DETERMINANTS OF NUTRITIONAL STATUS IN CHILDREN UNDER 5 YEARS IN INDIA: A MULTILEVEL APPROACH

by

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(Under the Direction of Alex K. Anderson)

ABSTRACT

Children aged below 5 years in India are amongst the most affected with poor nutritional status in the developing world. This dissertation examines different nutritional outcomes of children in India and their associated risk factors. This is a secondary data analysis using data from the National Health and Family Survey (NFHS) collected during 1992-2006. The three areas examined are 1) pregnancy outcome (birth weight and birth size of children) and related determinants, 2) determinants of undernutrition (stunting, underweight, wasting and anemia), and 3) determinants of childhood overweight. Significant regional, urban/rural and socio-economic disparity existed with respect to the outcomes studied. Maternal education and employment were important predictors of the overall nutritional status of children in the study. Other predictors were maternal autonomy, presence of grandparents in the household and dietary practices that significantly increased or decreased the risks of poor birth outcome and undernutrition in the children. For instance, low maternal autonomy increased the risks of poor pregnancy outcome with respect to birth weight and birth size of the child. Presence of grandparents in the household and intake of diet of good quality were important factors that decreased the risks of undernutrition in children. On the other hand, urban children and those from affluent households had the maximum risk of being overweight. Overall we observed higher prevalence of low birth weight and undernutrition in children from rural areas and a higher prevalence of overweight among urban children. This dissertation work identified both individual and household level risk factors of under 5 nutritional outcomes, suggesting the need for intervention programs targeting individuals and household as a means of overcoming these important public health problems.

INDEX WORDS: Undernutrition, birth weight, maternal autonomy, overweight, dietary intake, National Health and Family Survey

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DEDICATION

I would like to dedicate this work to my parents, Partha Sarathi and Kamal Ghosh Roy and my brother Prithwiraj Ghosh Roy for their unconditional love, support and trust in my decision to pursue a higher degree. This journey would have been impossible without your love and faith in my potentials. I have been blessed to have you as my family. Thank you so much for believing in me and standing by me. I would also like to dedicate this achievement to my sister Koyeli Khan (Papan) and sister-in-law Andrea Pinto Ghosh Roy (Andy) who have always been pillars of strength during the last four years. Papan and Andy, words cannot express how thankful I am to both of you. You have always succeeded to bring a smile to my face and keep me going during the toughest of times. I love you all very much and thank you for everything!

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CHAPTER 1

INTRODUCTION

Nutritional status of a population is a prominent reflection of a nation's economic development and public welfare policies. Adequate growth and nutritional status of children are monitored by the use of anthropometric measurements, specifically height and weight, which in combination with the age of the child forms the anthropometric indices (1). These are further classified as weight-for-age, length/height-for-age, weight-for-length/height and BMI-for-age and can be interpreted using the z-score classification system (1, 2). Thus a child with weight-for-age (WAZ) or weight-for-height (WHZ) less than -2.0 standard deviation (SD) is classified as being underweight or wasted respectively. Similarly a height-for-age (HAZ) < -2.0 SD indicates stunting or chronic under nutrition. On the other hand, a BMI-for-age (BAZ) less than -2.0 SD and greater than 2.0 SD indicates underweight and overweight respectively. Apart from the use of anthropometric measurements, the nutritional status of a child is also reflected by the hemoglobin level, which indicates the presence or absence of iron-deficiency anemia (3).

Malnutrition in its several forms of under nutrition, namely wasting, stunting and underweight has been coined as the "silent emergency" by the United Nations Children's Fund (UNICEF). It has been associated with endangering women and children across the world (4). To address the issue of child hunger and under nutrition, one of the primary objectives of the Millennium Development Goals (MDG) has been to improve the nutritional status of children worldwide (5). Almost 23.0% of children < 5 years from developing countries were identified to be moderately or severely underweight, while 28.0% were stunted, during 2000-2007 (6). The worst afflicted areas of under nutrition are South Asian countries where the prevalence of underweight (15.0%) and stunting (46.0%) exceeds those observed in other developing countries (6), with the highest prevalence observed in India (16.0% and 48.0% respectively) (5). At the same time it has been estimated that nearly 47% of preschool children worldwide are afflicted with anemia, with the highest prevalence in Africa (67%) and South Asia (65.5%) (3). In India, while the prevalence of stunted children < 3 years have notably declined from 45.5% in 1998-99 to 38.4% in 2005-06, the prevalence of LBW, underweight and anemia remains astonishingly high at 30.0%, 43.0% and 79.0% respectively (6,7).

One of the main causes of child mortality worldwide is attributed to under nutrition (6), and is estimated to cause at least 55.0% of all child deaths (8). A study of 10 cohorts from developing countries reported a significant increased risk (RR: 4.24; 95% CI: 3.13- 5.53) of overall child mortality associated with underweight (weight-for-age: -2.0 to -3.0 SDs) (9). Moreover, the same study reported a significant association of disease prevalence in children with weight-for-age < -1.0 SD, which followed a linear trend with increasing degrees of underweight. For instance, the relative risk of suffering from diarrhea increased from 5.39 (95% CI: 3.73 to 7.79) to 12.50 (95% CI: 7.19 to 21.73) for moderately underweight and severely underweight children respectively. The study also reported similar observations for other common childhood illnesses, namely pneumonia, malaria and measles (9). Deshmukh et al. (2009) detected iron-deficiency anemia in nearly 80.0% of children < 3 years living in the Wardha district of Central

India. While the overall prevalence of acute morbidity, i.e. fever, acute respiratory infections and diarrhea was almost 60.0%, children suffering from severe anemia were 9 times at risk of being morbid, compared to non-anemic children (10). These findings therefore indicate the significant association of poor nutritional status with childhood morbidity and mortality.

Adding to the crisis of undernutrition in children from the developing world is the high prevalence of low birth weight (<2.5 kg), that increases the infant mortality and morbidity rates (11). Low birth weight (LBW) is not only associated with neonatal and infant mortality and morbidity, but is an important determinant of growth retardation in children and development of chronic diseases such as diabetes mellitus, cardiovascular diseases and hypertension (11) in adults. Studies examining the determinants of LBW have identified maternal demography and nutritional status to be important predictors (12). Few studies have also considered the impact of prenatal care use on the incidence of LBW (12-14). Since maternal characteristics are linked to household and community factors which are further associated with the incidence of LBW, further examination of these factors are needed to understand their influence on pregnancy outcome in the Indian context. Additionally, status of women in the household have been closely related to the use of prenatal care (15) and nutritional status of the child (16), but studies documenting the impact of this factor on birth outcome are lacking.

Although the performance of developing countries with respect to child health and nutrition has been slow, there have been rapid economic growth and industrialization. Several economic reforms in the past decade have contributed to the remarkable economic growth in South Asia (17). Similarly, India too witnessed an overall economic expansion and a rise in annual Gross Domestic Product (GDP) from 4.0% in 2000 to 9.0% in 2007 (18). Along with economic accretion was the increased consumption of high saturated fat, refined carbohydrate and animal products, coupled with decreased consumption of fiber and physical activity patterns, culminating in increased risks of overweight/obesity (19). Several studies have reflected the growing incidence of overweight/obesity and related chronic diseases in adults and children from the developing world (20-21). It is thus paradoxical that developing countries are plagued by the double burden of under and over nutrition related health problems. While a major portion of the population (children and women) is still afflicted with the different manifestations of under nutrition, a large section of the population living in urban areas suffers from overweight and obesity (22, 23). Thus, in the light of the current scenario of health and nutrition in developing countries the gravity of the issue has been well established and thus needs to be studied further.

Several studies indicate that India is experiencing a paradigm shift in nutrition, specifically in urban areas (21, 24, 25). Griffith and Bentley (2005) evaluated the prevalence of overweight among urban women from the state of Karnataka, South India, showing the growing burden of the problem (26). While recent studies documented the prevalence of overweight and obesity among children < 5 years in India (27, 28), regional comparative studies on overweight prevalence and its determinants are lacking.

This dissertation project therefore examines the different factors influencing the nutritional status of children < 5 years in the context of birth outcome, undernutrition and overweight status. Chapter 2 provides detailed review of the literature outlining the different factors associated with pregnancy outcome and undernutrition status of children.

The nutrition transition in developing countries and prevalence of overweight in children from these countries are also reviewed. Chapter 3 discusses the factors associated with pregnancy outcome in Indian women. Chapter 4 describes the prevalence and determinants of undernutrition in children aged 0-35 months in India, while chapter 5 discusses the determinants of overweight in Indian children aged < 5 years. The summary of the major findings of this dissertation and future recommendations are discussed in chapter 6.

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CHAPTER 2

LITERATURE REVIEW

Introduction

This section reviews previous research addressing the nutritional status of children aged below 5 years and the various factors associated with it. The different areas covered include the association between pregnancy outcome and nutritional status of children, factors contributing to pregnancy outcome and the determinants of under and over nutrition status of children from developing countries. In the context of India, there is lack of information at the national and regional levels examining the factors associated with the above mentioned areas (to the best of our knowledge). This information is required to identify and address these issues for improving the health and overall nutritional status of these children.

Anthropometric indicators to assess nutritional status of children

The following section reviews the indicators used to assess the nutritional status of children less than 5 years. Anthropometric measurements are the most common tool used to assess the nutritional status of a population and to monitor growth in children (1). The anthropometric indices commonly used are weight-for-height, height-for-age and weight-for-age expressed as percentiles or z-scores representing the overall nutritional status of a child (1, 2). Wasting, stunting and underweight is identified by the weight-for-height, height-for-age and weight-for-age < - 2.0 standard deviation (SD) respectively, while weight-for-height and weight-for-age > 2.0 SD are also used to assess overweight in children (2). For the purpose of this dissertation project, we used the z-scores for each of these indicators.

The use of body mass index (BMI; weight/height^2) has also been used to assess overweight status in children 2 years and older with a cutoff > 95th percentile or 2.0 SD (2). Longitudinal studies have indicated a significant correlation between childhood BMI and adult adiposity (3). Moreover, comparison between BMI of Pima Indian children with their adiposity (measured by the dual energy x-ray absorptiometry) revealed a strong correlation with fat mass (r = 0.96–0.98; $p < 0.0001$) (4), thereby confirming the appropriateness of using BMI as an anthropometric indicator in children.

Importance of birth weight on nutritional status

The nutritional status of children is known to be influenced by several factors, of them birth weight is an important component. As defined by the World Health Organization, birth weight is the first weight of the newborn obtained within the first hour of life (5). A birth weight less than 2500 grams, is defined as low birth weight and is an universally accepted classification (5).

The relationship between birth weight and nutritional status of children at the end of their first year of life was investigated by Motta et al. (2005), who reported the significant influence of low birth weight on the incidence of underweight among children, compared to those who had birth weight above 2500 grams (6). More recent studies confirmed the importance of birth weight as a determinant of a child's nutritional status (7, 8). A study conducted in Vietnam, to assess the nutritional status and factors contributing to malnutrition in children less than five years of age also reported similar findings (7). Of the 650 children included in the study, 31.8% were underweight, 44.3%

were stunted and 11.9% were wasted. Interestingly, children born low birth weight had higher risks of being malnourished compared to their normal birth weight counterparts. The odds ratio for underweight, stunting and wasting were as high as 7.7, 5.6 and 5.2 respectively in low birth weight children thereby indicating the negative impact of low birth weight on future weight gain and linear growth pattern of a child. An increased risk of malnutrition, specifically low stature and underweight were also observed to be associated with low birth weight (RR = 1.6; 95%CI = 1.2-2.3) among children under 5 years in a longitudinal hospital based study in Brazil (8).

In addition to the influence of low birth weight on children's nutritional status, a growing body of evidence suggests its impact on health conditions and incidence of chronic diseases such as cardiovascular disease, hypertension and diabetes mellitus in adults (9- 11). Studies from the United Kingdom confirmed the association between low birth weight and cardiovascular disease (12). Similar findings were reported in studies conducted with the Asian-Indian population of South India. Among the 517 adult men and women born in Mysore, India, low birth weight, short birth length and small head circumference had significantly increased the risks of coronary heart disease (13). Additionally, prevalence of heart disease decreased with increasing birth weight in this study population thereby confirming the association between birth weight and incidence of coronary heart disease. Increased prevalence of hypertension was also observed among participants in the Nurses' Health Study- I, where the age-adjusted odds ratio for hypertension was 1.4 (95% CI = 1.3 - 1.5) in participants born low birth weight compared to those of birth weight > 2.5 kg (5 lb) (10). These evidences therefore strengthen the need to investigate the factors contributing to low birth weight and small birth size in order to prevent its incidence and reduce the prevalence of both under nutrition and chronic diseases.

Factors affecting pregnancy outcome: low- birth weight

Several studies have revealed that characteristics of women of child-bearing age influence outcomes of pregnancy, that is it affects the weight and length of the infant at birth. Maternal age less than 20 years and above 35 years has been associated with low birth weight, premature delivery, and clinical complications during pregnancy and labor leading to cesarean delivery (14). In addition to this, stressful working conditions during pregnancy have been found to result in small for gestational age babies and preterm delivery (15).

Literature suggests that mother's health and nutritional status play an important role on pregnancy outcome. Although maternal nutrition in developed population was found to have little effect on birth weight (16), other studies have shown that maternal nutrition depletion and inadequate nutrient reserve at the time of conception leads to preterm birth and fetal growth retardation (17). A study conducted by Rao et al. in 2001 found a strong association between maternal nutrition and mean birth weight and length of term infants in rural Indian women (18). Further evidence is provided through the cross-sectional study by Carvalho Padilha et al that included 433 pregnant women in Rio de Janeiro. Total gestational weight gain ($\beta = 25.29$; $p = 0.000$) and maternal nutritional status assessed through pre-gestational BMI ($\beta = 13.02$; $p = 0.037$) were significant predictors of birth weight of the newborn (19).

Pregnancy outcome is also known to depend on the utilization of prenatal care. Socio-economic difference is known to influence the utilization of health care services and prenatal care by mothers (18). Roos and Mustard (1997) studied this factor in a Canadian population having complete health care insurance. Their study revealed that there was inadequate or poor utilization of prenatal care services by women with low socio-economic status (SES), although the difference in birth weight was small when analyzed against service utilization (20). Impact of SES on birth weight and pre-term delivery was also seen in an urban city in Thailand (21).

Significant predictors of birth weight and birth size with respect to utilization of prenatal care services are influenced by the woman's status in the household and the society (22- 24). Studies on the influence of women's autonomy on utilization of prenatal care services have demonstrated that women with greater autonomy had greater utilization of prenatal care and safe delivery practices (22). Additionally, education and employment status of the mother which have been previously identified as important predictors of birth weight (25) have been shown to be significant determinants of women's autonomy (26). Currently it is not known if there is an association between women's autonomy and pregnancy outcome, specifically in India. This association is of concern as the prevalence of low birth weight in India is rather high (30.0%) (27).

<u>Determinants of undernutrition in children</u>

Epidemiological studies conducted in developing countries have identified several causes of undernutrition in children. The most prominent cause is poverty, followed by low levels of parental education, poor dietary intake by children and rural residence (28-30). For example, children < 5 years from low socio-economic households were found to have twice the risk of being stunted than children from rich households in Ghana (28). The association between poverty and undernutrition is mainly due to lack of adequate and nutritionally balanced diet, health care and poor living conditions. As reported by Jalan and Ravallion (2003), children living in households without piped water system were more susceptible to diarrhea that influenced their overall health status compared to those with access to piped water (31). Underweight among these children were also strongly associated with maternal education, as children of mothers with no formal education were more likely to be underweight than children of mothers with at least secondary school education (OR = 1.64; 95% CI = 1.04–2.59) (28). An examination of the Bangladesh Demographic Health Survey reported children from households with low socio-economic status and illiterate mothers were at a greater risk of being undernourished (29). Other studies have shown the influence of place of residence on the nutritional status of children. A study by Shen et al. (1996) revealed that despite economic reforms in both rural and urban China, higher percentage of rural children aged 2 to 5 years (38.0%) were stunted as compared to urban children (10.0%) (32). These evidence clearly indicate the increased risk of poor nutritional status for rural children compared to their urban counterparts.

In addition to the anthropometric indices that reflect optimal growth or growth faltering, iron nutriture is also indicative of overall nutritional status. Iron deficiency adversely affects the immune system and increases the onset of diseases in children (33). Children from both developing (Kenya and Bangladesh) and industrialized countries (United Kingdom and United States) were found to benefit from iron supplementation with respect to growth and reduced incidence of diarrhea and other infections (33). Among the various socio-demographic causes, maternal illiteracy and poverty remained primary causes (34, 35). Increased risk of anemia was observed among children of mothers with no education compared to children of mothers with secondary education in Indonesia (35). Moreover, in Brazil, pre-school children living in households with inadequate physical and sanitary conditions were found to be significantly at increased risk of anemia (34). A more recent study by Pasricha et al. (2010) also reported low ferritin and hemoglobin levels in children from households with low socio-economic status (36).

Maternal and household characteristics are directly associated with feeding and health care practices received by the child. Poor dietary intakes, lack of health care and incomplete immunization are immediate causes of undernutrition and have been identified as potential modifiable risk factors. Several epidemiological studies have confirmed the importance of dietary pattern and immunization coverage for optimum growth and nutritional status in children. The following section reviews the studies examining the association between these factors and undernutrition in children.

Dietary practices and nutritional status of children

The World Health Organization (WHO) has issued guidelines regarding infant and child feeding practices. These guidelines encourage the promotion of exclusive breastfeeding for the first six months and initiation of complementary feeding (introduction of solid foods) thereafter (37). The guidelines also promote continued breastfeeding till the child's second birthday. Notzon (1984) studied the changing pattern of breastfeeding in 7 developing countries using data from cross-sectional surveys. His study revealed a notable decline in average duration of breastfeeding in these countries, by ethnicity and modernization (38). More recently, the changing pattern of infant feeding practices in developing countries was reviewed by King and Ashworth (2002).

While extended breastfeeding and early introduction of complementary feeding were traditional norms among low-income mothers in Malaysia and the Caribbean, a notable decrease in the duration of breastfeeding was observed in these countries (39). Additionally, there has been an increased use of processed milk as a supplement for the infant, as a result of industrialization and promotion of infant formulas (39).

Early introduction of complementary feeding, that is before the age of 6 months is significantly associated with poorer growth patterns among infants. A longitudinal study of 4 cohorts of infants in Vietnam examined this association and reported growth faltering in infants receiving premature complementary feeding compared to exclusive breastfeeding at 3 months (40). Not only were weight and length gain delayed among infants who were partially breast-fed or weaned compared to exclusive breastfed infants at 1 to 3 months of age, a similar trend was also observed among infants aged 3 to 6 months, thereby confirming the negative consequences of early weaning. Additionally, morbidity from diarrhea and acute respiratory infections was significantly lower in infants who were exclusively breastfed compared to their weaned counterparts (40). In spite of the global guidelines on infant feeding practices, adherence to these recommendations is limited in developing countries. A longitudinal study of newborns in Malawi, Africa, highlighted this notion (41). Although universal breastfeeding was practiced for 18 months, rates of exclusive breastfeeding were only 19.0%, 8.0%, 2.0% and 0.0% at ages 1, 2, 3 and 4 mo, respectively. Moreover, the average age range of introduction of complementary foods varied from 2.5 to 6.3 months, indicating premature initiation of weaning (41).

