SOCIOECONOMIC DETERMINANTS OF REGIONAL DIFFERENCES IN

NUTRTIONAL STATUS OF CHILDREN IN INDIA

by

NIPA PATEL

A Thesis submitted to the

Graduate School-New Brunswick

Rutgers, The State University of New Jersey

in partial fulfillment of the requirements

for the degree of

Master of Science

Graduate Program in Nutritional Sciences

written under the direction of

Dr. Daniel Hoffman

and approved by

____

____

____

____

New Brunswick, New Jersey

[May, 2012]

ABSTRACT OF THE THESIS

Socioeconomic determinants of regional differences in

nutritional status of children in India

By Nipa Patel

Thesis Director:
Dr. Daniel Hoffman

While India has experienced rapid economic development during the last few decades, the prevalence of undernutrition remains high and the prevalence of overnutrition is increasing, creating a “double burden”. This trend is observed not only among the adult population of India, but also among the children of India. The National Family Health Surveys (NFHS), starting in 1992 and conducted every five years, collects nutritional data on participants and was used to address the question of which socioeconomic factors influence childhood nutritional status and whether or not these factors differ by state and wealth of different regions in India. To achieve this objective, the NFHS II data from 1998-1999 were studied using multiple linear regression analysis to predict child nutritional status for those under two years of age. Weight-for-height z-score (WHZ) was positively associated with Body Mass Index (BMI) and household standard of living, and an inverse relationship with respondent’s age. Height-for-age z-score (HAZ) was positively associated with years lived in place of residence, education level, BMI, and household standard of living and an inverse relationship with respondent’s age and type of employment. Analyses by region (West, South, North, Northeast, East, and Central) showed that the association between the socioeconomic factors with WHZ and HAZ among stunted, wasted, and overweight children varied among the six regions. In the wealthier regions, respondent's age, place of residence, and years lived in residence are significant predictors. In the less wealthy regions, respondent's ethnicity and employment are significant predictors. In conclusion, when assessing the nutritional status of children within the country of India, the association between socioeconomic factors with child WHZ and HAZ varies by region.

Acknowledgements

I would like to thank my committee members for their guidance. I would like to thank my advisor, Dr. Hoffman, for providing me the opportunity to perform a research project and supervising me through the complexities of it from beginning to end. I would also like to thank Dr. Rodgers and Dr. Fitzgerald for fielding any questions I had, and providing feedback and encouragement.

I would like to thank Dr. Premananda Bharati, who had graciously provided the data set for this project. She has also been of great help in steering me in the right direction for more information, as well as answering any and all questions.

I would like to thank a special friend and colleague, Lynnicia Massenburg, for her support and encouragement throughout the process.

I would like to thank my family and friends for their support and encouragement throughout the years, morally and intellectually. Thanks to my family: my mother Bharati Patel, father Kamlesh Patel, brother Hiral Patel, and sister Heena Patel. Thanks to my friends: Isabel Ramos, Carolina Espinosa, Jon Onulak, Emily Merewitz, Carmen Acevedo, and Dolores Wardrop.

I would also like to thank Professors who have guided me along the way: Professor Barbara Tangel, Professor Peggy Policastro, Dr. Susan Skelly, Dr. Judith Storch, Dr. Adria Sherman, and Dr. Dawn Braseamle.

Table of Contents

INTRODUCTION

India has experienced significant economic success over the past 20 years. With the prevalence of undernutrition still high yet constant, overnutrition has risen. This observation suggests that India is now facing the “double burden”, which is a high prevalence of both undernutrition and overnutrition. Even though India’s Gross National Product increased by 60% between 2001-02 and 2006-06, its economic development has not had a significant impact on the prevalence of undernutrition and may be associated with the rise of obesity (IIPS and ORC Macro 2007). Serious health complications are associated with the “double burden”, posing a significant public health problem.

Despite relative economic progress in India, the prevalence of undernutrition is still high. Among women, the prevalence of undernutrition has decreased from 36% to 33% between 1998-99 and 2005-06 (Arnold et al 2009). Yet, during the same span of time, the percent of women with a normal BMI has remained steady, from 53% to 52%, (Arnold et al 2009). For men, approximately 28% were classified as underweight in 2005 (Arnold et al 2009). Therefore, normal BMI is holding constant and underweight prevalence is slightly improving but still high.

Although the prevalence of normal BMI in India has held steady and the prevalence of underweight adults has decreased slightly, the prevalence of overweight adults has increased. Over the last two decades, the prevalence of overweight and obesity in Asian Indian females has increased. The percent of overweight and obese females in the early 1990’s was 3.5-4.1%, rose to 11% in 1998, and reached 15% in 2005

(Griffiths and Bentley 2001)(Arnold et al 2009). In addition, the prevalence of overweight men in 2005 was at 12% (Griffiths and Bentley 2001)(Arnold et al 2009). Overnutrition is on the rise in India, and when using waist circumference measurements, the numbers are even higher. The Indian Women's Health Study reported that abdominal obesity, defined as waist circumference greater than 88 cm for women, accounted for fifty-five percent of women ages 25-64 (Hariram and Talwar 2005). Based on these data, a segment of India that is overweight and obese is adding to the double burden.

This double burden that is affecting adults is also affecting the youth of India. Undernutrition among Asian Indian children is still a problem. In 2001, more than 50% of children in India were undernourished (Griffiths and Bentley 2001). Undernutrition continues to be a major public health problem in India among preschool children, with some improvements in stunting, but minimal changes in wasting and underweight (Antony and Laxmaiah 2008). Parallel to these observations, data collected from the NFHS I, II, and III also represent a decrease in stunting, but minimal change in the underweight prevalence of Asian Indian children. For children under three years of age, there was a 5% decrease in the percent of underweight children between 1992-1998 (Arnold et al 2009). Even though there was a significant decrease of underweight children within these six years, the next six years did not show a similar decline. From 1998-2005, there was a 1% decrease in the prevalence of underweight children under three years of age (Arnold et al 2009). Stunting among children under age three, however, dropped from 46% to 38% between 1998 and 2005 (Arnold et al 2009) (The

World Bank, n.d.). During the same period, even though prevalence of stunting decreased, there was still a high percent of children who were underweight, posing major health risks for, such as Kwashiorkor and Marasmus.

While the prevalence of underweight and stunting is decreasing, children in India are becoming overweight and obese. From 2002 to 2007, the prevalence of overweight children increased from 16% to 24% (Misra and Khurana 2008). In urban middle class alone, 10% percent of the children are overweight and, of the children who are obese, 50-80% of these obese children grow to be obese adults (Bhave et al 2004). Consequently, obese children who continue to be obese as adults have approximately a 50-100% higher risk of developing obesity-related disorders, such as cardiovascular disease and diabetes (Bhave et al 2004).

In addition to obesity, undernutrition also results in health complications. Increased sickness and death are more prevalent at BMI values below and above the normal 19.0-22.0 kg/m2 range for Asian Indians (Khongsdier 2002)(Hariram and Talwar 2005). There is a U-shaped morbidity and mortality relationship with BMI that can be observed in both adults and children (Khongsdier 2002)(Hariram and Talwar 2005). Adults with a high BMI have a higher risk for type 2 diabetes and cardiovascular disease (Hariram and Talwar 2005)(Agarwal 2008). On the other hand, a low BMI is associated with nutrient deficiencies and protein-energy malnutrition such as Kwashiorkor and Marasmus (Müller and Krawinkel 2005). Therefore, maintaining a BMI in the normal range poses less health risks.

What contributes to the double burden and the consequent health risks are significant environmental factors. While somewhat contradictory, factors that influence the risk of undernutrition also influence the risk of obesity. BMI above and below the normal range among the Asian Indian population can be attributed to: socioeconomic status (SES), education, region, and lifestyle. Socioeconomic status and obesity are inversely associated in developed countries, such as the United States, while they are positively associated in developing countries, such as India (Subramanian and Smith 2006) (Pednekar et al 2008)(Adams and Subramanian 2008). In the United States, BMI is inversely related to higher educational attainment, whereas in Asia, they are positively associated (Sauvaget et al 2008)(Adams and Subramanian 2008). In general, the same factors that are negatively associated with BMI within the United States are positively associated with BMI within developing countries, such as India.

The positive association between SES and BMI is observed in persons from affluent states in India (Subramanian and Smith 2006). Within the wealthier states, women of higher affluence were at a lower risk of being underweight compared to the lesser affluent women (Subramanian and Smith 2006). In addition to SES and education, both underweight and overweight prevalence also differ by region and lifestyle (Griffiths and Bentley 2001). The high prevalence of both obesity and undernutrition in India is associated with the type of region, urban or rural. Underweight susceptibility increased with more manual work and habitation of rural areas (Subramanian and Smith 2006). In urban regions, obesity is more prevalent among higher socioeconomic groups, individuals with higher education, and for those living sedentary lifestyles (Bhave et al

2004). In rural regions, by contrast, undernutrition is related to active lifestyles involving occupations such as farming, lower educational attainment, and lower economic status.

Therefore, we hypothesized that the weight-for-height and height-for-age of children is influenced by a household's standard of living, mother's education level, mother's ethnicity, and region (i.e. rural or suburban). We also expect to observe a variation in the effect of these factors on the dependent variables when the country is divided into distinct regions. Lastly, the effect of these predictors is also hypothesized to be associated differently with the dependent variables among the three different weight groups - stunted, wasted, and overweight - within each of the regions.

LITERATURE REVIEW

1.1 The prevalence of both overweight and undernutrition are high in India (Hariram and Talwar 2005). This observation is important as both are associated with health problems, such as Marasmus and Kwashiorkor with undernutrition, and cardiovascular disease and diabetes with overnutrition. Underlying genetic factors and phenotypic traits in the population may promote a greater susceptibility to being underweight or overweight. As a result, physical measurements of nutritional status are changed for this population to account for the differences affecting them. In addition, environmental factors such as region, standard of living, education, and occupation are related to an individual's BMI.

1.1.1 Asian Indian Phenotype

The Asian Indian phenotype is characterized by high fat (intra-abdominal and excess truncal subcutaneous fat) masked by a small body frame (Hariram and Talwar 2005). Intraperitoneal abdominal fat is located around the visceral organs and tends to be more metabolically active, predisposing individuals to diabetes and the metabolic syndrome (Bhave et al 2004)(Hariram and Talwar 2005). However, research shows that Asian Indians are more likely to have more truncal subcutaneous fat than visceral and are still susceptible to health conditions associated with visceral fat. For example, compared to Caucasians, South Indians tend to have three to five percent higher body fat for the same BMI (Bhave et al 2004). It was also found that compared to Caucasians, despite having similar body weight, BMI, and waist-to-hip ratio, South Asian men had a lower lean body mass indicating a higher total body fat consisting more of truncal subcutaneous fat mass (Chandalia et al 2007). South Asian men also tend to have larger adipocytes, which correlated with higher leptin concentrations and lower adiponectin (Chandalia et al 2007). Even though South Asians did not have a higher visceral fat content compared to Caucasian men, the presence of significantly larger adipocytes within the truncal subcutaneous fat increases the risk of insulin resistance and type 2 diabetes within this ethnic group (Abate and Chandalia 2007)(Chandalia et al 2007). This predisposition for Asian Indians to have a higher fat percentage per BMI compared to Caucasians presents a higher health risk.

1.1.2 Asian Indian Genetics

The genotype of this population may explain the phenotypic and metabolic characteristics of Asian Indians. Genetics may be the driving factor towards this ethnic predisposition to the Asian Indian Phenotype, and hence type 2 diabetes. Abate and Chandalia (2006) suggest that specific polymorphisms influence the development of type 2 diabetes in Asian Indians. One study compared the PPAR-γ2Pro12Ala receptor polymorphism between Caucasians and South Asians in Dallas, TX with and without diabetes and South Asians in Chennai, India with and without diabetes (Radha and Mohan 2006). Non-diabetic Caucasians who did not have diabetes showed a higher amount (20%) of PPAR-γ2Pro12Ala receptor polymorphism than Caucasians with diabetes (9%), suggesting a protective nature of this polymorphism against diabetes (Radha and Mohan 2006). Similarly, Caucasians without diabetes had lower insulin levels after a two hour Oral Glucose Tolerance Test (OGTT) (Radha and Mohan 2006). On the other hand, the percent of polymorphisms present in South Asians, with and without diabetes, in Dallas, TX (20 and 23%) and Chennai (19 and 19.3%) was similar and the fasting glucose and two hour OGTT did not differ among the groups (Radha and Mohan 2006). Therefore, lower amounts of the PPAR-γ2Pro12Ala receptor in Asian Indians may be an underlying factors predisposing the Asian Indian population to obesity, diabetes, and other related complications.

Similarly, a research study performed in the UK showed that Asian Indians, when compared to White and Afro-Caribbean individuals, had the best beta cell function yet the most insulin resistance (Abate and Chandalia 2006). This study supports Chandalia et al (2007) that Asian Indians have a higher amount of truncal fat and insulin resistance, even with lower BMI and the absence of obesity.

This unfortunate predisposition in adults also transcends to the younger generations. In India, the genetic predisposition to central adiposity and diabetes is becoming more noticeable among the adult and child population as the prevalence of overnutrition is rising. Compared to Caucasians, an independent association between the prevalence of gestational diabetes in late pregnancy and increased insulin resistance was reported in Asian and South Asian women (Retnakaran et al 2006). Thus, ethnicity influences “insulin resistance in pregnancy” (Retnakaran et al 2006). Gestational diabetes can lead to a heavier birth weight and may predispose the child to diabetes later in life; this inter-generational effect can predispose children to obesity (Bhave et al 2004)(Hariram and Talwar 2005). Therefore, the ethnic predisposition to obesity and diabetes puts future generations at risk.

1.1.3 Measurements of Nutritional Status

Given that the growing prevalence of both undernutrition and obesity is increasing in India, it is important to determine the best methods for assessing nutritional status. Traditionally, an individual's nutritional status is assessed by measurements of height and weight for children, and body mass index (BMI), waist-to-hip ratio, and waist circumference for adults.

