Current Research Journal of Social Sciences 2(3): 138-146, 2010
ISSN: 2041-3246

Submitted Date: February 19, 2010 Accepted Date: February 24, 2010 Published Date: June 15, 2010

Predictors of Overweight in Children under 5 Years of Age in India

P. Chakraborty and A.K. Anderson
Department of Foods and Nutrition, University of Georgia, 280 Dawson Hall,
United States of America

Abstract: The prevalence of early childhood overweight has increased dramatically in developing countries such as India. Lifestyle factors and socioeconomic status have been linked to the increasing prevalence of overweight in older children. The present study aimed to examine the predictors of overweight among children < 5 years in India. We performed a secondary data analysis using the most recent wave of India's National Health and Family Survey (NFHS 3) conducted from 2005-2006. The survey was conducted in all the 29 states in India and covered households from both rural and urban areas. Mothers aged 15-49 years with a child 5 years or younger (index child) were interviewed as part of the survey. For the purpose of the current study, participants with complete information on anthropometric indices of the index child were included in the final analysis. Our final analytical sample was therefore 23,814. Maternal characteristics such as urban residency, education and overweight/obese status increased the risk of overweight in index children. Children from the East-North East region were less likely to be overweight compared to their counterparts from North, South and Central-West regions of India. In addition to this, stunted children were at the greatest risk of having a Body Mass Index-for-age z score (BAZ) > 2.0. Dietary fat intake of the index child significantly increased the risk of childhood overweight. The study findings suggest the need to target nutrition and health programs toward the urban affluent households and educated women to prevent the onset of overweight during early childhood.

Key words: Maternal education, NFHS 3, regions, socioeconomic status, stunting and urban

INTRODUCTION

The increasing prevalence of childhood overweight has become a growing concern for public health, as nearly one-third of overweight children grow up to become overweight or obese adults (Whitaker *et al*., 1997) with increased risks of chronic diseases (Freedman *et al*., 1999; Goran, 2001). Children from industrialized countries are at an increasing risk of being overweight where the prevalence has more than doubled in the past three decades (Wang and Lobstein, 2006). It is estimated that nearly 40% of school-age children will be overweight in America, Eastern Mediterranean and European regions in recent years (Wang and Lobstein, 2006). Consequently, studies conducted on preschool children from industrialized and developing countries provide evidence of an increasing trend of overweight prevalence in this age group (Ogden *et al*., 1994; Martorell *et al*., 2000; Canning *et al*., 2004).

The cause of increasing childhood overweight in developing countries is attributed to the growing urbanization, transition towards a high fat Western diet and physical inactivity (Popkin, 2001). The existence of chronic undernutrition (stunting) in early childhood also seems to magnify the risks of being overweight and increased adiposity in these children (Popkin *et al*., 1996). With respect to increasing weight gain in early childhood, maternal socio-demographic characteristics such as education, employment and socioeconomic status and genetic factors may predispose a child to the risks of being overweight (Martorell *et al*., 2000; Vogels *et al*., 2006).

Similar to the observations in most developing countries, adaptation of a high caloric Western diet of refined cereals, fast foods and sedentary lifestyle in India are reported to be the primary causes of the increasing prevalence of overweight, insulin-resistance, metabolic syndromes and dyslipidemia in children (Popkin *et al*., 2001; Bhardwaj *et al*., 2008; Kaur *et al*., 2008). While children and adolescents (aged 5 to 18 years) from the country's capital Delhi, were reported to consume energy dense fast foods nearly 4 times a week (Kaur *et al*., 2008), a noticeable increase in overweight prevalence from 16.0% in 2002 to 24.0% in 2006-2007 was observed among this subpopulation (Bhardwaj *et al*., 2008). Previous studies conducted with urban school and preschool children document an overweight prevalence greater than 10.0% (Kaur *et al*., 2008) and 4.5% respectively (Kumar *et al*., 2008). Although the national prevalence of overweight among preschool children in

Corresponding Author: P. Chakraborty, Department of Foods and Nutrition, University of Georgia, 280 Dawson Hall, United States of America

India is similar to the estimated prevalence in developing countries (3.5 and 3.3% respectively), it is higher than the overall prevalence in Asia (2.9%) (de Onis and Blossner, 2000). In addition to this, a noticeable increase in overweight and obesity prevalence among older children have been reported in India (Chhatwal *et al*., 2004; Kaur *et al*., 2008). Simultaneously, with the majority of Indian children < 5 years still suffering from underweight and stunting, others are more prone to becoming overweight, which has public health impact on the country. It is therefore imperative to understand and identify the underlying causes of the growing public health problem in this subpopulation. To the best of our knowledge, there is a dearth of literature on factors associated with overweight among Indian children < 5 years of age. The present study therefore examines the predictors of overweight in these children.

MATERIALS AND METHODS

Study design and data: This study is a secondary data analysis of the most recent wave of India's National Family Health Survey (NFHS 3) conducted during 2005-2006. This survey is periodically conducted by the Ministry of Health and Family Welfare, Government of India, with technical assistance from ORC Macro, USA (IIPS, 2007). Sampling design of NFHS consisted of two-stage and three-stage stratifications in rural and urban areas respectively. The survey interviewed women aged 15-49 years and obtained information on demographic, socioeconomic and health of 124,285 women. Details about survey procedure and sampling are reported elsewhere (IIPS, 2007). To compare the regional differences in participants' characteristics and predictors of childhood overweight in the current study, we divided the country into 4 regions- namely: North, East-North East, South and Central-West regions (Mishra *et al*., 2005).