Evidence suggests that maternal characteristics such as age, education, employment and marital status impact infant feeding practices (42). Adherence to the feeding recommendations varied with respect to the mother's education level and SES (41). Previous studies have established the impact of household and community characteristics on infant feeding practices and overall nutritional status (43). A cross-cultural study by Abel et al (2001) in New-Zealand showed the existence of inter-ethnic similarities and differences in infant care and feeding practices (44). Kannan and group (1999) compared American mothers and Asian-Indian-American mothers residing in the United States for a median duration of 6 years with respect to infant feeding practices (45). Their study revealed that beliefs about prelacteals, introduction of solid foods and feeding carbonated beverages differed significantly between American and immigrant Asian-Indian-American mothers. This study thus accentuates the influence of culture on infant feeding practices. The influence of cultural beliefs and traditions on infant feeding practices and its effect on child's nutritional status in Puerto Rico was studied by Higgins in 2000. This again revealed that culture was an important predictor of infant feeding practice (46). Infant feeding practice is also influenced by other household factors such as presence of a grandparent and place of residence. Feeding practices in households with a grandmother present were significantly influenced with respect to the time of introduction and type of solid foods received by the infant (47). On the other hand, longitudinal and cross-sectional studies of rural and urban children in Bangladesh observed a 100.0% practice of breast-feeding at birth among rural mothers compared to 78.0% among urban elite mothers (48). On the other hand, urban and rural differences were observed for the decline in breast feeding rates and weaning of infants at 10 months of age (48), confirming the influence of residence on feeding practices.

In a low socio-economic rural African community, although breastfeeding was initiated in 99.0% of the study sample, more than 60.0% of the infants included in the study had been introduced to water during their first month of life (49). Moreover, nearly 95.0% of the infants were introduced to solid foods at 2-4 months of age (49). This study therefore highlights that although the rate of breast feeding initiation is relatively high in developing countries, exclusive breastfeeding is rarely practiced. Similarly, while breastfeeding was initiated by 97.0% mothers in a cross-sectional study in Brazil, early introduction of complementary feeding was the usual norm (50). Moreover, the dietary pattern of the infants/children aged 0 – 24 months mainly comprised of a higher intake of carbohydrate rich foods, cow's milk and lower intake of animal protein (50). Failing to initiate breastfeeding 6 hours after birth, lack of colostrum and improper complementary foods were all significant predictors of poor nutritional status of Indian children under 5 years of age (51).

Indicators of infant/child feeding practices

This section reviews the indicators in use for assessing infant and child feeding practices. For the purpose of this dissertation feeding practices include breastfeeding for infants < 6 months and dietary diversity for older children (> 6 months). Feeding practices are based on a 24 hour dietary recall by the mother/caretaker.

Researchers have identified differences in the assessment of exclusive breastfeeding with variability in the methods and breastfeeding definitions (52, 53). Aarts et al., (2000) examined the underlying differences between data pertaining to the 'current status of breastfeeding' (based on 24 hour recall) and 'exclusive breastfeeding since birth' (based on daily recording) and reported a discrepancy between the results (52). However, epidemiological studies have employed food records and dietary recall by the infants/children's caretakers to assess exclusive breastfeeding and dietary practices (54, 55). Information obtained retrospectively by Launer and group (2002) examined the accuracy of maternal recall regarding infant feeding practices and reported positive results (54). Although levels of accuracy were lower for formula feeding compared to other feeding practices, accuracy rates were significantly higher for breastfeeding and complementary feeding (54). The review by Li et al., (2005) also documents evidence of validity and reliability of maternal recall for infant feeding practices (55). Additionally, WHO has developed indicators for assessing breastfeeding practices for household surveys using the 24 hour dietary recall (56). Other studies have successfully utilized this approach to estimate the duration of exclusive breastfeeding (57). The national level Demographic and Health Surveys (DHS) have therefore incorporated the 24-hour feeding recall method to obtain information on infant and child feeding practices (58). Using data from the DHS for 5 Latin American countries, age specific composite feeding index was created to examine the association between feeding practices and nutritional status (stunting) of children (59). Similar national level household surveys such as the National Health and Nutrition Examination Survey have also successfully used household interview generated information to assess the prevalence of exclusive breastfeeding among US infants (60).

Childhood immunization and nutritional status

Immunization against the six vaccine preventable diseases namely poliomyelitis, diphtheria, pertusis (whooping cough), tetanus, tuberculosis and measles has been recognized as one of the most cost effective intervention strategies to reduce childhood morbidity and mortality (61). Previous studies have confirmed the importance of childhood immunization for optimal nutritional status (62, 63). In the Bangladesh based study of children aged 12-23 months, nearly 51.0% of children without measles immunization, i.e. incomplete immunization were stunted, while underweight and wasting were prevalent among 76.0% and 48.0% children respectively (62). Non-immunized children also reported higher frequencies of morbidity and hospitalization in this study (62). Another study in Indonesia reported higher prevalence of severe underweight, stunting and anemia in non-immunized children compared to completely immunized children (63). Non-immunized children were 9 times more likely to suffer from frequent diarrheal episodes compared to their immunized counterparts (63). These studies imply that children who miss being completely immunized are at a higher risk of poor nutritional status from repeated morbidities due to lack of immunity against the vaccine preventable diseases.

<u>Overweight in under 5 years old children in developing countries</u>

With changing life-style and growing urbanization, there has been a rapid increase in health problems related to over nutrition such as overweight and obesity in developing countries worldwide (64- 66). As reported by a number of researchers, an increase in Gross Domestic Product (GNP) is associated with higher energy intake from sugars, animal and vegetable fats and decrease in the consumption of complex carbohydrates (64, 67, 68). Urbanization in developing countries is accompanied with an increased consumption of processed foods, shorter duration of breast feeding and early weaning (64, 66). These changes termed as 'nutrition transition' (64) has been one of the key factors leading to increased rates of obesity and overweight in both adults and children.

Analysis of national representative data from Brazil revealed the simultaneous decline of the prevalence of under nutrition in children and increase in adult obesity (69) indicating the changing trend from under nutrition to over nutrition in this population. Similar observations were made in Chile, where obesity prevalence increased among all age groups (70). Even in Asian countries such as China and India, though malnutrition is still widely prevalent, a noticeable decline of under nutrition in children clubbed with increasing obesity among adults was observed (56). In China, while increasing rates of obesity has been observed among adults irrespective of socioeconomic status and place of residence, this trend was observed among the urban adult and high-income rural population in India (66). A cross-sectional study in India, of children aged 9-15 years also reported an overall prevalence of obesity and overweight at 11.1% and 14.2% respectively (71). SES of the children's households was a significant predictor of obesity and overweight.

While the consequences of nutrition transition have been clearly manifested among adults (66) and adolescents (71), several studies now document this observation among pre-school children as well (72, 73). de Onis and Blössner (2000) examined data from national nutrition surveys of 94 developing countries and reported the prevalence, changing trend, and geographic distribution of overweight in children aged below 5 years (73). Although the prevalence of overweight in the studied children was fairly low

(3.3%), 16 countries showed an increasing trend. Another study by Savva et al (2005) performed on pre-school children from Cyprus showed that while there was a decrease in the rate of under-nutrition, obesity was on the rise (74), indicating the urgency of this health issue.

Lower maternal educational level, increased intake of total daily energy and inadequate physical activity were identified as determinants of childhood overweight in Latin America (75). A cross-sectional study carried out in the schools of India's capital city Delhi, found SES to be positively correlated with BMI as nearly 12.0% of children from high-income group schools were consuming energy dense foods as compared with 7.2% of children from low-income group schools (76). Similarly, an examination of stunting, underweight, overweight and obesity in Guatemala reported a higher prevalence of stunting in children from low socio-economic status, while overweight and obesity prevalence was significantly higher among children from affluent households (77). At the same time, a study in Cameroon showed that low SES and low maternal education were predisposing factors for preschool children to be stunted and overweight (78).

Although several national nutrition surveys have been conducted in developing countries, including India, health policies and programs have overlooked the creeping problem of overweight in children. There is a dearth of literature on the prevalence and determinants of overweight in children under 5 years in developing countries. There is limited information on the prevalence of overweight among Indian children, although several studies indicate that India is experiencing a paradigm shift in nutrition, specifically in urban areas (64, 79, 80). Griffith and Bentley (2005) evaluated the prevalence of overweight among urban women from the state of Karnataka, South India, indicating the growing burden of the problem (81). Country wide comparative studies focusing on overweight in children under 5 years are lacking, thus strengthening the need to delve into this area.

An overview of the Demographic and Health Survey

The Demographic and Health Surveys (DHS) are nationally-representative household surveys conducted by MEASURE DHS and funded by the U.S. Agency for International Development (USAID). These surveys collect information for indicators in the areas of population health and nutrition, usually every 5 years to understand the trends in these indicators. These surveys conducted in more than 85 developing countries provide information to policy makers for planning, monitoring and evaluating programs in these areas (58). The samples covered through DHS are representative at the national, residence (urban-rural) and the regional levels. A two-stage stratification method is used as the sampling frame. In the first stage, Enumeration Areas (EA) are drawn from Census files, from which households are randomly selected from an updated list (second stage) (58). For this dissertation work, DHS conducted in India (National Health and Family Survey) was used.

National Health and Family Survey: sample design and data collection

The National Health and Family Survey (NFHS), conducted in India was initiated by the Ministry of Health and Family Welfare (MOHFW), Government of India (GOI) in 1992-93 (82-84). The International Institute for Population Science, Mumbai has been the sole agency responsible for the implementation of these surveys. Information from the three available surveys (1992-93; 1998-99; 2005-06) has been used in this dissertation research. Details of the survey have been discussed below and important links provided in Table 2.1.

Survey design and data collection

The surveys obtained information from married women in the age-group 13-49 years from all 29 states (82- 84). Similar to the methods employed by DHS, samples for NFHS were collected through stratified cluster sampling process. Samples for each state were drawn separately from urban and rural areas that were proportionate to the state's urban and rural population (84). The rural sample was first selected from villages that comprised the Primary Sampling Units (PSUs), from which households were randomly selected (second stage). In contrast, a three-stage stratification sampling was followed in the urban areas. Urban wards were first selected from the Census file based on PPS, followed by a census enumeration block (CEB). In the final stage, households were randomly selected within each selected CEB (84). In order to adjust for differences in the probability of oversampling of cases, sampling weight (national women's weight) provided by NFHS (84) was incorporated during data analysis (Table 2.1).

Survey instruments

Questionnaire: Information on household characteristics, participant's demography and anthropometric indicators were collected through questionnaires (household, women and men). The household questionnaire collected demographic information of usual residents and any visitor present from the night before the survey and household infrastructure. In addition to these information women's questionnaires covered areas of reproductive and general health, nutrition, child immunization and utilization of government services (Table 2.1). The content of the men's questionnaire included similar questions on the women's questionnaire and additional questions administered to men only (Table 2.1).

Biomarker and anthropometric measurement: *T*he NFHS III survey collected anthropometric measurements of women and children younger than 5 years, while only children under 4 years were measured in NFHS I and II. During the second and third phase of the survey (NFHS 2 and 3), trained health investigators collected blood samples from women age 15-49, and children age 6-59 months. Hemoglobin levels were further assessed using HemoCue on the fields.   For this dissertation project we used information pertaining to mothers having an index child less than 5 years from all the 3 surveys (82-84).

Rationale, specific aims and hypothesis

This dissertation examines the different factors influencing the nutritional status of children less than 5 years of age in India at individual and household levels. While the prevalence of under nutrition and low birth weight remains high in the country (83), a noticeable increase in overweight has been observed among children (71, 85, 86). However, national and regional studies looking into the factors are lacking in the literature. The purpose of this dissertation is to identify the key factors contributing to both under nutrition and over nutrition among children aged below 5 years and poor pregnancy outcome. The conceptual framework of the different independent and dependent variables used in this dissertation research is presented in Figure 2.1.

The first specific aim is to examine the influence of maternal and household characteristics on pregnancy outcome and identify existing regional differences. Our hypothesis was that maternal socio-demographic characteristics and household conditions would vary within regions with a significant impact on pregnancy outcome. The results of this study have been reported in chapter 3.

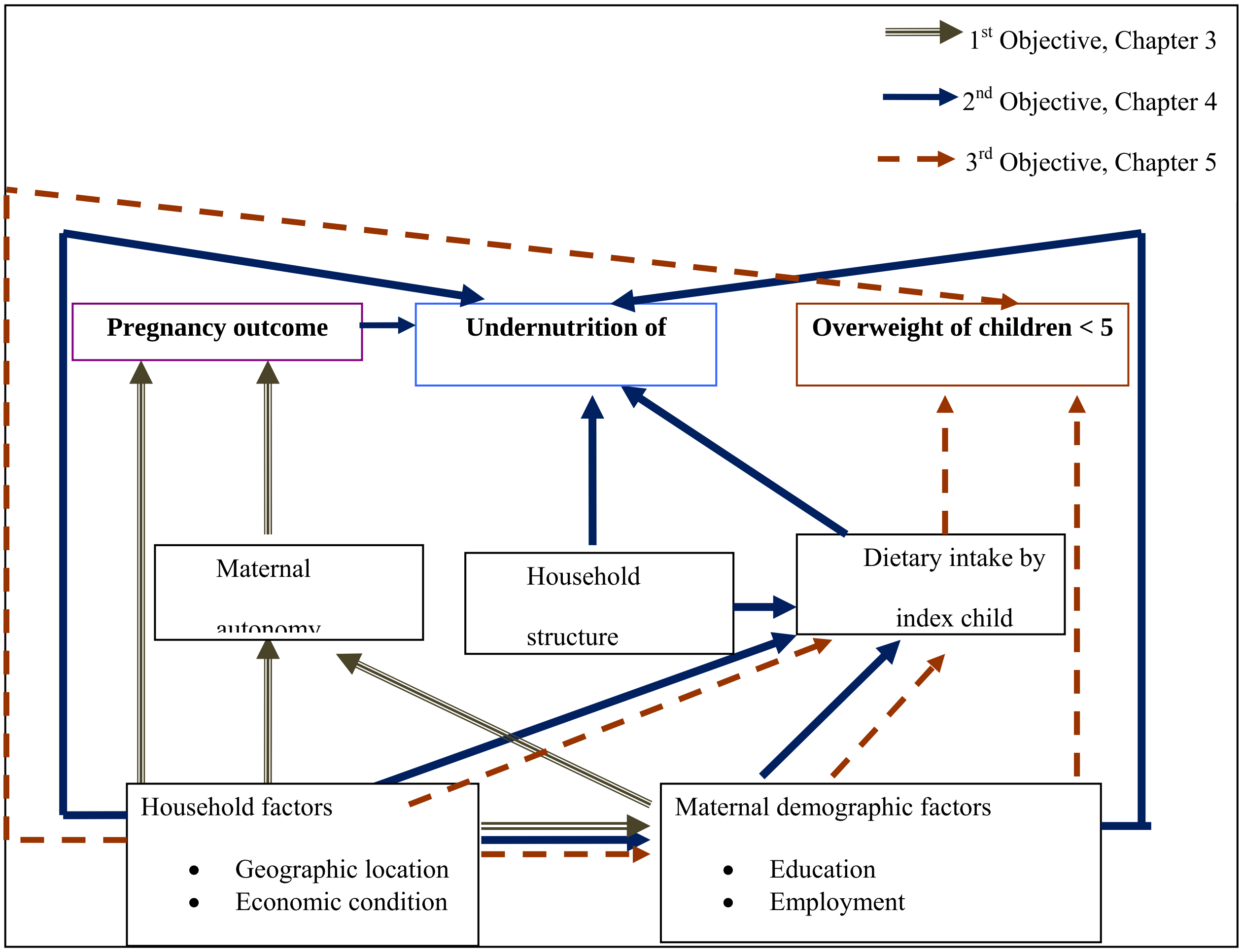
The second specific aim is to examine regional variation and individual (maternal) and household characteristics influencing undernutrition in children. It was hypothesized that regional cultural variation along with maternal, household and environmental characteristics would significantly influence nutritional status of children < 5 years. Results of this study have been reported in chapter 4.

The third study aimed to examine the prevalence of overweight among children aged below 5 years, existing trend between the 3 survey waves and the respective predictors. The hypothesis was that a noticeable increase in overweight prevalence would be observed across the survey waves. It was also hypothesized that maternal, child and household characteristics would influence the risk for childhood overweight. Chapter 5 documents the findings of the study addressing this specific aim.

Table 2.1: Links to DHS survey methodology and instruments

Title	Link
Overview of DHS methodology	http://www.measuredhs.com/aboutsurveys/dhs/methodology.cfm
DHS recode manual	http://www.measuredhs.com/pubs/pub_details.cfm?ID=739&srchTp=type
DHS methodology: biomarker assessment	http://www.measuredhs.com/pubs/pdf/DHSM7/DHS6_Biomarker_Manual_7Jun2011.pdf
Women survey questionnaire	http://www.measuredhs.com/pubs/pdf/DHSQ5/DHS5-Woman%27s-QRE-22-Aug-2008.pdf
Sample design and data collection: India	http://www.measuredhs.com/pubs/pdf/FRIND3/01Chapter01.pdf
DHS sampling weight	http://www.measuredhs.com/help/Datasets/sampling_weights.htm

Figure 2.1: Conceptual framework for examining the factors influencing nutritional status of children < 5 years in India.



The dependent variables included were pregnancy outcome (birth weight/birth size), undernutrition status and overweight in children. Independent variables included household factors, household structure, maternal socio-demographic factors, maternal autonomy and dietary intake by index child.

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CHAPTER 3

MATERNAL AUTONOMY AND LOW BIRTH WEIGHT IN INDIA[1]

[1] Chakraborty, P. and A.K. Anderson. 2011. *Journal of Women's Health*. 20:1373-82. Reprinted here with permission of publisher.

Abstract

Background: The prevalence of low birth weight (LBW) is a major public health issue in India (30.0%), and is the highest among South-Asian countries. Maternal autonomy or the mother's status in the household indicates her decision making power with respect to movement, finance, health care use and other household decisions. Autonomy of the mother is significantly associated with the child's nutritional status. Although previous studies in India reported the determinants of LBW, literature on the association between mother's autonomy and birth weight are lacking. This study therefore aims to examine the influence of maternal autonomy on birth weight of the newborn. Methods: The study, a secondary data analysis, examined data from the 2005-2006 National Health and Family Survey (NFHS-III) of India. A maternal autonomy score was created through proximal component factor analysis and categorized as high, medium and low autonomy levels. The main outcome variable included birth weight of the index child obtained from health cards and mother's recall. Descriptive and logistic regression analyses were performed. Results: Results from the study indicate that 20.0% of the index children included in the analysis was born LBW. Low maternal autonomy was one of the most important predictor of LBW (OR = 1.3, 95% CI = 1.1 – 1.5, p = 0.007), irrespective of socio-demographic and household characteristics, while medium autonomy level was not significant. Conclusion: These findings clearly indicate the importance of empowering women in India to combat the high incidence of LBW.