For adults, BMI is a widely used measure for assessing weight. Body Mass Index is a measurement tool used to classify an individual's weight relative to their height. It is based on a numerical scale with a normal range between 18.5 to 24.9 kg/m^2 (CDC 2011). Those who carry more weight than normal for their height are classified either as overweight with a BMI between 25.0-29.9 kg/m^2 or obese, with a BMI of 30 kg/m^2 or higher (CDC 2011). Underweight individuals, by contrast, weigh lower than normal for their height and have a BMI below 18.5 kg/m^2 (CDC 2011). Adult males and females with BMI values of 18.5, 17.0, and 16.0 are categorized as mildly, moderately, or severely energy-deficient, or grade 1, 2, or 3 underweight, respectively (Bailey and Ferro-Luzzi 1995). The standard US BMI for classifying overweight individuals is above 25 and for obesity is greater than 30 (Bhave et al 2004)(CDC 2011).

In terms of fat distribution, waist circumference assesses central adiposity and is a more reliable predictor of the metabolic syndrome, cardiovascular disease, and type 2 diabetes than BMI (Mohan and Deepa 2006) (Hariram and Talwar 2005). Risk for central obesity is defined as waist circumference over 102 cm for men and 88 cm for women (Bhave et al 2004). Therefore, those who have waist circumference values indicating central obesity are at a higher risk for type 2 diabetes, metabolic syndrome, and cardiovascular disease.

In spite of this, is the same BMI does not always suggest a similar body compositions, and differences need to be accounted for among varying body types. Assessments of overweight and obesity for Asian Indians, however, use lower cut-off points for BMI and waist circumference. The normal BMI and waist circumference cutoff ranges for Asian Indians are 19.0-22.0 (BMI) and 72.0-85.0 cm (waist circumference) for men and 65.5-80.0 cm (waist circumference) for women (Mohan and Deepa 2006). Therefore, for Asian Indians, the BMI cut-off for obesity is greater than 25.0 instead of 30.0, and for determining overweight, a BMI between 23.0-24.9 instead of 25.0-30.0 (Mohan and Deepa 2006)(Bhave et al 2004).

For children, nutritional status is determined by measuring weight and height relative to age and gender. Standardized weight-for-height z-score (WHZ) has been used to assess acute undernutrition or wasting, height-for-age z-score (HAZ) for chronic undernutrition or stunting, and weight-for-age z-score (WAZ) for acute/chronic nutrition or underweight (Bailey and Ferro-Luzzi 1995)(Müller and Krawinkel 2005)(Antony and Laxmaiah 2008). Standardized growth charts are used as a reference, where height and weight for a specific age and sex are defined within a certain interval. Underweight is defined as those being under the fifth percentile of BMI for age and sex (CDC 2011)(Bhave et al 2004). Overweight classification is the 85th percentile of BMI for age and sex, and obesity in the 95th percentile of BMI for age and sex (CDC 2011)(Bhave et al 2004). Comparing measurements to a reference population of healthy children, HAZ less than two standard deviations from the left of the median is classified as stunted, WAZ less than two standard deviations from the left of the median as underweight, and WHZ greater than two standard deviations from the right of the median as overweight (Surkan et al 2011).

Child WHZ, HAZ, and WAZ measurements are used to assess nutritional status because children up to three years of age are more susceptible to undernutrition, and any deviation from normal reflects past problems, current development of society, and general health of a population (Subramanyam et al 2010). Such anthropometric measurements, of both adults and children, have provided further insight into India's state of nutrition, namely, the double burden of the prevalence of undernutrition and overnutrition in India.

1.2 Factors Influencing the Double Burden

The double burden of disease is associated with a number of factors such as lifestyle, SES, region, education, religion, breast-feeding, type of work, region, and diet, all of which contribute to an individual's BMI (Griffiths and Bentley 2001). For example, the odds of being underweight increase as the standard of living and education years decrease (Subramanian and Smith 2006)(Subramanyam et al 2010). Other factors that are associated with an increased risk of being underweight include: being a member of a scheduled caste, other backward tribe, or no caste; living in a small city, town, or rural area compared to a large city; and performing manual or agricultural work versus being a homemaker or involved in nonmanual work (Subramanian and Smith 2006). Scheduled castes, the lowest in traditional Hindu caste hierarchy, and scheduled tribes, about 700 which are “geographically isolated with limited economic and social interaction,” are the most socially disadvantaged (Subramanian et al 2006). Other backward castes are a “diverse collection of ‘intermediate’ castes” that are low but above scheduled castes (Subramanian et al 2006). Data from the National Family Health Survey (NFHS) were used to report that children from scheduled castes and scheduled tribes were more likely to be undernourished compared to those from other castes or no castes (Subramanyam et al 2010).

In addition to ethnicity, region, standard of living, and occupation also show to influence BMI. The odds of being overweight and obese increase as the standard of living and years of education increase (Subramanian and Smith 2006). Individuals performing non-manual work are more likely to be overweight or obese compared to those performing manual work such as agriculture (Subramanian and Smith 2006). A higher standard of living allows for more available funds to purchase foods (Subramanian and Smith 2006). As a result, people in higher SES groups consume about 37% of their energy from fat compared to only 17% in lower income groups (Subramanian and Smith 2006). The effect of region, SES, education, and lifestyle on BMI will be explored in greater detail.

1.2.1 Regions (rural/urban)

There is a relationship between BMI and regional inhabitation (Griffiths and Bentley 2001). While the rural areas of India are impoverished, the urban regions are prospering (Antony and Laxmaiah 2008). In the urban regions, lifestyle adaptations have emerged from the economic growth, contributing to the rise in obesity. For example, urbanization is associated with less healthy eating patterns, sedentary pursuits, and inadequate play areas (Bhave et al 2004). By contrast, underweight has been linked to more manual work, which is more prevalent in rural areas (Subramanian and Smith 2006). Thus, underweight is more prevalent in rural areas compared to urban areas, which also show a higher prevalence of overweight.

In India, as in other developing countries, obesity is more prevalent in urban areas, whereas undernutrition is more prevalent in rural areas. When separated by region, there were more underweight women in rural (20%) than in urban (12%) areas, and more overweight women in urban (37%) than in rural (8%) (Sauvaget et al 2008). These studies show that the double burden may be influenced by rural and urban communities, with a higher prevalence of undernutrition in rural areas and overnutrition in urban areas.

1.2.2 Socioeconomic Status is Positively Associated with BMI

In addition to the rural and urban areas, the presence of overnutrition is being influenced by the differences in socioeconomic status (Agarwal 2008). SES, measured by factors such as income, education, and occupation, shows to be positively associated with BMI in India (Banerjee and Mukherjee 2006).

1.2.2.1 Income level is positively associated with BMI

Income level, an indicator of SES, shows to contribute to the positive association with nutritional status. In rural War Khasi in northeast India, even with a prevalence of chronic energy deficiency in 35% of the adult males, there is a positive relationship between income and BMI (Khongsdier 2002). Adults with a high income have a significantly higher BMI than those in the lower and middle income group (Khongsdier 2002). This relationship is also prevalent among the child population. In high, middle, and lower income group schools in Chennai, 22% of adolescents were overweight or obese in wealthy schools compared to 4.5% in lower income group schools (Bhave et al 2004). Also, In a cross-sectional analysis of the NFHS 1, 2, and 3, the prevalence of childhood underweight, severe underweight, stunting, and severe stunting all decreased as household wealth increased (Subramanyam et al 2010).

1.2.2.2 Education level is positively associated with BMI

With obesity more prevalent in high-income groups and undernutrition in low-income groups, the level of educational attainment also shows a positive association with nutritional status. Women who had completed primary education were more likely to be categorized as overweight or obese compared to those who had not completed primary education (Griffiths and Bentley 2001). Lower educational attainment was associated with a lower BMI for both men and women (Shukla et al 2002). For example, obesity was prevalent in 11.1% of female college graduates in Mumbai versus 5.1% in illiterate Indian women; conversely, illiterate Indian women showed a 24.3% prevalence of underweight (Shukla et al 2002).

Even in rural areas, where there is a higher prevalence of underweight than in urban areas, education plays a major role (Bhandari and Zaidi 2004). The prevalence of underweight for illiterate women in urban areas was 32% compared to 45% in rural areas (Bhandari and Zaidi 2004). However, for women who have attained a secondary education or higher, the underweight prevalence dropped to 12% in urban areas and

22% in rural areas (Bhandari and Zaidi 2004). Consequently, despite regional differences, education has a significant impact on BMI.

Childhood undernutrition is also linked to maternal education, similar to the relationship that was previously observed between household wealth and child nutritional status (Subramanyam et al 2010). As maternal education increases, the prevalence of child underweight, severely underweight, stunting, and severe stunting decreases (Subramanyam et al 2010). Obesity, on the other hand, is associated with higher education.

1.2.2.3 Lifestyle Changes (through urbanization and SES)

Many developing countries are facing urbanization. With urbanization come many lifestyle adaptations, which in India show to influence nutritional status. Mumbai, and most of urban India, is experiencing a nutritional transition (Pednekar et al 2008). Industrialization and urbanization in parts of India have increased the standard of living, which has also brought on an increase in weight gain and obesity among the population (Mohan and Deepa 2006). In many of the urban regions of India, overweight and obesity are more prevalent due to lower energy expenditure resulting from automated technology and sedentary activities, such as television and video games (Pednekar et al 2008). In addition, highly processed and prepackaged foods and fast foods in India are more expensive than in the United States (Pednekar et al 2008). Therefore, those earning higher incomes are able to afford these foods, thereby contributing to the positive linear relationship between SES and BMI (Pednekar et al 2008). On the other hand, rural populations in less developed countries tend be exposed to poor hygienic conditions, low SES, and minimal access to medical attention, resulting in a higher prevalence of undernutrition (Sauvaget et al 2008). Lifestyle has a big impact on BMI, whereby engagement in manual and agricultural work pertaining to a higher physical activity level is associated with undernutrition, or non-manual work with a lower physical demand is associated with overnutrition (Subramanian and Smith 2006). Therefore, various lifestyle factors common to urban and rural regions show to influence the nutritional status of an individual.

The availability of highly processed energy-dense foods (e.g. burgers, pizza, chowmein, fruit drinks) replacing healthier and natural vitamin and mineral rich foods illustrates a transition toward a westernized lifestyle in urban areas (Bhave et al 2004)(Agarwal 2008). Those who are wealthier are able to afford non-consumable goods, such as televisions and video games, which encourage sedentary behaviors (Bhave et al 2004)(Agarwal 2008). In addition, the competitive academic environment among the wealthier creates another sedentary pursuit, where children spend most of their time studying (Bhave et al 2004)(Agarwal 2008). Lastly, because exercise has been used as one way of punishment, physical activity is negatively perceived. Unsafe road conditions and environment in the urban and industrialized areas also discourage walking and biking, making people more dependent on motorized transportation (Bhave et al 2004). Secondary to the wealth arising from urbanization and industrialization is a lifestyle that promotes overnutrition.

1.3 Addressing the double burden in India

While more children and adults in India are becoming obese, a majority of the population still experiences complications from undernutrition. Malnourished individuals may be programmed to accumulate fat for storage faster in preparation for future starvation (Bhave et al 2004). Moreover, stunted individuals who experience urbanization are exposed to the westernized diet, and have the chance of accumulating more central fat due to their body type (Bhave et al 2004). Agarwal (2008) attributes the rise in obesity to lifestyle changes and suggests to adopt healthy lifestyles, such as a healthful diet, increasing physical activity, and decreasing sedentary activities. The double burden in India needs to be addressed to prevent further health complications.

1.3.1 U-shaped morbidity and mortality relationship with Body Mass Index (BMI)

A BMI above and below the normal range increases the risk of morbidity and mortality and understanding the causes of a BMI out of the normal range may help prevent future disease. There is a U-shaped relationship between BMI and mortality, whereby mortality increases as BMI decreases or increases away from the normal range, indicating an increased risk of death as one is below or above the normal range of BMI (Khongsdier 2002). For example, there is an associated rise in death rates and mild to severe leanness (BMI<16kg/m^2) in the lower range of BMI (Pednekar et al. 2008)(Sauvaget et al 2008). Consequently, it is important to maintain a healthy weight in the normal range throughout one's lifespan.

One is prone to health disadvantages as their BMI goes below or above the normal range. Deviations from a normal body weight increase the risk of morbidity and mortality (Hariram and Talwar 2005). Length of time of exposure to a greater BMI (obesity in some cases) may be correlated to higher morbidity and mortality risk (Hariram and Talwar 2005). Greater abdominal fat means a larger number of fats cells, which will require more blood flow and increased lipolysis (Hariram and Talwar 2005). Increased lipolysis results in more circulating free fatty acids (nonesterified fatty acids), which have been linked to insulin resistance, atherogenic dyslipedimea, and hypertension in obese individuals (Hariram and Talwar 2005). Common complications of obesity are osteoarthritis, reproductive abnormalities, sleep apnea, and diabetes (Hariram and Talwar 2005). Overweight and obesity can also be associated with mental and emotional stress. Individuals may become depressed and have low self-confidence due to a poor body image, which can lead to negatively affect their home and social interactions (Agarwal 2008).

The rise in childhood overweight and obesity is more concerning now than ever, as children are also experiencing obesity-related complications. Even more troubling is that obesity affects their sexual maturation; females experience menarche at a much earlier age such as 10 or 11 years old, and males actually mature much later (Lobstein et al 2004). Ultimately, these ailments lead to more physical and social impairments for the individual, and a higher amount of deaths and decreased productivity for the society (Lobstein et al 2004).