Subjects: For the present study, we included non-pregnant women with a living child < 5 years (index child) from singleton births, with complete information on anthropometric indices resulting in an analytical sample size of 23,814.

Dependent variable: Childhood overweight was assessed using the World Health Organization's (WHO) cut-off value of > 2.0 standard deviation for Body Mass Index-for-age z score (BAZ) (WHO, 2006). This is a standardized variable that has been shown to predict overweight/obesity related complications in children (Bell *et al*., 2007). We used BAZ in the current study because of the lack of information on other reliable indicators of adiposity such as body composition and skin fold thickness measurements in the NFHS data sets.

Independent variables: Independent variables were grouped into different categories namely socio-demographic characteristics, place of residence and infant/child feeding practices. Variables of interest capturing the socio-demographic characteristics were age, employment, religion, education and economic status of the respondent together with age and gender of the index child. Socioeconomic status of the respondents was based on the wealth index classifications of NFHS (IIPS, 2007). Region and urban/rural area were variables capturing the respondent's place of residence.

The NFHS 3 obtained information on height and weight measurements of women aged 15 to 49 years and children born between January 2000 and 2001. These measurements were used as a proxy to assess the nutritional status of mothers and the index child. Long term nutritional status (stunting) of the index child was captured using height-for-age z score (HAZ) categorized as stunted (HAZ < -2.0) or normal (HAZ ≥ -2.0) (WHO, 2006). Maternal Body Mass Index (BMI) was used to classify mothers as underweight (< 18.5 kg/m^2), normal (18.5–24.9 kg/m^2), overweight (25.0- 29.9 kg/m^2) and obese (≥ 30.0 kg/m^2) based on WHO's recommendations (WHO, 1995).

Variables capturing infant/child-feeding practices included foods fed 24 h prior to the survey. These foods were further grouped as carbohydrate (e.g., porridge, potatoes/tubers and/or bread/other grain products) and protein rich foods (e.g., meat, beans, pulses, nuts, eggs, milk and milk products), fruits and vegetables (e.g., green leafy vegetables, yellow or orange fruits and vegetables) and fats and oil.

Statistical analysis: The NFHS data sets were downloaded from Demographic and Health Survey (Measure DHS, 2009), and analyzed using SPSS for Windows version 16.0 (SPSS Inc, Chicago, IL). We used a sample weight (national women's weight) to adjust for oversampling and non-response from different places within the country. General description of the data is reported as weighted means ± standard deviation (SD) and percentages. Covariates were analyzed primarily as categorical variables in bivariate analysis.

BAZ score of the index child was dichotomized as BAZ score >2.0 (overweight) versus BAZ score between ±2.0 (normal weight) and used as the dependent variable for logistic regression. Univariate and multivariate logistic regression were performed to identify the predictors of childhood overweight. Variables from each of the groups of independent variables (as described above) that were significant in the univariate analyses were further used in multivariate logistic regression to determine the independent influence of each variable on childhood overweight after adjusting for other important covariates. Results were considered significant if $p \leq 0.05$.

Table 1: Socio-demographic characteristics of women in NFHS 3 (2005-2006) by region of residence[1] (N = 23,814)

	Regions				
	North n = 3222	East-North East n = 7103	South n = 4152	Central-West n = 9337	
Characteristics	(%)				p-value[2]
Religion					< 0.001
Hindu	76.8	73.5	80.5	83.0	
Muslim	12.0	21.8	13.1	14.6	
Christian	0.4	3.0	6.1	0.3	
Sikh	10.6	0.1	0.0	0.3	
Other[3]	0.0	1.6	0.3	2.0	
Maternal age (years)					< 0.001
15-19	4.4	9.0	5.4	5.4	
20-24	30.8	32.0	35.3	31.2	
25-29	36.4	31.4	36.7	34.0	
30-34	18.8	17.0	15.6	18.3	
35-39	6.5	7.1	5.3	8.3	
40-44	2.5	2.6	1.6	2.3	
45-49	0.6	0.9	0.1	0.5	
Education level of respondent					< 0.001
No education	47.1	48.0	26.9	47.2	
Primary	12.3	16.7	15.1	12.4	
Secondary	32.7	31.6	46.5	33.9	
Higher/college	8.0	3.7	11.5	6.5	
Respondent employed					< 0.001
Yes	33.6	25.1	35.0	32.3	
No	66.4	74.9	65.0	67.7	
Place of residence					< 0.001
Urban	28.8	17.7	38.1	29.5	
Rural	71.2	82.3	61.9	70.5	
Socioeconomic status (wealth index)[4]					< 0.001
Poorest	12.8	30.9	9.4	22.9	
Poorer	13.1	26.2	15.8	21.0	
Middle	20.6	19.3	25.3	18.4	
Richer	24.4	14.5	26.7	18.7	

[1] North: Jammu and Kashmir, Himachal Pradesh, Haryana, Punjab, Delhi, Uttar Pradesh, Uttaranchal; East-North East: Bihar, Jharkhand, Chhattisgarh, West Bengal, Orissa, Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura; South: Andhra Pradesh, Karnataka, Kerala, Tamil Nadu; Central-West: Maharashtra, Goa, Gujarat, Madhya Pradesh, Rajasthan

[2] Significant difference between the four regions (χ^2 -test)

[3] Other religions include Buddhist, Jain, Zoroastrian, Doni-polo and no religion

[4] Wealth index: definition based on NFHS classification (IIPS, 2007)

