state BMI levels.

One set of studies by Subramanian and Smith (2006) analyzed a sample of 77,220 women from India, with multiple categories of BMI (underweight, pre-overweight, overweight, & obese) as the outcome. They found that affluent states had lower risk of underweight, but this was seen mainly in women of high socioeconomic position. State-level measures of affluence did not modify the positive association between socioeconomic position and categories of overweight. Subramanian, Perkins, and Khan (2009) conducted repeated cross-sectional analyses in nationally representative samples of 76,514 and 80,054 women aged 15-49 drawn from the 1998-1999 and 2005-2006 Indian National Family Health Survey, respectively. Results suggested a strong positive relationship between socioeconomic status (SES) and BMI at both time points and across urban and rural areas. Although the ratio of underweight to overweight women decreased from 3.3 in 1998-1999 to 2.2 in 2005-2006, there were still considerably more underweight women than overweight women. A slight excess of overweight women as compared with underweight women was reported only in the top wealth quintile and in groups with higher education.

The current study expands upon the prior work by examining geographic variations across Indian states in BMI among women. We use the 2005-2006 data from the Indian National Family Health Survey (NFHS) to develop state-specific models of BMI, and compare states on the levels of BMI of women who live within them. We also try to examine the individual versus contextual predictors of these variations in an attempt to classify states based on BMI status.

Methods

Data sources

All the variables in this study were obtained from the Indian National Family Health Survey (NFHS). NFHS is a large-scale, multi-wave survey conducted in a representative sample of households throughout India. The survey provides state and national information for India on fertility, infant and woman mortality, the practice of family planning, maternal and women's health, reproductive health, nutrition, anemia, and utilization and quality of health and family planning services. Each successive wave of the NFHS has had two specific goals: a) to provide essential data on health and family welfare needed by the India Ministry of Health and Family Welfare and other agencies for policy and program purposes, and b) to provide information on important emerging health and family welfare issues. For the current cross-sectional analyses, we used NFHS-3, which is the third in a series of national surveys, and the latest year (2005-06) for which data were available. NFHS-3 conducted interviews with more than 230,000 respondents; this study utilized data from the women sample (N = 118,734).

Predictor variables

We used binary variables to indicate each state of residence of the women at the time of the interview. NFHS-3 data permits state-level analyses of women in the 28 states in India. We use these women in pooled analyses on the entire data set.

Women-level characteristics included woman's wealth status, age, religion, education, marital status, employment status, and health behaviors (alcohol drinking and smoking). Wealth status was developed from the wealth index, which is a composite measure of the cumulative living standard of a household (Rutstein & Johnson, 2004). It is calculated using ownership of household assets, such as televisions, bicycles, materials used for housing construction, types of water access and sanitation facilities, and so on (please see Rutstein & Johnson, 2004; for further detail on the methodology used to construct the wealth index). We used standardized wealth scores to classify the sample population into wealth quintiles: poorest (the bottom 20%), poor (21%-40%), middle (41%-60%), rich (61%-80%), and richest (81%-100%),

Binary variables for religion (Muslim, Jewish/Christian, Sikh, Jain, "Other religion" or no religion) and for educational status (no formal education, primary education, secondary education, and post-secondary education) were obtained directly from the data. We classified women into either married, separated/divorced, or never married. A binary employment status indicated whether a woman was currently working. Binary health behavior variables indicated whether or not a woman was currently using alcohol and currently smoking cigarettes.

The health-system variable included information on sources of health care. We categorized women into insurance categories of public insurance, private insurance, or no insurance.

The geographic-variable included information on the rural versus urban status of the community in which women resided.

Outcome variable

We constructed an ordinal Body Mass Index (BMI) variable to assess the respondent's nutritional status. BMI is defined as weight in kilograms divided by height squared in meters (kg/m^2) and adjusted for altitude. We used 18.5 as the cut-off point to assess whether or not a woman was currently underweight, 25 as a cut-off point between normal weight and overweight, and 30 as the cut-off point between overweight and obese.