The lower range of BMI is associated with undernutrition, morbidity, and mortality and lowers the quality of health and productivity. Commonly associated with undernutrition is malnutrition, such as protein-energy malnutrition (Marasmus and Kwashiorkor), and micronutrient deficiencies (Müller and Krawinkel 2005). Marasmus is identified when all the available energy and nutrients are endogenously mobilized resulting in subcutaneous fat and muscle loss (Müller and Krawinkel 2005). Kwashiorkor usually occurs "with edema, changes to hair and skin colour, anemia, hepatomegaly, lethargy, severe immune deficiency and early death" resulting from a diet deficient in protein (Müller and Krawinkel 2005)(NCBI 2012). Protein-energy malnutrition and micronutrient deficiencies are interlinked, and a lack of one micronutrient can also lead to deficiencies of other micronutrients (Müller and Krawinkel 2005). Chronic energy deficiency results in low productivity, which is associated with lower economic productivity (output), physical activity, reproductivity, and increased mortality (Subramanian and Smith 2006)(Shukla et al 2002).

In terms of mortality, the risk of death in both women and men of different ages with a BMI below normal is higher compared to those with a normal BMI (Pednekar et al 2008). The reason for this is because malnutrition can lead to infections, and both conditions can worsen the other (Scrimshaw and Sangiovanni 1997). Furthermore, the relationship between malnutrition and morbidity and mortality is a logarithmic relationship rather than an additive (directly linear) relationship, implying that malnutrition may increase the severity of morbidity and lead to mortality (Pelletier et al.

1993). Therefore, the risk of morbidity and mortality increases exponentially when one is malnourished.

1.3.2 Economic costs of the double burden

The costs of treating obesity and undernutrition are tremendous. Direct costs involve hospitalizations, treatments for type 2 diabetes, medications for asthma, and prescription medications for complications resulting from having a higher BMI, or nutrition therapy for the lower end of BMI. Not only are there direct medical costs as a result of obesity, but indirect and intangible ones as well (Lobstein et al 2004). Indirect costs related to the extreme BMI's include days taken off for sickness/treatments which ultimately affect productivity. Those who experience chronic energy deficiency already have a lower output due to lower energy intake, thus decreasing productivity and economic output. Unfortunately, the intangible costs are emotional and mental self-reflections, such as depression and low self-confidence, and experiencing the loss of loved ones (Lobstein et al 2004). For just the treatment of type 2 diabetes, the costs (direct and indirect) were estimated at $425 per capita in 2007 and if held constant, estimated to cost $30 billion in 2025 (PricewaterhouseCoopers 2007). These numbers reflect only the treatment of one disease, type 2 diabetes, but as mentioned, there are many other costs resulting from both undernutrition and overnutrition. Consequently, because of the high prevalence and costs of undernutrition and obesity in India, there is an urgent need to alleviate the double burden.

1.4 Reducing the double burden

There are many ways to respond to the rise in prevalence of obesity and undernutrition in India, but the most important are awareness, nutritional education, and monitoring progress. An effective treatment action should include administering nutritional education, encouraging an active lifestyle over sedentary behaviors, preventing gestational diabetes and force-feeding, and "promot[ing] exclusive breast feeding for six months" (Bhave et al 2004). Bhave et al (2004) also suggest that yearly physical exams should involve monitoring of age, weight, and height, and that accelerated growth across centiles should be discouraged. Since the energy-dense foods are more expensive in India and thereby available to those of higher economic status, nutrition interventions should aim to educate on making healthier buying decisions with their wealth in order to save their health.

1.5 Predictions

It is predicted that in determining child HAZ and WHZ, region, education level, and household standard of living will be significant predictors. Other variables that may also influence the predictions of HAZ and WHZ may be ethnicity and mother's BMI. Separation of the country by GDP is expected to show a difference in association between the predictors and dependent variables by region. Within each region, there may also be a difference in association between the predictors and dependent variables by weight group: stunted, wasted, and overweight.

The questions we are proceeding to answer are: What factors are contributing to the nutritional status of children under 2 years in India? Is there a regional difference?

If there is a regional difference, how does it vary?

METHODOLOGY:

Data used for this study were collected by the International Institute for Population Sciences (IIPS) in India and reported as the National Family Health Survey II (NFHS-2). Target sampling size was determined using the 1991 population statistics and a target sample size of 4,000, 3,000, and 1,500 females were determined for states with a population of more than 25 million, between 2-25 million, and less than 2 million, respectively. For some states, target sample sizes were increased to estimate for the major regions of the state and metropolitan cities. Systematic sampling was used to have a representative sample of urban and rural areas, as well as slum and non-slum areas. More detailed information can be found in the Chapter 1 Introduction of the NFHS-2 report. (IIPS and ORC Macro 2000)

Height and weight were measured of both the mother and the child. Hemoglobin levels of mother and child were measured using the HemoCue system. Further information on materials and procedures can be found within the chapters of the National Report for the NFHS II. (IIPS and ORC Macro 2000)

Questionairres (Household, Woman's, and Village) were administered to determine background characteristics of the household and respondent (female) including marital status, employment status, occupation, education, number of household members, religion, ethnicity, pregnancy status, number of children born, daughters and sons alive, died, home, or elsewhere. A list of other factors can be found at (IIPS and ORC Macro 2000)

Region was separated by 26 states of India at the time. Ethnicity was measured as scheduled caste, scheduled tribe, other backwards caste, or general. Residence was measured as urban or rural. Previous residence was represented as city or countryside. Highest education level was recorded as no education, primary, secondary, and higher. Religion was one of Hindu, Christian, Muslim, Sikh, Buddhist/Neobuddhist, Jain, Jewish, other, and no religion. Current type of employment was measured as paid employee away, paid employee home, self-employed away, self-employed home, unpaid away, unpaid home. Standard of living index was separated by low (0-14), medium (15-24), and high (25-67) (The scores took into account: house type, toilet facility, source of lighting, main fuel for cooking, source of drinking water, separate room for cooking, ownership of house, ownership of agricultural land, ownership of irrigated land, ownership of livestock, ownership of durable goods). Current marital status was determined as married, not living together, widowed, or divorced. (IIPS and ORC Macro 2000)

Data was selected according to types of measurement methods performed and reasonable limits. Height for age, weight for age, and weight for height were selected between -4.00 to 4.00 to ensure a large sample size of reasonable measures. This created a sample size of 22,365 from 27,019. Respondent's height was selected between a range of 130.00 and 180.00 cm, bringing the sample size to 22,307. Body Mass Index was selected greater than or equal to 13.0 and less than 50.0, bring the sample size to 22,289. Weight of child was selected between 2.0-39.0 kilograms, bringing the sample size to 22,289. Birth weight of the child was collected in grams, therefore it was transformed into kilograms and selected for weights less than 4.5, bringing the sample size to 6,790. Height of the child was selected between 20 and 95, children 24 months and under, and non-pregnant females. The final sample size was 4,618. Cutoff points for child measurements were determined using extreme ranges of the WHO growth charts for children under the age of 2 years.

After the selection criteria were established, the sample size was reduced to 4,618. Descriptive statistics were conducted for the final sample and the sample was subdivided into six regions based on the published NFHS regional divisions and categorized by GDP (highest first): West, South, North, Northeast, East, and Central. Descriptive statistics were completed for each of the regions and t-tests were performed comparing each of the regions to the other for a total of 15 comparisons. Once the significant differences of variables among regions was observed, general linear models were run for the country of India using the entire sample. The dependent variables were weight for height and height for age. After attaining a best-fit model for predicting weight for height and another for predicting height for age for the whole country, each of the six regions was subdivided into three weight groups (stunted defined as HAZ < -2.00, wasted defined as WHZ < -2.00, and overweight defined as WHZ > 2.00). For each weight group in each region, the two regression models were carried out to determine associations and significant predictors. SPSS statistics software was used to perform data analyses.

RESULTS:

Table 1
Basic Descriptive Statistics of sample presented as mean (standard deviation)

	N	Mean (standard deviation)
HAZ	4618	-0.983 (1.322)
WAZ	4618	-1.161 (1.178)
WHZ	4618	-0.688 (1.209)
BMI	4618	20.643 (3.564)

HAZ, WAZ, and WHZ of child under the year of age 2
BMI of adult respondent between the ages of 15-47

Table 2
Linear regression analysis determining the association between WHZ and respondent's age, BMI, and household standard of living

Model	*$1a_1$*	*$1a_2$*	*1b*	*1c*
		Dependent variable weight for height		
Constant	-1.833	-1.781	-1.907	-1.932
	(0.127)	(0.134)	(0.136)	(0.139)
Respondent's age	-0.016*	-0.014*	-0.015*	-0.015*
	(0.004)	(0.004)	(0.004)	(0.004
BMI	0.059*	0.060*	0.061*	0.062*
	(0.005)	(0.005)	(0.005)	(0.005)
Household Standard of Living (reference low)	0.119* (0.030)			
Medium		0.179*	0.179*	0.180*
		(0.055)	(0.055)	(0.055)
High		0.257*	0.251*	0.260*
		(0.063)	(0.063)	(0.063)
Education Level (reference no education)	0.023 (0.021)			
Primary		-0.064	-0.054	-0.053
		(0.063)	(0.063)	(0.063)
Secondary		0.084	0.102	0.100
		(0.055)	(0.055)	(0.055)
Higher		0.019	0.030	0.029
		(0.065)	(0.065)	(0.065)
REGIONS			0.057*	
			(0.012)	
STATEGDPCAPITA				0.011*
				(0.003)

* $P < 0.05$ is considered significant, model *$1a_1$*: adjusted R square of 0.040, model *$1a_2$*: adjusted R square of 0.042, model 1b: adjusted R square of 0.047, model 1c: adjusted R square of 0.045

Table 3
Linear regression analysis determining the association between HAZ and respondent's age, years lived in residence, BMI, employment, household standard of living, education level, and ethnicity

Model	$2a_1$	$2a_2$	*2b*	*2c*
	Dependent variable height for age			
Constant	-2.742 (0.182)	-2.599 (0.189)	-2.594 (0.191)	-2.588 (0.193)
Respondent's age	-0.018* (0.005)	-0.019* (0.005)	-0.019* (0.005)	-0.019 (0.005)
Residence	0.071 (0.041)	0.067 (0.041)	0.067 (0.041)	0.067 (0.041)
Years lived in residence	0.001* (0.000)	0.001* (0.000)	0.001* (0.000)	0.001* (0.000)
Children 5 and under	-0.044* (0.020)	-0.050* (0.020)	-0.050* (0.020)	-0.050* (0.020)
Respondent's age at 1st birth	0.040* (0.007)	0.040* (0.007)	0.040* (0.007)	0.040* (0.007)
BMI	0.042* (0.006)	0.043* (0.006)	0.043* (0.006)	0.043* (0.006)
Employment	-0.036* (0.014)	-0.042* (0.014)	-0.042* (0.014)	-0.042* (0.014)
Household Standard of Living (reference low)	0.136* (0.034			
Medium		0.164* (0.061)	0.164* (0.061)	0.163* (0.061)
High		0.292* (0.071)	0.292* (0.071)	0.292* (0.071)
Ethnicity (reference no caste)	0.022 (0.019)			
Scheduled caste		-0.168* (0.063)	-0.168* (0.063)	-0.161* (0.063)
Scheduled tribe		0.194* (0.067)	0.197* (0.068)	0.198* (0.068)
Other backward caste		0.091* (0.046)	0.091 (0.046)	0.090 (0.046)
Education Level (reference no education)	0.049* (0.024)			
Primary		0.122 (0.069)	0.121 (0.069)	0.121 (0.069)
Secondary		0.126* (0.062)	0.125* (0.062)	0.125* (0.062)
Higher		0.173* (0.076)	0.173* (0.076)	0.173* (0.076)
REGIONS			-0.003 (0.013)	
STATEGDPCAPITA				-0.001 (0.003)

* $P < 0.05$ is considered significant, model $2a_1$: adjusted R square of 0.050, model $2a_2$: adjusted R square of 0.054, model 2b: adjusted R square of 0.054, model 2c: adjusted R square of 0.054

Table 4

Multiple linear regression analysis determining the association between HAZ for stunted children and respondent's education, BMI, ethnicity, current type of employment, and type of place of residence in six regions of India

	West	South	North	Northeast	East	Central
Model	*3a*	*4a*	*5a*	*6a*	*7a*	*8a*
	dependent variable stunted height for age					
Constant	-3.089	-3.028	-3.369	-2.899	-3.200	-2.727
	(0.344)	(0.326)	(0.520)	(0.580)	(0.505)	(0.548)
Respondent's age	-0.001	-0.016	0.002	-0.001	-0.012	-0.020
	(0.009)	(0.009)	(0.011)	(0.009)	(0.012)	(0.015)
Residence	0.231*	0.091	-0.083	0.060	-0.034	0.019
	(0.074)	(0.070)	(0.098)	(0.105)	(0.009)	(0.135)
Years lived in residence	0.001	0.000	0.002	-0.002	-0.002	-0.002
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)
Children 5 and under	0.063	0.000	0.041	-0.042	-0.004	-0.034
	(0.034)	(0.035)	(0.045)	(0.056)	(0.042)	(0.046)
Respondent's age at 1st	-0.001	0.005	0.015	0.009	0.015	0.017
birth	(0.012)	(0.013)	(0.017)	(0.013)	(0.018)	(0.026)
BMI	-0.008	0.021*	0.004	-0.003	0.022	0.005
	(0.001)	(0.011)	(0.011)	(0.023)	(0.020)	(0.019)
Employment	-0.019	-0.012	0.004	0.033	-0.091*	-0.014
	(0.020)	(0.027)	(0.034)	(0.033)	(0.041)	(0.036)
Household Standard of Living						
(reference low)						
Medium	0.018	0.080	0.157	0.114	0.047	-0.014
	(0.097)	(0.081)	(0.221)	(0.131)	(0.117)	(0.148)
High	0.166	0.101	0.132	-0.322	0.109	0.171
	(0.177)	(0.115)	(0.234)	(0.179)	(0.176)	(0.192)
Ethnicity						
(reference no caste)						
Scheduled caste	-0.053	-0.007	0.100	0.265	0.069	-0.231
	(0.093)	(0.106)	(0.113)	(0.182)	(0.117)	(0.207)
Scheduled tribe	-0.087	-0.230	0.302	0.208	0.371*	0.112
	(0.127)	(0.253)	(0.331)	(0.110)	(0.149)	(0.234)
Other backward caste	-0.101	0.002	0.137	0.605	0.073	0.008
	(0.084)	(0.080)	(0.115)	(0.386)	(0.126)	(0.139)
Education Level						
(reference no education)						
Primary	0.098	0.049	-0.026	0.019	0.072	0.040
	(0.105)	(0.098)	(0.151)	(0.159)	(0.124)	(0.180)
Secondary	0.222*	0.016	-0.009	-0.001	0.117	0.354
	(0.094)	(0.093)	(0.137)	(0.154)	(0.130)	(0.182)
Higher	0.378*	0.088	0.057	-0.071	0.192	0.358
	(0.121)	(0.130)	(0.160)	(0.187)	(0.225)	(0.235)