RESULTS

Characteristics of participants: The socio-demographic characteristics of the participants from the four regions are presented in Table 1. Hinduism was the primary religion practiced across the country, along with Muslim, Christianity, Sikhism and other minor religions (Buddhism, Jainism Zoroastrian, Doni-polo) and no religion. Almost 98.0% of the participants were married in the four regions. Majority (> 60.0%) of the participants were aged between 20- 29 years (26.7 ± 5.5 years). While there was a significant regional difference in education levels and employment status of participants, the highest illiteracy (48.0%) and unemployment (75.0%) rates were observed in the East-North East region (Table 1). Additionally, a greater proportion of rural women (35.2%) of the four regions were employed as compared to their urban counterparts (19.0%), with nearly 75.0% engaged in agricultural related activities. In contrast, the few employed urban women were professionals and of a higher socioeconomic status (data not shown). With respect to socioeconomic status, a greater percentage of participants (30.9%) from the poorest socioeconomic category came from the East-North East region as compared to only 9.4% of the participants from the Southern region (Table 1). The mean age of the index child was 26.0 ± 16.4 months (range: 0 to 59 months). More than 50.0% of the children included in our analysis were males.

Distribution and characteristics of overweight children: Childhood overweight was widely prevalent in urban areas (3.5%) as compared to rural areas (2.1%). There was a significant (p<0.001) regional difference in overweight prevalence, with the highest observed in the Southern region (3.3%), followed by North (2.6%), Central-West (2.6%) and East-North East (1.8%) regions. Interestingly, overweight prevalence was similar in the urban areas of the four regions (North: 2.7% ; East North East: 3.3%; South: 3.5%; Central West: 3.9%). Childhood

Table 2: Characteristics of normal weight vs. overweight children in NFHS 3 (2005-2006); (N = 23,814)

Characteristics	Normal weight children[1] n = 23227 (%)	Overweight children[1] n = 587	p-value[2]
Age of index child			< 0.001
< 6.0 months 10.6	13.0		
6.0 to 11.9 months	12.8	17.2	
12.0 to 23.9 months	25.7	32.6	
24.0 to 35.9 months	20.8	15.9	
≥ 36.0 months	30.5	21.3	
Gender			0.07
Male	54.8	58.4	
Female	45.2	41.6	
Religion			< 0.01
Hindu	79.0	75.1	
Muslim	16.1	17.4	
Christian	2.1	3.7	
Sikh	1.6	1.5	
Other[3]	1.1	2.2	
Socioeconomic status (wealth index)[4]			0.001
Poorest	21.7	16.4	
Poorer	20.7	15.2	
Middle	20.2	17.9	
Richer	19.5	25.2	
Richest	17.9	25.4	
Index child's HAZ[1]		< 0.001	
Stunted	45.1	66.8	
Normal	54.9	33.2	
Mother working			< 0.001
Yes	31.0	23.7	
No	69.0	76.3	
Education level of mother			< 0.001
No education	44.1	34.1	
Primary	14.2	12.4	
Secondary	35.0	45.5	
Higher/college	6.7	8.0	
Maternal BMI (kg/m^2)			< 0.001
Underweight	37.8	30.2	
Normal	53.5	55.7	
Overweight	7.1	10.6	
Obese	1.6	3.4	

BMI, Body Mass Index. HAZ, Height-for-age z-score
[1]: Normal weight: -2.0 < BMI z-score ≤ 2.0; Overweight: BMI z-score > 2.0; Stunted: HAZ < -2.0; Normal: ≥ -2.0 (WHO, 2006)
[2]: Significant difference between the normal weight and overweight children (χ^2 -test)
[3]: Other religions include Buddhist, Jain, Zoroastrian, Doni-polo and no religion
[4]: Wealth index: definition based on NFHS classification (IIPS, 2007)

overweight was highest in rural parts of the Southern region (3.2%) compared to the other regions (North: 2.6%; East North East: 1.4%; Central west: 2.0%)

Table 2 presents the characteristics of children according to their weight status (normal weight vs. overweight). Compared to normal weight children, overweight children were likely to be 12.0 to 23.9 months of age (p<0.001; Table 2). Additionally, overweight children belonged to Hindu and affluent households (high socioeconomic status) (Table 2). There were significant differences between maternal characteristics for normal weight and overweight children (Table 2). Over 66.0% of the overweight children were also stunted compared to normal weight counterparts (p<0.001). There was no association between gender of the index child and overweight prevalence in the study population.

Predictors of childhood overweight: Results from the univariate logistic regression are presented in Table 3. Residing in the East- North East region had a protective