Geographic Information Systems maps

Descriptive maps were created using Arc Map10. Base maps for India were downloaded from DIVA-GIS[1]. Shape files with state-level boundaries were used because data from the World Health Survey were at the state level. Data on underweight and overweight from the World Health Survey were then imported into Arc Maps. We used linking variables to import into these Arc maps descriptive as well as multivariable (odds ratios) data.

Analyses

We weighted analyses to account for the complex sampling design of NFHS. We assessed all bivariate associations between predictor and outcome variables with simple logistic regression for continuous variables and chi-square analyses of homogeneity for categorical variables. Design-based F statistics were used to assess significance levels.

We first estimated state-stratified models by regressing our BMI variable on women-level characteristics using women residing in a single state. Twenty-eight such models, one for each state, were estimated in order to present our descriptive odds ratios. For multivariable analyses, we estimated a weighted ordinal logistic regression model using all women in the sample using state-level dummies. We first estimated a model with only state fixed effects in order to observe variations across states, and then with person-level and contextual predictors in an attempt to explain these variations. Uttar Pradesh was chosen as the referent state because of the highest prevalence of underweight observed among women resident within it.

Results

Prevalence of underweight in India

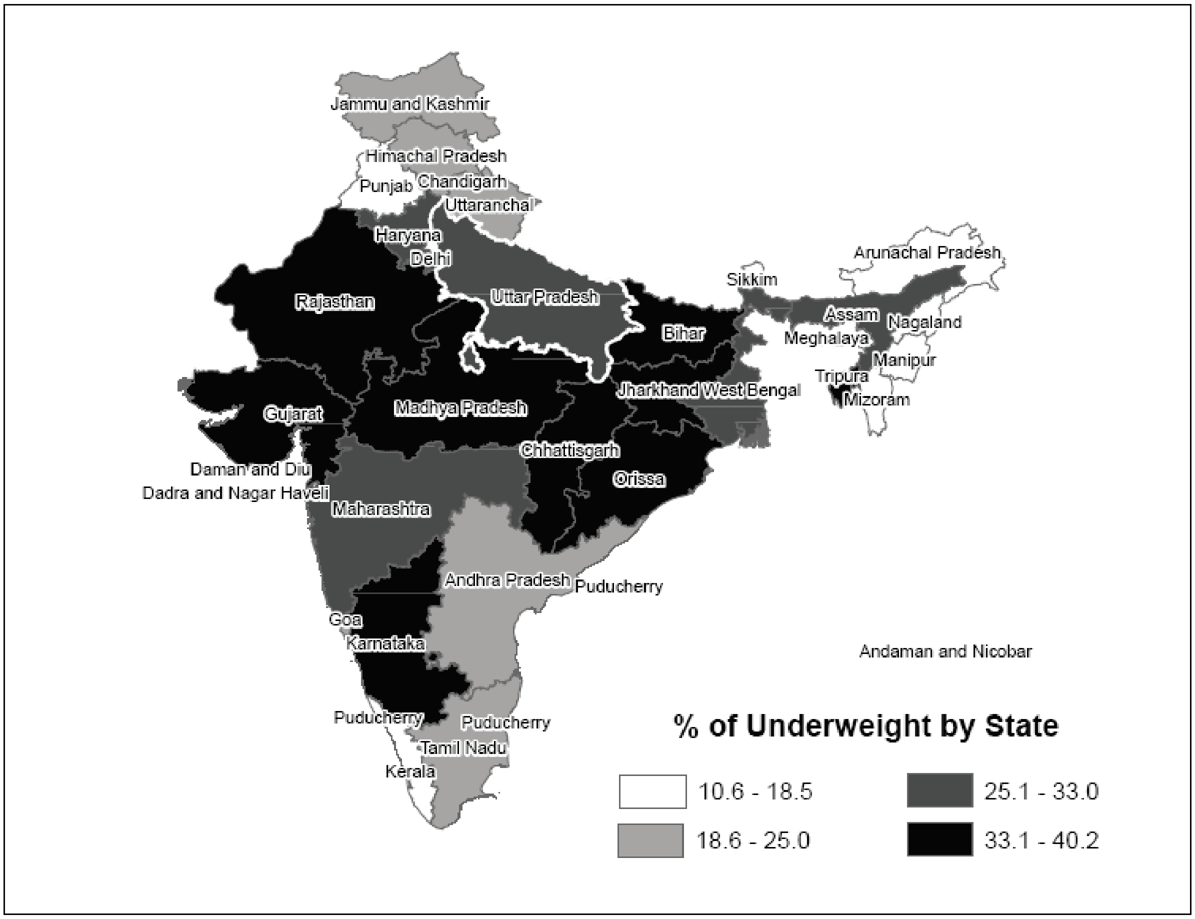
Descriptive analysis showed that 29% of the total 118,734 participants had a BMI lower than 18.5, and were classified as underweight in this study. Figure 1 shows the distribution of the underweight by state in India, and reveals that Uttar Pradesh had the highest number of people who were underweight, followed by Maharashtra, West Bengal, and Karnataka. The Northeastern states had fewer underweight respondents compared to the other zones. Among the southern states, Kerala had an underweight population similar to the northeastern and northwestern parts of the country, and fewer numbers of underweight individuals compared to neighboring states.