* P < 0.05 is considered significant, model 3a: adjusted R square of 0.082, model 4a: adjusted R square of -0.009, model 5a: adjusted R square of -0.047, model 6a: adjusted R square of 0.041, model 7a: adjusted R square of 0.044, model 8a: adjusted R square of 0.118

Table 5

Multiple linear regression analysis determining the association between WHZ among stunted children and respondent's age, BMI, and standard of living in six regions of India

	West	**South**	**North**	**Northeast**	**East**	**Central**
Model	*3b*	*4b*	*5b*	*6b*	*7b*	*8b*
	dependent variable stunted weight for height					
Constant	-1.651	-2.355	-1.695	-1.406	-3.376	-1.470
	(0.618)	(0.535)	(0.897)	(1.292)	(0.929)	(1.110)
Respondent's age	-0.037*	-0.018	-0.014	-0.017	-0.010	-0.001
	(0.019)	(0.017)	(0.023)	(0.020)	(0.024)	(0.032)
BMI	0.070*	0.096*	0.078*	0.053	0.127*	0.035
	(0.025)	(0.024)	(0.027)	(0.058)	(0.046)	(0.047)
Household Standard of Living						
(reference low)						
Medium	0.206	0.018	0.077	0.850*	0.571*	-0.258
	(0.229)	(0.174)	(0.524)	(0.349)	(0.266)	(0.361)
High	0.469	0.440	-0.001	1.286*	1.218*	-0.224
	(0.278)	(0.243)	(0.550)	(0.477)	(0.400)	(0.457)
Education Level						
(reference no education)						
Primary	-0.135	-0.189	0.100	0.138	-0.226	0.049
	(0.254)	(0.220)	(0.355)	(0.425)	(0.293)	(0.409)
Secondary	0.186	0.332	-0.004	0.009	-0.140	0.424
	(0.224)	(0.194)	(0.312)	(0.408)	(0.298)	(0.375)
Higher	-0.139	0.364	0.016	-0.301	0.162	0.508
	(0.281)	(0.267)	(0.342)	(0.474)	(0.519)	(0.487)

* $P < 0.05$ is considered significant, model 3b: adjusted R square of 0.051, model 4b: adjusted R square of 0.116, model 5b: adjusted R square of 0.012, model 6b: adjusted R square of 0.041, model 7b: adjusted R square of 0.148, model 8b: adjusted R square of -0.051

Table 6
Multiple linear regression analysis determining the association between HAZ of wasted children and respondent's current age, age at first birth, BMI, education, type of employment, and years live in place of residence in six regions of India

	West	**South**	**North**	**Northeast**	**East**	**Central**
Model	*3c*	*4c*	*5c*	*6c*	*7c*	*8c*
			dependent variable underweight height for age			
Constant	-4.272	-1.546	-4.234	4.550	-0.657	-3.574
	(1.226)	(1.191)	(2.429)	(3.730)	(1.828)	(2.756)
Respondent's age	-0.107*	-0.058	-0.042	-0.018	-0.016	0.024
	(0.037)	(0.032)	(0.059)	(0.080)	(0.053)	(0.076)
Residence	0.116	0.057	0.542	-0.967	0.172	0.759
	(0.302)	(0.234)	(0.487)	(0.866)	(0.364)	(0.775)
Years lived in residence	-0.002	0.005*	0.005	-0.007	0.005	0.009
	(0.003)	(0.003)	(0.006)	(0.007)	(0.005)	(0.007)
Children 5 and under	-0.031	-0.109	-0.060	-0.216	-0.137	0.024
	(0.138)	(0.122)	(0.195)	(0.497)	(0.129)	(0.284)
Respondent's age at 1st	0.171*	0.052	0.044	-0.182	0.069	-0.007
birth	(0.047)	(0.043)	(0.088)	(0.112)	(0.060)	(0.112)
BMI	0.145*	0.054	0.121	0.059	-0.106	0.016
	(0.039)	(0.036)	(0.065)	(0.140)	(0.084)	(0.101)
Employment	-0.144	-0.046	-0.020	0.206	-0.099	-0.492*
	(0.085)	(0.088)	(0.231)	(0.190)	(0.330)	(0.213)
Household Standard of Living						
(reference low)						
Medium	-0.171	0.120	-0.159	1.588	0.934*	0.568
	(0.370)	(0.286)	(0.876)	(0.875)	(0.459)	(0.964)
High	0.292	0.108	-0.353	0.606	1.189	1.387
	(0.448)	(0.413)	(0.900)	(1.407)	(0.632)	(1.072)
Ethicity						
(reference no caste)						
Scheduled caste	0.269	-0.725	-0.550	-1.651	-0.274	-1.005
	(0.442)	(0.384)	(0.645)	(1.166)	(0.478)	(1.217)
Scheduled tribe	-0.119	-2.002	0.864	0.376	0.097	0.222
	(0.495)	(1.184)	(0.989)	(0.727)	(0.610)	(1.104)
Other backward caste	0.458	0.104	0.051	-1.907	-0.120	0.539
	(0.309)	(0.304)	(0.573)	(1.513)	(0.420)	(0.669)
Education Level						
(reference no education)						
Primary	0.288	0.339	1.083	-1.435	0.156	-0.349
	(0.425)	(0.370)	(0.870)	(0.904)	(0.498)	(0.849)
Secondary	-0.224	0.069	1.028	-0.718	-0.117	-0.420
	(0.413)	(0.327)	(0.883)	(0.911)	(0.473)	(0.949)
Higher	-1.123*	0.534	0.810	-1.402	0.331	-0.023
	(0.489)	(0.451)	(1.032)	(1.305)	(0.713)	(1.182)

* $P < 0.05$ is considered significant, model 3c: adjusted R square of 0.136, model 4c: adjusted R square of 0.082, model 5c: adjusted R square of -0.024, model 6c: adjusted R square of 0.085, model 7c: adjusted R square of 0.010, model 8c: adjusted R square of 0.020

Table 7
Multiple linear regression analysis determining the association between WHZ among wasted children and respondent's current age in six regions of India

	West	South	North	Northeast	East	Central
Model	*3d*	*4d*	*5d*	*6d*	*7d*	*8d*
	dependent variable underweight weight for height					
Constant	-2.422	-2.528	-2.198	-2.375	-2.407	-1.905
	(0.267)	(0.232)	(0.518)	(0.827)	(0.442)	(0.456)
Respondent's age	-0.006	-0.006	-0.008	0.013	0.006	-0.016
	(0.009)	(0.007)	(0.017)	(0.015)	(0.013)	(0.020)
BMI	-0.004	0.009	-0.007	-0.039	-0.014	-0.002
	(0.011)	(0.010)	(0.021)	(0.040)	(0.025)	(0.029)
Household Standard of Living						
(reference low)						
Medium	0.099	-0.023	-0.007	-0.026	0.120	-0.072
	(0.101)	(0.074)	(0.307)	(0.250)	(0.124)	(0.282)
High	0.209	0.020	-0.053	0.466	0.327	-0.286
	(0.122)	(0.106)	(0.299)	(0.388)	(0.182)	(0.316)
Education Level						
(reference no education)						
Primary	0.115	-0.122	0.072	0.168	-0.240	-0.183
	(0.118)	(0.100)	(0.254)	(0.263)	(0.144)	(0.274)
Secondary	0.106	0.051	0.077	0.162	-0.123	-0.165
	(0.114)	(0.087)	(0.236)	(0.253)	(0.136)	(0.260)
Higher	-0.071	-0.115	-0.242	0.297	-0.259	0.049
	(0.132)	(0.115)	(0.268)	(0.357)	(0.206)	(0.302)

* $P < 0.05$ is considered significant, model 3d: adjusted R square of -0.002, model 4d: adjusted R square of 0.009, model 5d: adjusted R square of -0.019, model 6d: adjusted R square of -0.036, model 7d: adjusted R square of -0.010, model 8d: adjusted R square of -0.036

Table 8
Multiple regression analysis determining the association between HAZ of overweight children and respondent's age at first birth and type of resident in six regions of India

	West	**South**	**North**	**Northeast**	**East**	**Central**
Model	*3e*	*4e*	*5e*	*6e*	*7e*	*8e*
		dependent variable overweight height for age				
Constant	5.984	-9.862	7.610	-7.205	-3.977	-12.932
	(0.000)	(3.630)	(6.945)	(2.938)	(0.000)	(0.000)
Respondent's age	-0.572	-0.160	-0.173	0.010	0.662	
	(0.000)	(0.075)	(0.177)	(0.057)	(0.000)	
Residence	-2.098	1.317*	-1.357	0.116	1.543	
	(0.000)	(0.604)	(1.433)	(0.600)	(0.000)	
Years lived in residence	0.002	-0.001	0.013	-0.013	0.015	
	(0.000)	(0.007)	(0.031)	(0.008)	(0.000)	
Children 5 and under	-3.289	-0.111	-0.043	-0.116	1.112	
	(0.000)	(0.337)	(0.788)	(0.368)	(0.000)	
Respondent's age at 1st		0.399*	-0.153	-0.014	-0.399	
birth		(0.146)	(0.214)	(0.099)	(0.000)	
BMI	0.789	0.121	0.011	0.246	-0.487	0.553
	(0.000)	(0.107)	(0.086)	(0.125)	(0.000)	(0.000)
Employment	-0.116	0.287	0.007	-0.162		
	(0.000)	(0.239)	(0.438)	(0.206)		
Household Standard of Living						
(reference low)						
Medium	0.497	0.455		0.857		
	(0.000)	(1.009)		(0.766)		
High		-0.038	-0.281	-0.468	-0.374	
		(0.990)	(1.658)	(1.100)	(0.000)	
Ethnicity						
(reference no caste)						
Scheduled caste	-0.371	1.937	-2.087	0.359		
	(0.000)	(2.032)	(1.620)	(1.490)		
Scheduled tribe	-0.937			0.225	-0.084	
	(0.000)			(0.587)	(0.000)	
Other backward caste	0.449	-0.268	0.817		0.063	
	(0.000)	(0.594)	(2.459)		(0.000)	
Education Level						
(reference no education)						
Primary	-1.153	0.481	0.651	0.682		
	(0.000)	(2.043)	(2.200)	(0.944)		
Secondary	-7.138	-1.024	0.749	0.481		0.168
	(0.000)	(2.009)	(1.521)	(1.021)		(0.000)
Higher	-1.888	-1.767	-0.397	0.272	2.428	
	(0.000)	(2.333)	(1.865)	(1.866)	(0.000)	

* $P < 0.05$ is considered significant, model 4e: adjusted R square of 0.167, model 5e: adjusted R square of -0.525, model 6e: adjusted R square of 0.395

Tables 1-7 in Appendix A represent the descriptive variables for the country of India, followed by each of the regions (West, South, North, Northeast, East, and Central). Tables 1-15 in Appendix B represent the comparisons of each of the variables between regions. Significant differences are observed with a p-value < 0.05 between the two means of the selected regions.

The current age of the respondent was inversely associated with WHZ, while body mass index of the respondent and household standard of living were positively associated with WHZ. Region of respondent was also positively associated with WHZ when added to the model (1b). Finally, state GDP per capita was also positively associated with weight for height in the final model (1c).

There is an inverse relationship between HAZ and the current age of the respondent, number of children five and under, and current type of employment and a positive relationship between HAZ and years lived in place of residence, highest educational level, age of respondent at first birth, body mass index of respondent, and household standard of living (Model 2a). The addition of Region (model 2b) or state GDP per capita (Model 2c) suggests that neither variable was significantly associated with HAZ.

Table 4 shows that among stunted children, type of place of residence, secondary education, and higher education are positively associated with child HAZ in the West region (Model 3a). BMI shows to be positively associated with child HAZ in the South region (Model 4a). Lastly, current type of employment is negatively associated and being a part of a scheduled tribe is positively associated with child HAZ in the East region (Model 7a).

Table 5 shows that in predicting WHZ among stunted children, current age of the respondent is negatively associated. BMI of the respondent is positively associated in the West, South, North, and East regions (Models 3b, 4b, 5b, and 7b). Medium and high standard of living are positively associated in the Northeast and East regions (Models 6b and 7b).

Table 6 presents the prediction of HAZ among wasted children. In the West region, current age of the respondent and higher educational level are negatively associated while age of the respondent at first birth and BMI of the respondent are positively associated (Model 3c). Years lived in the place of resident is positively associated in the South (Model 4c). Medium standard of living is positively associated in the East region (Model 7c). In the Central, current type of employment is negatively associated (Model 8c).

Table 7 shows that in predicting WHZ among wasted children, the only significant predictor is the age of the respondent in the South region with a negative association (Model 4d). Table 8, presenting the prediction of HAZ among overweight children, shows that the type of place of residence and age of the respondent at first birth are positively associated in the South region (Model 4e). Lastly, there are no significant predictors for WHZ among overweight children in any of the regions (Table 9).

DISCUSSION

It is clear from the literature that social and environmental factors contribute to the nutritional status of an individual (Subramanian et al 2007)(Fall 2009) (Khan and Kraemer 2009). A direct association between individual as well as child BMI and standard of living has been established (Subramanian et al 2007) (Midha et al 2011). Developing countries such as India and Bangladesh are facing the worldwide phenomenon of urbanization (Khan and Kraemer 2009). Observations of factors correlated to individual BMI in Bangladesh are similar to the patterns observed in other developing countries, such as India; BMI is dependent on age, education, occupation, household economic status, food habits, and sedentary lifestyles (Khan and Kraemer 2009).