Table 3: Predictors of childhood overweight: univariate logistic regression

Independent variables	Odds ratio (95% CI)	p-value
Maternal characteristics		
Region[2]		
North	1.0[1]	
East-North East	0.6 (0.5- 0.8)	0.004
South	1.2 (0.9- 1.6)	0.080
Central-west	0.9 (0.7- 1.2)	NS
Place of residence		
Rural	1.0	< 0.001
Urban	1.7 (1.4, 2.0)	
Religion		
Hindu	1.0	
Muslim	1.1 (0.9, 1.4)	NS
Christian	1.8 (1.2, 2.9)	0.005
Sikh	0.8 (0.5, 1.9)	NS
Other[3]	2.5 (1.2, 5.1)	0.008
Education of respondent		
No education	1.0	
Primary	1.1 (0.8, 1.5)	NS
Secondary	1.7 (1.4, 2.0)	< 0.001
Higher/college	1.5 (1.1, 2.1)	0.008
Respondent working		
Yes	1.0	
No	1.4 (1.2, 1.7)	< 0.001
Socioeconomic status (Wealth index)[4]		
Poorest	1.0	
Poorer	0.9 (0.7,1. 3)	NS
Middle	1.1 (0.9, 1.5)	NS
Richer	1.7 (1.3, 2.2)	< 0.001
Richest	1.8 (1.4, 2.4)	< 0.001
Maternal BMI (kg/m^2)		
Underweight	1.0	
Normal	1.3 (1.1, 1.6)	0.005
Overweight	1.8 (1.4,2.5)	< 0.001
Obese	2.6 (1.6, 4.2)	< 0.001
Characteristics of the index child		
Child's age		
< 6.0 months	1.0	
6.0 to 11.9 months	1.1 (0.8, 1.5)	NS
12.0 to 23.9 months	1.0 (0.8, 1.3)	NS
24.0 to 35.9 months	0.6 (0.4, 0.8)	0.003
≥ 36.0 months	0.6 (0.4, 0.7)	< 0.001
Gender		
Male	1.0	
Female	0.8 (0.7- 1.0)	NS
Index child's HAZ		
Normal (HAZ ≥ -2.0)	1.0	
Stunted (HAZ < -2.0)	2.6 (2.0, 3.0)	< 0.001
Child feeding practices[5]		
Received carbohydrate rich foods		
No	1.0	
Yes	0.9 (0.7, 1.2)	NS
Received protein rich foods		
No	1.0	
Yes	1.1 (0.0,1.4)	0.100
Received fruits and vegetables		
No	1.0	
Yes	1.1 (0.8, 1.2)	NS
Received foods made from fats and oil		
No	1.0	
Yes	1.5 (1.1, 1.8)	0.020

BMI, body mass index; CI, confidence interval. HAZ, Height-for-age z-score
[1]: OR of 1.0 indicates reference category for each independent variable
[2]: North: Jammu & Kashmir, Himachal Pradesh, Haryana, Punjab, Delhi, Uttar Pradesh, Uttaranchal; East-North East: Bihar, Jharkhand, Chhattisgarh, West Bengal, Orissa, Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura; South: Andhra Pradesh, Karnataka, Kerala, Tamil Nadu; Central-west: Maharashtra, Goa, Gujarat, Madhya Pradesh, Rajasthan
[3]: Other religions include Buddhist, Jain, Zoroastrian, Doni-polo and no religion
[4]: Wealth index: definition based on NFHS classification (IIPS, 2007)
[5]: Variables adjusted for age of the index child

effect on childhood overweight (OR = 0.6; 95% CI: 0.5 to 0.8, p = 0.004; Table 3). Children from urban areas were nearly twice as likely to be overweight (p<0.01; Table 3) compared to rural counterpart. Index children from Christian (OR = 1.8; 95% CI: 1.2 to 2.9, p = 0.005)

Table 4: Logistic regression models of independent predictors of childhood overweight

Independent variables	Odds ratio (95% CI)	p-value
Model 1: Maternal characteristics		
Region[2]		
North	1.0[1]	
East-North East	0.7 (0.5, 0.9)	0.040
South	1.1 (0.8, 1.4)	NS
Central-west	0.9 (0.7, 1.3)	NS
Place of residence		
Rural	1.0	
Urban	1.5 (1.2, 1.8)	< 0.001
Maternal education level		
No education	1.0	
Primary	1.0 (0.8, 1.5)	NS
Secondary	1.4 (1.1, 1.7)	0.010
Higher/college	1.2 (0.7, 1.5)	NS
Respondent working		
Yes	1.0	
No	1.3 (1.0, 1.5)	0.020
Maternal BMI (kg/m^2)		
Underweight	1.0	
Normal	1.2 (1.0, 1.5)	0.040
Overweight	1.5 (1.1, 2.1)	0.010
Obese	2.1 (1.2, 3.3)	0.005
Model 2: Characteristics of index child		
Age of index child		
< 6.0 months	1.0	
6.0 to 11.9 months	0.9 (0.7, 1.3)	NS
12.0 to 23.9 months	0.7 (0.5, 1.1)	NS
24.0 to 35.9 months	0.4 (0.3, 0.6)	< 0.001
≥ 36.0 months	0.4 (0.3, 0.5)	< 0.001
Index child's HAZ		
Normal (HAZ ≥ -2.0)	1.0	
Stunted (HAZ < -2.0)	2.9 (2.4, 3.4)	< 0.001
Model 4: Significant predictors from models 1 to 3[3, 4, 5]		
Region[2]		
North	1.0	
East-North East	0.6 (0.5, 0.9)	0.030
South	1.3 (0.9, 1.7)	NS
Central-west	0.9 (0.7, 1.3)	NS
Place of residence		
Rural	1.0	
Urban	1.4 (1.2, 1.8)	< 0.001
Education of respondent		
No education	1.0	
Primary	1.5 (1.1, 1.9)	0.010
Secondary	1.6 (1.3, 2.0)	< 0.001
Higher/college	1.5 (0.9, 2.2)	0.060
Maternal BMI (kg/m^2)		
Underweight	1.0	
Normal	1.3 (1.0, 1.6)	0.020
Overweight	1.9 (1.3, 2.7)	0.001
Obese	2.5 (1.4, 4.6)	0.003
Index child's HAZ		
Normal (HAZ ≥ -2.0)	1.0	
Stunted (HAZ < -2.0)	4.0 (3.2, 5.0)	< 0.001
Received foods made from fats and oil		
No	1.0	
Yes	1.3 (1.0, 1. 8)	0.030

BMI, body mass index; CI, confidence interval. HAZ, Height-for-age z-score

[1] OR of 1.0 indicates reference category for each independent variable.

[2]North: Jammu & Kashmir, Himachal Pradesh, Haryana, Punjab, Delhi, Uttar Pradesh, Uttaranchal; East-North East: Bihar, Jharkhand, Chhattisgarh, West Bengal, Orissa, Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura; South: Andhra Pradesh, Karnataka, Kerala, Tamil Nadu; Central-west: Maharashtra, Goa, Gujarat, Madhya Pradesh, Rajasthan.

