HOUSEHOLD-LEVEL DETERMINANTS OF WEIGHT STATUS AMONG INDIAN CHILDREN AND ADOLESCENTS: A DYADIC MULTILEVEL ANALYSIS

Ilana Raskind, M.Sc.[1]

Solveig A. Cunningham, Ph.D.[2]

Regine Haardörfer, Ph.D.[1]

Shailaja Patil, M.D.[3]

1. Department of Behavioral Sciences & Health Education, Emory University
2. Hubert Department of Global Health, Emory University
3. Department of Community Medicine, Shri. B.M. Patil Medical College, BLDE University, Bijapur, India

Abstract submitted to the 2015 meeting of the Population Association of America

Household-level determinants of weight status among Indian children and adolescents: A dyadic multilevel analysis

Background

India, like many other low and middle-income (LMIC) countries, is currently facing a double burden of increasing overweight/obesity and persistent undernutrition. Among children and adolescents, prevalence estimates range from 4.5%-23.9% and 1.3%-6.1% for overweight and obese, respectively, with varying gender-specific estimates (1-5). Concurrently, the prevalence of undernutrition is estimated at 48.9% among girls and 45.5% among boys (6). Both underweight and overweight/obese in childhood and adolescence are associated with numerous short-term physical and psychological health conditions (7), as well as with the development of chronic health conditions later in life including hypertension, metabolic syndrome, type 2 diabetes mellitus, and cardiovascular disease (3, 8, 9). These health outcomes impact all levels of society from individual quality of life to nationwide economic productivity, underscoring the importance of research that furthers our understanding of how the double burden of disease manifests in diverse settings.

The double burden of disease exists as a function of several larger global trends including ongoing epidemiologic, demographic, and nutrition transitions. The impact of these transitions on weight status and nutrition is made manifest in factors such as the increasing availability and affordability of obeseogenic food and beverages, decreased physical activity and increased sedentary lifestyles, rural-urban migration, urbanization, and deepening poverty and inequality (10, 11). In India, weight status varies widely by socio-economic status, urban and rural residence, gender, and socio-cultural context (8, 12, 13). This study seeks to identify whether unhealthy weight is clustered within families (including underweight, overweight/obese, and concurrent underweight and overweight/obese), as well as whether household level determinants are differentially associated with weight status among opposite gender siblings in Bijapur, India.

Prior research in India has demonstrated poorer nutritional outcomes among girls, which may be the result of cultural and gender norms such as preferential feeding practices for men and boys, and limited maternal control of household resources (14, 15). Recent studies have also indicated a higher prevalence of overweight/obese among women and girls (5, 13, 16). To date, limited research has been conducted in this setting with a focus on the critical period of adolescence. This study aims to address this gap as adolescence is a time when gender norms (e.g. regarding marriageability or body image norms) may become significantly more pronounced.

Globally, current approaches to addressing unhealthy weight have highlighted the importance of viewing the problem from a multi-level and socio-ecologic perspective wherein social and environmental factors, operating at different systemic levels, act as key determinants of health behavior and health outcomes (17). As part of this framework, the home environment is increasingly viewed as a critical context in which to consider potential risk and protective factors for nutritional and weight outcomes (18-20). However, much of the existing research has been conducted in developed country settings. Of the studies which have been conducted in India, very few have made use of multi-level modeling techniques, which allow us to statistically account for naturally occurring familial structures, where children and adolescents are typically nested within households, and appropriately estimate how variables occurring at different levels are associated with both the outcome and each other (21).

Looking more closely at the household-level determinants of weight status, research has identified various patterns of familial clustering. In a South Indian sample, offspring BMI and macronutrient intake were significantly correlated with the BMI and macronutrient intake of both parents (22), while a study conducted among families in New Delhi found that adiposity was most strongly correlated among siblings (23). Among siblings, research has identified both concordant and discordant clustering, with differences in both birth order and gender combinations (24-26). Further research is needed to elucidate meaningful and consistent patterns.

Few studies on familial clustering have been conducted in India, and to our knowledge, no studies have analyzed siblings as interdependent dyads, each of whom may be differentially impacted by household level variables. The theoretical framework behind dyadic data analysis views dyads (e.g. sibling-sibling, parent-child, husband-wife) as the fundamental units of human interaction (27). As such, dyadic data analysis allows us to structure the data and perform our analyses in such a way that not only accounts for the interdependence among siblings but investigates differences between and within dyads.

Through a multi-level dyadic analysis, this study aims to address the aforementioned gaps in the literature by answering the following questions:

1. Is there familial clustering of weight status?
2. Is the weight status of opposite gender siblings similarly or differentially associated with home environment and other family-level correlates?