The results presented in this thesis are consistent with current research. Household standard of living and respondent's BMI are associated with child's WHZ within the country of India. It is apparent that as household standard of living increases, there is an associated increase in the WHZ of the child. Furthermore, when adding a regional and state variable to the model, there was a significant association with child WHZ. It is apparent that child's WHZ differs by region and even by individual state; further investigation by subdividing regions proved as such. Even though there were no significant associations between regions and state to child's HAZ, the relationships between HAZ and education level, standard of living, and BMI of the respondent are positively associated. In addition, for the country as a whole, HAZ shows to also be affected by type of place of residence as well as ethnicity.

Research shows that even in urban poor and rural women, those who attained higher education were at a higher risk of overweight than those with no education (Subramanian et al 2009). Similarly, of those who were underweight, those with a higher level of education were less likely to be underweight, 40.7% versus 8.6% with greater than 15 years of education (Subramanian et al 2009). Of the groups that were overweight and obese, 6.2% and 1.5% had no education and 31.5% and 9.0% had greater than 15 years of education (Subramanian et al 2009). A similar relationship can also be observed from our data analysis, that in the West region, the wealthiest region, the improvement of HAZ among stunted children shows to be more significantly associated with a higher level of education than just secondary education or lower. This demonstrates the positive relationship between BMI and nutritional status within the region and more challenges to overcome for the less fortunate.

From the analysis of our regression models, which were separated by weight group among the various regions, there is a consistent observation where increased standard of living, education, and BMI of respondent are positively associated with child HAZ and WHZ among stunted and wasted children. In the wealthier states however, other factors also come into play. Such factors include the age of the respondent, type of place of residence, and years lived in place of residence. For overweight children in the South, the second wealthiest region, HAZ is associated with type of place of residence. An explanation for this could be that among those who are highly educated and wealthier, a group where there is a higher prevalence of overnutrition, other factors may start to influence nutritional status. The type of place of residence is also associated to HAZ among stunted children in the West and years lived in the place of residence is positively associated with HAZ among wasted children in the South. The age of respondent is negatively associated in the West with both WHZ among stunted children and HAZ among wasted children.

In the less wealthier states, however, current type of emloyment and ethnicity become significant predictors of child nutritional status. In the East region, current type of employment and being a part of a scheduled tribe are associated with HAZ among stunted children. Current type of employment is also associated with HAZ among wasted children in the Central region. A possible explanation for this may be in less wealthier states, where there may be more lower standard living and less of a transition to medium and higher, social caste system and occupation influence child nutritional status.

In many developing countries, obesity tends to be a condition of high socioeconomic status (Khan and Kraemer 2009). Certain factors that are tied to urban living and higher socioeconomic status contribute to this relationship. Jeemon et al (2009) identify significant predictors of overweight to be the level of urbanization, physical activity, and frequency of meals outside the home. Reflecting on the relationship between BMI and education level, there was a higher prevalence of overweight and obesity among those individuals who read newspapers/magazines daily; those who did not were more likely to be underweight (Khan and Kraemer 2009). A reason for this can be tied to occupation. In terms of occupation, Khan and Kraemer (2009) observed that underweight was highest for unskilled laborers and obesity was highest for those in sales; women were less likely to be underweight and more likely to be overweight in positions of higher rank. Our models show that within the Central region of lowest wealth, the association between occupation and HAZ among wasted children shows that as one goes from being paid to unpaid, HAZ decreases.

Even though India, like many other developing countries, is growing economically, there is a slow increase in overweight with minimal to no decrease in underweight; this parallels the unequal economic growth (Subramanian et al 2007). Explanations for this occurrence can be attributed to income inequality and rural to urban migration (Subramanian et al 2007)(Khan and Kraemer 2009). Subramanian et al (2006) observed that the double burden was more prevalent in areas with a higher level of income inequality. An expected trickle down mechanism in the wealthier states was minimally observed; even though overnutrition was more prevalent in the richer states, the risk of underweight was not less in economically flourishing states than in those experiencing lower levels of economic growth (Subramanian et al 2007). Our data support the established positive association between household standard of living and nutritional status. Among stunted children in the Northeast and East regions, standard of living is positively associated with child WHZ. Furthermore, for women in richer states, the risk of underweight in the lowest quintile was higher (Subramanian et al 2007). Khan and Kraemer (2009) also observed within Bangladesh that those who migrated from rural to urban areas were at more risk of being underweight. On the other hand there was a higher prevalence of overweight and obesity for those who were non-migrants (Khan and Kraemer 2009). The reason for this relationship lies in the association between rural-urban migration and stress and anxiety; there is less social support, lack of education, and occupational experience for those transitioning from rural to urban locations (Khan and Kraemer 2009). This may again explain why our analysis showed a significant association between type of place of residence and HAZ among both stunted and overweight children in the West. Our data also demonstrate that the prevalence of undernutrition and overnutrition tend to be higher in the wealthier regions, and the difference between the two are bigger as well in the wealthier regions.

As presented in our data analysis and consistent with published research, region, education level, and standard of living are significantly associated to BMI. With these elements are tied other social and environmental factors that also affect the outcome of the relationship. Such factors include age of respondent, type of residence, ethnicity, and occupation. This divide in extreme BMI of underweight and overweight present health concerns and need to be addressed. Programming will need to take into consideration the messages being sent to the public, since there is a high prevalence of both undernutrition and overnutrition in close proximity.

Limitations:

Even though there was a large sample size for data analysis, a limitation might be that the sample size representative for the country as a whole was small. Due to a lower percentage of data collected of overweight individuals, there may not have been an even sampling of the different weight groups. Therefore, overweight and its associated factors may have a lower contribution towards relationships observed and thereby bias certain associations concluded. Additionally, this being a cross-sectional study, causation can not be inferred. Lastly, R squared values present a low percent of variability in predicting HAZ and WHZ among the varying weight groups in each region. Therefore, other contributors to WHZ and HAZ are present but have not been measured. One such factor would be energy intake, and another may be infliction of a disease state. Collecting more information may get us closer to those variables influencing child nutritional status.

References

Abate, N., & Chandalia, M. (2007). Ethnicity, type 2 diabetes & migrant asian indians. *Indian Journal of Medical Research, 125*(3), 251-258.

Adams, K. F., & Subramanian, S. V. (2008). Commentary: Is the concern regarding overweight/obesity in india overstated? *International Journal of Epidemiology, 37*(5), 1005-1007.

Agarwal, R. K. (2008). Childhood obesity: Emerging challenge. *Indian Pediatrics, 45*(6), 443-444.

Antony, G. M., & Laxmaiah, A. (2008). Human development, poverty, health & nutrition situation in india. *Indian Journal of Medical Research, 128*(2), 198-205.

Arnold, F., Parasuraman, S., Arokiasamy, P., and Kothari, M. (2009). Nutrition in India. National Family Health Survey (NFHS-3), India, 2005-06. Mumbai: International Institute for Population Sciences; Calverton, Maryland, USA: ICF Macro.

Bailey, K. V., & Ferro-Luzzi, A. (1995). Use of body mass index of adults in assessing individual and community nutritional status. *Bulletin of the World Health Organization, 73*(5), 673-680.

Banerjee, I., & Mukherjee, D. (2006). Onset of obesity is late in affluent bengali boys. *Indian Pediatrics, 43*(8), 743-743.

Bhandari, L., & Zaidi, L. (2004). Reviewing the costs of malnutrition in india. *Indicus Analytics,* 1-77.

Bhave, S., Bavdekar, A., & Otiv, M. (2004). IAP national task force for childhood prevention of adult diseases: Childhood obesity. *Indian Pediatrics, 41*(6), 559-575.

Center for Disease Control and Prevention. (2011). *Healthy weight: it's not a diet, it's a lifestyle!* Retrieved from http://www.cdc.gov/healthyweight/assessing/bmi/adult_bmi/index.html#Interpreted.

Center for Disease Control and Prevention. (2011). *Healthy weight: it's not a diet, it's a lifestyle!* Retrieved from http://www.cdc.gov/healthyweight/assessing/bmi/childrens_bmi/about_childrens_bmi.html#What%20is%20BMI%20percentile.

Center for Disease Control and Prevention. (2010). *Growth Charts.* Retrieved from http://www.cdc.gov/growthcharts/who_charts.htm.

Chandalia, M., Lin, P., Seenivasan, T., Livingston, E. H., Snell, P. G., Grundy, S. M., et al. (2007). Insulin resistance and body fat distribution in south asian men compared to caucasian men. *PLoS ONE, 2*(8), e812-doi:10.1371/journal.pone.0000812.

Fall, C. (2009). Maternal nutrition: Effects on health in the next generation. *The Indian Journal of Medical Research, 130*(5), 593-599.

Griffiths, P. L., & Bentley, M. E. (2001). The nutrition transition is underway in india. *The Journal of Nutrition, 131*(10), 2692-2700.

Hariram, V., & Talwar, K. (2005). Healthy weight, healthy shape. *Indian Journal of Medical Research, 122*(3), 187-190.

International Institute for Population Sciences (IIPS) and ORC Macro. (2000). *National Family Health Survey (NFHS-2), 1998–99: India*. Mumbai: IIPS.

International Institute for Population Sciences (IIPS) and ORC Macro. (2007). *National Family Health Survey (NFHS-3), 2005-06: India*. Mumbai: IIPS.

Jeemon, P., Prabhakaran, D., Mohan, V., Thankappan, K. R., Joshi, P. P., Ahmed, F., et al. (2009). Double burden of underweight and overweight among children (10-19 years of age) of employees working in indian industrial units. *The National Medical Journal of India, 22*(4), 172-176.

Khan, M. M., & Kraemer, A. (2009). Factors associated with being underweight, overweight and obese among ever-married non-pregnant urban women in bangladesh. *Singapore Medical Journal, 50*(8), 804-813.

Khongsdier, R. (2002). Body mass index and morbidity in adult males of the war khasi in northeast india. *European Journal of Clinical Nutrition, 56*(6), 484-489.

Lin, E. H. B., Rutter, C. M., Katon, W., Heckbert, S. R., Ciechanowski, P., Oliver, M. M., et al. (2010). Depression and advanced complications of diabetes. *Diabetes Care, 33*(2), 264-269.

Lobstein, T., Baur, L., Uauy, R., & IASO International Obesity TaskForce. (2004). Obesity in children and young people: A crisis in public health. *Obesity Reviews : An Official Journal of the International Association for the Study of Obesity, 5 Suppl 1*, 4-104.

Midha, T., Nath, B., Kumari, R., Rao, Y. K., & Pandey, U. (2011). Childhood obesity in india: A meta-analysis. *Indian Journal of Pediatrics,* Misra, A., & Khurana, L. (2008). Obesity and the metabolic syndrome in developing countries. *Journal of Clinical Endocrinology & Metabolism, 93*(11 Supplement 1), s9-s30.

Mohan, V., & Deepa, R. (2006). Obesity and abdominal obesity in asian indians. *Indian Journal of Medical Research, 123*(5), 593-596.

Muller, O., & Krawinkel, M. (2005). Malnutrition and health in developing countries. *Canadian Medical Association Journal, 173*(3), 279-286.

National Center for Biotechnology Information (NCBI), U.S. National Library of Medicine. (2012). *Kwashiorkor.* Retrieved from http://www.ncbi.nlm.nih.gov/pubmedhealth/PMH0002571/.

Pednekar, M. S., Hakama, M., Hebert, J. R., & Gupta, P. C. (2008). Association of body mass index with all-cause and cause-specific mortality: Findings from a prospective cohort study in mumbai (bombay), india. *International Journal of Epidemiology, 37*(3), 524-535.

Pelletier, D. L., Frongillo, E. A.,Jr, & Habicht, J. P. (1993). Epidemiologic evidence for a potentiating effect of malnutrition on child mortality. *American Journal of Public Health, 83*(8), 1130-1133.

PricewaterhouseCoppers. (2007). *Healthcare in India: Emerging Market Report 2007.* Retrieved from http://www.pwc.com/en_GX/gx/healthcare/pdf/emerging-market-report-hc-in-india.pdf.

Radha, V., & Mohan, V. (2007). Genetic predisposition to type 2 diabetes among asian indians. *The Indian Journal of Medical Research, 125*(3), 259-274.

Retnakaran, R., Hanley, A. J., Connelly, P. W., Sermer, M., & Zinman, B. (2006). Ethnicity modifies the effect of obesity on insulin resistance in pregnancy: A comparison of asian, south asian, and caucasian women. *The Journal of Clinical Endocrinology and Metabolism, 91*(1), 93-97.

Retnakaran, R., Hanley, A. J. G., Connelly, P. W., Sermer, M., & Zinman, B. (2006). Ethnicity modifies the effect of obesity on insulin resistance in pregnancy: A comparison of asian, south asian, and caucasian women. *Journal of Clinical Endocrinology & Metabolism, 91*(1), 93-97.

Sauvaget, C., Ramadas, K., Thomas, G., Vinoda, J., Thara, S., & Sankaranarayanan, R. (2008). Body mass index, weight change and mortality risk in a prospective study in india. *International Journal of Epidemiology, 37*(5), 990-1004.

Scrimshaw, N., & SanGiovanni, J. (1997). Synergism of nutrition, infection, and immunity: An overview. *The American Journal of Clinical Nutrition, 66*(2), 464S-477S.

Shukla, H. C., Gupta, P. C., Mehta, H. C., & Hebert, J. R. (2002). Descriptive epidemiology of body mass index of an urban adult population in western india. *Journal of Epidemiology and Community Health, 56*(11), 876-880.

Subramanian, S. V., & Smith, G. D. (2006). Patterns, distribution, and determinants of under- and overnutrition: A population-based study of women in india. *The American Journal of Clinical Nutrition, 84*(3), 633-640.

Subramanian, S. V., Kawachi, I., & Smith, G. D. (2007). Income inequality and the double burden of under- and overnutrition in india. *Journal of Epidemiology and Community Health, 61*(9), 802-809.