[3]Adjusted for age of the index child.

[4]Model 3 was not created because only fat intake was a significant predictor of childhood overweight

[5]Hosmer and Lemeshow test χ^2 value = 7. 9 (p = 0.4)

and other minor religion (OR = 2.5; 95% CI: 1.2 to 5.1, p = 0.008) households had greater risks of being overweight as compared to children from other religions (Hindu, Muslim, Sikh, Jain, Zoroastrian, Doni-polo and no religion). The odds of being overweight was almost doubled for children of mothers with either secondary or higher education compared to children of mothers with no formal education (Table 3). Other significant predictors of childhood overweight were maternal unemployment (OR = 1.4; 95% CI: 1.2 to 1.7, p<0.001), affluent households (OR= 1.8; 95% CI: 1.4 to 2.4, p<0.001) and maternal overweight (OR = 1.8; 95% CI: 1.4 to 2.5, p<0.001) and obesity (OR = 2.6; 95% CI: 1.6 to 4.2, p<0.001) (Table 3). Children aged > 24.0 months were less likely to be overweight compared to younger children. Stunted children were at a three-fold increased risk of being overweight compared to children with normal stature/height.

Results of the multivariate logistic regression analysis are presented in Table 4. In model 1 (Table 4), higher maternal BMI, residing in an urban area, maternal education level (secondary education) and unemployment were significant independent predictors of childhood overweight, while residing in East-North East remained a protective factor (Table 4). In the second model stunting was the only independent predictor of childhood overweight, with an odds ratio of 2.9 (95% CI: 2.4 to 3.4, p<0.001; Table 4). The final model (Model 4; Table 4) examined the independent influence of all significant predictors from models 1-3. Stunting, maternal overweight/obesity, urban residence, maternal education and consumption of a high fat diet by the index child remained significant independent predictors of childhood overweight, after adjusting for important covariates (Table 4). Moreover, East-North East region had a protective effect on childhood overweight (Table 4).

DISCUSSION

The current study presents the predictors of overweight among children < 5 years in India. The observation of an increased risk of childhood overweight in urban compared to rural areas in the present study is a confirmation of reports from previous studies conducted on preschool children from India (Kumar *et al.*, 2008) and other developing countries (de Onis and Blossner, 2000). Even in the less developed East-North East region, overweight prevalence remained significantly higher in the urban area, confirming the impact of urban lifestyle as observed previously (de Onis and Blossner, 2000; Kumar *et al.*, 2008). With respect to household socioeconomic status, our univariate logistic regression showed an increased risk for childhood overweight with higher wealth categories. This finding is similar to a previous study of 9-15 years old Indian children from three different socioeconomic status (Chhatwal *et al.*, 2004). This observation is in contrast to observations reported from industrialized countries such as the US, where child food insecurity increased the risks of overweight in children aged 3 to 5 years (Casey *et al.*, 2006). Low socioeconomic households in industrialized

countries face the crisis of food insecurity, a factor associated with higher consumption of low cost calorie dense diets and physical inactivity, culminating in increased prevalence of childhood overweight (Casey *et al*., 2001; Drewnowski, 2004). These practices, on the other hand, are speculated to be profound amongst children from affluent households in India, thereby increasing the risks of overweight in this section of the population. This is also evident from findings of the present study and a previous report by Kaur *et al.* (2008). According to the NFHS 3 report (IIPS, 2007), 48.0% of the urban population belonged to the highest socioeconomic households as compared to only 7.4% in the rural areas. This may have contributed to the insignificant association of socioeconomic status with overweight in the multivariate analysis in the presence of place of residence.

Our results also indicate a strong influence of maternal BMI on childhood overweight. Children of overweight/obese mothers were at an increased risk of being overweight compared to their counterparts of underweight/normal weight mothers, which is consistent with previous report by Bell *et al.* (2007). The authors reported a significant positive correlation between maternal BMI and child's BAZ and observed an increase of 0.07 BAZ for every unit increase in maternal BMI. The influence of maternal adiposity on childhood overweight can be explained by genetic predisposition, as 50.0% of the variation in BMIs of twins reared apart was attributed to genes alone (Allison *et al*., 1996). Association between parental and childhood overweight is also attributed to familial similarities in dietary practice and environment, as reported by Fisher and Birch (1995). Other researchers have observed fat consumption and adiposity in children aged 3 to 5 years to strongly correlate ($r = 0.75$, $p<0.01$) with parental adiposity (Allison *et al*., 1996). Present findings from the current study are also confirmed by a study from Germany, which found preschool children (<6 years) of overweight mothers to be at an increased risk of having higher BAZ (Bergmann *et al*., 2003).

Increased risk of overweight among children of mothers with secondary education observed in the present study is in agreement with findings by Martorell *et al.* (2000). Our observation of maternal unemployment to be a risk factor for childhood overweight in the current study, although not significant in the multivariate analysis, was surprising. This is in contrast to what has been reported by Takahashi *et al.* (1999) and Anderson *et al.* (2003) who studied children from Japan and US respectively. Moreover, Armar-Klemesu *et al.* (2000) have documented an association between maternal employment and childhood overweight among advantaged households in Ghana, a developing country. In India, a higher proportion of educated and unemployed women were from urban affluent households (IIPS, 2007), while working rural women with lower literacy rates were usually engaged in daily-labor or agriculture related activities belonged to lower socioeconomic status (IIPS, 2007). Thus, it can be speculated that unemployed urban mothers, with greater purchasing power, are possibly shifting towards a high calorie Western diet and sedentary lifestyle, thereby influencing the dietary practice and physical activity levels of their children. Transitions to calorie dense diets comprising of fast foods and sweetened beverages and inadequate physical activity in children have been identified as leading causes of overweight in developing countries (Popkin, 1994; 2001). Further studies on lifestyle and physical activity patterns of urban children are essential to understand the underlying causes of the higher prevalence of overweight in children of educated, non-working mothers.