[1] http://www.diva-gis.org/datadown

Bivariate results

Bivariate analyses show a statistically significant difference in proportions of underweight individuals across the various states ($p<0.000$; not shown in tables). Female respondents who had higher levels of education, who were married, and who were employed, all had a lower prevalence of being underweight (all at $p<0.000$). Fewer women who smoked and consumed alcohol were underweight, when compared to women who did not smoke or consume alcohol.

Figure 1. Descriptive map showing percentage distribution of underweight by states[2]



Regression results

On ordinal logistic regression, BMIs were significantly associated with state fixed effects (Waldχ^2=1710.33, df=51, p=0.000 from model with robust standard errors; shown in Table 1, model 1). Figure 2 map IIa displays these ordered odds ratios of having a higher BMI for women in a particular state compared to those in Uttar Pradesh; a larger circle represent a higher value of these odds ratios (ORs). Residents in states such as Punjab (OR: 3.1), Delhi (OR: 3.0), and Kerala (OR:

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2 Maps represent administrative boundaries. Actual political boundaries may be different from shown.

2.9) had higher odds of having increased BMI compared to residents of Uttar Pradesh (all with $p<=0.001$).

Figure 2. Map representing changes in Odds Ratios with inclusion of additional predictors.[3]

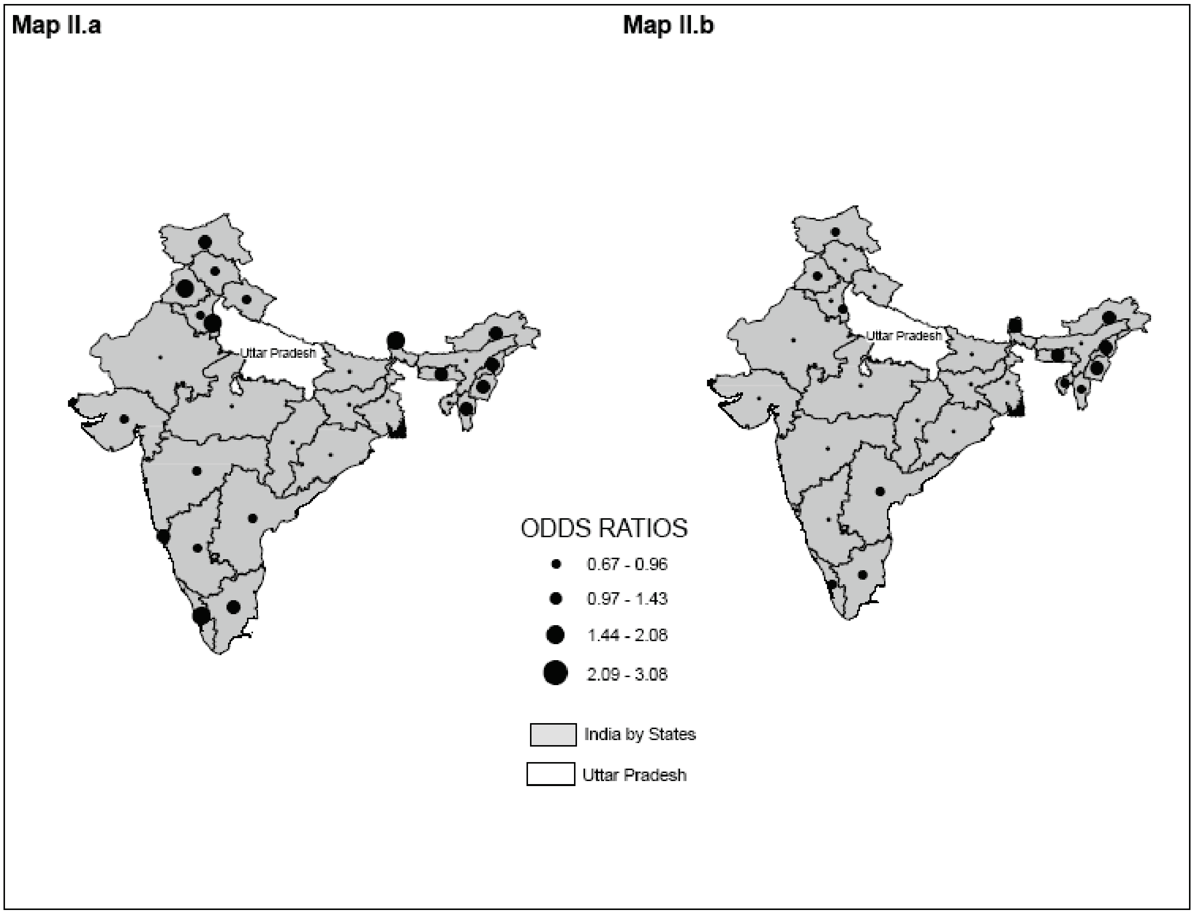