Subramanian, S. V., Perkins, J. M., & Khan, K. T. (2009). Do burdens of underweight and overweight coexist among lower socioeconomic groups in india? *The American Journal of Clinical Nutrition, 90*(2), 369-376.

Subramanyam, M. A., Kawachi, I., Berkman, L. F., & Subramanian, S. V. (2010). Socioeconomic inequalities in childhood undernutrition in india: Analyzing trends between 1992 and 2005. *PloS One, 5*(6), e11392.

Surkan, P.J., Kennedy, C.E., Hurley, K.M., Black, M.M. (2011). Maternal depression and early childhood growth in developing countries: systematic review and meta-analysis. *Bulletin of the World Health Organization, 89*(8), 545-560.

The World Bank. (n.d). *India: Overview of Childhood Undernutrition.* Retrieved from http://siteresources.worldbank.org/SOUTHASIAEXT/Resources/223546-1171488994713/3455847-1232124140958/5748939-1234285802791/IndiaNutrition.pdf.

Appendix A

Table 1
Descriptive Statistics for India

Variable	N	Mean ± SD or %	Range
Respondent's age	4618	25.028 ± 4.715	15.000 - 45.000
Years lived in residence	4615	28.756 ± 39.728	0.000 - 96.000
Household members	4618	7.094 ± 3.510	2.000 - 38.000
Children 5 and under	4618	1.642 ± 1.029	0.000 - 9.000
Respondent's age at 1st birth	4618	21.163 ± 3.811	12.000 - 41.000
Living children	4618	1.925 ± 1.139	1.000 - 9.000
BMI	4618	20.643 ± 3.564	13.344 - 40.598
Child's age	4618	0.513 ± 0.563	0.000 - 2.000
Birth weight of child (kg)	4618	2.806 ± 0.627	0.500 - 4.500
Weight of child (kg)	4618	7.812 ± 2.107	2.200 - 16.300
Height of child (cm)	4618	70.162 ± 8.553	49.000 - 94.200
HAZ	4618	-0.983 ± 1.322	-4.000 - 3.930
WAZ	4618	-1.161 ± 1.178	-3.990 - 3.770
WHZ	4618	-0.688 ± 1.209	-3.950 - 3.840
Residence	4618		
Urban	2365	51.2	
Rural	2253	48.8	
Previous residence	3406		
City	1347	39.5	
Countryside	2059	60.5	
Education level	4618		
No education	712	15.4	
Primary	747	16.2	
Secondary	2014	43.6	
Higher	1145	24.8	
Highest year of education	3905		
0	14	0.4	
1	306	7.8	
2	810	20.7	
3	557	14.3	
4	651	16.7	
5	1423	36.4	
6	30	0.8	
7	96	2.5	

8	14	0.4
9	2	0.1
12	2	0.1
Religion	4614	
Hindu	3323	72.0
Muslim	558	12.1
Christian	487	10.6
Sikh	112	2.4
Buddhist/Neo Buddhist	61	1.3
Jain	24	0.5
Jewish	1	0.0
No religion	4	0.1
10	20	0.4
11	15	0.3
Other	9	0.2
Ethnicity	4612	
Scheduled caste	598	13.0
Scheduled tribe	489	10.6
Other backward caste	1399	30.3
None of them	2126	46.1
Educational attainment	4618	
No education	712	15.4
Incomplete primary	414	9.0
Complete primary	333	7.2
Incomplete secondary	1305	28.3
Complete secondary	709	15.4
Higher	1145	24.8
Current marital status	4618	
Married	4560	98.7
Widowed	13	0.3
Divorced	4	0.1
Not living together	41	0.9
Employment	4616	
Did not work	3637	78.8
Paid employee, away	447	9.7
Paid employee, home	102	2.2
Self-employed, away	68	1.5
Self-employed, home	126	2.7
Unpaid worker, away	176	3.8
Unpaid worker, home	60	1.3

Sex of child	4618	
Male	2470	53.5
Female	2148	46.5
Household standard of living	4546	
Low	653	14.4
Medium	2189	48.2
High	1704	37.5

Table 2
Descriptive Statistics for the West Region

Variable	N	Mean ± SD or %	Range
Respondent's age	1000	25.161 ± 4.714	15.000 - 43.000
Years lived in residence	1000	26.269 ±38.417	0.000 - 96.000
Household members	1000	7.258 ± 3.597	3.000 - 24.000
Children 5 and under	1000	1.658 ± 1.077	0.000 - 6.000
Respondent's age at 1st birth	1000	21.174 ± 4.042	12.000 - 41.000
Living children	1000	2.008 ± 1.210	1.000 - 9.000
BMI	1000	20.400 ± 3.639	13.619 - 38.636
Child's age	1000	0.494 ± 0.544	0.000 - 2.000
Birth weight of child (kg)	1000	2.782 ± 0.637	0.700 - 4.500
Weight of child (kg)	1000	7.665 ± 2.076	2.200 - 14.800
Height of child (cm)	1000	70.052 ± 8.448	49.000 - 91.700
HAZ	1000	-1.035 ± 1.306	-3.960 - 3.610
WAZ	1000	-1.323 ± 1.119	-3.950 - 3.550
WHZ	1000	-0.853 ± 1.108	-3.950 - 3.470
Residence	1000		
Urban	643	64.3	
Rural	357	35.7	
Previous residence	767		
City	334	43.5	
Countryside	433	56.5	
Education level	1000		
No education	145	14.5	
Primary	166	16.6	
Secondary	448	44.8	
Higher	241	24.1	
Highest year of education	855		
0	4	0.5	
1	67	7.8	
2	219	25.6	
3	111	13.0	
4	152	17.8	
5	277	32.4	
6	6	0.7	
7	13	1.5	
8	6	0.7	
Religion	1000		

Hindu	704	70.4
Muslim	179	17.9
Christian	65	6.5
Sikh	3	0.3
Buddhist/Neo Buddhist	36	3.6
Jain	13	1.3
Ethnicity	999	
Scheduled caste	123	12.3
Scheduled tribe	56	5.6
Other backward caste	196	19.6
None of them	624	62.5
Educational attainment	1000	
No education	145	14.5
Incomplete primary	100	10.0
Complete primary	66	6.6
Incomplete secondary	308	30.8
Complete secondary	140	14.0
Higher	241	24.1
Current marital status	1000	
Married	995	99.5
Widowed	1	0.1
Not living together	4	0.4
Employment	1000	
Did not work	775	77.5
Paid employee, away	99	9.9
Paid employee, home	21	2.1
Self-employed, away	5	0.5
Self-employed, home	29	2.9
Unpaid worker, away	52	5.2
Unpaid worker, home	19	1.9
Sex of child	1000	
Male	534	53.4
Female	466	46.6
Household standard of living	963	
Low	108	11.2
Medium	478	49.6
High	377	39.1

Table 3
Descriptive Statistics for the South Region

Variable	N	Mean ± SD or %	Range
Respondent's age	1418	24.337 ± 4.460	15.000 - 45.000
Years lived in residence	1418	37.432 ± 43.309	0.000 - 96.000
Household members	1418	6.719 ± 3.229	2.000 - 26.000
Children 5 and under	1418	1.559 ± 1.004	0.000 - 7.000
Respondent's age at 1st birth	1418	20.841 ± 3.619	13.000 - 38.000
Living children	1418	1.812 ± 0.990	1.000 - 9.000
BMI	1418	20.694 ± 3.585	13.344 - 40.204
Child's age	1418	0.525 ± 0.563	0.000 - 2.000
Birth weight of child (kg)	1418	2.842 ± 0.556	0.750 - 4.500
Weight of child (kg)	1418	7.770 ± 2.062	2.600 - 15.800
Height of child (cm)	1418	70.395 ± 8.537	49.000 - 94.200
HAZ	1418	-0.922 ± 1.318	-3.970 - 3.490
WAZ	1418	-1.214 ± 1.134	-3.920 - 3.770
WHZ	1418	-0.810 ± 1.178	-3.950 - 3.820
Residence	1418		
Urban	595	42.0	
Rural	823	58.0	
Previous residence	907		
City	278	30.7	
Countryside	629	69.3	
Education level	1418		
No education	208	14.7	
Primary	227	16.0	
Secondary	665	46.9	
Higher	318	22.4	
Highest year of education	1210		
0	1	0.1	
1	105	8.7	
2	244	20.2	
3	166	13.7	
4	215	17.8	
5	445	36.8	
6	10	0.8	
7	20	1.7	
8	2	0.2	
12	2	0.2	

Religion	1418	
Hindu	1072	75.6
Muslim	235	16.6
Christian	111	7.8
Ethnicity	1416	
Scheduled caste	197	13.9
Scheduled tribe	21	1.5
Other backward caste	809	57.1
None of them	389	27.5
Educational attainment	1418	
No education	208	14.7
Incomplete primary	117	8.3
Complete primary	110	7.8
Incomplete secondary	420	29.6
Complete secondary	245	17.3
Higher	318	22.4
Current marital status	1418	
Married	1405	99.1
Widowed	5	0.4
Not living together	8	0.6
Employment	1416	
Did not work	1101	77.8
Paid employee, away	173	12.2
Paid employee, home	40	2.8
Self-employed, away	9	0.6
Self-employed, home	32	2.3
Unpaid worker, away	42	3.0
Unpaid worker, home	19	1.3
Sex of child	1418	
Male	733	51.7
Female	685	48.3
Household standard of living	1412	
Low	287	20.3
Medium	742	52.5
High	383	27.1

Table 4
Descriptive Statistics for the North Region

Variable	N	Mean ± SD or %	Range
Respondent's age	783	25.608 ± 4.276	16.000 - 41.000
Years lived in residence	783	19.548 ± 33.405	0.000 - 96.000
Household members	783	7.286 ± 3.214	3.000 - 23.000
Children 5 and under	783	1.645 ± 0.984	0.000 - 8.000
Respondent's age at 1st birth	783	21.766 ± 3.410	14.000 - 38.000
Living children	783	1.912 ± 1.075	1.000 - 8.000
BMI	783	21.600 ± 4.168	14.073 - 40.598
Child's age	783	0.521 ± 0.571	0.000 - 2.000
Birth weight of child (kg)	783	2.698 ± 0.634	0.600 - 4.500
Weight of child (kg)	783	7.947 ± 2.188	2.600 - 16.300
Height of child (cm)	783	69.898 ± 8.788	49.000 - 91.100
HAZ	783	-1.035 ± 1.292	-3.980 - 3.060
WAZ	783	-1.006 ± 1.171	-3.740 - 3.080
WHZ	783	-0.428 ± 1.242	-3.950 - 3.840
Residence	783		
Urban	437	55.8	
Rural	346	44.2	
Previous residence	657		
City	294	44.7	
Countryside	363	55.3	
Education level	783		
No education	98	12.5	
Primary	91	11.6	
Secondary	324	41.4	
Higher	270	34.5	
Highest year of education	684		
1	36	5.3	
2	102	14.9	
3	97	14.2	
4	72	10.5	
5	327	47.8	
6	11	1.6	
7	33	4.8	
8	5	0.7	
9	1	0.1	
Religion	782		

Hindu	614	78.5
Muslim	48	6.1
Christian	6	0.8
Sikh	106	13.6
Buddhist/Neo Buddhist	3	0.4
Jain	4	0.5
Other	1	0.1
Ethnicity	782	
Scheduled caste	111	14.2
Scheduled tribe	12	1.5
Other backward caste	139	17.8
None of them	520	66.5
Educational attainment	783	
No education	98	12.5
Incomplete primary	30	3.8
Complete primary	61	7.8
Incomplete secondary	159	20.3
Complete secondary	165	21.1
Higher	270	34.5
Current marital status	783	
Married	775	99.0
Widowed	5	0.6
Not living together	3	0.4
Employment	783	
Did not work	670	85.6
Paid employee, away	59	7.5
Paid employee, home	11	1.4
Self-employed, away	8	1.0
Self-employed, home	10	1.3
Unpaid worker, away	25	3.2
Unpaid worker, home	670	85.6
Sex of child	783	
Male	439	56.1
Female	344	43.9
Household standard of living	774	
Low	29	3.7
Medium	226	29.2
High	519	67.1

Table 5
Descriptive Statistics for the Northeast Region

Variable	N	Mean ± SD or %	Range
Respondent's age	588	26.395 ± 5.513	15.000 - 44.000
Years lived in residence	586	32.481 ± 41.247	0.000 - 96.000
Household members	588	6.560 ± 3.013	2.000 - 22.000
Children 5 and under	588	1.752 ± 0.860	0.000 - 5.000
Respondent's age at 1st birth	588	21.731 ± 4.248	13.000 - 39.000
Living children	588	2.218 ± 1.433	1.000 - 9.000
BMI	588	20.676 ± 2.634	14.160 - 31.907
Child's age	588	0.537 ± 0.593	0.000 - 2.000
Birth weight of child (kg)	588	3.033 ± 0.634	0.500 - 4.500
Weight of child (kg)	588	8.224 ± 2.132	2.900 - 14.200
Height of child (cm)	588	70.715 ± 8.733	49.100 - 91.800
HAZ	588	-0.882 ± 1.386	-4.000 - 3.810
WAZ	588	-0.789 ± 1.255	-3.800 - 3.770
WHZ	588	-0.306 ± 1.291	-3.920 - 3.780
Residence	588		
Urban	258	43.9	
Rural	330	56.1	
Previous residence	408		
City	151	37.0	
Countryside	257	63.0	
Education level	588		
No education	78	13.3	
Primary	123	20.9	
Secondary	282	48.0	
Higher	105	17.9	
Highest year of education	510		
0	2	0.4	
1	44	8.6	
2	106	20.8	
3	76	14.9	
4	128	25.1	
5	141	27.6	
6	2	0.4	
7	10	2.0	
8	1	0.2	
9	2	0.4	