Introduction

The high prevalence of low birth weight (LBW) remains to be one of the most critical public health issues in developing countries, specifically South Asia. Of the total at term deliveries, 15.5% infants are born LBW worldwide (1). While the incidence of LBW in developing countries is 16.5%, nearly 27.0% of the newborns are LBW in South Asia, as compared to 15.0% in Africa and 6.0% in East Asia. Among the countries in South Asia, India along with Bangladesh has the highest reported cases of LBW (30.0%) (1).

Consequences of LBW are not limited to the individual child alone, but have detrimental effects on the society as a whole. It is one of the major determinants of neonatal mortality and morbidity and childhood growth retardation (2). Children born LBW may experience physical growth faltering, manifested as decreased body weight, height and head circumference when compared to normal weight infants (3). Additionally, studies show that LBW infants have poor academic performance during school age, and are at an increased risk of developing chronic diseases later in adult life (2,4). A strong association between fetal undernutrition, LBW and the development of insulin resistance and type 2 diabetes in later life has been observed among adult populations from Europe and USA (5,6). LBW is reported to be one of the potential risk factors for high systolic blood pressure and development of insulin resistance among Indian children (7). Examination of the relationship between birth weight and nutritional status of Vietnamese children aged below 5 years, found an increased risk of underweight, stunting and wasting among children born LBW compared to their counterparts born normal birth weight (> 2500.0 gram) (8).

Maternal characteristics such as nutritional status, age, education and socio-economic status have been associated with intrauterine growth and subsequent birth weight of an infant. Another important predictor of birth weight is utilization of prenatal care, which is influenced by women's autonomy and other cultural practices (2, 9, 10). Other studies have observed that a woman's autonomy influences her health behaviors, thus contributing to their overall health status (11). A study by Shroff and colleagues also observed an association between mother's autonomy and the nutritional status of her child (12).

The concept of women's autonomy has been defined in different ways by several authors. For example, Begin et al., captured the caregiver's autonomy through their decision-making authority, which they found to be negatively associated with stunting among their children (13). In the study by Smith et al., women's autonomy was defined by equality between men and women (14). The authors observed a positive influence of maternal autonomy on the overall nutrition of children from developing countries (14). Other key dimensions of women's autonomy reported in the scientific literature include decision-making authority in the household, freedom of movement, financial independence and attitude towards domestic violence (15-17). Using these individual domains of autonomy, Shroff et al., reported a significant increased risk of stunting among children of mothers with low autonomy in India (12). These studies mentioned above document the significant role women's autonomy play in the nutritional status of their children. However, to the best of our knowledge, studies examining the influence of autonomy as defined by a composite score on birth weight and birth size are limited.

Considering the magnitude of LBW prevalence, poor nutritional status of children as well as the regional distribution of these problems in India, there is a need to investigate the impact of women's autonomy on LBW deliveries in this population. In addition, Jejeebhoy and Sathar, have also reported disparity in autonomy of women from North and South India (16). Even though previous studies from India have explored the determinants of LBW (3,18,19) the literature is limited on the role of maternal autonomy and its subsequent influence on birth weight and birth size in this population. Also, we did not find any study that used a composite score with the different domains of autonomy as mentioned above to examine this association. The current study therefore aims to examine the association of maternal autonomy with birth outcome (i.e. birth weight and maternal perception of the infant's birth size) in India.

Methods

Study design and data

This study is a secondary data analysis of the recent wave of India's National Family Health Survey (NFHS 3) conducted in 2005-2006 (20). This nationally representative multi-stage household survey interviewed women in the reproductive age group (15-49 years) from the states of India, covering 124,285 women. Details about the data collection and sample stratification are reported elsewhere (20). To compare the regional prevalence of LBW deliveries, we divided the country into 5 regions- namely: North, East, North-East, South and Central-West regions (20). Prevalence of poor pregnancy outcome was also examined by place of residence (urban and rural) of the index children. For the purpose of this study, information pertaining to non-pregnant women with index child < 5 years (n = 34,300) from singleton births, with complete information on birth weight/birth size was extracted. The final analytical sample-sizes used in the present study were therefore 14,407 (40.8%) for measured birth weight and 33,881 (98.8%) for maternal perception of birth size.

Outcome measure

Pregnancy outcome of the respondents included in our analysis were determined with respect to the birth weight (grams) of the index child obtained from health cards (n = 2201; 15.3%) and mother's recall (n = 12206; 84.6%). We used the World Health Organization's (WHO) classification of LBW, i.e. birth weight less than 2500.0 grams, (1) to categorize it as either LBW or normal birth weight.

More than 50.0% of deliveries in India are non-institutional and infants are not weighed at birth (NFHS 3), leading to missing information on birth weight. To address the issue of missing information on birth weight, the use of 'mother's subjective assessment' of infant's birth size has been reported to be a reliable indicator (1). Reliability of using maternal perception of infant's birth size was examined using data from the Demographic and Health Surveys (DHS) of 15 countries (9). The study reported a strong association between mother's perception of birth size and birth weight (9). Similar studies from Pakistan also reported a consistent relationship between infant's birth weight and mother's assessment of birth size (11).

In the current study we observed a moderate association between infant's birth weight and mother's perception of birth size ($\kappa = 0.50$). The sensitivity and specificity values comparing mother's estimate of birth size as a measure of birth weight (N = 14,407) were 0.59 and 0.89 respectively, with a positive predictive value (PPV) of 0.54

(Table 3.1). We therefore used the mother's perception of the birth size of the infant in addition to birth weight to assess whether both measures have similar predictors.

Independent variables

The primary independent variable used in our analysis was maternal autonomy. Previous studies that have reported on women's autonomy used individual measures such as decision-making power of women in household activities, health seeking behavior, freedom of movement, financial independence and attitude towards wife beating or domestic violence to measure autonomy (16, 17, 23). Our autonomy score was created by use of individual autonomy measures selected through the principal component factor analysis (PCA) . The final variables used to define women's autonomy were participants' responses (1= respondent alone; 2= respondent and husband; 3= respondent and other; 4= husband or partner alone; 5= someone else; 6= other) to the following: "final say on own health care," "final say on making large household purchases," "final say on making purchases for daily needs" and "final say on visits to family or relatives." The reliability of using the above mentioned variables to compute maternal autonomy score was assessed by Cronbach's alpha ($\alpha = 0.80$). The autonomy score (range: 4.0-24.0) was categorized as high (score: 4.0- 7.0), medium (score: 8.0- 15.0) and low (score: 16.0-24.0) maternal autonomy. A similar autonomy score, based on these 4 dimensions was recently used by Acharya et al., to examine the influence of socio-demographic factors influencing autonomy of Nepali women (24).

Other covariates included in our analysis were socio-demographic and biomedical characteristics of the mothers along with their nutritional status and household characteristics. Maternal age, education, religion, caste/tribe and employment status were used to describe maternal socio-demographic characteristics. Utilization of prenatal care and parity captured the biomedical information pertaining to the participants included in our analysis. Maternal nutritional status was based on their Body Mass Index (BMI) obtained from the survey data sets. These were further used to categorize the mothers as underweight (BMI < 18.5 kg/m^2) and normal/overweight (BMI > 18.5 kg/m^2) according to the WHO classification.

Information on household characteristics obtained included place of residence (regions and rural/urban), sex of the household head and SES of the households. SES of the households was assessed based on the wealth index classifications used in NFHS III, as discussed elsewhere (20). The five categories of the given wealth index, ranging from 'poorest' to 'richest' were further categorized as 'poor,' 'middle' and 'rich' in the present study.

Statistical Analysis

The NFHS data sets were downloaded from Measure DHS,26 and analyzed using SPSS for windows version 16.0 (SPSS Inc, Chicago, IL). A sample weight (national women's weight) was used to adjust for oversampling and non-response from various places within the country. We used the measured birth weight data (N = 14,407) as the sample for descriptive and bivariate analysis. Prevalence of poor pregnancy outcome is reported as weighted percentages. Chi-square analyses were used to compare maternal and household characteristics by region of residence. Predictors of birth weight (LBW vs. normal) and birth size (small vs. average/large) were identified through weighted univariate and multivariate logistic regression. Factors associated with maternal autonomy were also examined using multivariate logistic regression. All results were considered significant if $p < 0.05$.

Results

Characteristics of study participants and households

The socio-demographic, biomedical and household characteristics of the participants from the five regions are presented in Table 3.2. Majority (> 60.0%) of the participants were aged between 20- 29 years, with a mean age of 25.9 ± 4.9 years. More than 70.0% of the participants were Hindu, while the remaining followed Islam, Christianity, Sikhism, Buddhism, Jainism and other minor religions (Zoroastrian and Doni-polo) or no religion. A significant regional difference was observed with respect to education levels and employment status of the participants (Table 3.2). The percentage of mothers with no formal education was highest in the East (23.7%) region compared to other regions. Participants not employed outside the homes also followed a similar trend (East: 83.0%). Biomedical characteristics of the participants were similar in the five regions (Table 3.2). Medical advice obtained for prenatal care was fairly similar in the five regions (data not shown). In terms of parity, nearly 60.0% of the participants were multiparous. Out of the 14407 households included in our analysis, nearly 90.0% were headed by male members. Majority of the households (80.0%) from the North region belonged to the highest socioeconomic category, while only 45.4% households in the East were in this category (Table 3.2).

Characteristics of mothers with low autonomy

Participants with low autonomy were younger in age (15- 19 years; 43.0%), followed Islam (28.8%) religion, have had no formal education (29.0%) and were not engaged in any form of employment outside the home (27.0%), as compared to participants with higher autonomy (Figure 3.1a). Furthermore, a significant association was observed between the nutritional status, i.e. underweight (BMI < 18.0 kg/m2) of participants and low autonomy ($p < 0.05$). A higher proportion of participants with low autonomy were from the North (28.6%) and East (32.7%) regions as compared to North-East (9.7%), South (22.5%) and Central-West (25.0%) regions. Nearly 30.0% of participants with low autonomy were of low SES (Figure 3.1b). There was also significant difference between the degrees of autonomy of participants with respect to the sex of the household head ($p < 0.05$). Among the female headed households, 26.3% of the mothers had a high autonomy in contrast to 19.1% from male headed households (Figure 3.1b). Interestingly, relationship of participants with the household head was significantly associated with their level of autonomy. Low autonomy was observed among participants who were either daughter-in-law (42.0%) or other relative (34.0%) of the household head, compared to wives (15.0%) or daughters (27.0%) of the household head.

Multiple logistic regressions examining factors associated with participant's autonomy are presented in Table 3.3. Socio-demographic and household characteristics of participants were significantly associated with their autonomy status (Table 3.3). For example, higher maternal age, education level, being employed and belonging to nuclear households improved their degree of autonomy. On the other hand, mothers who followed the Islam religion were more likely to be of low autonomy (OR = 1.21, 95% CI = 1.05- 1.40, $p = 0.008$) compared to their Hindu counterparts. In addition, mothers from the East region were more likely to have low autonomy, while those from the North east had higher autonomy compared to their counterparts from the North (Table 3.3). Nutritional status and utilization of prenatal care were other factors strongly associated with the level of autonomy of the mothers. Mothers with higher BMI normal/overweight) were almost 10.0% less likely to have low autonomy (Table 3.3).

Prevalence of poor pregnancy outcome

Although, the mean birth weight of index children included in our analysis was 2835.0 ± 666.4 g, nearly 20.0% of them were born LBW and were widely prevalent in the North region as compared to the other four regions ($p < 0.001$; Figure 3.2a). Nearly 27.0% of all pregnancies in the North resulted in LBW newborns, followed by Central-West (21.2%), East (20.04%), North- East (16.8%) and South (16.2%) regions. A similar trend was observed for the mother's perception of her newborn's birth size. There was also a significant ($p < 0.001$) difference in LBW prevalence among urban and rural areas (Figure 3.2b). In terms of the mother's perception of the newborn's birth size nearly equal proportions of the mothers perceived them as larger than average, average or small, irrespective of the place of residence (urban/rural; Figure 3.2b).

Predictors of low birth weight/size

Univariate logistic regression analysis was used to explore other covariates besides maternal autonomy that are associated with our outcomes of interest. Variables that came out significant were subsequently used in the multivariate analysis. Tables 3.4 and 3.5 present results from multivariate logistic regression analyses that examined the independent association of maternal autonomy on birth weight (Table 3.4) and birth size (Table 3.5). Our final multivariate models therefore contained all significant covariates in addition to maternal autonomy adjusting for important confounders.

In terms of infant's birth weight, low maternal autonomy significantly increased the risk of delivering a LBW infant (OR = 1.28; 95% CI: 1.07 to 1.53, $p = 0.007$; Table 3.4), compared to mothers with high autonomy, and was one of the most important predictors. However, there was no significant influence of mothers with medium autonomy on birth weight. Formal education in the secondary and higher (college) levels, belonging to higher SES household and good nutritional status of the mother remained to be protective against LBW (Table 3.4). Residing in any of the four regions, i.e. East, North-East, South and Central-West also reduced the odds of LBW by nearly 50.0% - 60.0% as compared to residing in the North. Among other risk factors, rural residence increased the odds of LBW delivery by 14.0%, in the presence of important covariates. Unlike the results from the univariate logistic regression analysis, religion of the mother had no independent association with the infant's birth weight (Table 3.4).

Similar to the observations for birth weight, low maternal autonomy remained a significant independent predictor for small birth size, as perceived by the mother, when controlled for maternal and household characteristics (OR = 1.28, 95% CI: 1.07 to 1.53, $p = 0.007$; Table 3.5). Here again we observed that mothers with formal education at the higher/college level had 30.0% reduced risks of delivering small infants. While religions such as Islam and Christianity had no significant association with the infant's birth size, those following other minor religions were more likely to report smaller birth size of the infant (OR = 1.40, 95% CI = 1.15- 1.70, p = 0.001; Table 3.5) compared to Hindu mothers. Other independent factors such as good nutritional status of the mothers, higher SES and regions of residence other than the North significantly reduced the risks of reporting small birth size of the infants. However, place of residence (urban/rural) was no longer significant in the multivariate model.

Discussion

The findings from this study confirm our hypothesis that low maternal autonomy is an important predictor of unfavorable birth outcome in terms of birth weight and mother’s perception of the birth size, in India. The composite score used to measure women’s autonomy in the present study unlike previous studies captured the different domains of autonomy in a single autonomy variable that influenced birth weight and birth size.

As observed in our study, mothers with low autonomy were more viable to risk factors for unfavorable birth outcome. In our study population, poor nutritional status or underweight, a critical factor for intra-uterine growth retardation and LBW, was most prevalent among women with low autonomy. Similar to this observation, other studies suggest that women who have low autonomy are more likely to be undernourished or suffer from chronic energy deficiency (27, 28). Dharmalingam et al., examined the data from NFHS 2 (1998-1999) and identified maternal nutritional status as one of the most important determinants influencing intra-uterine growth and therefore the infant’s birth weight (29). The recent review by Muthayya, also reports the influence of micronutrient and fatty acid deficiencies on inadequate weight gain during pregnancy and the incidence of LBW (30). It is therefore plausible women with low autonomy and poor nutritional status was at a higher risk of delivering LBW or small infants.

Utilization of prenatal care influences pregnancy outcome in terms of complications faced by the mother and the newborn’s birth weight (31). In the hospital based case-control study conducted in Ahmedabad, India, lack of prenatal care was a significant independent predictor of term LBW delivery (31). These results further confirm our findings, as use of prenatal care, an independent predictor of LBW was also strongly associated with maternal autonomy. Mistry, Galal and Lu, (32) reported that women with low autonomy were less likely to obtain prenatal care, that probably increased their risks of delivering LBW infants. Women with high autonomy or decision making power in the household were more likely to utilize prenatal care irrespective of the women's age, educational level and relationship to household head, (32) thereby confirming our study results.

Our findings about the socio-demographic and household characteristics of women with low autonomy are consistent with previous studies (16, 33, 34). In our study population, women with low autonomy had significantly less years of formal education, were unemployed and were from households with low SES, compared to women with medium or high autonomy. Similar observations were made in Sri Lanka, where education and employment in a paid work were significant contributors for achieving financial autonomy (33). Interestingly, education and employment were not significant contributors of social autonomy in Sri Lanka, which is in contrast to our finding. The study examined the predictors of financial and social autonomy independently (33) while we used a cumulative autonomy score (as previously discussed), which possibly contributed to the contrasting findings. Education and employment in paid work outside the home remained important predictors of women's autonomy and reproductive rights, specifically with contraceptive use in Oman indicating the importance of these demographic factors on women's status (34). Our findings also follow a similar trend as evident from the significant association of maternal socio-demographic characteristics and levels of autonomy.

Consistent with our results, previous studies have identified maternal education to be an important predictor of poor pregnancy outcome (2, 35). In the population based study in Quebec, lower levels of maternal education increased the risks of LBW and smaller birth size (small-for-gestation age) It is likely that women with lower levels of education practice unsuitable health habits and have poor economic conditions, during pregnancy that may influence fetal growth. In India, women with no formal education or those with lower levels of education are usually from lower SES households and rural areas (20) factors that limit their access to proper health care resources, thereby increasing their risk of having adverse birth outcomes. In addition, lower SES and rural residence were significant risk factors for LBW in this study population. These results are confirmed by meta-analysis results reported by Kramer (2) that documents the increased risk of delivering LBW infants in women from low SES households and/or those belonging to rural areas.

While religion of the mothers had no independent association with birth weight, those following minor religions (Sikh, Jain, Buddhist, Zoroastrian, Doni-polo and no religion) were 40.0% more likely to perceive their infant's birth size as small. However, due to the small sample size of this group (n = 954), it is difficult to draw any conclusions. In contrast to our observations, Sikh infants were reported to have a significantly larger birth size compared to Hindu infants born in Britain (36). In addition, an examination of birth weight of infants in North India reported that Sikh infants were 36.0 grams heavier than Hindu, Muslim or Christian (37). The differences in observations made in the current study could be attributed to the different religious groups (Hindu, Islam, Christian and others) included in our analysis.

Another important contribution of this study is the confirmation of mother's perception of infant's birth size is a reasonable proxy measure for birth weight in India. Similar to the observations made by Boerma et al., (21) in 15 developing countries, proportion of infants weighed at birth was only 40.3%, whereas 98.0% of mothers recalled their infant's birth size. The sensitivity or "the proportion of low-birth-weight children identified by the relative size-at-birth indicator", (21) between the two measures was 59.10%. In addition the PPV i.e. "the proportion of LBW children among those identified by the perceived birth size indicator," (21) was also nearly 54.0%. These values indicate that in the absence of measured birth weight, mother's perception of the infant's birth size is a reliable proxy measure for the birth weight. Moreover, maternal autonomy remained an important independent predictor of both birth weight and the relative birth size of the infant as reported by the mother, irrespective of maternal and household characteristics. These findings further suggest that in the absence of measured birth weight, maternal perception of birth size can be substituted in surveys and other health and nutrition need determinations. However, as majority of the birth weight were by mother's recall, there exist the potential for random misclassification, thereby limiting the reliability of this data. Moreover, facility based deliveries where the infant was measured at birth, could have influenced the mother's perception of the birth size. Thus these findings need to be interpreted with caution. As mentioned in the previous sections, a large proportion of subjects (48.8%) with missing information on birth weight were excluded from the analysis. Characteristics of subjects included and excluded from the analysis varied significantly for education level, SES, place of residence and autonomy level. It is also possible that the exclusion of those with missing data may have contributed to the observed prevalence of low birth weight (20.0%) in this sample that is lower than that previously reported for India (30.0%) (1).