Methods

Sample

The study uses data from a representative sample of approximately 400 households in Bijapur City in the State of Karnataka, Southern India. A stratified random sample of adolescents between the ages of 13-16 was selected from three public and three private schools in urban Bijapur City. An equal number of male and female students were then randomly selected from each school. Adolescents were interviewed at school, and a subsequent home visit was conducted to interview the adolescent's primary caregiver, as well as a sibling closest in age and of the opposite gender.

Measures

The outcome of interest in this study is age and gender-specific BMI (kg/meters^2) z-score, for both adolescents and their opposite gender siblings. World Health Organization (WHO) cut-offs were used to determine weight categories of underweight, normal weight, overweight, and obese (28). Individual-level variables for adolescent and sibling include age, gender, and type of school attended (categorized as government vs. private). Variables have also been created to identify birth order within the sibling pair, as well as composite variables that identify each sibling by both gender and birth order (i.e. older sister, younger brother; older brother, younger sister). Other individual-level, non-demographic variables for adolescent and sibling include whether or not they play outside of school hours, how often they participate in household chores, whether or not they are forced to eat more at meals, and whether or not they need to ask permission to eat something in the home.

Household-level variables include caregiver BMI (kg/meters^2), caregiver age, caregiver level of education (categorized as illiterate, primary, higher primary, pre-university course, and degree/professional school), household religion (categorized as Hindu vs. non-Hindu), household caste (categorized as General Class, Other Backward Classes, and Scheduled Caste/Scheduled Tribe), and household income (INR/month). Other household-level, non-demographic, variables include whether children are permitted to play outdoors (categorized as boys only, girls only, both, and neither), and several questions regarding household gender norms and beliefs.

Analysis

All analyses conducted account for the complex sampling methods used in the study design, and for clustering within the sampled schools.

Univariate and bivariate analyses

Univariate analyses of each variable will be conducted to obtain descriptive statistics, assess normality of distributions, and check for outliers and influential observations. Bivariate analyses will be performed separately for adolescents and their siblings on the outcome variable, BMI z-score, with each other variable to assess initial significance and examine the linearity of each association.

Dyadic analysis

To do conduct a dyadic analysis, variables are categorized into *between-dyad variables*, or variables that differ from dyad to dyad, but are the same for both members of the dyad (e.g. caregiver BMI, household income), and within-dyad variables that differ between the two members of a dyad, but when averaged together each dyad has an identical score (e.g. gender). Variables can also be *mixed independent variables*, which vary both within and between dyads (e.g. school type, age). Adolescent and sibling dyads will be examined to see how much they vary on the outcome measure, BMI z-score, providing an initial indication of whether opposite gender siblings in the same household vary in weight status.

Multi-level dyadic analysis

Using the dyadic data structure, multi-level models will be estimated with the children as the level 1 unit of analysis, and the household as the level 2 unit of analysis. Several models will be sequentially estimated to isolate the individual-level effects from the household-level effects on the outcome of BMI z-score (21). The first model estimated will be a null model used to assess how much the average child/adolescent BMI z-score varies between households:

$$Y_{ij} = \Upsilon_{00} + u_{oj} + r_{ij} \quad (1)$$

Where Y_{ij} is the BMI z-score of the i^{th} child/adolescent in the j^{th} household; r_{ij} is the random effect for the child/adolescent; Υ_{00} is the unadjusted average BMI z-score in the data; and u_{oj} is the random effect for the j^{th} household. If this model is significant it will indicate that average BMI z-score significantly varies between households. The next model will estimate whether this significant variation is the result of significant differences in individual-level variables, or whether variance at the household level will still be significant once individual-level variables are accounted for.

$$Y_{ij} = \Upsilon_{00} + \Sigma\, \beta_{kj} x_{ijk} + u_{oj} + r_{ij} \quad (2)$$

Where Υ_{00} is the adjusted average BMI z-score; x_{ijk} is variable k of the i^{th} child/adolescent in the j^{th} household, and β_{kj} is the estimated impact of that variable. If variance at the household level is still significant after the individual-level variables are added, the third model will add the level 2 household predictors to identify which variables are significant predictors of child/adolescent BMI z-score.

$$Y_{ij} = \Upsilon_{00} + \Sigma\, \Upsilon_{0l} w_{lj} + \Sigma\, \beta_{kj} x_{ijk} + u_{oj} + r_{ij} \quad (3)$$

Where Υ_{00} is the adjusted average BMI z-score; Υ_{0l} is the impact of household level variable l; w_{lj} is variable l of the j^{th} household; x_{ijk} is variable k of the i^{th} child/adolescent in the j^{th} household, and β_{kj} is the estimated impact of that variable.