Religion	587	
Hindu	213	36.3
Muslim	15	2.6
Christian	296	50.4
Buddhist/Neo Buddhist	20	3.4
Jain	1	0.2
No religion	4	0.7
10	20	3.4
11	15	2.6
Other	3	0.5
Ethnicity	588	
Scheduled caste	41	7.0
Scheduled tribe	346	58.8
Other backward caste	39	6.6
None of them	162	27.6
Educational attainment	588	
No education	78	13.3
Incomplete primary	87	14.8
Complete primary	36	6.1
Incomplete secondary	209	35.5
Complete secondary	73	12.4
Higher	105	17.9
Current marital status	588	
Married	566	96.3
Widowed	2	0.3
Divorced	4	0.7
Not living together	16	2.7
Employment	588	
Did not work	384	65.3
Paid employee, away	79	13.4
Paid employee, home	16	2.7
Self-employed, away	22	3.7
Self-employed, home	38	6.5
Unpaid worker, away	35	6.0
Unpaid worker, home	14	2.4
Sex of child	588	
Male	299	50.9
Female	289	49.1
Household standard of living	577	
Low	73	12.7

Medium	373	64.6
High	131	22.7

Table 6
Descriptive Statistics for the East Region

Variable	N	Mean ± SD or %	Range
Respondent's age	550	24.464 ± 4.421	15.000 - 37.000
Years lived in residence	549	20.641 ± 34.330	0.000 - 96.000
Household members	550	7.278 ± 3.842	3.000 - 33.000
Children 5 and under	550	1.593 ± 1.155	0.000 - 9.000
Respondent's age at 1st birth	550	20.787 ± 3.694	13.000 - 32.000
Living children	550	1.744 ± 0.968	1.000 - 6.000
BMI	550	19.817 ± 3.022	13.790 - 34.153
Child's age	550	0.496 ± 0.556	0.000 - 2.000
Birth weight of child (kg)	550	2.751 ± 0.606	0.500 - 4.500
Weight of child (kg)	550	7.683 ± 2.033	2.900 - 14.100
Height of child (cm)	550	69.881 ± 8.192	49.500 - 88.700
HAZ	550	-1.027 ± 1.324	-3.850 - 3.930
WAZ	550	-1.257 ± 1.225	-3.990 - 3.770
WHZ	550	-0.779 ± 1.227	-3.780 - 3.540
Residence	550		
Urban	268	48.7	
Rural	282	51.3	
Previous residence	455		
City	190	41.8	
Countryside	265	58.2	
Education level	550		
No education	119	21.6	
Primary	96	17.5	
Secondary	229	41.6	
Higher	106	19.3	
Highest year of education	431		
0	6	1.4	
1	40	9.3	
2	92	21.3	
3	67	15.5	
4	68	15.8	
5	153	35.5	
7	5	1.2	
Religion	548		
Hindu	488	89.1	
Muslim	47	8.6	

Christian	7	1.3
Jewish	1	0.2
Other	5	0.9
Ethnicity	550	
Scheduled caste	105	19.1
Scheduled tribe	35	6.4
Other backward caste	107	19.5
None of them	303	55.1
Educational attainment	550	
No education	119	21.6
Incomplete primary	62	11.3
Complete primary	34	6.2
Incomplete secondary	159	28.9
Complete secondary	70	12.7
Higher	106	19.3
Current marital status	550	
Married	543	98.7
Not living together	7	1.3
Employment	550	
Did not work	493	89.6
Paid employee, away	18	3.3
Paid employee, home	7	1.3
Self-employed, away	16	2.9
Self-employed, home	9	1.6
Unpaid worker, away	4	0.7
Unpaid worker, home	3	0.5
Sex of child	550	
Male	310	56.4
Female	240	43.6
Household standard of living	544	
Low	122	22.4
Medium	267	49.1
High	155	28.5

Table 7
Descriptive Statistics for the Central Region

Variable	N	Mean ± SD or %	Range
Respondent's age	279	24.667 ± 5.058	15.000 - 44.000
Years lived in residence	279	27.566 ± 38.510	0.000 - 96.000
Household members	279	8.631 ± 4.865	3.000 - 38.000
Children 5 and under	279	1.864 ± 1.114	0.000 - 8.000
Respondent's age at 1st birth	279	20.616 ± 3.898	13.000 - 34.000
Living children	279	1.982 ± 1.233	1.000 - 8.000
BMI	279	20.128 ± 3.442	13.448 - 35.762
Child's age	279	0.487 ± 0.555	0.000 - 2.000
Birth weight of child (kg)	279	2.636 ± 0.778	0.900 - 4.500
Weight of child (kg)	279	7.564 ± 2.175	2.700 - 13.300
Height of child (cm)	279	69.492 ± 8.630	49.100 - 90.000
HAZ	279	-1.085 ± 1.328	-3.970 - 3.630
WAZ	279	-1.334 ± 1.153	-3.870 - 2.340
WHZ	279	-0.829 ± 1.113	-3.710 - 2.780
Residence	279		
Urban	164	58.8	
Rural	115	41.2	
Previous residence	212		
	100	47.2	
Countryside	112	52.8	
Education level	279		
No edducation	64	22.9	
Primary	44	15.8	
Secondary	66	23.7	
Higher	105	37.6	
Highest year of education	215		
0	1	0.5	
1	14	6.5	
2	47	21.9	
3	40	18.6	
4	16	7.4	
5	80	37.2	
6	1	0.5	
7	15	7.0	
8	1	0.5	
Religion	279		

Hindu	232	83.2
Muslim	34	12.2
Christian	2	0.7
Sikh	3	1.1
Buddhist/Neo Buddhist	2	0.7
Jain	6	2.2
Ethnicity	277	
Scheduled caste	21	7.6
Scheduled tribe	19	6.9
Other backward caste	109	39.4
None of them	128	46.2
Educational attainment	279	
No education	64	22.9
Incomplete primary	18	6.5
Complete primary	26	9.3
Incomplete secondary	50	17.9
Complete secondary	16	5.7
Higher	105	37.6
Current marital status	279	
Married	276	98.9
Not living together	3	1.1
Employment	279	
Did not work	214	76.7
Paid employee, away	19	6.8
Paid employee, home	7	2.5
Self-employed, away	8	2.9
Self-employed, home	8	2.9
Unpaid worker, away	18	6.5
Unpaid worker, home	5	1.8
Sex of child	279	
Male	155	55.6
Female	124	44.4
Household standard of living	276	
Low	34	12.3
Medium	103	37.3
High	139	50.4

Appendix B

Table 1
Group Statistics and t-test for Equality of Means between North and Central regions

Variable	R1	N	Mean ± SD	P
BMI	1	783	21.600 ± 4.168	0.000*
	2	279	20.128 ± 3.442	
WHZ	1	783	-0.428 ± 1.242	0.000*
	2	279	-0.829 ± 1.113	
WAZ	1	783	-1.006 ± 1.171	0.000*
	2	279	-1.334 ± 1.153	
HAZ	1	783	-1.035 ± 1.292	0.580
	2	279	-1.085 ± 1.328	
Birth weight of child (kg)	1	783	2.698 ± 0.634	0.188
	2	279	2.636 ± 0.778	
Height of child (cm)	1	783	69.898 ± 8.788	0.506
	2	279	69.492 ± 8.630	
Weight of child (kg)	1	783	7.947 ± 2.188	0.012*
	2	279	7.564 ± 2.175	
Years lived in residence	1	783	19.548 ± 33.405	0.001*
	2	279	27.566 ± 38.510	
Respondent's age at 1st birth	1	783	21.766 ± 3.410	0.000*
	2	279	20.616 ± 3.898	
Respondent's age	1	783	25.608 ± 4.276	0.003*
	2	279	24.667 ± 5.058	
Household members	1	783	7.286 ± 3.214	0.000*
	2	279	8.631 ± 4.865	

* p-values <0.05 are significant.

Table 2
Group Statistics and t-test for Equality of Means between North and East regions

Variable	R2	N	Mean ± SD			P
BMI	1	783	21.600	±	4.168	0.000*
	2	550	19.817	±	3.022	
WHZ	1	783	-0.428	±	1.242	0.000*
	2	550	-0.779	±	1.227	
WAZ	1	783	-1.006	±	1.171	0.000*
	2	550	-1.257	±	1.225	
HAZ	1	783	-1.035	±	1.292	0.918
	2	550	-1.027	±	1.324	
Birth weight of child (kg)	1	783	2.698	±	0.634	0.126
	2	550	2.751	±	0.606	
Height of child (cm)	1	783	69.898	±	8.788	0.971
	2	550	69.881	±	8.192	
Weight of child (kg)	1	783	7.947	±	2.188	0.026*
	2	550	7.683	±	2.033	
Years lived in residence	1	783	19.548	±	33.405	0.561
	2	549	20.641	±	34.330	
Respondent's age at 1st birth	1	783	21.766	±	3.410	0.000*
	2	550	20.787	±	3.694	
Respondent's age	1	783	25.608	±	4.276	0.000*
	2	550	24.464	±	4.421	
Household members	1	783	7.286	±	3.214	0.968
	2	550	7.278	±	3.842	

* p-values <0.05 are significant.

Table 3
Group Statistics and t-test for Equality of Means between North and Northeast regions

Variable	R3	N	Mean ± SD	P
BMI	1	783	21.600 ± 4.168	0.000*
	2	588	20.676 ± 2.634	
WHZ	1	783	-0.428 ± 1.242	0.077
	2	588	-0.306 ± 1.291	
WAZ	1	783	-1.006 ± 1.171	0.001*
	2	588	-0.789 ± 1.255	
HAZ	1	783	-1.035 ± 1.292	0.036*
	2	588	-0.882 ± 1.386	
Birth weight of child (kg)	1	783	2.698 ± 0.634	0.000*
	2	588	3.033 ± 0.634	
Height of child (cm)	1	783	69.898 ± 8.788	0.088
	2	588	70.715 ± 8.733	
Weight of child (kg)	1	783	7.947 ± 2.188	0.019*
	2	588	8.224 ± 2.132	
Years lived in residence	1	783	19.548 ± 33.405	0.000*
	2	586	32.481 ± 41.247	
Respondent's age at 1st birth	1	783	21.766 ± 3.410	0.866
	2	588	21.731 ± 4.248	
Respondent's age	1	783	25.608 ± 4.276	0.003*
	2	588	26.395 ± 5.513	
Household members	1	783	7.286 ± 3.214	0.000*
	2	588	6.560 ± 3.013	

* p-values <0.05 are significant.

Table 4
Group Statistics and t-test for Equality of Means between North and West regions

Variable	R4	N	Mean ± SD			P
BMI	1	783	21.600	±	4.168	0.000*
	2	1000	20.400	±	3.639	
WHZ	1	783	-0.428	±	1.242	0.000*
	2	1000	-0.853	±	1.108	
WAZ	1	783	-1.006	±	1.171	0.000*
	2	1000	-1.323	±	1.119	
HAZ	1	783	-1.035	±	1.292	0.996
	2	1000	-1.035	±	1.306	
Birth weight of child (kg)	1	783	2.698	±	0.634	0.006*
	2	1000	2.782	±	0.637	
Height of child (cm)	1	783	69.898	±	8.788	0.709
	2	1000	70.052	±	8.448	
Weight of child (kg)	1	783	7.947	±	2.188	0.006*
	2	1000	7.665	±	2.076	
Years lived in residence	1	783	19.548	±	33.405	0.000*
	2	1000	26.269	±	38.417	
Respondent's age at 1st birth	1	783	21.766	±	3.410	0.001*
	2	1000	21.174	±	4.042	
Respondent's age	1	783	25.608	±	4.276	0.039*
	2	1000	25.161	±	4.714	
Household members	1	783	7.286	±	3.214	0.864
	2	1000	7.258	±	3.597	

* p-values <0.05 are significant.

Table 5
Group Statistics and t-test for Equality of Means between North and South regions

Variable	R5	N	Mean ± SD	P
BMI	1	783	21.600 ± 4.168	0.000*
	2	1418	20.694 ± 3.585	
WHZ	1	783	-0.428 ± 1.242	0.000*
	2	1418	-0.810 ± 1.178	
WAZ	1	783	-1.006 ± 1.171	0.000*
	2	1418	-1.214 ± 1.134	
HAZ	1	783	-1.035 ± 1.292	0.052
	2	1418	-0.922 ± 1.318	
Birth weight of child (kg)	1	783	2.698 ± 0.634	0.000*
	2	1418	2.842 ± 0.556	
Height of child (cm)	1	783	69.898 ± 8.788	0.196
	2	1418	70.395 ± 8.537	
Weight of child (kg)	1	783	7.947 ± 2.188	0.060
	2	1418	7.770 ± 2.062	
Years lived in residence	1	783	19.548 ± 33.405	0.000*
	2	1418	37.432 ± 43.309	
Respondent’s age at 1st birth	1	783	21.766 ± 3.410	0.000*
	2	1418	20.841 ± 3.619	
Respondent’s age	1	783	25.608 ± 4.276	0.000*
	2	1418	24.337 ± 4.460	
Household members	1	783	7.286 ± 3.214	0.000*
	2	1418	6.719 ± 3.229	

* p-values <0.05 are significant.

Table 6
Group Statistics and t-test for Equality of Means between Central and East regions

Variable	R6	N	Mean ± SD			P
BMI	1	279	20.128	±	3.442	0.182
	2	550	19.817	±	3.022	
WHZ	1	279	-0.829	±	1.113	0.567
	2	550	-0.779	±	1.227	
WAZ	1	279	-1.334	±	1.153	0.389
	2	550	-1.257	±	1.225	
HAZ	1	279	-1.085	±	1.328	0.554
	2	550	-1.027	±	1.324	
Birth weight of child (kg)	1	279	2.636	±	0.778	0.020*
	2	550	2.751	±	0.606	
Height of child (cm)	1	279	69.492	±	8.630	0.526
	2	550	69.881	±	8.192	
Weight of child (kg)	1	279	7.564	±	2.175	0.439
	2	550	7.683	±	2.033	
Years lived in residence	1	279	27.566	±	38.510	0.009*
	2	549	20.641	±	34.330	
Respondent’s age at 1st birth	1	279	20.616	±	3.898	0.537
	2	550	20.787	±	3.694	
Respondent’s age	1	279	24.667	±	5.058	0.552
	2	550	24.464	±	4.421	
Household members	1	279	8.631	±	4.865	0.000*
	2	550	7.278	±	3.842	

* p-values <0.05 are significant.