Conclusion

Due to the cross-sectional nature of the data the results of this study need to be interpreted with caution. However, due to the large analytical sample size, results can be generalized to the Indian population. Moreover, the measure of maternal autonomy was derived from a composite score that included several domains of autonomy as previously discussed and adds to the study's strengths. There could be recall bias on participants reporting on decision making authority of mothers within the household because of the cross-sectional nature of the data collection if used individually limiting the reliability of this indicator.

Several national level programs in India, such as the Integrated Child Development Services (ICDS) scheme, focus on elevating the nutrition and health status of women through supplementary nutrition and prenatal council.[20] While this forms an essential component of maternal health care programs, results from our study suggests the need to include strategies to improve women's status in the society. Promotion of gender equality and women's empowerment through financial independence as contained in the Millennium Development Goals (MDG),[38] are means of improving women's autonomy. Empowerment programs in Andhra Pradesh, India supported by the World Bank and others such as the Bangladesh Rural Advancement Committee (BRAC) have considerably increased women's autonomy in domains such as mobility, economic security, involvement in household purchases and political and legal awareness.[39, 40] Our study results suggest that effective implementation of similar programs in India and other developing countries will not only impact women's own well-being but reduce the burden of LBW.

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Table 3.1: Statistical measures for accuracy of perceived birth size as indicators of birth weight

	Birth weight n (%); mean ± SD		Accuracy measures (%)			
Perceived birth size	Normal BW	LBW	Sensitivity	Specificity	PPV[a]	NPV[b]
Large/average	11002 (91.2); 3101.8 ± 513.3	1304 (47.3); 2066.3 ± 259.8	60.0	89.4	53.0	91.2
Smaller than average	1057 (8.8); 2803.5 ± 440.1	1451 (52.7); 1849.3 ± 384.8				

[a.] Positive predictive value

[b.] Negative predictive value

Table 3.2: Descriptive characteristics of the study participants and their households by regions

Characteristics	National estimate	Regions[a]					
	n = 14407	North n= 1495	East n= 2712	North-East n= 456	South n= 4822	Central-West n= 4922	p^b
Socio-demographic characteristics	n (%)						
Maternal age							< 0.001
15- 19	922(6.4)	16 (4.5)	275 (10.1)	21 (4.6)	274 (5.7)	285 (5.8)	
20-24	5168 (35.9)	472 (31.6)	1031 (38.0)	135 (29.6)	1752 (36.3)	1778 (36.1)	
25-29	5124 (35.6)	605 (40.5)	893 (32.9)	146 (32.0)	1688 (35.0)	1792 (36.4)	
30-34	2339 (16.2)	269 (18.0)	389 (14.3)	95 (20.8)	796 (16.5)	791 (16.1)	
35-39	689 (4.8)	66 (4.4)	101 (3.7)	48 (10.5)	244 (5.1)	230 (4.7)	
40+[c]	165 (1.1)	16 (1.1)	22 (0.8)	20 (2.4)	68 (1.4)	47 (0.8)	
Religion							< 0.001
Hindu	11562 (80.3)	1136 (76.0)	2309 (85.1)	327 (71.7)	3831 (79.4)	3959 (80.4)	
Muslim	1892 (13.1)	114 (7.6)	355 (13.1)	31 (6.8)	677 (14.0)	715 (14.5)	
Christian	442 (3.1)	7 (0.5)	22 (0.8)	78 (17.1)	302 (6.3)	34 (0.7)	
Other[d]	511 (3.5)	238 (15.9)	26 (1.0)	20 (4.4)	13 (0.3)	214 (4.3)	
Type of caste or tribe							< 0.001
Scheduled caste	2359 (16.4)	238 (16.2)	537 (20.6)	56 (13.6)	817 (17.5)	710 (14.5)	
Scheduled tribe	874 (6.1)	57 (3.9)	165 (6.3)	132 (32.1)	163 (3.5)	356 (7.3)	
Other backward class	5453 (37.9)	365 (24.8)	599 (23.0)	85 (20.7)	2714 (58.3)	1690 (34.6)	
None of them (general)	5340 (37.1)	811 (55.1)	1301 (50.0)	138 (33.6)	964 (20.7)	2126 (43.5)	
Education level							< 0.001
No education	2795 (19.4)	318 (21.3)	643 (23.7)	57 (12.5)	827 (17.2)	949 (19.3)	

Primary	1871 (13.0)	144 (9.6)	418 (15.4)	61 (13.4)	716 (14.9)	531 (10.8)	
Secondary	7682 (53.3)	701 (46.9)	1399 (51.6)	281 (61.6)	2595 (53.8)	2707 (55.0)	
Higher	2059 (14.3)	332 (22.2)	252 (9.3)	57 (12.5)	683 (14.2)	735 (14.9)	
Employed							
Yes	3654 (25.4)	319 (21.4)	462 (17.0)	107 (23.5)	1399 (29.1)	1367 (27.8)	< 0.001
No	10732 (74.5)	1174 (78.6)	2248 (83.0)	348 (76.5)	3416 (70.9)	3545 (72.2)	
Autonomy							< 0.001
High	2820 (19.6)	262 (17.7)	393 (14.8)	95 (21.4)	1044 (22.0)	1027 (21.1)	
Medium	7753 (53.8)	797 (53.7)	1401 (52.6)	305 (68.8)	2633 (55.5)	2617 (53.8)	
Low	3621 (25.1)	424 (28.6)	870 (32.7)	43 (9.7)	1069 (22.5)	1216 (25.0)	
Biomedical characteristics							
Prenatal care received							< 0.001
Yes	13891 (96.4)	1453 (97.2)	2529 (93.3)	435 (95.4)	4752 (98.7)	4721 (95.9)	
No	512 (3.6)	42 (2.8)	182 (6.7)	21 (4.6)	65 (1.3)	201 (4.1)	
Parity							< 0.001
Primiparous	5629 (39.1)	622 (41.6)	1215 (44.8)	226 (49.5)	1178 (36.9)	1789 (36.3)	
Multiparous	8778 (60.9)	874 (58.4)	1496 (55.2)	231 (50.5)	3044 (63.1)	3133 (63.7)	
Household characteristics							
Sex of HH head							< 0.001
Male	12858 (89.3)	1367 (91.4)	2374 (87.5)	396 (86.7)	4186 (86.8)	4536 (92.2)	
Female	1549 (10.7)	129 (8.6)	338 (12.5)	61 (13.3)	636 (13.2)	386 (7.8)	
Socio-economic status							
Poor	2960 (20.5)	113 (7.6)	951 (35.1)	78 (17.1)	886 (18.4)	932 (18.9)	< 0.001
Middle	2682 (18.6)	166 (11.1)	528 (19.5)	126 (27.6)	1164 (24.1)	698 (14.2)	
Rich	8765 (60.8)	1216 (81.3)	1232 (45.4)	253 (55.4)	2772 (57.5)	3292 (66.9)	

[a]. North: Jammu & Kashmir, Himachal Pradesh, Haryana, Punjab, Delhi, Uttar Pradesh, Uttaranchal; East: Bihar, Jharkhand, Chhattisgarh, West Bengal, Orissa; North-East:

Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura; South: Andhra Pradesh, Karnataka, Kerala, Tamil Nadu; Central-west: Maharashtra, Goa, Gujarat, Madhya Pradesh, Rajasthan.

[b]. Significant difference between maternal characteristics by region (χ^2 test)

[c]. Includes women aged 40–49 years.

[d]. Other religions: Sikh, Buddhist, Zoroastrian, Doni-polo, and no religion.

Table 3.3: Characteristics of women with low autonomy (n = 14,407)

Characteristics	n	Odds Ratio (95% CI)	*p*
Maternal characteristics			
Age			
15-19	922	1.00	
20-24	5168	0.79 (0.66- 0.94)	0.009
25-29	5124	0.53 (0.44- 0.64)	< 0.001
30-34	2339	0.45 (0.37- 0.56)	< 0.001
35-39	689	0.49 (0.36- 0.66)	< 0.001
40+	165	0.50 (0.30- 0.82)	0.007
Religion			
Hindu	11562		
Muslim	1892	1.18 (1.05- 1.40)	0.015
Christian	442	0.45 (0.30- 0.70)	< 0.001
Other[a]	511	0.92 (0.72- 1.16)	0.468
Education level			
No education	2795	1.00	
Primary	1871	0.80 (0.67- 0.93)	0.004
Secondary	7682	0.68 (0.60- .76)	0.001
Higher	2059	0.44 (0.37- 0.53)	< 0.001
Employed			
No	10732	1.00	
Yes	3654	0.84 (0.75- 0.93)	0.001
Maternal BMI			
Underweight	4117	1.00	
Normal/overweight	9711	0.89 (0.82- 0.98)	0.017
Prenatal care			
Yes	13891	1.00	
No	512	1.28 (1.02- 1.63)	0.04
Household characteristics			
Regions			
North	1495	1.00	
East	2712	1.24 (1.05- 1.50)	0.013
North east	456	0.38 (0.26- 0.57)	< 0.001
South	4822	1.03 (0.87- 1.22)	0.741
Central-west	4922	0.89 (0.76- 1.05)	0.167

Relationship to household head			
Head	407	1.00	< 0.001
Wife	7090	1.28 (0.83- 2.00)	0.264
Daughter	1573	1.32 (0.80- 2.20)	0.279
Daughter-in-law	4575	3.60 (2.31- 5.58)	0.001
Other[c]	762	3.05 (1.88- 4.94)	< 0.001

[a.] Other religions: Sikh, Jain, Buddhist, Zoroastrian, Doni-polo and no religion

[b.] Household SES was not significant in the multivariate model

[c.] Grandchild, parent, other relatives and domestic servants

Table 3.4: Predictors of birth weight (n = 14,407)

		Low birth weight			
Independent variables	n	Unadjusted Odds ratio (95% CI)	*p*	Adjusted Odds ratio (95% CI)	*p*
Maternal characteristics					
Autonomy					
High	2820	1.00		1.00	
Medium	7753	1.12 (1.03- 1.25)	0.040	1.05 (0.91- 1.30)	0.520
Low	3621	1.40 (1.22- 1.57)	0.001	1.28 (1.07- 1.53)	0.007
Education level					
No education	2795	1.00		1.00	
Primary	1871	0.95 (0.83- 1.09)	0.645	0.94 (0.78- 1.12)	0.510
Secondary	7682	0.70 (0.63- 0.78)	0.001	0.78 (0.67- 0.92)	0.003
Higher	2059	0.47 (0.41- 0.55)	0.001	0.48 (0.37- 0.64)	< 0.001
Religion					
Hindu	11562	1.00		1.00	
Muslim	1892	0.95 (0.84- 1.08)	0.461	0.87 (0.72- 1.07)	0.193
Christian	442	0.80 (0.62- 1.03)	0.086	0.93 (0.60- 1.45)	0.744
Other[c]	511	1.24 (1.01- 1.53)	0.041	1.23 (0.91- 1.66)	0.183
Prenatal care received					
Yes	13891	1.00		1.00	
No	512	2.01 (1.61- 2.45)	0.001	1.70 (1.32- 2.20)	< 0.001
Nutritional status					
Underweight	4117	1.00		1.00	
Normal/overweight	9711	0.67 (0.62- 0.74)	< 0.001	0.69 (0.61- 0.78)	< 0.001
Household characteristics					
Region					
North	1495	1.00		1.00	
East	2712	0.70 (0.60- 0.81)	0.001	0.50 (0.40- 0.63)	< 0.001
North- East	456	0.55 (0.42- 0.73)	0.001	0.38 (0.24- 0.61)	< 0.001
South	4822	0.53 (0.46- 0.61)	0.001	0.63 (0.52- 0.76)	< 0.001

Central-West	4922	0.74 (0.64-0.84)	0.001	0.48 (0.40- 0.58)	< 0.001
Place of residence					
Urban	6605	1.00		1.00	
Rural	7802	1.34 (1.24-1.46)	0.001	1.14 (1.01- 1.28)	0.033
Socio-economic status					
Low	2960	1.00		1.00	
Medium	2682	0.95 (0.84-1.07)	0.435	1.04 (0.90- 1.25)	0.630
High	8765	0.66 (0.60-0.74)	0.001	0.81 (0.52- 0.96)	0.014

CI, confidence interval.

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

[b]. Adjusted for maternal age, caste/tribe, marital status, birth interval, parity, sex of household head and relationship of respondent to household head.

[c.] Other religions: Sikh, Jain, Buddhist, Zoroastrian, Doni-polo and no religion

Hosmer & Lemeshow test: $\chi^2 = 6.54$, p= 0.60

Table 3.5: Predictors of perceived birth size (n = 33,881)

		Small birth size n = 34,300			
Independent variables	n	Unadjusted Odds ratio[a] (95% CI)	*p*	Adjusted Odds ratio[a] (95% CI)	*p*
Maternal characteristics					
Autonomy					
High	5757	1.00		1.00	
Medium	18158	1.23 (1.09- 1.40)	0.001	1.05 (0.91- 1.30)	0.520
Low	9785	1.48 (1.30- 1.71)	0.001	1.28 (1.07- 1.53)	0.007
Education level					
No education	15763	1.00		1.00	
Primary	4802	0.85 (0.78- 1.19)	0.205	1.00 (0.90- 1.10)	0.960
Secondary	11519	0.74 (0.66- 0.83)	0.001	0.94 (0.85- 1.03)	0.250
Higher	2216	0.46 (0.39- 0.54)	0.001	0.68 (0.55- 0.85)	0.001
Religion					
Hindu	27085	1.000		1.00	
Muslim	5540	0.99 (0.93- 1.07)	0.979	0.97 (0.88- 1.07)	0.623
Christian	721	0.70 (0.56- 0.86)	0.001	0.87 (0.61- 1.66)	0.356
Other[c]	954	1.20 (1.03- 1.40)	0.019	1.40 (1.15-1.70)	0.001
Prenatal care received					
Yes	26796	1.00		1.00	
No	7496	1.75 (1.40- 2.19)	0.001	1.02 (0.94- 1.07)	0.590
Nutritional status					
Underweight	13025	1.00		1.00	
Normal/overweight	19884	0.80 (0.75- 0.84)	< 0.001	0.86 (0.81- 0.93)	< 0.001
Household characteristics					
Region					
North	4386	1.00		1.00	
East	8560	0.89 (0.82- 0.97)	0.015	0.80 (0.72- 0.89)	< 0.001
North- East	1409	0.82 (0.71- 0.96)	0.011	0.75 (0.60- 0.93)	0.010
Central-West	13888	0.85 (0.78- 0.92)	0.001	0.82 (0.74- 0.91)	< 0.001

South	6057	0.67 (0.61- 0.74)	0.001	0.66 (0.58- 0.75)	< 0.001
Place of residence					
Urban	9455	1.00		1.00	
Rural	24845	1.24 (1.13- 1.35)	0.001	1.03 (0.94- 1.13)	0.463
Socio-economic status					
Low	15313	1.00		1.00	
Medium	6711	0.86 (0.80- 0.92)	0.001	0.87 (0.80- 0.96)	0.003
High	12277	0.67 (0.63- 0.72)	0.001	0.74 (0.67- 0.81)	< 0.001

CI, confidence interval.

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

[b]. Adjusted for maternal age, caste/tribe , marital status, birth interval, parity, sex of household head and relationship of respondent to household head.

[c]. Other religions: Sikh, Jain, Buddhist, Zoroastrian, Doni-polo and no religion