Another interesting finding from the present study was the increased risk of overweight among children from Christian and minor religious groups (Buddhist, Jain, Zoroastrian, Doni-polo and no religion) compared to other religions (Hindu, Muslim and Sikh). This finding could be due to the diversity in socioeconomic standing and/or dietary practice and lifestyle/behavioral practices dictated by the different religious teachings. As evident in the NFHS 3 report, a greater proportion of Christian (31.1%) and Jain (87.0%) women were from higher socioeconomic households and had received more years of formal education (Christian: 23.5%; Jain: 52.0%), (IIPS, 2007). A second reason for the increased risk of overweight in these groups could be the relatively small proportion of the sub-population belonging to Christianity and minor religious groups (3.0% and1.5% respectively) as compared to Hindus (81.6%), (IIPS, 2007). However, in the presence of other socio-demographic characteristics, religion was not a significant predictor of childhood overweight, possibly due to its relationship with other maternal demographic and lifestyle characteristics.

Results from this study also show a strong relationship between childhood stunting and overweight, indicating the coexistence of under and over nutrition in this population. This finding is consistent with a previous study by Fernald and Neufeld (2007) that reports the dual prevalence of stunting and overweight in 10.0% of children aged 24 to 60 months in a rural community in Mexico. Similarly, Popkin *et al.* (1996) have reported a strong significant association between stunting and overweight in children from the Republic of South Africa and Russia. Stunted or undernourished children with reduced lean body mass and lower basal metabolic rate are at an increased risk of excess adipose tissue deposition, in the absence of nutrient dense foods required for linear growth (Popkin *et al*., 1996). Additionally, 'early nutritional programming' may affect the potential for linear growth but not weight gain (Popkin *et al*., 1996). Due to limited information in the data, the various

biological and environmental factors that may affect stunting and thereby lead to the onset of overweight were not explored in the current study.

Decreased risk of childhood overweight in children > 2 years, is an important finding of the study. Children > 2 years of age are less likely to be overweight possibly due to the decreased growth rate and stabilization of adipocytes after the first year of life (Rolland-Cachera *et al*., 1984) that may influence their appetite and reduce food consumption. Children in this age group also develop feeding skills, dietary preferences and are more physically active, thereby expending more energy and reducing their risks of being overweight. In contrast, parental control of infant feeding practices and restricted physical movement during infancy may be a potential cause of rapid weight gain and adiposity (Ong *et al*., 2006). Additionally, accelerated weight gain or 'catch up growth' between birth to 2 years significantly increases the risks of overweight and central adiposity in children at 5 years (Ong *et al*., 2000), with a higher population attributable risk (15.7%) for rapid weight gain in infancy than in early childhood (11.7%), (Ekelund *et al*., 2006). Moreover, the prevalence of low birth weight deliveries in India is one of the highest (28.0%) among developing countries (15.0%) (UNICEF, 2008), which may explain a rapid catch-up growth in infancy that increases the risk of overweight in childhood and later adulthood. Present finding of higher risk of overweight for children < 2 years is also in line with observations made by Schroeder *et al.* (1995). The study observed a rapid growth rate in height and weight of Guatemalan children below 2 years of age, in contrast to children beyond 2 years. It can therefore be speculated that prevalence of stunting in children < 2 years ('the critical period of life'), if severe, may increase the risk of a child becoming overweight later in life. These findings also accentuate the need for future studies to examine the biological mechanism between growth rate, stunting and overweight in this population.

This study also identified the intake of dietary fats as a potential predictor of childhood overweight. Although this is in accord with other studies of older children aged 6 to 11 years (Tucker *et al*., 1997; Moreno *et al*., 2000), it is in contrast to studies of children aged below 5 years (Davies, 1997; Newby *et al*., 2003). Assessment of fat intake in the current study was based on the mother's report of foods (containing fats and oil) consumed by the child within 24 h prior to the survey. In the absence of the quantity of foods consumed, we were not able to analyze the food to estimate the fat content of such foods. On the other hand, studies reporting insignificant association between childhood overweight and fat intake in preschool children used the actual fat content of the diet in the assessment (Davies, 1997; Newby *et al*., 2003). It is therefore, difficult to interpret the association between fat intake and overweight in the study population.

Study limitations and significance: A potential limitation of the study is that NFHS data sets do not provide adequate information on infant/child feeding practice and lifestyle factors of children, and hence their association with childhood overweight could not be examined satisfactorily. A high proportion of the surveyed women had missing information on the index child's anthropometric measurements and was therefore, excluded from the final analysis. Characteristics of households included and excluded from the final analysis were similar except for place of delivery and maternal education level. The large analytical sample-size and representativeness of the study sample add to the strengths of the study's findings. Due to the cross-sectional nature of the data, causality between maternal characteristics, dietary practices and childhood overweight cannot be confirmed. Therefore, the results need to be interpreted with caution.