Table 1, model 2 shows results obtained by regressing the ordinal BMI variable on our full set of individual and state characteristics. The overall model is significant (Wald χ^2 =9753.54, df=28, p=0.000 from model with robust standard errors). Adjusting for these characteristics causes changes in the odds ratios for several states. Some states—Punjab, Delhi, and Sikkim—show declines in their odds ratios (suggesting that individual-level factors successfully explain BMI prevalence within these states). Other states—Rajasthan, Jharkhand, and Madhya Pradesh—show little or no change in odds ratios, suggesting that BMI prevalence is unrelated to individual-level characteristics. Map II.b in Figure 2 reveals this phenomenon graphically: adjusted odds ratios are highest among several eastern states when compared to Uttar Pradesh.

Several of the individual characteristics were also significantly associated with having a higher BMI. BMI revealed a gradient with increasing wealth. Interpretability of odds ratios on the religion variables were adversely affected by model instability due to the relatively small number of individuals belonging to Jain and other faiths. All forms of education were associated with increasing

[3] Maps represent administrative boundaries. Actual political boundaries may be different from shown.

BMI compared to individuals without formal education, as was being married or separated. People who were employed and those who reported smoking cigarettes had slightly lower odds of increased BMI. Rural dwellers also had lower odds of having a high BMI when compared to urban dwellers.