Hosmer & Lemeshow test: $\chi^2 = 5.34$, p= 0.72

Figure 3.1 a: Maternal autonomy by socio-demographic characteristics

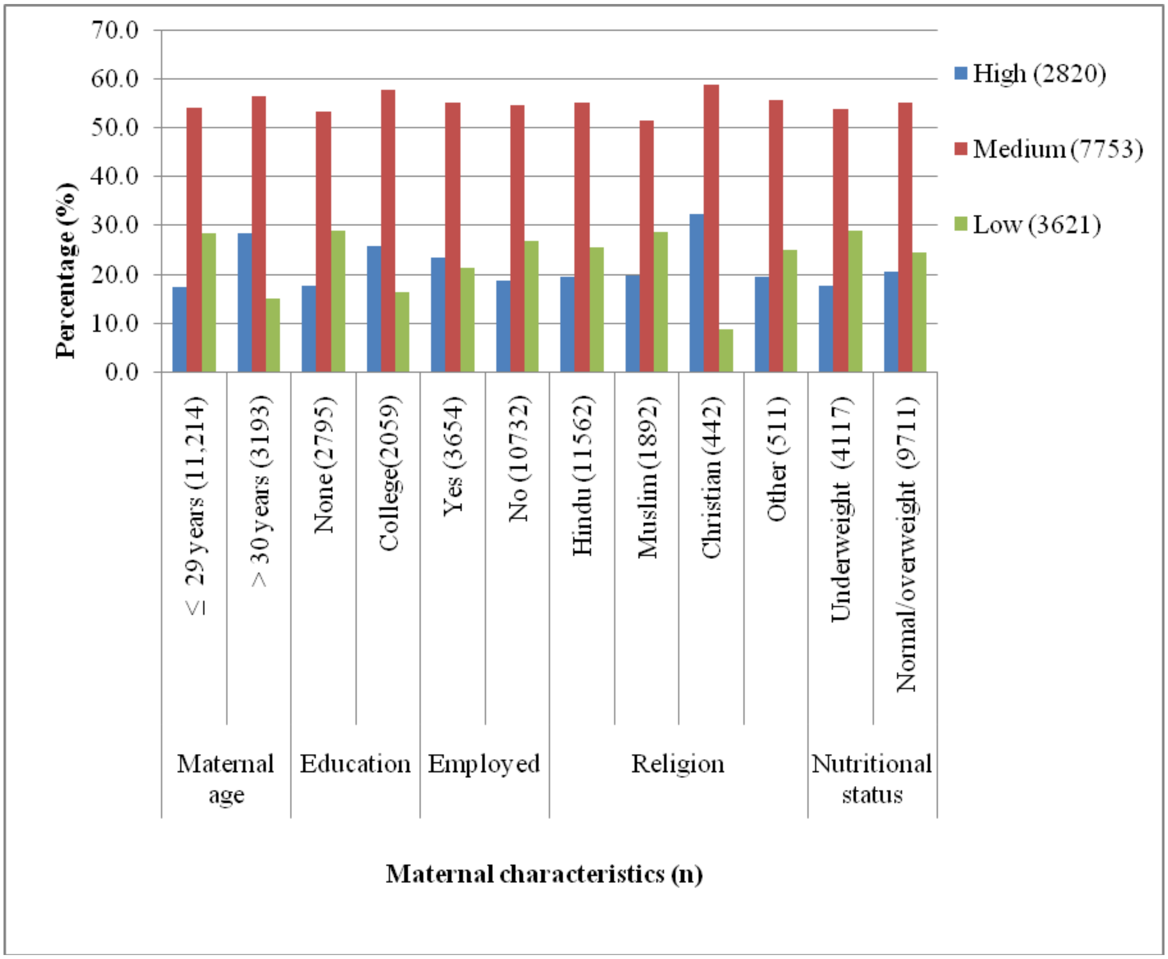


Figure 3.1 b: Maternal autonomy by household characteristics

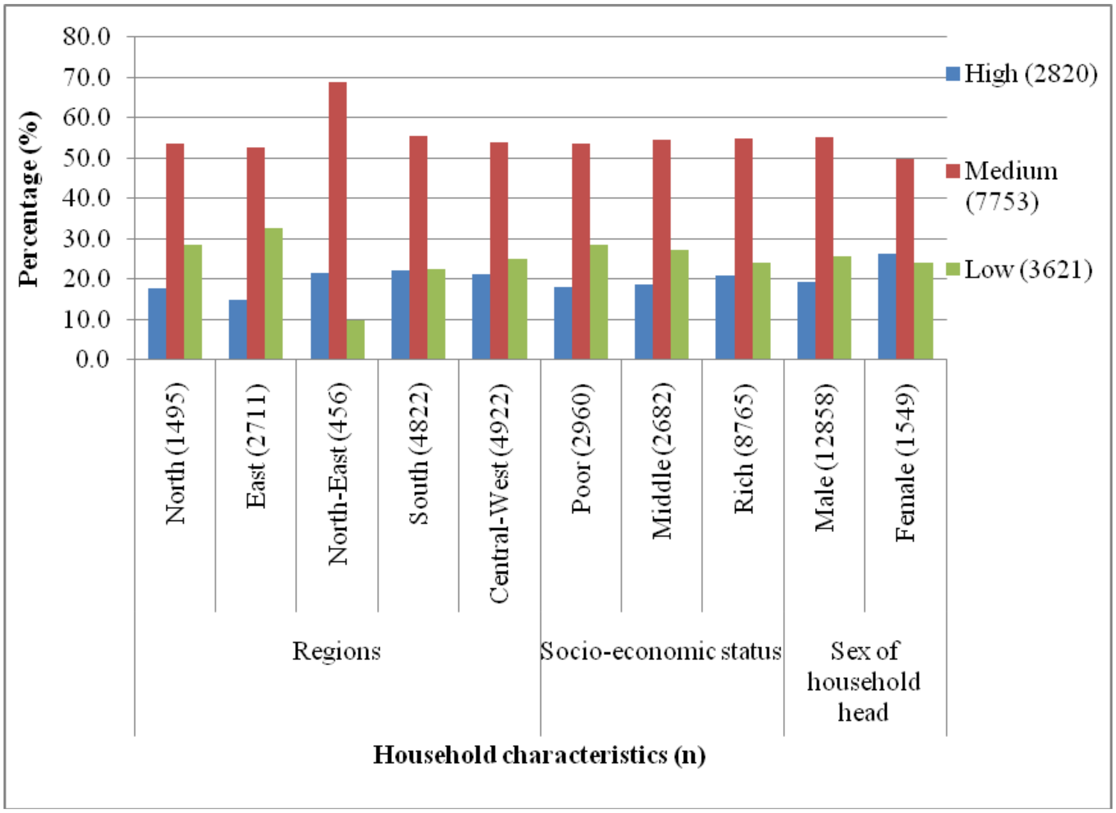
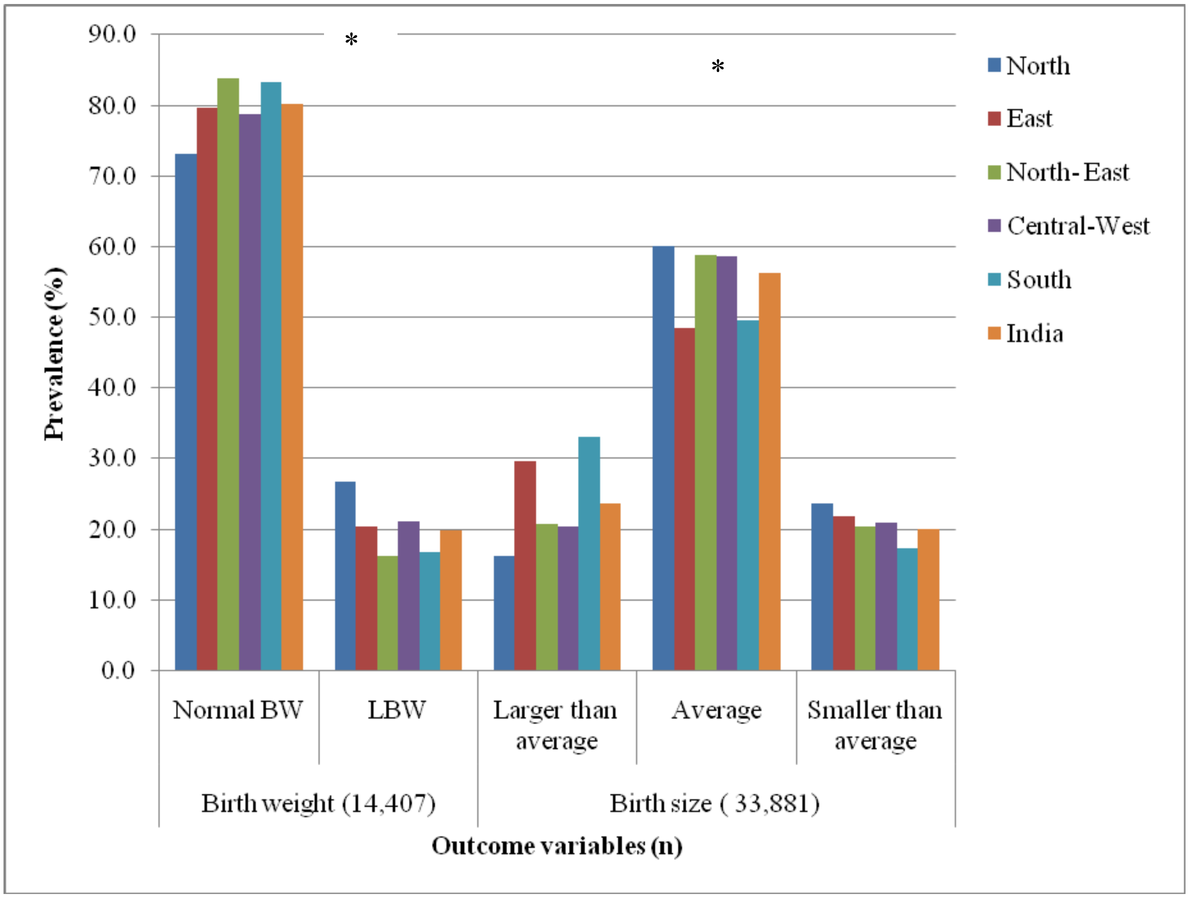


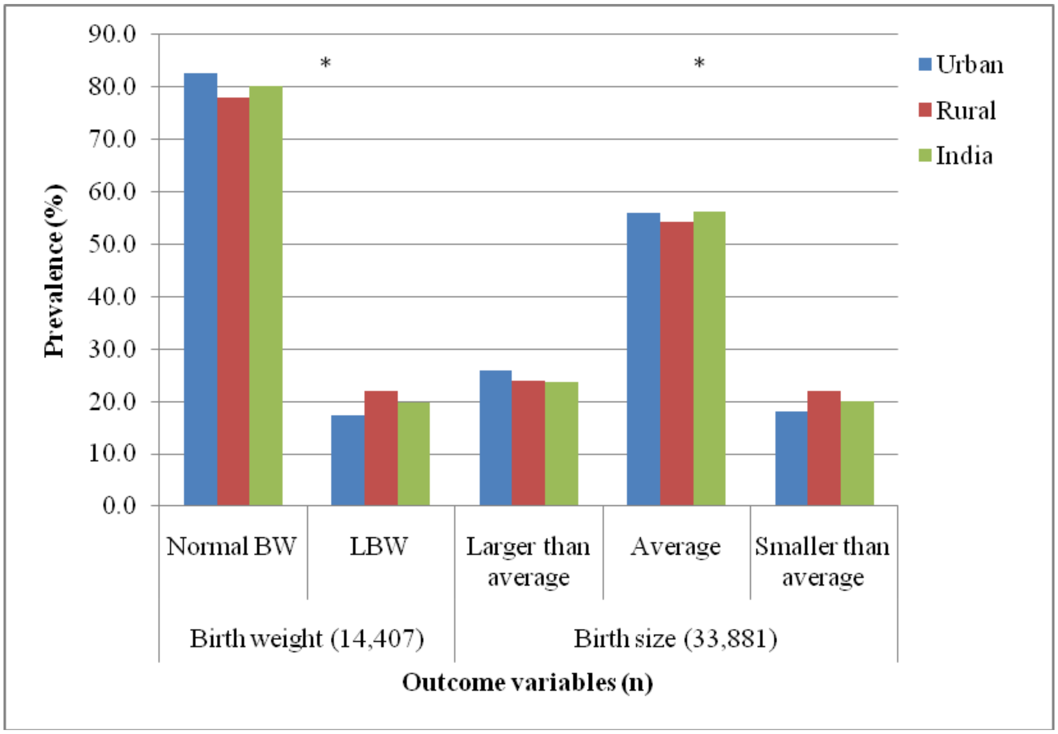
Figure 3.2 a: Prevalence of pregnancy outcome by region



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

*. Significant difference between pregnancy outcomes by region, $p < 0.001$ (χ^2 test)

Figure 3.2 b: Prevalence of pregnancy outcome by urban and rural areas



*. Significant difference between LBW prevalence by urban and rural areas, $p < 0.001$ (χ^2 test)

CHAPTER 4

HOUSEHOLD AND INDIVIDUAL FACTORS ASSOCIATED WITH UNDERNUTRITION OF CHILDREN < 3 YEARS FROM INDIA[1]

[1] Chakraborty, P. and A. K. Anderson. To be submitted to *Maternal & Child Nutrition.*

Abstract

This is a secondary data analysis using the National Health and Family Survey (NFHS) conducted between 1992 and 2006. The main aims of the study were to examine the prevalence and predictors of undernutrition in children aged 0-35 months in India. Childhood nutritional status was assessed using the WHO growth standards for height-for-age (HAZ), weight-for-age (WAZ) and weight-for-height (WHZ) and WHO recommended cut-off values for hemoglobin level. Weighted descriptive and ordinal logistic regression analyses were used. The proportional odds ratio for the associations between nutrition status and dependent variables was estimated suing the ordinal logistic regression. There was a notable decline in the prevalence of stunting and underweight between the first and last survey waves (1992- 2006), while prevalence of wasting remained almost unchanged. There was a slight increase in the prevalence of anemia between the second and third survey waves. Children from East and Central-west regions showed the highest prevalence of undernutrition. Our multivariate analysis showed that maternal illiteracy, employment, rural residence, socio-economic status and diet quality were significant independent predictors of undernutrition. Factors such as household structure and immunization status were not independent predictors in the multivariate analysis. However, significant interaction was observed between diet quality and immunization status for the indicators of undernutrition confirming the importance of up-to-date immunization for optimal nutritional status of children. Children residing in joint households with grandparents were also protected against chronic undernutrition, i.e. stunting. The results from this study confirm urban-rural and socio-economic disparity in

nutritional outcomes of children in India. Hence, the need for programs and policies to close these gaps in India.

Introduction

The nutritional status of children has been successfully assessed by the use of the anthropometric indices such as height and weight, and biomarkers such as hemoglobin (1, 2). Height and weight measurements have been used to derive indicators for undernutrition such as stunting (low height-for-age), wasting (low weight-for-height) and underweight (low weight-for-age). Stunting, the indicator of chronic undernutrition, may be due to extended food deprivation and/or illnesses, while wasting indicates acute or more recent undernutrition. Underweight on the other hand may reflect both chronic and acute undernutrition without making a definite distinction between them (3). Hemoglobin level, an indicator of iron nutriture is one of the most common biomarker used for population based assessment of iron status and iron deficiency anemia (2).

Undernutrition among young children is closely associated with lowered immune system (4) and incidence of infectious diseases (5), predisposing them to severe undernutrition and morbidity. It is also one of the leading causes of under-five mortality in developing countries (6). According to UNICEF, the basic underlying causes of undernutrition are dietary insufficiency and recurring infections. With decreased nutrient intake, immune system weakens resulting in further aggravation of the disease condition (7). Furthermore, undernourished children are at a higher risk of developing functional impairment in adult life, thereby negatively affecting economic productivity and the society as a whole (8).

National survey data from 22 developing countries reported an overall decrease of chronic undernutrition by 3.0% over the years (8). In spite of this, the overall prevalence of stunting (34.0%), underweight (23.0%) and wasting (13.0%) remains high (7). In addition, iron deficiency anemia afflicts more than 40.0% of pre-school children in developing countries and is deemed to be a severe public health problem (9). These statistics are evidence that undernutrition is a public health burden in these countries. While a number of countries in Asia are hard hit, the observed prevalence of underweight (16.0%) and stunting (48.0%) among children in India is one of the highest in this region (7).

Previous studies have examined the influence of socio-demographic factors on the nutritional status of children (10). Household income, parental educational level and dietary habits were major contributors of weight gain in children living in low-income area in Kolkata, India (10). Children from low socio-economic households were found to have twice the risk of being stunted than children from rich households in Ghana (11). A recent study from Northeastern Brazil reported a significant decline in child undernutrition by increasing years of maternal education, economic status and health care facilities (12). Studies have also demonstrated the influence of place of residence on the nutritional status of children (13). Shen et al. (1996) have observed that despite economic reforms in both rural and urban China, a higher percentage of rural children aged 2 to 5 years (38.0%) were stunted as compared with urban children (10%). Also, poor social and economic conditions for the child are important factors associated with the occurrence of anemia (14).

In addition, feeding practices have long been recognized as potential determinant of children's nutritional status (15). Inadequate intake of macro and micro-nutrients by children < 5 years were found to have a negative influence on their nutritional status (16, 17). Delayed initiation of breastfeeding and improper weaning practices have been identified as important dietary risk factors for undernutrition among children < 5 years (18).

Over the past years, India has witnessed few changes in feeding practices for infants and children. The National Family and Health Survey reports indicate that breastfeeding is universally practiced by more than 90.0% of Indian women (19- 21). However, breastfeeding initiation within the first hour of birth has remained relatively low (24.5%), in spite of its increase since the first survey wave (9.5%) (19- 21). Moreover, rates of exclusive breastfeeding for infants < 4 months have remained constant at around 50.0%. On the other hand it is of concern to note that more than 50.0% of infants at 6-9 months are fed liquids such as cow's milk but do not receive solid foods, thereby increasing their risks of nutritional deficiencies (19- 21).

The prevalence of undernutrition and the impact of socio-economic disparities (10, 22, 23) and feeding practices (24, 25) on children's nutritional status in India have been previously examined. Som et al. in 2007, examined factors influencing child stunting from 3 states of India, namely Bihar, Kerala and West Bengal and reported the influence of child feeding practices and maternal education on stunting (26). However, literature on the relationship between regional disparities, household characteristics, diet quality and undernutrition in India is limited. The current study therefore aims to examine the different predictors of undernutrition at the individual and household levels and the interplay between each of these predictors.

Methods

Study design and data

This study is a secondary data analysis of the third wave of India's National Family Health Survey (NFHS 3) conducted from 2005-2006 (20). This is a nationally representative multi-stage household survey that interviewed women in the reproductive age group (15-49 years) from the states of India, covering 124,285 women. Details about the data collection and sample stratification are reported elsewhere (20).

To compare the regional prevalence of childhood undernutrition (stunting, underweight, wasting and anemia), the country was divided into 5 geographical regions: North, East, North-East, South and Central-West regions (20). Prevalence of undernutrition was also examined by place of residence (urban and rural) of the index children. We also examined the trend in undernutrition prevalence over the three survey waves (NFHS 1-3) from 1992-2006.

Subjects

For the purpose of this study, information pertaining to non-pregnant women at the time of interview with a child < 5 years (index child) from singleton births, with complete anthropometric measurements (height and weight) was extracted. The final analytical sample-size for NFHS 3 and the pooled data (NFHS 1, 2 and 3) set were 19,918 and 53,834, respectively.

Outcome measure

The World Health Organization's (WHO) growth standards for children aged below 5 years were used to categorize their nutritional status (2). Height-for-age z-score was categorized as normal ($HAZ \geq -2.0$ SD), mild stunting (-2.0 SD $> HAZ \geq -3.0$ SD) and severe stunting (HAZ < -3.0 SD). Normal weight-for-age and weight-for height as z-scores ≥ -2.0 SD. Moderate underweight/wasting and severe underweight/wasting as -2.0 SD > WAZ/WHZ ≥ -3.0 SD and WAZ/WHZ < -3.0 SD, respectively. Hemoglobin level of the index child aged 6-35 months was categorized as severe anemia (Hb ≤ 7.0 g/dl), moderate/mild anemia (10.9 g/dl ≥ Hb > 7.0 g/dl) and non-anemic (Hb ≥ 11.0g/dl) (2).

Independent variables

Independent variables examined included socio-demographic characteristics, household characteristics, feeding practices and immunization status of the child. Variables on socio-demographic characteristics were maternal age, religion, education and employment status, and age and gender of the index child. Household characteristics examined were geographic location, i.e. urban/rural residents and region, socio-economic status (SES) and household type. For the purpose of this study we created several variables as discussed below:

Household socio-economic status (SES): We used the wealth indices, computed from household ownership of assets and housing characteristics (20) to categorize household SES as poor, medium and high.

Type of household: Household type was classified as nuclear and joint based on the mother's response. Nuclear households comprised of the index child living with parents and other siblings (if any), while joint households comprised of index child living with parents and/or siblings and other family members. We further categorized joint households as joint with child's grandparents/joint without child's grandparents with respect to the mother's relationship to the household head (daughter-in-law/daughter).

Diet Quality: Feeding practices were captured using variables describing the duration of the child being breastfed, frequency of receiving solid foods and foods received 24 hours prior to the survey. Foods received by the child were further grouped as protein (meat, beans, pulses, nuts, eggs, milk and milk products) rich foods, cereal and cereal products (porridge, bread and other grain products), fruits and vegetables (potatoes, tubers, green leafy vegetables, yellow or orange fruits and vegetables) and fats and oil. To assess overall diet quality we computed a score based on the different food group consumption and frequency of receiving these foods by the child as reported by the mother. The score (mean: 6.98 ± 4.62, range: 0 to 32) was further divided into tertiles and categorized as 'poor' = 0-5, 'medium' = 6-8 and 'good' = ≥ 9. Breastfeeding status was considered in computing the diet quality score for infants < 6 months. As per the mother's report, infants being breastfed and not consuming any other liquid/solid food items were identified as having good diet quality. Similarly, infants being breastfed and also consuming some liquid/solid foods were categorized as having a medium diet quality. Poor diet quality indicated not being breastfed but receiving other liquid/solid foods.