So far, the focus of existing health policies and nutrition programs in India has been on infectious diseases, undernutrition and mortality. Additionally, supplementary nutrition programs in developing countries, including India, may be contributing to the increasing overweight prevalence being seen among previously undernourished population. Data from 19 Latin American countries reported that while 20.0% of the population received supplementary nutrition, only 12.0% of the population was undernourished (Kain and Uauy, 2001) suggesting possible overfeeding of well nourished children. The two major food assistance programs in Latin America, the Chilean supplementary feeding program and the National Nursery Schools Council Program were associated with over nutrition among children < 6 years in spite of the reduction in undernutrition (Uauy *et al*., 2001). Similarly, in India, children (< 5 years) from low socioeconomic status receive supplementary nutrition through mid-day meal programs, (in public schools) and the Integrated Child Development Scheme (ICDS) (Misra and Khurana, 2008). It is plausible that these supplementary feeding programs, while reducing the burden of undernutrition, may be predisposing the same children to overweight (excess weight gain). Therefore, nutrition programs need to be designed and well targeted to reduce the prevalence of undernutrition while preventing the onset of overweight in children < 5 years. These programs also need to target lifestyle modification, specifically for urban children from affluent households. Child feeding practices, focusing on the concepts of variety and moderation of the different food groups as well as adequate physical activity, need to be integrated into health promotion programs. In conclusion, factors such as urban residency, socioeconomic status, maternal education and overweight/obesity, and childhood stunting identified as predictors of childhood overweight in our study population have significant public health

implications in the fight against rising prevalence of overweight obesity worldwide. There is, therefore a need for longitudinal studies to examine whether these predictors have actual causal relationships to childhood overweight in India.

REFERENCES

Allison, D.B., J. Kaprio, M. Korkeila, M. Koskenvuo, M.C. Neale and K. Hayakawa, 1996. The heritability of Body Mass Index among an international sample of monozygotic twins reared apart. Int. J. Obes., 20(6): 501-506.

Anderson, P.M., K.F. Butcher and P.B. Levine, 2003. Maternal employment and overweight children. J. Health Econ., 22(3): 477-504.

Armar-Klemesu, M., M.T. Ruel, D.G. Maxwell, C.E. Levin and S.S. Morris, 2000. Poor maternal schooling is the main constraint to good child care practices in Accra. J. Nutr., 130(6): 1597-1607.

Bell, L.M., S. Byrne, A. Thompson, N. Ratnam, E. Blair, M. Bulsara, T.W. Jones and E.A. Davis, 2007. Increasing Body Mass Index z-score is continuously associated with complications of overweight in children, even in the healthy weight range. J. Clin. Endocrinol. Metab., 92(2): 517-522.

Bergmann, K.E., R.L. Bergmann, R.L., R. von Kries, O. Böhm, R. Richter, J.W. Dudenhausen and U. Wahn, 2003. Early determinants of childhood overweight and adiposity in a birth cohort study: Role of breast-feeding. Int. J. Obes., 27(2): 162-172.

Bhardwaj, S., A. Misra, L. Khurana, S. Gulati, P. Shah and N.K. Vikram, 2008. Childhood obesity in Asian Indians: a burgeoning cause of insulin resistance, diabetes and sub-clinical inflammation. Asia. Pac. J. Clin. Nutr., 17(S1): 172-175.

Canning, P.M., M.L. Courage and L.M. Frizzell, 2004. Prevalence of overweight and obesity in a provincial population of Canadian preschool children. CMAJ, 171(3): 240-242.

Casey, P.H., K. Szeto, S. Lensing, M. Bogle and J. Weber, 2001. Children in food-insufficient, low-income families: prevalence, health, and nutrition status. Arch. Pediatr. Adolesc. Med., 155(4): 508-514.

Casey, P.H., P.M. Simpson, J.M. Gossett, M.L. Bogle, C.M. Champagne, C. Connell, D. Harsha, B. McCabe-Sellers, J.M. Robbins, J.E. Stuff and J. Weber, 2006. The association of child and household food insecurity with childhood overweight status. Pediatrics, 118(5): e1406- e1413.

Chhatwal, J., M. Verma and S.K. Riar, 2004. Obesity among preadolescents of a developing country (India). Asia. Pac. J. Clin. Nutr., 13(3): 231-235.

Davies, P.S.W., 1997. Diet composition and Body Mass Index in pre-school children. Eur. J. Clin. Nutr., 51(7): 443-448.

de Onis, M. and M. Blossner, 2000. Prevalence and trends of overweight among preschool children in developing countries. Am. J. Clin. Nutr., 72(4): 1032-1039.

Drewnowski, A., 2004. Obesity and the food environment: Dietary energy density and diet costs. Am. J. Prev. Med., 27(3): 154-162.

Ekelund, U., K.K. Ong, Y. Linne, M.N. Søren Brage, D.B. Dunger, N.J. Wareham and S. Rössner, 2006. Upward weight percentile crossing in infancy and early childhood independently predicts fat mass in young adults: the Stockholm Weight Development Study (SWEDES). Am. J. Clin. Nutr., 83(2): 324-330.

Fernald, L.C. and L.M. Neufeld, 2007. Overweight with concurrent stunting in very young children from rural Mexico: Prevalence and associated factors. Eur. J. Clin. Nutr., 61(5): 623-632.

Fisher, J.O. and L.L. Birch, 1995. Fat preferences and fat consumption of 3- to 5-year-old children are related to parental adiposity. J. Am. Diet. Assoc., 95(7): 759-764.

Freedman, D.S., W.H. Dietz, S.R. Srinivasan and G.S. Berenson, 1999. The relation of overweight to cardiovascular risk factors among children and adolescents: The Bogalusa Heart Study. Pediatrics, 103(6): 1175.

Goran, M.I., 2001. Metabolic precursors and effects of obesity in children: a decade of progress, 1990-1999. Am. J. Clin. Nutr., 73(2): 158-171.