Table 7
Group Statistics and t-test for Equality of Means between Central and Northeast regions

Variable	R7	N	Mean ± SD			P
BMI	1	279	20.128	±	3.442	0.010*
	2	588	20.676	±	2.634	
WHZ	1	279	-0.829	±	1.113	0.000*
	2	588	-0.306	±	1.291	
WAZ	1	279	-1.334	±	1.153	0.000*
	2	588	-0.789	±	1.255	
HAZ	1	279	-1.085	±	1.328	0.042*
	2	588	-0.882	±	1.386	
Birth weight of child (kg)	1	279	2.636	±	0.778	0.000*
	2	588	3.033	±	0.634	
Height of child (cm)	1	279	69.492	±	8.630	0.054
	2	588	70.715	±	8.733	
Weight of child (kg)	1	279	7.564	±	2.175	0.000*
	2	588	8.224	±	2.132	
Years lived in residence	1	279	27.566	±	38.510	0.095
	2	586	32.481	±	41.247	
Respondent’s age at 1st birth	1	279	20.616	±	3.898	0.000*
	2	588	21.731	±	4.248	
Respondent’s age	1	279	24.667	±	5.058	0.000*
	2	588	26.395	±	5.513	
Household members	1	279	8.631	±	4.865	0.000*
	2	588	6.560	±	3.013	

* p-values <0.05 are significant.

Table 8
Group Statistics and t-test for Equality of Means between Central and West regions

Variable	R8	N	Mean ± SD			P
BMI	1	279	20.128	±	3.442	0.264
	2	1000	20.400	±	3.639	
WHZ	1	279	-0.829	±	1.113	0.745
	2	1000	-0.853	±	1.108	
WAZ	1	279	-1.334	±	1.153	0.890
	2	1000	-1.323	±	1.119	
HAZ	1	279	-1.085	±	1.328	0.574
	2	1000	-1.035	±	1.306	
Birth weight of child (kg)	1	279	2.636	±	0.778	0.001*
	2	1000	2.782	±	0.637	
Height of child (cm)	1	279	69.492	±	8.630	0.331
	2	1000	70.052	±	8.448	
Weight of child (kg)	1	279	7.564	±	2.175	0.477
	2	1000	7.665	±	2.076	
Years lived in residence	1	279	27.566	±	38.510	0.618
	2	1000	26.269	±	38.417	
Respondent's age at 1st birth	1	279	20.616	±	3.898	0.040*
	2	1000	21.174	±	4.042	
Respondent's age	1	279	24.667	±	5.058	0.128
	2	1000	25.161	±	4.714	
Household members	1	279	8.631	±	4.865	0.000*
	2	1000	7.258	±	3.597	

* p-values <0.05 are significant.

Table 9
Group Statistics and t-test for Equality of Means between Central and South regions

Variable	R9	N	Mean ± SD	P
BMI	1	279	20.128 ± 3.442	0.015*
	2	1418	20.694 ± 3.585	
WHZ	1	279	-0.829 ± 1.113	0.806
	2	1418	-0.810 ± 1.178	
WAZ	1	279	-1.334 ± 1.153	0.109
	2	1418	-1.214 ± 1.134	
HAZ	1	279	-1.085 ± 1.328	0.059
	2	1418	-0.922 ± 1.318	
Birth weight of child (kg)	1	279	2.636 ± 0.778	0.000*
	2	1418	2.842 ± 0.556	
Height of child (cm)	1	279	69.492 ± 8.630	0.107
	2	1418	70.395 ± 8.537	
Weight of child (kg)	1	279	7.564 ± 2.175	0.132
	2	1418	7.770 ± 2.062	
Years lived in residence	1	279	27.566 ± 38.510	0.000*
	2	1418	37.432 ± 43.309	
Respondent’s age at 1st birth	1	279	20.616 ± 3.898	0.351
	2	1418	20.841 ± 3.619	
Respondent’s age	1	279	24.667 ± 5.058	0.270
	2	1418	24.337 ± 4.460	
Household members	1	279	8.631 ± 4.865	0.000*
	2	1418	6.719 ± 3.229	

* p-values <0.05 are significant.

Table 10
Group Statistics and t-test for Equality of Means between East and Northeast regions

Variable	R10	N	Mean ± SD			P
BMI	1	550	19.817	±	3.022	0.000*
	2	588	20.676	±	2.634	
WHZ	1	550	-0.779	±	1.227	0.000*
	2	588	-0.306	±	1.291	
WAZ	1	550	-1.257	±	1.225	0.000*
	2	588	-0.789	±	1.255	
HAZ	1	550	-1.027	±	1.324	0.071
	2	588	-0.882	±	1.386	
Birth weight of child (kg)	1	550	2.751	±	0.606	0.000*
	2	588	3.033	±	0.634	
Height of child (cm)	1	550	69.881	±	8.192	0.098
	2	588	70.715	±	8.733	
Weight of child (kg)	1	550	7.683	±	2.033	0.000*
	2	588	8.224	±	2.132	
Years lived in residence	1	549	20.641	±	34.330	0.000*
	2	586	32.481	±	41.247	
Respondent’s age at 1st birth	1	550	20.787	±	3.694	0.000*
	2	588	21.731	±	4.248	
Respondent’s age	1	550	24.464	±	4.421	0.000*
	2	588	26.395	±	5.513	
Household members	1	550	7.278	±	3.842	0.000*
	2	588	6.560	±	3.013	

* p-values <0.05 are significant.

Table 11
Group Statistics and t-test for Equality of Means between East and West regions

Variable	R11	N	Mean ± SD			P
BMI	1	550	19.817	±	3.022	0.001*
	2	1000	20.400	±	3.639	
WHZ	1	550	-0.779	±	1.227	0.223
	2	1000	-0.853	±	1.108	
WAZ	1	550	-1.257	±	1.225	0.286
	2	1000	-1.323	±	1.119	
HAZ	1	550	-1.027	±	1.324	0.912
	2	1000	-1.035	±	1.306	
Birth weight of child (kg)	1	550	2.751	±	0.606	0.359
	2	1000	2.782	±	0.637	
Height of child (cm)	1	550	69.881	±	8.192	0.701
	2	1000	70.052	±	8.448	
Weight of child (kg)	1	550	7.683	±	2.033	0.872
	2	1000	7.665	±	2.076	
Years lived in residence	1	549	20.641	±	34.330	0.004*
	2	1000	26.269	±	38.417	
Respondent’s age at 1st birth	1	550	20.787	±	3.694	0.063
	2	1000	21.174	±	4.042	
Respondent’s age	1	550	24.464	±	4.421	0.004*
	2	1000	25.161	±	4.714	
Household members	1	550	7.278	±	3.842	0.918
	2	1000	7.258	±	3.597	

* p-values <0.05 are significant.

Table 12
Group Statistics and t-test for Equality of Means between East and South regions

Variable	R12	N	Mean ± SD	P
BMI	1	550	19.817 ± 3.022	0.000*
	2	1418	20.694 ± 3.585	
WHZ	1	550	-0.779 ± 1.227	0.601
	2	1418	-0.810 ± 1.178	
WAZ	1	550	-1.257 ± 1.225	0.458
	2	1418	-1.214 ± 1.134	
HAZ	1	550	-1.027 ± 1.324	0.111
	2	1418	-0.922 ± 1.318	
Birth weight of child (kg)	1	550	2.751 ± 0.606	0.002*
	2	1418	2.842 ± 0.556	
Height of child (cm)	1	550	69.881 ± 8.192	0.225
	2	1418	70.395 ± 8.537	
Weight of child (kg)	1	550	7.683 ± 2.033	0.399
	2	1418	7.770 ± 2.062	
Years lived in residence	1	549	20.641 ± 34.330	0.000*
	2	1418	37.432 ± 43.309	
Respondent’s age at 1st birth	1	550	20.787 ± 3.694	0.771
	2	1418	20.841 ± 3.619	
Respondent’s age	1	550	24.464 ± 4.421	0.571
	2	1418	24.337 ± 4.460	
Household members	1	550	7.278 ± 3.842	0.001*
	2	1418	6.719 ± 3.229	

* p-values <0.05 are significant.

Table 13
Group Statistics and t-test for Equality of Means between Northeast and West regions

Variable	R13	N	Mean ± SD	P
BMI	1	588	20.676 ± 2.634	0.108
	2	1000	20.400 ± 3.639	
WHZ	1	588	-0.306 ± 1.291	0.000*
	2	1000	-0.853 ± 1.108	
WAZ	1	588	-0.789 ± 1.255	0.000*
	2	1000	-1.323 ± 1.119	
HAZ	1	588	-0.882 ± 1.386	0.028*
	2	1000	-1.035 ± 1.306	
Birth weight of child (kg)	1	588	3.033 ± 0.634	0.000*
	2	1000	2.782 ± 0.637	
Height of child (cm)	1	588	70.715 ± 8.733	0.136
	2	1000	70.052 ± 8.448	
Weight of child (kg)	1	588	8.224 ± 2.132	0.000*
	2	1000	7.665 ± 2.076	
Years lived in residence	1	586	32.481 ± 41.247	0.003*
	2	1000	26.269 ± 38.417	
Respondent’s age at 1st birth	1	588	21.731 ± 4.248	0.009*
	2	1000	21.174 ± 4.042	
Respondent’s age	1	588	26.395 ± 5.513	0.000*
	2	1000	25.161 ± 4.714	
Household members	1	588	6.560 ± 3.013	0.000*
	2	1000	7.258 ± 3.597	

* p-values <0.05 are significant.

Table 14
Group Statistics and t-test for Equality of Means between Northeast and South regions

Variable	R14	N	Mean	±	SD	P
BMI	1	588	20.676	±	2.634	0.916
	2	1418	20.694	±	3.585	
WHZ	1	588	-0.306	±	1.291	0.000*
	2	1418	-0.810	±	1.178	
WAZ	1	588	-0.789	±	1.255	0.000*
	2	1418	-1.214	±	1.134	
HAZ	1	588	-0.882	±	1.386	0.547
	2	1418	-0.922	±	1.318	
Birth weight of child (kg)	1	588	3.033	±	0.634	0.000*
	2	1418	2.842	±	0.556	
Height of child (cm)	1	588	70.715	±	8.733	0.449
	2	1418	70.395	±	8.537	
Weight of child (kg)	1	588	8.224	±	2.132	0.000*
	2	1418	7.770	±	2.062	
Years lived in residence	1	586	32.481	±	41.247	0.018*
	2	1418	37.432	±	43.309	
Respondent's age at 1st birth	1	588	21.731	±	4.248	0.000*
	2	1418	20.841	±	3.619	
Respondent's age	1	588	26.395	±	5.513	0.000*
	2	1418	24.337	±	4.460	
Household members	1	588	6.560	±	3.013	0.306
	2	1418	6.719	±	3.229	

* p-values <0.05 are significant.

Table 15
Group Statistics and t-test for Equality of Means between West and South regions

Variable	R15	N	Mean ± SD	P
BMI	1	1000	20.400 ± 3.639	0.049*
	2	1418	20.694 ± 3.585	
WHZ	1	1000	-0.853 ± 1.108	0.363
	2	1418	-0.810 ± 1.178	
WAZ	1	1000	-1.323 ± 1.119	0.020*
	2	1418	-1.214 ± 1.134	
HAZ	1	1000	-1.035 ± 1.306	0.037*
	2	1418	-0.922 ± 1.318	
Birth weight of child (kg)	1	1000	2.782 ± 0.637	0.013*
	2	1418	2.842 ± 0.556	
Height of child (cm)	1	1000	70.052 ± 8.448	0.328
	2	1418	70.395 ± 8.537	
Weight of child (kg)	1	1000	7.665 ± 2.076	0.221
	2	1418	7.770 ± 2.062	
Years lived in residence	1	1000	26.269 ± 38.417	0.000*
	2	1418	37.432 ± 43.309	
Respondent’s age at 1st birth	1	1000	21.174 ± 4.042	0.034*
	2	1418	20.841 ± 3.619	
Respondent’s age	1	1000	25.161 ± 4.714	0.000*
	2	1418	24.337 ± 4.460	
Household members	1	1000	7.258 ± 3.597	0.000*
	2	1418	6.719 ± 3.229	

* p-values <0.05 are significant.

Appendix C

Table 9
Multiple linear regression analysis determining the relationship between WHZ of overweight children and the predictors in six regions of India

	West	**South**	**North**	**Northeast**	**East**	**Central**
Model	*3f*	*4f*	*5f*	*6f*	*7f*	*8f*
		dependent variable overweight weight for height				
Constant	3.176	3.784	3.323	4.567	3.179	12.435
	(1.655)	(0.730)	(1.036)	(1.153)	(1.495)	(0.000)
Respondent's age	-0.001	-0.050*	-0.057	-0.010	0.023	
	(0.099)	(0.019)	(0.037)	(0.018)	(0.053)	
BMI	-0.029	-0.028	0.015	-0.055	-0.066	-0.533
	(0.085)	(0.028)	(0.022)	(0.048)	(0.096)	(0.000)
Household Standard of Living						
(reference low)						
Medium	0.214	0.189		-0.223		
	(0.555)	(0.258)		(0.363)		
High	0.649	0.169	0.368	-0.460	0.777	
	(0.757)	(0.245)	(0.333)	(0.491)	(0.418)	
Education Level						
(reference no education)						
Primary	-0.469	0.752	0.708	-0.012		
	(0.899)	(0.397)	(0.534)	(0.390)		
Secondary	-0.224	0.160	0.221	-0.274	0.073	-0.165
	(0.575)	(0.366)	(0.330)	(0.413)	(0.689)	(0.000)
Higher	-0.642	0.679	-0.045	-0.133	-0.119	
	(0.739)	(0.387)	(0.372)	(0.731)	(0.652)	

model 3f: adjusted R square of -0.806, model 4f: adjusted R square of 0.222, model 5f: adjusted R square of 0.014, model 6f: adjusted R square of -0.015, model 7f: adjusted R square of -0.141