After these models are estimated and initial significant associations are detected, interaction terms will be added to the model and tested for significance. In particular, interaction terms will be created between each household level variable and a variable indicating whether the person in the dyad is a boy or a girl. As each sibling dyad is comprised of one boy and one girl, these interaction terms will allow us to assess whether household level factors are differentially associated with the weight status of boys and girls within the same household. All models will be assessed for multicollinearity.

Preliminary results

Preliminary analyses were conducted using demographic variables from the individual and household levels. Initial results indicate that weight status was significantly correlated within families. As indicated in Table 1, significant correlations ($p<.0001$) were identified between girl-boy sibling pairs, girl-mother pairs, and boy-mother pairs. All overweight/obese children/adolescents had an overweight/obese mother indicating clustering of unhealthy weight. Further, the slight majority of underweight girls and boys had overweight/obese mothers, indicating the presence of a double burden of unhealthy weight within households. The preliminary multi-level dyadic analysis indicated that there is significant variation in child/adolescent BMI z-score between households (ICC=.40; see results in Table 2). In the individual-level model, girls weighed significantly more than boys. In the household-level model, girls remained significantly heavier than boys, and caregiver BMI became the most significant predictor of child/adolescent BMI z-score, with a positive linear association between the two variables. Household income of 10-20,000 and greater than 20,000 INR/month were significant predictors of child/adolescent BMI z-score (reference category of less than 5,000 INR/month), with a positive linear association between the two variables. These initial results support the hypothesized presence of familial clustering of weight status, as well as the presence of a double burden of unhealthy weight within households.

Table 1. Body weight distributions within families, Bijapur, India
Girl sibling-boy sibling pairs N=210
Parent-child pairs N=606

	Boy sibling			Mother		
Girl sibling	Underweight	Normal weight	Overweight or obese	Underweight	Normal weight	Overweight or obese
Underweight	30.4	67.7	1.9	13.0	42.4	44.6
Normal weight	22.5	70.7	6.8	5.2	27.3	67.5
Overweight/obese	0	75.3	24.7	0	0	100.0
	ρ=.38***			ρ=.41***		
Boy sibling						
Underweight	-	-	-	10.0	44.8	45.2
Normal weight	-	-	-	1.7	23.5	74.8
Overweight/obese	-	-	-	0	0	100.0
				ρ=.39***		

Note. Table displays row percentages.
ρ indicates the Pearson correlation coefficient between the BMI (body weight index)/BMI z-score (for age <19 years) of the two family members ***p<.0001

Table 2. Results from Dyadic Multilevel Model Assessing Individual and Household-Level Predictors of Children's BMI z-score (range from -3 SD to 3 SD)

Parameter	**Model 1**	**Model 2**	**Model 3**
Fixed effects			
Intercept	-.89 (.06)***	-1.18 (.34)***	-4.00 (.61)***
Level 1 (N_{child}=606)			
Girl		0.27 (.09)*	0.30(.09)**
Boy		(ref)	(ref)
Age (range: 4-22 years)		0.01 (.02)	.003 (.02)
Level 2 ($N_{household}$=404)			
Caregiver BMI			.11 (.01)***
Caregiver age			.0002 (.009)
Caregiver education			
Illiterate			(ref)
Primary school			.04 (.18)
Higher primary			.02 (.19)
PUC[1]			-.10 (.21)
Degree/professional			.17 (.21)
Religion			
Hindu			(ref)
Non-Hindu			.10 (.16)
Caste			
General			-.27 (.19)
Other backward classes			.04 (.17)
Scheduled caste/tribe			(ref)
Income			
<5,000 INR/month			(ref)
5-10,000 INR/month			.31 (.19)
10-20,000 INR/month			.47 (.20)*
>20,000 INR/month			.49 (.21)*
Household size			-.04 (.02)
Random effects			
Intercept variance	.77***	.81***	.53***
ICC	.40		

Note. Variances are in parentheses. *p<.05 **p<.001 ***p<.0001
[1]Pre-University Course (PUC) is a two-year intermediate course which must be passed to enter university.