IIPS and Macro International, 2007. National Family Health Survey (NFHS-3), 2005-06: India. Vol: I. Mumbai: IIPS.

Kain, J. and R. Uauy, 2001. Targeting strategies used by the Chilean National Supplementary Feeding program. Nutr. Res., 21(4): 677-688.

Kaur, S., H.P. Sachdev, S.N. Dwivedi, R. Lakshmy and U. Kapil, 2008. Prevalence of overweight and obesity amongst school children in Delhi, India. Asia. Pac. J. Clin. Nutr., 17(4): 592-596.

Kumar, H.N., P. Mohana, S. Kotian, B.S. Sajjan and S.G. Kumar, 2008. Prevalence of overweight and obesity among pre-school children in semi urban South India. Indian Pediatr., 45(6): 497-499.

Martorell, R., L.K. Khan, M.L. Hughes and L.M. Grummer-Strawn, 2000. Overweight and obesity in preschool children from developing countries. Int. J. Obes., 24(8): 959-967.

Measure DHS (Demographic and Health Surveys), 2009. Maryland, USA. Retrieved from: www.measuredhs.com.

Mishra, V., R.D. Retherford and K.R. Smith, 2005. Cooking smoke and tobacco smoke as risk factors for stillbirth. Int. J. Environ. Health Res., 15(6): 397-410.

Misra, A., and L. Khurana, 2008. Obesity and the metabolic syndrome in developing countries. J. Clin. Endocrinol. Metab., 93(11): s9-30.

Moreno, L.A., A. Sarria, A. Lazaro and M. Bueno, 2000. Dietary fat intake and body mass index in Spanish children. Am. J. Clin. Nutr., 72(5): 1399S-1403.

Newby, P.K., K.E. Peterson, K.E., C.S. Berkey, J. Leppert, W.C. Willett and G.A. Colditz, 2003. Dietary composition and weight change among low-income preschool children. Arch. Pediatr. Adolesc. Med., 157(8): 759-764.

Ogden, C.L., R.P. Troiano, R.R. Briefel, R.J. Kuczmarski, K.M. Flegal and C.L. Johnson, 1997. Prevalence of overweight among preschool children in the United States, 1971 through 1994. Pediatrics, 99(4): e1-7.

Ong, K.K., M.L. Ahmed, P.M. Emmett, M.A. Preece, D.B. Dunger and the ALSPAC Study Team, 2000. Association between postnatal catch-up growth and obesity in childhood: prospective cohort study. BMJ, 320(7240): 967-971.

Ong, K.K, P.M. Emmett, S. Noble, A. Ness, D.B. Dunger and the ALSPAC Study Team, 2006. Dietary energy intake at the age of 4 months predicts postnatal weight gain and childhood Body Mass Index. Pediatrics, 117(3): e503-e508.

Popkin, B.M., 1994. The nutrition transition in low-income countries: An emerging crisis. Nutr. Rev., 52(9): 285-298.

Popkin, B.M., M.K. Richards and C.A. Montiero, 1996. Stunting is associated with overweight in children of four nations that are undergoing the nutrition transition. J. Nutr., 126(12): 3009-3016.

Popkin, B.M., 2001. The nutrition transition and obesity in the developing world. J. Nutr., 131(3): 871S-873.

Popkin, B.M., S. Horton, S. Kim, A. Mahal and S.G. Jin, 2001. Trends in diet, nutritional status and diet-related noncommunicable diseases in China and India: The economic costs of the nutrition transition. Nutr. Rev., 59(12): 379-390.

Rolland-Cachera, M., M. Deheeger, F. Bellisle, M. Sempe, M. Guilloud-Bataille and E. Patois, 1984. Adiposity rebound in children: A simple indicator for predicting obesity. Am. J. Clin. Nutr., 39(1): 129-135.

Schroeder, D.G., R. Martorell, J.A. Rivera, M.T. Ruel and J.P. Habicht, 1995. Age-differences in the impact of nutritional supplementation on growth. J. Nutr., 125(4): S1051-S1059.

Takahashi, E., K. Yoshida, H. Sugimori, M. Miyakawa, T. Izuno, T. Yamagami and S. Kagamimori, 1999. Influence factors on the development of obesity in 3-year-old children based on the Toyama study. Prev. Med., 28(3): 293-296.

Tucker, L.A., G.T. Seljaas and R.L. Hager, 1997. Body fat percentage of children varies according to their diet composition. J. Am. Diet. Assoc., 97(9): 981-986.

Uauy, R., C. Albala and J. Kain, 2001. Obesity trends in Latin America: Transiting from under- to overweight. J. Nutr., 131(3): 893S-899.

UNICEF, 2008. State of the World's Children 2009. Maternal and Newborn Health. New York, USA.

Vogels, N., D.L.A. Posthumus, E.C.M. Mariman, F. Bouwman, A.D.M. Kester, A.D.P. Rump, G. Hornstra and M.S. Westerterp-Plantenga, 2006. Determinants of overweight in a cohort of Dutch children. Am. J. Clin. Nutr., 84(4): 717-724.

Wang, Y. and T. Lobstein, 2006. Worldwide trends in childhood overweight and obesity. Int. J. Pediatr. Obes., 1(1): 11-25.

Whitaker, R.C., J.A. Wright, M.S. Pepe, K.D. Seidel and W.H. Dietz, 1997. Predicting obesity in young adulthood from childhood and parental obesity. N. Engl. J. Med., 337(13): 869-873.

WHO, 1995. Physical status: The use and interpretation of anthropometry. Geneva, Switzerland.

WHO, 2006. WHO child growth standards- length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age methods and development. Switzerland, Geneva.