Immunization status: Information on immunizations received by the child was obtained from health card or mother's recall. A cumulative vaccine score (range: 0 to 9) was created based on whether the child had received the recommended vaccines till age 9 months. These are namely BCG (1 dose), Polio (4 doses), DPT (3 doses) and measles (1 dose) according to the National Immunization Schedule (27). The score was further categorized as 'up-to-date immunization,' 'some/incomplete immunization' and 'no immunization' taking into consideration the age of the child and vaccines received. For example, index child < 2 months and having received BCG and Polio (score = 2) was classified as having 'up-to-date immunization' status. Children (< 2 months) with a score = 1 were classified as having 'incomplete immunization' status and those with score = 0 as having 'no immunization.'

Statistical Analysis

The NFHS data sets were downloaded from Measure DHS (28), and analyzed using SPSS for windows version 16.0 (SPSS Inc, Chicago, IL). A sample weight (national women's weight) was used to adjust for oversampling and non-response from various places within the country. Descriptive characteristics are reported as weighted percentage, means and standard deviations. Prevalence of undernutrition is reported as weighted percentages. Bivariate comparisons of undernutrition prevalence, feeding practices and immunization coverage by regions were examined with chi-square tests. The nutritional status of the children was grouped into 3 ordinal categories namely normal, mildly undernourished (mild stunting, underweight, wasting and anemia) and severely undernourished (severe stunting, underweight, wasting and anemia). To examine the predictors of nutritional status we used the proportional odds model (ordinal logistic regression analyses). The normal height-for-age, weight-for-age, weight-for-height and hemoglobin categories were used as the reference categories in the ordinal logistic regression analysis. Variables that came up significant in the univariate analyses were further examined in the multivariate models to determine the independent influence of the variable on nutritional status, after adjusting for other important covariates. The correlation between birth weight and the nutrition indicators was weak and explained only about 5.0% of the variability for each of them. The individual correlation coefficient between birth weight and the four indicators are as follows: HAZ:r = 0.16, $p < 0.001$, WAZ: r = 0.25, $p < 0.001$, WHZ: r = 0.15, $p < 0.001$ and hemoglobin level: r = 0.05, $p < 0.001$. However, based on previous studies indicating the influence of birth weight on nutrition indicators, the multivariable models were adjusted for this covariate. We also examined interactions between several independent variables in the multivariate model. All results were considered significant if $p < 0.05$.

Results

Characteristics of study participants and households from NFHS 3

Descriptive characteristics of the participants and their households are presented in Table 4.1. More than 60.0% of the mothers were aged between 20- 29 years, with a mean age of 25.7 ± 5.3 years. Nearly 80.0% of the mothers were Hindu, while the remaining belonged to Muslim, Christian, Sikh and other minor religions (Buddhist, Jain, Zoroastrian, Doni-polo and no religion). With respect to education levels, a greater proportion (47.6%) of the mothers had no formal education, while only 5.7% had received higher or college education (Table 4.1). The mean age of the index children included in the analysis for height and weight indicators was 16.18 ± 9.7 months (range: 0 to 35 months) while mean age of children examined for anemia was 18.80 ± 8.50 months (range: 6-35 months). Notable characteristic of the households were that majority (75.3%) were resided in rural areas. Nearly 47.0% of the households were of low socio-economic status while the remaining were either middle income (19.6%) or high income (33.8%) households. Household structures included nuclear and joint families with/without the child's grandparents (Table 4.1). Also, 90.0% of the households were headed by a male member.

Nutritional status of children aged 0- 35 months: NFHS 1-3

The three survey waves of NFHS were used to assess the trend of undernutrition (stunting, underweight, wasting) prevalence over the years. The prevalence of child undernutrition significantly varied in the three survey waves (Figure 4.1; $p < 0.001$). There was a notable decline in the prevalence of stunting and underweight between NFHS 1 (1992-1993) and NFHS 3 (2005-2006). While 43.0% of the children were stunted in NFHS 3, it was as high as 50.0% in NFHS 1. A 7.0% decline in underweight was also observed across the three survey waves. However, prevalence of wasting was almost similar for NFHS 1 (25.7%) and 3 (24.2%), with a slight decline (21.1%) for NFHS 2. There was a slight increase in mild/moderate anemia prevalence between NFHS 2 (65.4%) and NFHS 3 (75.6%) while severe anemia prevalence decreased from 4.8% to 3.6% during the two survey waves. Hemoglobin levels for children were not measured in NFHS 1.

Distribution of the nutritional status of index children from the third survey wave (NFHS 3) by regions and urban/rural residence is presented in Figure 4.2 (a- d). The mean z-scores for HAZ, WAZ and WHZ and hemoglobin level were lower among rural children compared to their urban counterparts (Figure 4.2 a-d). Children from Central-west rural areas had the lowest HAZ scores while the mean z-scores for WAZ and WHZ was lowest for rural East region compared to children from rural areas of the other regions (Figures 4.2a- 3c). Also with respect to hemoglobin level, children from Central-west rural areas had the lowest level, while it was observed to be highest among children from urban East and North east regions (Figure 4.2d). We observed a significant regional difference in the prevalence of undernutrition (Table 4.2). The prevalence of mild stunting (24.7%) and severe stunting (22.8%) were profound in the East and Central-west regions respectively ($p < 0.001$; Table 4.2) as compared to North, North east and South regions. Also, a higher proportion of children from East region were severely underweight (19.0%) and wasted (9.4%). In contrast, the highest prevalence of severe anemia was observed in North (5.9%) and Central-west (4.1%) regions (Table 4.2). However, children from the South region had better nutritional status, compared to their counterparts from the other regions (Table 4.2). Undernutrition prevalence in some states was higher than others. The highest prevalence of undernutrition, i.e. stunting (46.2%), underweight (54.0%), wasting (34.6%) and anemia (88.0%) were observed in Bihar (East). Other states with poor growth indicators were Jharkhand and Chhattisgarh in the East and Madhya Pradesh in the Central west regions (data not shown). In contrast, more than 70.0% of children were of normal height-for-age category in Sikkim (71.3%) and Manipur (74.4%) in the North east, Goa (77.0%) in the Central west and Kerala (72.0%) in the South. Majority of children of normal weight-for-age and weight-for-height were from the states of Sikkim (83.3% and 86.3%), Mizoram (85.5% and 88.6%), Manipur (82.3% and 88.6%), Goa (81.1% and 87.1%) and Kerala (77.5% and 83.3%). In addition, non-anemic children belonged to Manipur (46.0%), Mizoram (44.0%), Goa (50.0%), and Kerala (43.2%).

Characteristics of children with poor nutritional status

The results of chi-square tests examining the different characteristics of children with normal, low and very low HAZ, WAZ and WHZ scores are presented in Table 4.3.

As shown in Table 4.3, higher proportions of children aged 13-24 months had poor indicators for all the three categories status compared to children in the other age groups ($p < 0.001$). The prevalence of undernutrition was also more pronounced among male children (> 50.0%) compared to their female counterparts. Results from the chi-square test also showed a significant association ($p < 0.001$) between maternal socio-demographic characteristics (age, religion, education level and employment status) and the different nutrition indicators (Table 4.3).

Household characteristics such as socio-economic status (SES) and household type also had significant association with each of the nutrition indicators (Table 4.3). Majority (> 50.0%) of the mildly undernourished or severely undernourished (59.0% - 69.0%) children were from households with poor SES ($p < 0.001$; Table 4.3). Among the three types of households (nuclear, joint with/without grandparents), children from nuclear families were more likely to be undernourished compared to those from joint family households (Table 4.3). The characteristics of children with normal hemoglobin level, and mild/moderate and severe anemia were similar to our above observations (Appendix A).

The associations between feeding practices and nutritional status of the index child are presented in Table 4. A sub-analysis of infant feeding practices for index children < 6 months of age revealed no significant association between breast feeding practices (exclusive breastfeeding and BF on demand) with their current nutritional status (data not shown). The quality of the child's diet, and consuming the following: protein rich foods (animal and plant proteins), fruits and vegetables, cereals and fats and oils were all significantly associated with the child's nutritional status (Table 4.4). A very high prevalence of severe underweight (77.0%) and severe wasting (84.0%) were observed among children whose mothers reported did not consume any protein rich foods compared to children who received animal and/or plant proteins. Higher prevalence of poor nutrition status was also noted among children not fed fruits and vegetables and fats and oils according to mothers report. Contrast to this, prevalence of undernutrition was higher among children who received cereals and cereal based products compared to children who did not consume this food group (Table 4.4). Prevalence of undernutrition was significantly higher among children fed a diet of poor quality compared to their counterparts who were reported to consume a diet of good quality (Table 4.4). Similarly, prevalence of mild/moderate and severe anemia were lower among children fed protein rich foods and diet of good quality. However, children consuming cereals and related products were more likely to be anemic (Figure 4.3).

Immunization status was significantly associated with the nutritional indicators examined ($p < 0.001$). Children with incomplete/some immunization or no immunization were significantly undernourished, compared to children with up-to-date immunization (Figure 4.4). Prevalence of stunting, underweight, wasting and anemia were 36.1%, 31.0%, 17.7% and 73.2% respectively, among children with up-to-date immunization. In contrast, 41.2%, 42.0%, 30.0% and 82.5% of the children with no immunization were either stunted, underweight, wasted or anemic, respectively (Figure 4.4).

Feeding practices and immunization coverage by region and state

We observed significant regional differences between feeding practice and immunization status of children ($p < 0.001$). Percentage of children receiving diets of good quality was highest in the East (51.2%) and South (50.0%) regions, followed by

North east (45.6%), Central-west (40.0%) and North (37.8%). However, only 20.0% of children in the East region had received up-to-date immunization, compared to 53.4% in the South. Up-to-date immunization rates in the North, North east and Central west regions were 27.2%, 17.0% and 22.1% respectively. From examination of the individual states, we observed that percentage of children receiving a diet of good quality was lowest in the Eastern states of Jharkhand (39.2%) and Bihar (49.1%) and Central-west state of Madhya Pradesh (41.0%). In contrast, Kerala (83.4%) and Goa (77.4%) had the highest proportion of children receiving good diet quality. More than 50.0% of children in Sikkim (43.0%), Manipur and Mizoram in the North east were reported to consume a diet of good quality. With respect to immunization status, nearly 72.0% of children in Kerala and Goa had received up-to-date immunization. This was relatively lower in Sikkim (43.0%) and Mizoram (23.2%) in the North east and lowest in Bihar (10.6%).

Determinants of nutritional status

Univariate ordinal logistic regression: The results of univariate ordinal logistic regression examining the determinants of nutritional status of children are presented in Table 4.5. Maternal socio-demographic characteristics, household features and feeding practices were significantly associated with the three indicators of nutritional status. Unlike the results from our chi-square analysis (Table 4.3), maternal age between 20-29 years was an important determinant of normal nutritional status. Children whose mothers reported being Christian, Sikh and Jain were more likely, while those of mothers following other religions were less likely to be of normal height-for-age compared to children of mothers practicing Hinduism (Table 4.5). With respect to underweight and wasting, Sikh children were more likely to have normal weight-for-age (OR = 2.46, 95%

CI = 1.85- 3.28, $p < 0.001$) and weight-for-height (OR = 2.42, 95% CI = 1.67- 3.49, $p < 0.001$). Furthermore, Christian and Jain children were more likely to have normal hemoglobin level compared to children of Hindu mothers. Similar to the findings from the bivariate analysis (Table 4.3), children of mothers with higher than secondary education, were nearly 50.0% more likely to have normal nutritional indicators (Table 4.5). Interestingly, children of mothers employed in income generating services were less likely to have a normal nutritional status compared to children of mothers who were employed.

We observed significant associations between the geographic location of household resident (region and urban or rural areas), household SES and structure, and the nutritional status of the index child (Table 4.5). Children from rural households were less likely to have normal indicators for nutrition status (Table 4.5). Among the five regions, children from the South had higher probability of being well nourished, i.e. had normal nutrition indicators, as compared to children from North regions. In addition, children from North-East region were also more likely to be non-anemic, as compared to children from North region. Higher SES household was a significant determinant of normal nutritional status, compared to middle and low SES households (Table 4.5). While joint households had a protective effect on the child's nutritional status as compared to nuclear households, joint households with the child's grandparents had a higher odds of having children with normal height-for-age (OR = 1.48; 95% CI = 1.39- 1.58; $p < 0.001$), weight-for-age (OR = 1.46, 95% CI = 1.37- 1.56, $p < 0.001$) ,weight-for-height (OR = 1.19, 95% CI = 1.10- 1.28, $p < 0.001$) and hemoglobin level (OR =

1.25; 95% CI = 1.16- 1.35, $p < 0.001$) compared to nuclear or joint households without the grandparents (Table 4.5).

Children whose diet included food groups such as protein foods, fruits and vegetables, fats and oils had increased likelihood of being of normal nutritional status compared to those not receiving these food groups (Table 4.5). On the other hand, cereals and cereal products intake had a negative association with height-for-age (OR = 1.09; 95% CI = 1.01- 1.19; $p < 0.031$) and hemoglobin level (OR = 1.55; 95% CI = 1.40- 1.72, $p < 0.001$) of the index child. However, not including them in the diet decreased the odds of the child having a normal weight-for-age (OR = 0.81; 95% CI = 0.75- 0.88; $p < 0.001$) and weight-for-height (OR =0.87; 95% CI = 0.79- 0.95; $p < 0.001$) significantly (Table4.5). As expected, the nutritional status of the index child was positively associated with good diet quality (Table 4.5). Having received up-to-date or some immunization significantly increased the odds of being of normal nutritional status compared to no immunization for the four indicators (Table 4.5).

Multivariate ordinal logistic regression: The significant variables from Table 4.5 were included in the final models to examine the independent predictors for stunting, underweight, wasting and anemia in the study population (Tables 4.6- 4.9). The models were adjusted for important covariates such as maternal age, religion, age and gender of the index child. In the model examining independent predictors of stunting, maternal socio-demographic and household characteristics such as employment status, household structure and region of residence were not significant predictors. Household SES was positively associated with height-for-age, by more than doubling the odds of having normal linear growth for children belonging to high SES households. Moreover, children from rural households were less likely to have normal height-for-age (OR = 0.84; 95% CI = 0.74- 0.96, p = 0.006) than children from urban households (Table 4.6). Diet quality of the child also remained an important significant predictor in the final model for height-for-age when controlled for important covariates (Table 4.6). It was interesting to note that significant association of immunization status with stunting occurred when interacted with diet quality. Children with an up-to-date immunization status but receiving diets of medium (OR = 5.32, 95% CI = 1.85- 15.28, p = 0.002) quality were more likely to have normal linear growth than children with no immunization and receiving good diet quality. Although, household structure had no independent association with stunting, children form joint households with grandparents present and reported consuming quality diet increased their odds of having a normal linear growth (Table 4.6). Although, household SES was a significant main effect for normal linear growth, children from high SES household but consuming a diet of medium quality had a reduced odds of having a normal height-for-age (OR = 0.38, 95% CI = 0.21- 0.71, p = 0.002; Table 6).

Independent predictors of underweight in children were household SES, and diet quality, in the presence of other important covariates (Table 4.7). While maternal education and regional residence had no independent association with underweight, there was a strong interaction effect between the two factors. Children belonging to households in the East and having mothers with no education were at lower odds of normal weight-for-age (OR = 0.33, 95% CI = 0.13- 0.85, p = 0.021; Table 4.7). Other significant interactions were between diet quality (good quality) and Central-west region that significantly increased the likelihood of normal weight (Table 4.7).

In the multivariate model examining the determinants of wasting, regional location of the household, SES and diet quality were the significant independent predictors. Residents of the East region were less likely to have normal weight children (OR = 0.50, 95% CI = 0.33- 0.77, p = 0.001, Table 4.8). In addition, households with high SES had the highest probability of having normal weight children (Table 4.8). As observed for the other indicator, here again children receiving good quality diets were more likely to have normal weight (OR = 2.51, 95% CI = 1.38- 3.14; p = 0.033). Although immunization status did not influence weight status independently, its interaction with diet quality was significant (Table 4.8). Based on the interaction effects we observed that children who although had received a diet of poor quality but up-to-date on their immunization (OR = 2.17, 95% CI = 1.05- 4.50, p = 0.037) were more likely to be normal weight-for-height compared to children who received diet of good quality but were not up-to-date on their immunization. Interaction between household SES and maternal education also influenced normal weight status. Children of mothers with only primary education and from households with high SES were at a higher risk of being wasted compared to children of more educated mothers (Table 4.8).

The Independent predictors of anemia in children were maternal education level, household SES and diet quality in the presence of other important covariates (Table 4.9). Children of mothers with primary or no formal education were less likely to have normal hemoglobin levels compared to children of educated mothers (Table 4.9). In addition, belonging to high SES households significantly increased the odds of being non-anemic (OR = 1.96; 95% CI = 1.31- 2.94, p = 0.001). Moreover, having received a medium quality diet but from a household with medium SES increased the odds of being non-anemic (OR = 1.92; 95% CI = 1.03- -2.88, *p* = 0.0082), indicating the importance of both diet quality and SES on anemia prevention. Surprisingly, children from households in the East region and receiving poor quality diet were protected from anemia compared to children from the other regions (OR = 1.71; 95% CI = 1.03- 2.84, *p* = 0.038, Table 4.9). We also observed a significant association between immunization status and anemia and their interaction with the quality of the child's diet. Children with an up-to-date immunization status but receiving diets of poor (OR = 2.32, 95% CI = 1.01- 5.34, *p* = 0.047) quality were more likely to be non-anemic than children with no immunization and receiving good quality diet. It was interesting to note that children with some immunization and also receiving medium quality diet were associated with three times the odds of having normal hemoglobin level (Table 4.9).

Discussion

The current study examined the different factors associated with nutritional status of children aged < 3 years from India. Results from our study confirm that undernutrition prevalence; in terms of stunting, underweight, wasting and iron deficiency anemia continue to be high in spite of the steady increase in Gross Domestic Product (GDP) over the past three decades (29). According to the WHO, anemia prevalence greater than 40.0% is a significant public health problem and iron-deficiency is the most probable cause (2). In this study, nearly 80.0% of children aged less than 3 years were found to be anemic according to their hemoglobin values. Interestingly, we also observed an increase in anemia prevalence among children between NFHS 2 and 3. In both surveys waves, similar methods for data collection were used except for Nagaland in the Northeast Region where blood hemoglobin levels were not assessed in NFHS 3. However, the small sample size from Nagaland, and its exclusion from the survey could not have contributed to the increased prevalence of anemia in NFHS 3. Future time trend studies for different sub-groups are necessary to identify the cause of increased anemia prevalence in NFHS 3.

In addition to iron-deficiency anemia, 42.4 %, 39.7 % and 23.7 % children were stunted, underweight and wasted, respectively. These results clearly show the graveness of the undernutrition situation during early childhood in India. The vast rural-urban disparity in undernutrition prevalence in India confirmed by our results, shows that rural children continue to be at an increased risk of undernutrition compared to their urban counterparts (22). Results of this study show that children from the East and Central-west regions are more likely to be wasted, but surprisingly those from the East region and also receiving poor quality diet were less likely to be anemic (Hb < 11.0 gm/dl). The dietary pattern in the East region comprises mainly of non-vegetarian foods such as fish and poultry, while lacto-vegetarians are more common in the other regions (30). It is plausible that while the intake of non-vegetarian foods protect the children from becoming anemic, high incidence of poverty and lack of up-to-date immunization in the East region negatively affect short term nutritional status of these children. Moreover, children from these regions seem to meet their iron requirement from the non-vegetarian diets, their protein and other macronutrient intake remain lower than the recommended levels, thus affecting their overall nutritional status. It is therefore paradoxical that although children from East region are at a reduced risk for anemia, they are more susceptible to acute undernutrition (wasting).