Table 1. Multivariable analysis of BMI

Predictors	Model 1 Odds ratio (95% CI)		Model 2 Odds ratio (95% CI)	
States of Residence				
Jammu	1.7	(1.5, 2.0)***	1.3	(1.2, 1.5)***
Himachal Pradesh	1.3	(1.2, 1.5)***	0.8	(0.7, 0.9)**
Punjab	3.1	(2.7, 3.6)***	1.4	(1.2, 1.6)***
Uttaranchal	1.3	(1.1, 1.5)***	0.9	(0.8, 1.0)
Haryana	1.4	(1.2,1.7)***	0.9	(0.8, 1.1)
Delhi	3	(2.6, 3.6)	1.1	(0.9, 1.3)
Rajasthan	1	(0.9, 1.1)	0.9	(0.8,1.0)**
Bihar	0.7	(0.6, 0.8)***	0.7	(0.6, 0.7)***
Sikkim	2.4	(2.2, 2.7)***	1.9	(1.7, 2.3)***
Arunachal Pradesh	1.8	(1.6, 2.0)***	1.9	(1.6, 2.3)***
Nagaland	1.6	(1.5, 1.8)***	1.5	(1.3,1.7)***
Manipur	2.1	(1.9, 2.3)***	2.1	(1.9,2.3)***
Mizoram	1.9	(1.8, 2.2)***	1.3	(1.1,1.5)***
Tripura	0.9	(0.8, 1.1)	1.1	(0.9,1.2)
Meghalaya	1.7	(1.5, 1.9)***	1.7	(1.4, 2.0)***
Assam	0.9	(0.8, 1.1)	1	(0.8,1.1)
West Bengal	0.9	(0.8, 1.1)	0.8	(0.8, 0.9)***
Jharkhand	0.7	(0.6, 0.8)***	0.7	(0.7,0.9)***
Orissa	0.8	(0.7, 0.9)***	1	(0.9,1.1)
Chhattisgarh	0.7	(0.6, 0.8)***	0.9	(0.8,1.0)*
Madhya Pradesh	0.8	(0.7, 0.9)***	0.8	(0.7,0.9)***
Gujarat	1.2	(1.0, 1.4)*	0.8	(0.7,0.7)***
Maharashtra	1.1	(1.0, 1.3)	0.7	(0.7,0.8)***
Goa	1.7	(1.5, 2.0)***	0.7	(0.7,0.9)***
Kerala	2.9	(2.6, 3.2)***	1.3	(1.2,1.5)***
Tamilnadu	1.7	(1.5,2.0)***	1.3	(1.1,1.4)***

Predictors	Model 1 Odds ratio (95% CI)		Model 2 Odds ratio (95% CI)	
Karnataka	1.2	(1.0, 1.3)*	0.9	(0.8,1.0)
Andhra Pradesh	1.3	(1.1, 1.5)***	1	(0.9,1.1)
Uttar Pradesh	1	--	1	--
Wealth Index				
Poorest			0.2	(0.2,0.3)***
Poorer			0.3	(0.3,0.4)***
Middle			0.3	(0.3,0.4)***
Richer			0.5	(0.5,0.6)***
Richest			1	
Age			1	(1.0,1.0)***
Religion				
Muslim			1.2	(1.1,1.3) ***
Judeo-Christian			1.2	(1.0,1.3) **
Sikh			1.4	(1.3,1.7) ***
Buddhist			1	(0.8,1.2)
Jain			0.8	(0.6,1.0)
Other religion			1.3	(1.0,1.5) *
No religion			0.4	(0.1,1.0)
Hindu			1	--
Education Status				
Primary education			1.3	(1.2,1.3) ***
Secondary education			1.3	(1.2,1.3) ***
Tertiary education			1.4	(1.3,1.5) ***
No education			1	--
Marital Status				
Married			1.8	(1.7, 1.9) ***
Separated			1.7	(1.5, 1.8) ***
Never married			1	--
Employment Status				
Employed			0.9	(0.8,0.9) ***
Not employed			1	--

Predictors	Model 1 Odds ratio (95% CI)		Model 2 Odds ratio (95% CI)	
Health Behaviors				
Consumes alcohol			0.9	(0.8,1.1)
Smokes cigarettes			0.6	(0.6,0.7) ***
Access to Public Health Resources				
Has a regular source of care			0.9	(0.9,1.0) **
Is insured			1.2	(1.1,1.2) ***
Residence				
Rural			0.8	(0.7,0.8) ***
Urban			1	--