Works cited

1. Midha T, Nath B, Kumari R, Rao Y, Pandey U. Childhood Obesity in India: A Meta-Analysis. The Indian Journal of Pediatrics 2012;79(7):945-948.
2. Raj M, Sundaram KR, Paul M, Deepa AS, Kumar RK. Obesity in Indian children: time trends and relationship with hypertension. Natl Med J India 2007;20(6):288-93.
3. Gupta N, Goel K, Shah P, Misra A. Childhood Obesity in Developing Countries: Epidemiology, Determinants, and Prevention. Endocrine Reviews 2012;33(1):48-70.
4. Khadilkar VV, Khadilkar AV, Cole TJ, Chiplonkar SA, Pandit D. Overweight and obesity prevalence and body mass index trends in Indian children. Int J Pediatr Obes 2011;6(2-2):e216-24.
5. Chopra SM, Misra A, Gulati S, Gupta R. Overweight, obesity and related non-communicable diseases in Asian Indian girls and women. Eur J Clin Nutr 2013;67(7):688-696.
6. Gragnolati M, Shekar M, Das Gupta M, Bredenkamp C, Lee Y. India's undernourished children: a call for reform and action. Washington, D.C.: World Bank; 2005.
7. Must A, Anderson SE. Effects of obesity on morbidity in children and adolescents. Nutr Clin Care 2003;6(1):4-12.
8. Wang YC, McPherson K, Marsh T, Gortmaker SL, Brown M. Health and economic burden of the projected obesity trends in the USA and the UK. The Lancet 2011;378(9793):815-825.
9. Singh AS, Mulder C, Twisk JW, van Mechelen W, Chinapaw MJ. Tracking of childhood overweight into adulthood: a systematic review of the literature. Obes Rev 2008;9(5):474-88.
10. Popkin BM, Adair LS, Ng SW. Global nutrition transition and the pandemic of obesity in developing countries. Nutrition Reviews 2012;70(1):3-21.
11. Popkin BM. An overview on the nutrition transition and its health implications: the Bellagio meeting. Public Health Nutr 2002;5(1a):93-103.
12. Gulati S, Misra A, Colles SL, Kondal D, Gupta N, Goel K, et al. Dietary intakes and familial correlates of overweight/obesity: a four-cities study in India. Ann Nutr Metab 2013;62(4):279-90.
13. Subramanian SV, Smith GD. Patterns, distribution, and determinants of under- and overnutrition: a population-based study of women in India. The American Journal of Clinical Nutrition 2006;84(3):633-640.
14. Bose S. The effect of women's status and community on the gender differential in children's nutrition in India. Journal of Biosocial Science 2011;43:513-533.
15. Pande R. Selective gender differences in childhood nutrition and immunization in rural India: The role of siblings. Demography 2003;40(3):395-418.
16. Misra A, Shah P, Goel K, Hazra DK, Gupta R, Seth P, et al. The High Burden of Obesity and Abdominal Obesity in Urban Indian Schoolchildren: A Multicentric Study of 38,296 Children. Annals of Nutrition and Metabolism 2011;58(3):203-211.
17. Huang TT, Drewnosksi A, Kumanyika S, Glass TA. A systems-oriented multilevel framework for addressing obesity in the 21st century. Prev Chronic Dis 2009;6(3):A82.
18. Larson NI, Wall MM, Story MT, Neumark-Sztainer DR. Home/family, peer, school, and neighborhood correlates of obesity in adolescents. Obesity 2013;21(9):1858-1869.
19. Crawford DA, Ball K, Cleland VJ, Campbell KJ, Timperio AF, Abbott G, et al. Home and neighbourhood correlates of BMI among children living in socioeconomically disadvantaged neighbourhoods. Br J Nutr 2012;107(7):1028-36.
20. Miller DP. Associations between the home and school environments and child body mass index. Soc Sci Med 2011;72(5):677-84.
21. Raudenbush SW, Bryk AS. Hierarchical Linear Models: Applications and Data Analysis Methods. Thousand Oaks, CA: SAGE Publications, Inc.; 2002.
22. Swaminathan S, Thomas T, Yusuf S, Vaz M. Clustering of diet, physical activity and overweight in parents and offspring in South India. Eur J Clin Nutr 2013;67(2):128-134.
23. Gupta S, Kapoor S. Gender differences in familial aggregation of adiposity traits in Aggarwal Baniya families. Eurasian Journal of Anthropology 2011;2(2):85-95.
24. Roemmich JN, White TM, Paluch R, Epstein LH. Energy intake, parental control of children's eating, and physical activity in siblings discordant for adiposity. Appetite 2010;55(2):325-331.
25. Price J, Swigert J. Within-family variation in obesity. Economics & Human Biology 2012;10(4):333-339.
26. Pachucki MC, Lovenheim MF, Harding M. Within-Family Obesity Associations: Evaluation of Parent, Child, and Sibling Relationships. American Journal of Preventive Medicine (0).
27. Kenny DA, Kashy DA, Cook WL. Dyadic Data Analysis. New York, NY: Guilford Press; 2006.
28. de Onis M, Lobstein T. Defining obesity risk status in the general childhood population: Which cut-offs should we use? International Journal of Pediatric Obesity 2010;5(6):458-460.