State specific analysis showed that more than one-third of children in the states of Bihar, Chhattisgarh and Jharkhand in the East and Madhya Pradesh in the Central-west region had the highest prevalence of stunting, underweight, wasting and anemia. The India State Hunger Index (ISHI) developed from the NFHS 3 and the 61^{st} National Sample Survey (NSS; 2004-05) captures the interconnectedness between hunger, poverty and mortality (31). It reported the state specific prevalence of undernutrition and mortality for the period 2004- 2006 (31). Consistent with our findings, Chhattisgarh, Bihar, Jharkhand and Madhya Pradesh had the highest ISHI, that is indicative of the highest prevalence of calorie under-nourishment, underweight among children < 5years and under five mortality rates. In addition, as our findings suggest, these states also reported a poor dietary intake and incomplete immunization records for most children, thus explaining the increased undernutrition prevalence. In contrast, low prevalence of undernutrition was observed in Kerala and Goa where greater proportions of children received good quality diet and had complete immunization as recommended. Moreover, maternal literacy was comparatively higher in Kerala and Goa than the other states. These findings clearly support the notion that nutritional status of children is positively associated with the development and environment of their place of residence (26).

In line with the above findings, we also observed that maternal education level was an important determinant of child's nutritional status, specifically for anemia. As observed by Reed et al. (1996), children of mothers with no/primary education were more likely to be underweight (32). This confirms the importance of maternal education as a determinant of child's nutritional status. An examination of the Bangladesh Demographic and Health Survey also reported that undernutrition was most profound among children of illiterate mothers (33). Mothers with low levels of education generally lack awareness on the nutritional and health care requirements of the child that increases their risk of undernutrition. In India, nearly 76.6% of illiterate women belonged to the lowest wealth category compared to only 8.2% in the highest wealth quintile (20). In addition, almost 50.0% of rural mothers have had no formal education compared to 22.0% of their urban counterparts (20). This disparity in educational attainment by mother's SES and place of residence may have contributed to the lack of significant association between maternal education level and nutritional status (stunting, underweight and wasting) of the child in the multivariate analysis. However, consistent with previous findings from Indonesia (34), maternal education remained an independent predictor for childhood anemia in our study population.

Another interesting observation from our study was the protective effect of maternal unemployment on child's nutritional status. In India, a higher proportion of unemployed women are more likely to come from urban affluent households, while working women mostly come from rural lower socio-economic household (20). Thus, it is plausible that unemployed mothers were in a better position to afford diverse food groups and provide a nutritious diet and appropriate nurturing environment to their children, thereby improving their nutritional status. Although it is expected that an employed mother would benefit child's health by improving economic condition and purchasing power, our findings imply that mothers employed outside the home may have a negative influence on children's nutritional status, through reduced time allocation for child care and supervised feeding. In the study by Engel (1991), infants of employed mothers in urban Guatemala were found to be stunted compared to infants of nonemployed mothers (35). Employed mothers are more likely to return to work post-delivery and may be unable to exclusively breastfeed their infants till 6 months as recommended (36). Similarly, Abbi et al. (1991) examined the association between maternal employment and child health in rural India and reported a negative influence of maternal employment on the height-for-age and weight-for-age of children aged 0-35 months (37), a confirmation of findings from the current study.

While maternal characteristics play a significant role in determining the nutritional status of children, household characteristics such as SES and structure (nuclear/joint households) were found to be equally important. We observed that children from affluent households had reduced risks of poor nutritional status. In a recent study, Kanjilal et al (2010) documented that nearly 50.0% of children from the highest SES quintile were of better nutritional status compared to those in the poorest wealth quintile (38), a confirmation of our findings. Similar observations have been made in the lower Sindh area of Pakistan, where stunted pre-school children were more likely to come from households with low family income (39). Moreover, in our study, rural children from medium SES households were more likely to be non-anemic compared to children living in low SES households. These results further reinforce the evidence that economic status of the household or family play an important role in childhood nutritional status. Household SES can influence nutritional status through several ways, such as low quality and inadequate dietary intake, unsanitary living conditions and therefore increased infections and morbidity. Children < 5 years living in households with piped water system are reported to experience significantly reduced prevalence and shorter duration of diarrhea reflecting in their overall health status compared to those without access to piped water (40).

We also observed that the presence of grandparents of children living in the same household significantly protected against undernutrition. A previous study from Tanzania also reported that the presence of grandparents, specifically grandmothers in the household improved the nutritional status of children through better child care practices (41). Moreover, children benefit from the presence of grandmothers, with respect to cognitive and health outcomes (42) and psychological and sociological well being (43). Sear et al. (2000) confirmed the positive influence of grandparents on the health and wellbeing of children in their study but also distinguished between the influence by maternal and paternal grandmothers (44). They concluded that maternal grandmothers were more likely to influence the nutritional and health outcomes of children compared to paternal grandmothers (44). In the present study, presence of grandparents was assessed based on the relationship of the mother with the household head and only 5.0% (n = 1036) of the children were in households with maternal grandparents. We therefore did not distinguish between maternal and paternal grandparents in our analysis. However, children belonging to joint households with grandparents but receiving medium quality diet were more likely to be of normal linear growth. These children probably received better care and attention from their grandparents that improved their long-term nutritional status. These results therefore suggest that apart from diet, child care practices such as hygiene behaviors, caregiver's attention and health care enhances the long-term nutritional status of the child.

The other important factor that influenced nutritional status of the children was diet quality. The comprehensive diet quality score used in our analysis accounted for breastfeeding practices for infants aged 0-6 months and dietary diversity and frequency of receiving foods for children aged 6-35 months. Exclusive breastfeeding (EBF) has been recognized to have a potential effect on growth and nutritional status of infants < 6 months and has been recommended by the World Health Organization (45). As expected, infants in our study population who were being exclusively breastfed (identified as receiving good diet quality) were more likely to have better nutritional status compared to non-exclusively breast fed infants. Additionally, for older children aged 6-35 months, receiving a wide variety of foods frequently, i.e. receiving a diet of good quality promoted optimal growth and maintained a normal nutritional status. Arimond and Ruel (2004) reported the positive impact of dietary diversity on nutritional status of children aged 6-23 months using data from 11 Demographic and Health Surveys (46). In the study by Zhang et al. (2009), an infant and child feeding index (ICFI) was created that accounted for breast feeding, bottle feeding, meal frequency, variety and frequency of food groups consumed by children aged 6-11 months (47). Both Zhang et al. (2009) and Sawadogo et al. (2005) reported positive correlations between ICFI and the anthropometric indices (47, 48), which is a confirmation of our findings. Similar to our findings, Assis et al (2004) have also reported significant association between dietary intake and childhood anemia in Brazil (14).

The importance of proper feeding practices for optimal growth and nutritional status of children have been well recognized (45, 49- 51). In India, in spite of universal breastfeeding, non-exclusive breastfeeding, delayed initiation of breastfeeding and complementary feeding and lack of dietary diversity are widespread (20). Inadequate feeding practices such as prolonged breastfeeding and delayed weaning have also been observed among mothers in rural Bundelkhand area in India (52). Prevailing food beliefs related to delayed introduction of semi-solid foods and type of foods could also be possible contributors of undernutrition. Mothers usually feed diluted cow's and buffalo milk, soups and gruels made of rice, sago, tapioca and mashed banana to the infant that are nutritionally inadequate (53). In our study population, cereals and related products were the major foods consumed by the child, while consumption of other food groups remained very low (20), resulting in a low diet quality score. While cereal based foods may be energy dense, they lack other essential nutrients, such as proteins and micronutrients, required for optimal growth in infants and children. A cross-sectional study in Tanzania reported increased prevalence of undernutrition among children fed energy-dense but low in nutrient foods such as maize porridge (54). Similarly, an increased intake of cereals, poor dietary diversity and low intake of micronutrients resulted in stunting among children aged < 5 years in a rural South African community (15, 55). These studies further support our observation of high undernutrition prevalence and its association with poor diet quality.

Finally, immunization status of the study children was found to be an important predictor of their nutritional status. Nearly 2.5 million children in India die every year due to illnesses, most of which are preventable through timely immunization (20). The Universal Immunization Program (UIP) launched by the Ministry of Health and Family Welfare includes vaccination of children against six preventable diseases (tuberculosis, measles, diphtheria, whooping cough, tetanus, and polio). Surprisingly, in the present study, immunization status of the child did not have an independent effect on nutritional status. While this is in accord with the Tanzania based study (56), it is in contrast to previous studies that have reported that undernourished children were more likely to have incomplete immunization status (39, 57). A case-control study in Bangladesh observed that non-immunized children were twice as likely to be stunted, underweight, and wasted than children with complete immunization records (58). It is noteworthy to mention here that while these studies included children aged 12-23 months with complete/incomplete immunization status, our study considered age specific up-to-date immunization for children 0-35 months. Significant disparities in immunization coverage between urban and rural population and the different socio-economic class exist in India (20). Only 39.0% of children in rural areas were completely immunized versus 58.0% in urban areas. Moreover, complete immunization coverage rate was 24.0% for children from low SES households compared to 71.0% in high SES households (20). This could have contributed to the insignificant association of immunization status and the nutrition indicators in the multivariate analysis in the presence of place of residence and household SES. One of the possible causes of missed immunization in rural areas and low SES households could be lack of awareness and access to health care services. The 'perception of long distance to immunization site' of mothers and care givers in Greece was one of the major barriers to complete and age-appropriate childhood immunization (59). Even within India, poor service delivery of health care facilities and social access were primary reasons for incomplete immunization status of children (60).

However, significant interaction effect between immunization and diet quality observed in the current study confirms the protective role of immunization against undernutrition in children. The importance of immunization as a public health strategy to prevent the onset of infectious diseases and reduce childhood mortality has been widely recognized (61). Simultaneously, the synergistic relationship between infection and nutritional status of children is well documented (62, 63). These evidences are a confirmation that children with complete/ up-to-date immunizations have increased immunity and are less susceptible to infections, thereby maintaining their overall nutritional and health status, compared to children with partial or no immunization.

Study limitations and significance

A potential limitation of the study is that NFHS data sets do not provide adequate information on dietary patterns of children with respect of quantity of foods received. Although the diet quality score was inclusive of breastfeeding practices for infants aged below 6 months and foods received by children aged 6-35 months, the employed cross-sectional method for data collection may lack reliability and not be a true representation of the child's normal dietary intake. Moreover, exclusive breast feeding of infants < 6 months was assessed based on mother's report of current breastfeeding status and whether the infant had received any liquids/solids 24 hours prior to the survey, while dietary information of children aged 6- 35 months was assessed through a 24-hour dietary recall of different foods. This form of data collection may suffer from recall bias and therefore their association with childhood undernutrition needs to be interpreted with caution. A high proportion of the surveyed women had missing information on the index child's anthropometric and hemoglobin measurements and was therefore excluded from the final analysis. Characteristics of households included and excluded from the final analysis were similar except for place of delivery and maternal education level. In addition, due to the cross-sectional nature of the data, causality between maternal and household characteristics and nutritional status of children cannot be ascertained. However, the large analytical sample-size and representativeness of the study sample add to the strengths of the study's findings.

Results from our study suggest the need for future longitudinal studies focusing on dietary practices of mothers with respect to quantity and quality of foods consumed by children. Longitudinal studies controlling for childhood morbidity, need to examine the association between dietary diversity, nutrient intake and child's nutritional status in this population. This is of particular interest as there may be a potential deficiency of nutrients among children, specifically those identified to be at risk of being undernourished. Moreover, our findings suggest the need to include older adults/grandparents living in joint households in existing health promotion programs such as the Integrated Child Development Services (ICDS) scheme and the National Rural Health Mission (NRHM). Nutrition education programs need to target rural and urban poor population. Previous community intervention trials have reported the significant effect of nutrition and health education programs in improving feeding practices of urban slum dwellers (64). Our findings further suggest the need for grass-root programs promoting Infant and Young Child Feeding (IYCF) and care practices.

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Table 4.1: Descriptive characteristics of participants and households from NFHS 3

Characteristics	**n**	**%**
Maternal age (years)		
15-19	1817	9.1
20-24	7455	37.4
25-29	6251	31.4
30-34	2893	14.5
35-39	1121	5.6
40-44	308	1.5
45-49	73	0.4
Maternal education level		
No education	9473	47.6
Primary	2749	13.8
Secondary	6559	32.9
Higher	1137	5.7
Maternal religion		
Hindu	15632	78.5
Muslim	3296	16.5
Christian	402	2.0
Sikh	277	1.4
Other[1]	311	1.6
Maternal employment		
No	14309	72.0
Yes	5586	28.0
Household characteristics		
Place of residence		
Urban	4919	24.7
Rural	14999	75.3
Region of residence[2]		
North	2669	13.4
East	5310	26.7
North East	815	4.1
Central West	8059	40.5
South	3065	15.4
Household type[3]		
Nuclear	8413	43.8
Joint with child's grandparents	6459	33.7
Joint without child's grandparents	4314	22.5
Household socio-economic status		
Poor	9289	46.6
Middle	3903	19.6
High	6726	33.8

[1.] Buddhist, Jain, Zoroastrian, Doni-polo or no religion

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

[3.] Type of household: Nuclear: Index child living with parents and siblings, Joint with grandparents: Index child living with parents, siblings, relatives including grandparents, Joint with grandparents: Index child living with parents, siblings and other relatives excluding grandparents

Table 4.2: Prevalence of undernutrition among index children 0- 35 months of age by region

Nutrition indicators[3]	**Region**[1, 2] **n (%)**				
	North	East	North East	Central West	South
Height-for-age					
Normal	1682 (63.0)	2968 (55.9)	503 (61.7)	4363 (54.1)	1968 (64.2)
Stunted	513 (19.2)	1309 (24.7)	166 (20.4)	1859 (23.1)	613 (20.0)
Severely Stunted	474 (17.8)	1033 (19.5)	146 (17.9)	1837 (22.8)	484 (15.8)
Weight-for-age					
Normal	1795 (67.3)	2807 (52.9)	541 (66.4)	4685 (58.1)	2177 (71.0)
Underweight	564 (21.1)	1494 (28.1)	179 (22.0)	2019 (25.0)	644 (21.0)
Severely underweight	310 (11.6)	1009 (19.0)	95 (11.7)	1356 (16.8)	244 (8.0)
Weight-for-height					
Normal	2128 (79.7)	3774 (71.1)	669 (82.1)	6114 (75.9)	2513 (82.0)
Wasted	373 (14.0)	1035 (19.5)	90 (11.0)	1202 (14.9)	363 (11.8)
Severely wasted	169 (6.3)	500 (9.4)	56 (6.9)	743 (9.2)	188 (6.1)
Hemoglobin level					
Normal	459 (22.7)	856 (20.4)	155 (26.1)	1123 (18.5)	606 (24.1)
Mild-moderate anemia	1445 (71.4)	3259 (77.8)	427 (71.8)	4688 (77.3)	1813 (72.1)
Severe anemia	120 (5.9)	73 (1.7)	13 (2.2)	250 (4.1)	97 (3.9)

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

[2]. $p < 0.001$ for χ^2 test

[3]. Classification according to WHO guidelines: (1, 2)

Severely stunted/underweight/wasted < -3.0 HAZ, Stunted/underweight/wasted -2.99 to -2.0 HAZ, Normal > -2.0 HAZ; Severe anemia < 7.0 g/dl; moderate/mild anemia: 10.9 g/dl > Hb > 7.1 g/dl; normal: Hb ≥ 11.0g/dl

Table 4.3: Characteristics of index children by nutritional status

Characteristics	HAZ[1]			WAZ[1]			WHZ[1]		
	Normal n (%)	Mild Stunting n (%)	Severe stunting n (%)	Normal n (%)	Mild underweight n (%)	Severe underweight n (%)	Normal n (%)	Mild wasting n (%)	Severely wasting n (%)
Age of index child (mos)									
0-6	3203 (20.4)	497 (7.5)	350 (6.1)	2815 (16.9)	772 (10.7)	463 (11.2)	2837 (12.9)	713 (18.0)	500 (25.0)
7-12	2793 (17.8)	741 (11.2)	505 (8.8)	2570 (15.4)	923 (12.8)	545 (13.2)	2888 (13.1)	736 (18.5)	415 (20.8)
13-24	3259 (20.8)	1888 (28.6)	1797 (31.3)	3940 (23.7)	1844 (25.5)	1159 (28.0)	5406 (24.5)	1040 (26.2)	497 (24.8)
25-35	2394 (15.3)	1443 (21.9)	1411 (24.6)	2857 (17.2)	1477 (20.4)	914 (22.1)	4350 (19.7)	638 (16.1)	260 (13.0)
Maternal age (years)									
15- 19	1031 (9.0)	410 (9.2)	375 (9.4)	1048 (8.7)	456 (9.3)	313 (10.4)	1339 (8.8)	325 (10.6)	153 (9.2)
20-24	4457 (38.8)	1700 (38.1)	1298 (32.7)	4724 (39.4)	1747 (35.7)	984 (32.6)	5724 (37.7)	1113 (36.3)	617 (37.3)
25-29	3665 (31.9)	1380 (30.9)	1207 (33.4)	3854 (32.1)	1539 (31.4)	858 (28.5)	4850 (31.9)	938 (30.6)	464 (28.0)
30-34	1597 (13.9)	635 (14.2)	662 (16.7)	1612 (13.4)	761 (15.5)	520 (17.2)	2186 (14.4)	424 (13.8)	283 (17.1)
35-39	559 (4.9)	251 (5.6)	311 (7.8)	598 (5.0)	285 (5.8)	238 (7.9)	826 (5.4)	195 (6.4)	100 (6.0)
40-44	142 (1.2)	67 (1.5)	100 (2.5)	132 (1.1)	92 (1.9)	84 (2.8)	218 (1.4)	58 (1.9)	32 (1.9)
45-49	33 (0.3)	17 (0.4)	22 (0.6)	36 (0.3)	19 (0.4)	18 (0.6)	55 (0.4)	11 (0.4)	6 (0.4)
Religion									
Hindu	8958 (78.0)	3566 (80.0)	3190 (78.3)	9295 (77.4)	3928 (80.1)	2410 (79.9)	11852 (78.0)	2442 (79.7)	1338 (80.8)