Note : Overall Test Statistics Wald test = 9753.6, p=0.00

p≤0.05* , p≤0.01**, p≤0.001*

Discussion

In this paper, we describe state-level variations in BMI among female respondents in a nationally representative survey in India. The results suggest a four-fold variation in BMI between Uttar Pradesh on one hand with the highest percentage of residents who are underweight, and the northeastern states of Arunachal Pradesh, Nagaland, Manipur, and Mizoram, which collectively possess the lowest percentage of underweight residents. Clearly, reducing such variations in BMI in general, and in underweight status in particular, is of critical importance to health policymakers. Not only is it an issue that assumes added salience in the light of increasing food prices throughout much of India, but low BMI is also associated with increased mortality and requires a public health approach to its optimization (Pednekar, Hakama, Hebert, & Gupta, 2008; Sauvaget et al., 2008; Subramanian, Perkins, & Khan, 2009).

Explanations for why these inter-state variations occur are only partially related to sociodemographic factors. Addition of income and wealth variables, educational and demographic variables, and health behaviors alter the odds of having a low BMI in some states, but not in others. For example, the odds of having a higher weight are nearly halved adjusting for the above variables in Punjab (odds ratios fell from 3.1 to 1.4), Kerala (2.9 to 1.3), Goa (1.7 to 0.7), and Delhi (3.0 to 1.1), suggesting that in these states, much of the variation in weight appears to be explained by individual-level characteristics. The policy implications for such states also seem straightforward. For example, continuing investments in education, health education targeted toward health-adverse behaviors, and access to public health resources may all pay dividends in reducing underweight status among residents in these states.

The effects of individual-level determinants of having a low BMI in some other states is less clear. In several states, adjustment for these variables does not seem to affect odds of having a lower weight. In Bihar and Jharkhand, odds ratios do not change from 0.7, and there is little change observed in Arunachal Pradesh (1.8 to 1.9), Nagaland (1.6 to 1.5), Madhya Pradesh (0.8 with no change), and

Manipur (2.1 with no change). In these states, the drivers of BMI do not seem to be demographic, but are likely related to variables to which we do not have access in our model. These include the genotype characteristics of the female respondents, macroeconomic and developmental factors such as food security, and health-related factors such as the availability, accessibility, and quality of health care services, particularly those directed toward women. It is likely in these states that variations in BMI are a function of development, and that narrow, person-level, health-focused solutions may not succeed in reducing variability in this measure.

Such a conceptualization suggests a typology of states. One set is characterized by relatively high levels of development where optimizing BMI can occur through primarily person-level means as observed by differences in their odds ratios between models 1 and 2 on Table 1 (Punjab, Kerala, or Delhi, for example). Another set consists of states with relatively low levels of development where efforts to optimize BMI solely at the person-level are unlikely to succeed (Rajasthan, Bihar, and Madhya Pradesh, for example). In these latter states, some combination of individual (e.g., health promotion) and contextual (e.g., strengthening food distribution systems) efforts are necessary in order to improve BMI.

Our data set, however, does not allow us the ability to identify specific contextual interventions that might increase BMI among female respondents to this national survey. Lacking information on food prices and a more complete picture of extant health resources in a state, we use state fixed effects is an attempt to subsume these particular state-level unobserved characteristics that might influence BMI. Data that allow parsing of the individual versus contextual determinants of BMI are necessary to fully address this question. Our study also suffers from other limitations, including our focus on women, which ignores the challenges of underweight among men. It is likely that men and women have different person-level determinants of BMI but, because this study focused only on women, we are unable to identify these determinants.

Despite these limitations, this study of over 100,000 women representative of women in India offers insights into the determinants of geographical variations in BMI across states, and offers potential policy approaches that can mitigate such variations. In an era of rising food prices, supply constraints on food, and increasing competition for health resources, understanding and alleviating BMI variations is of critical importance to the safeguarding of women's health in India.

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