Muslim	1904 (16.6)	633 (15.5)	698 (17.6)	2039 (17.0)	772 (15.8)	485 (16.1)	2544 (16.7)	504 (16.5)	247 (14.9)
Christian	262 (2.3)	66 (1.5)	74 (1.9)	284 (2.4)	85 (1.7)	33 (1.1)	334 (2.2)	42 (1.4)	26 (1.6)
Sikh	203 (1.8)	47 (1.1)	27 (0.7)	217 (1.8)	41 (0.8)	19 (0.6)	245 (1.6)	22 (0.7)	10 (0.6)
Other [2]	158 (1.4)	88 (2.0)	65 (1.6)	169 (1.4)	75 (1.5)	68 (2.3)	223 (1.5)	53 (1.7)	35 (2.1)
Education level									
No education	4740 (41.3)	2236 (50.1)	3608 (62.8)	4793 (39.9)	2630 (53.5)	2061 (68.4)	6791 (44.7)	1680 (54.8)	1003 (60.5)
Primary	1521 (13.2)	646 (14.5)	841 (14.6)	1610 (13.4)	709 (14.5)	429 (14.2)	2073 (13.6)	461 (15.1)	214 (12.9)
Secondary	4304 (37.4)	1424 (31.9)	1211 (21.1)	4625 (38.5)	1448 (29.6)	486 (16.1)	5347 (35.2)	828 (27.0)	384 (23.2)
Higher	920 (8.0)	155 (3.5)	84 (1.5)	977 (8.1)	122 (2.5)	38 (1.3)	987 (6.5)	94 (3.1)	56 (3.4)
Employed									
Yes	2877 (24.7)	1351 (30.3)	1408 (35.4)	2926 (24.4)	1564(32.0)	1095 (36.4)	4201 (27.7)	903(29.5)	481 (29.1) [4]
No	8638 (75.3)	3108 (69.7)	2564 (64.6)	9062 (75.6)	3331 (68.0)	1917 (63.6)	10978 (72.3)	2158 (70.5)	1173 (70.9) [4]
Place of residence									
Urban	3167 (27.6)	1002 (22.5)	751 (18.9)	3493 (29.1)	968 (19.8)	458 (15.2)	3998 (26.3)	580 (18.9)	341 (20.6)
Rural	8318 (72.4)	3458 (77.5)	3223 (81.1)	8511 (70.9)	3931 (80.2)	2557 (84.8)	11200 (73.7)	2484 (81.1)	1315 (79.4)
Socio-economic status									
Poor	4588 (40.0)	2235 (50.1)	2465 (62.0)	4512 (37.6)	2692 (54.9)	2085 (69.2)	6541 (43.0)	1775 (57.9)	973 (58.7)
Middle	2227 (19.4)	932 (20.9)	744 (18.7)	2393 (19.9)	1022 (20.9)	488 (16.2)	3044 (20.0)	558 (18.2)	301(18.2)
High	4669 (40.7)	1292 (29.0)	765 (19.3)	5100 (42.5)	1185 (24.2)	441 (14.6)	5613 (36.9)	731 (23.9)	383 (23.1)

Type of household[3]									
Nuclear	4555 (41.3)	1896 (43.9)	1962 (51.2)	4745 (41.2)	2182 (45.8)	1486 (51.0)	6285 (42.9)	1383 (46.8)	745 (46.7)
Joint with child's grandparents	4057 (36.7)	1401 (32.5)	1001(26.1)	4207 (36.5)	1466(30.8)	787 (27.0)	5034 (34.4)	902 (30.5)	523 (32.8)
Joint without child's grandparents	2428 (22.0)	1017 (23.6)	868 (22.7)	2561 (22.2)	1112 (23.4)	641 (22.0)	3317 (22.7)	669 (22.6)	327 (20.5)

1. p value < 0.001 for χ^2 test

2. Buddhist, Jain, Zoroastrian, Doni-polo or no religion

3. Type of household: Nuclear: Index child living with parents and siblings, Joint with grandparents: Index child living with parents, siblings, relatives including grandparents, Joint with grandparents: Index child living with parents, siblings and other relatives excluding grandparents

4. Not significant across type of employment

Table 4.4: Feeding practices by nutritional status of index children 0- 35 months of age

Feeding practices	HAZ			WAZ			WHZ		
	Normal n (%)	Mild Stunting n (%)	Severe stunting n (%)	Normal n (%)	Mild underweight n (%)	Severe underweight n (%)	Normal n (%)	Mild wasting n (%)	Severe wasting n (%)
Duration of BF									
Never BF	190 (1.2)	70 (1.1)	57 (1.0)	219 (1.3)	66 (0.9)	31 (0.8)	266 (1.2)	28 (0.7)	23 (1.2)
Still BF	10248 (65.4)	4300 (65.3)	4101 (71.4)	10557 (63.4)	4925 (68.1)	3167 (76.6)	14043 (63.7)	3024 (76.2)	1582 (79.1)
0-6 months	739 (4.7)	238 (3.6)	187 (3.3)	803 (4.8)	262 (3.6)	100 (0.9)	978 (4.4)	131 (3.3)	56 (2.8)
7-12 months	1232 (7.9)	428 (6.5)	323 (5.6)	1378 (8.3)	426 (5.9)	178 (4.3)	1731 (7.9)	152 (3.8)	100 (5.0)
> 12 months	3267 (20.8)	1553 (23.6)	1077 (18.7)	3686 (22.6)	1554 (21.5)	657 (15.9)	5023 (22.8)	636 (16.0)	238 (11.9)
Received protein rich foods									
Yes	3067 (26.8)	1435 (32.3)	1051 (26.7)	3542 (29.7)	1321 (27.1)	690 (23.0)	4613 (30.5)	668 (21.9)	271 (16.4)
No	8363 (73.2)	3001 (67.7)	2883 (73.3)	8393 (70.3)	3550 (72.9)	2304 (77.0)	10489 (69.5)	2379 (78.1)	1379 (83.6)
Received fruits & vegetables									
Yes	4201 (36.7)	2147 (48.4)	1800 (45.5)	4897 (41.0)	2066 (42.3)	1184 (14.5)	6592 (43.6)	1055 (34.6)	500 (30.3)
No	7239 (63.3)	2288 (51.6)	2157 (54.5)	7053 (59.0)	2819 (57.7)	1812 (60.5)	8538 (56.4)	1998 (65.4)	1149 (69.7)
Received cereals/cereal based foods									
Yes	7756	3626	3320	8673	3748 (76.7)	2281 (76.3)	3593	925	626

	(67.8)	(81.6)	(83.9)	(72.5)			(23.7)	(30.3)	(38.0)
No	3688 (32.2)	820 (18.4)	636 (16.1)	3290 (27.5)	1140 (23.3)	715 (23.7)	3593 (76.3)	2130 (69.7)	1023 (62.0)
Received fats & oils									
Yes	1500 (13.1)	732 (16.5)	526 (13.3)	1785 (14.9)	640 (13.1)	333 (11.1)	2333 (15.4)	303 (9.9)	121 (7.3)
No	9949 (86.9)	3710 (83.5)	3435 (86.7)	10177 (85.1)	4249 (86.9)	2668 (88.9)	12810 (84.6)	2754 (90.1)	1530 (92.7)
Diet quality									
Good	4960 (44.3)	2057 (47.2)	1560 (40.5)	5425 (46.5)	2091 (42.2)	1133 (38.7)	6805 (46.0)	1170 (39.1)	603 (37.3)
Medium	1453 (13.0)	205 (4.7)	156 (4.1)	1259 (10.8)	358 (7.5)	197 (6.7)	1274 (8.6)	309 (10.3)	232 (14.4)
Poor	4772 (42.7)	2094 (48.1)	2132 (55.4)	4995 (42.8)	2409 (50.3)	1595 (54.5)	6706 (45.4)	1511 (50.5)	781 (48.3)

[1.] $p < 0.05$ value for χ^2 test

Table 4.5: Factors associated with higher/normal nutritional status of children: Univariate ordinal logistic regression

Variables	**Low HAZ score vs. normal**	**Low WAZ score vs. normal**	**Low WHZ score vs. normal**	**Low Hb level vs. normal**
	OR (95% CI); *p*			
Maternal characteristics				
Maternal age				
15- 19	1.00	1.00	1.00	1.00
20-24	1.16 (1.05- 1.28); 0.005	1.29 (1.17- 1.43); < 0.001	1.16 (1.03- 1.31); 0.012	1.30 (1.14- 1.48); < 0.001
25-29	1.08 (0.98- 1.20); 0.134	1.20 (1.09- 1.33); 0.201	1.22 (1.09- 1.38); 0.001	1.31 (1.15- 1.50); < 0.001
30-34	0.92 (0.82- 1.03); 0.147	0.93 (0.83- 1.04); 0.201	1.07 (0.94- 1.22); 0.307	1.31 (1.13- 1.51); < 0.001
35-39	0.73 (0.63- 0.84); < 0.001	0.82 (0.71- 0.94); 0.006	0.99 (0.84- 1.17); 0.918	1.21 (1.01- 1.45); 0.040
40-44	0.60 (0.63- 0.48); < 0.001	0.55 (0.44- 0.69); < 0.001	0.86 (0.66- 1.11); 0.244	1.02 (0.76- 1.37); 0.898
45-49	0.62 (0.40- 0.96); 0.033	0.69 (0.44- 1.07); 0.094	1.11 (0.65- 1.91); 0.703	0.69 (0.38- 1.24); 0.217
Religion				
Hindu	1.00	1.00	1.00	1.00
Muslim	0.99 (0.92- 1.07); 0.860	1.10 (1.02- 1.18); 0.016	1.09 (0.99- 1.19); 0.067	1.08 (0.99- 1.18); 0.077
Christian	1.33 (1.09- 1.62); 0.006	1.69 (1.36- 2.09); < 0.001	1.55 (1.20- 2.02); 0.001	1.93 (1.56- 2.39); < 0.001
Sikh	2.05 (1.57- 2.67); < 0.001	2.46 (1.85- 3.28); < 0.001	2.42 (1.67- 3.49); < 0.001	1.02 (0.77- 1.36); 0.877
Buddhist	0.84 (0.62- 1.15); 0.288	1.14 (0.82- 1.58); < 0.001	0.99 (0.68- 1.45); 0.970	1.29 (0.90- 1.86); 0.162
Jain	2.13 (1.08- 4.18); 0.028	2.51 (1.21- 5.17); 0.013	1.72 (0.76- 3.90); 0.195	2.39 (1.28- 4.44); 0.006
Minor/ no religion	0.58 (0.42- 0.81); 0.001	0.35 (0.25- 0.48); < 0.001	0.52 (0.36- 0.75); < 0.001	0.93 (0.60- 1.43); 0.737

Education level				
No education	1.00	1.00	1.00	1.00
Primary	0.28 (0.24- 0.34); < 0.001	0.23 (0.19- 0.28); < 0.001	0.48 (0.39- 0.58); < 0.001	0.48 (0.41- 0.56); < 0.001
Secondary	0.45 (0.39- 0.53); < 0.001	0.40 (0.34- 0.48); < 0.001	0.68 (0.57- 0.81); < 0.001	0.66 (0.58- 0.76); 0.001
Higher than Secondary	1.52 (1.45- 2.66); < 0.001	2.16 (1.14- 2.59); < 0.001	2.47 (1.63- 3.11); < 0.001	1.87 (1.23- 2.24); < 0.001
Employed				
No	1.00	1.00	1.00	1.00
Yes	0.55 (0.24- 0.76); < 0.001	0.77 (0.48- 0.85); < 0.001	0.56 (0.25- 0.87); 0.029	0.28 (0.19- 0.46); < 0.001
Household characteristics				
Place of residence				
Urban	1.00	1.00	1.00	1.00
Rural	0.68 (0.64- 0.73); < 0.001	0.53 (0.50- 0.57); < 0.001	0.69 (0.63- 0.74); < 0.001	0.61 (0.57- 0.66); 0.001
Region1				
North	1.00	1.00	1.00	1.00
East	0.78 (0.71- 0.85); < 0.001	0.55 (0.50- 0.60); < 0.001	0.63 (0.56- 0.70); < 0.001	1.02 (0.91- 1.14); 0.740
North-east	0.95 (0.82- 1.12); 0.557	0.96 (0.82- 1.14); 0.666	1.14 (0.94- 1.40); 0.190	1.51 (1.26- 1.81); < 0.001
Central-west	0.70 (0.64- 0.76); < 0.001	0.67 (0.61- 0.73); < 0.001	0.79 (0.71- 0.87); < 0.001	0.94 (0.84- 1.04); 0.238
South	1.07 (0.97- 1.19); 0.193	1.23 (1.10- 1.37); < 0.001	1.15 (1.01- 1.31); 0.037	1.26 (1.12- 1.43); 0.001
Socio-economic status				
Poor	1.00	1.00	1.00	1.00
Middle	1.41 (1.31- 1.52); < 0.001	1.75 (1.63- 1.89); < 0.001	1.48 (1.36- 1.61); < 0.001	1.31 (1.20- 1.43); < 0.001
High	2.42 (2.27- 2.59); < 0.001	3.44 (3.21- 3.68); < 0.001	2.10 (1.94- 2.27); < 0.001	1.93 (1.79- 2.08); < 0.001
Type of household[2]				

Nuclear	1.00	1.00	1.00	1.00
Joint with child's grandparents	1.48 (1.39- 1.58); < 0.001	1.46 (1.37- 1.56); < 0.001	1.19 (1.10- 1.28); < 0.001	1.25 (1.16- 1.35); < 0.001
Joint without child's grandparents	1.12 (1.05- 1.21); 0.001	1.15 (1.07- 1.24); < 0.001	1.13 (1.04- 1.23); < 0.001	0.96 (0.88- 1.06); 0.429
Feeding practices[3]				
Received protein rich foods				
Yes	1.00	1.00	1.00	1.00
No	0.71 (0.66- 0.75); < 0.001	0.64 (0.60- 0.68); < 0.001	0.67 (0.61- 0.73); < 0.001	0.81 (0.76- 0.87); < 0.001
Received fruits & vegetables				
Yes	1.00	1.00	1.00	1.00
No	0.82 (0.77- 0.87); < 0.001	0.73 (0.68- 0.78); < 0.001	0.81 (0.75- 0.87); < 0.001	0.90 (0.84- 0.97); 0.005
Received cereals/cereal based foods				
Yes	1.00	1.00	1.00	1.00
No	1.09 (1.01- 1.19); 0.031	0.81 (0.75- 0.88); < 0.001	0.87 (0.79- 0.95) < 0.001	1.55 (1.40- 1.72); < 0.001
Received fats & oils				
Yes	1.00	1.00	1.00	1.00
No	0.77 (0.71- 0.84); < 0.001	0.66 (0.61- 0.72); < 0.001	0.64 (0.56-0.74); < 0.001	0.94 (0.86- 1.03); 0.173
Diet quality				
Poor	1.00	1.00	1.00	1.00
Medium	1.18 (1.04- 1.35); 0.013	0.86 (0.77- 0.97); 0.015	0.90 (0.80- 1.02); 0.095	0.72 (0.66- 0.78); 0.001
Good	1.68 (1.53- 1.77); < 0.001	1.55 (1.33- 1.85); < 0.001	1.21 (1.10- 1.96); < 0.001	1.84 (1.77- 2.92); 0.001
Immunization status[4]				
No immunization	1.0	1.0	1.0	1.00
Some	1.17 (1.06- 1.30);	1.15 (1.04- 1.27); 0.006	1.12 (1.01- 1.25);	0.92 (0.80- 1.07);

immunization/incomplete	0.002		0.050	0.276
Up-to-date immunization	2.16 (1.92- 2.42); < 0.001	2.21 (1.97- 2.47); < 0.001	1.66 (1.46- 1.88); < 0.001	1.35 (1.16- 1.57); < 0.001

Hb: Hemoglobin; HAZ: Height-for-age z score; WAZ: weight-for-age z score; WHZ: weight-for-height z score; OR: Odds Ratio; CI: Confidence Interval

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

[2]. Type of household: Nuclear: Index child living with parents and siblings, Joint with grandparents: Index child living with parents, siblings, relatives including grandparents, Joint with grandparents: Index child living with parents, siblings and other relatives excluding grandparents

[3]. Corrected for age of index child

[4]. Corrected for age of index child and recommended vaccines

Table 4.6: Adjusted multivariable ordinal logistic regression for determinants of normal height for children < 3 years

Variables	**Low HAZ score (stunting) vs. Normal[1] OR (95% CI); *p***
Maternal characteristics	
Education level	
No education	1.00
Primary	0.32 (0.20- 0.51); 0.001
Secondary	0.48 (0.31- 0.72); 0.001
Higher than Secondary	1.45 (1.29-2.78); 0.001
Employed	
No	1.00
Yes	0.61 (0.47- 1.39); 0.115
Household characteristics	
Place of residence	
Urban	1.00
Rural	0.84 (0.74- 0.96); 0.006
Region[2]	
North	1.00
East	1.35 (0.44- 4.10); 0.595
North-east	0.90 (0.20- 4.01); 0.894
Central-west	0.56 (0.20- 1.54); 0.262
South	0.84 (0.28- 2.51); 0.751
Socio-economic status	
Poor	1.00
Middle	1.69 (1.27- 2.25); < 0.001
High	2.50 (1.91- 3.27); < 0.001
Type of household[3]	
Nuclear	1.00
Joint with child's grandparents	0.54 (0.21- 1.37); 0.195
Joint without child's grandparents	0.52 (0.18- 1.44); 0.208
Feeding practices	
Diet quality	
Poor	1.00
Medium	0.85 (0.26-2.78); 0.783
Good	1.43 (1.12- 2.52); 0.030
Immunization status	
No immunization	1.0
Some immunization/incomplete	0.73 (0.26- 2.09); 0.558
Up-to-date immunization	0.72 (0.25- 2.09); 0.552
Interaction effects	
Diet quality* type of household	
Medium diet* joint with child's grandparents	1.86 (1.04- 3.30); 0.040
Diet quality*immunization status	

Medium diet*up-to-date immunization	5.32 (1.85- 15.28); 0.002
Diet quality*household SES	
Medium diet* high SES	0.38 (0.21- 0.71); 0.002

HAZ: Height-for-age z score; OR: Odds Ratio; CI: Confidence Interval

[1]. Adjusted for maternal age, religion, age, gender and birth weight of index child

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

[3]. Type of household: Nuclear: Index child living with parents and siblings, Joint with grandparents: Index child living with parents, siblings, relatives including grandparents, Joint with grandparents: Index child living with parents, siblings and other relatives excluding grandparents

Table 4.7: Adjusted multivariable ordinal logistic regression for determinants of normal weight-for-age for children < 3 years

Variables	**Low WAZ score (underweight) vs. Normal[1] OR (95% CI); *p***
Maternal characteristics	
Education level	
No education	1.00
Primary	0.99 (0.21- 4.73); 0.987
Secondary	1.89 (0.42- 8.55); 0.406
Higher than Secondary	2.15 (0.70- 3.58); 0.569
Employed	
No	1.00
Yes	1.54 (0.46- 2.81); 0.214
Household characteristics	
Place of residence	
Urban	1.00
Rural	1.02 (0.90- 1.16); 0.776
Region	
North	1.00
East	1.99 (0.52- 7.58); 0.314
North-east	3.21 (0.34- 29.95); 0.306
Central-west	1.00 (0.32- 3.16); 0.900
South	1.73 (0.48- 6.19); 0.400
Socio-economic status	
Poor	1.00
Middle	1.29 (0.27- 6.09); 0.745
High	5.10 (1.27- 20.50); 0.022
Type of household[3]	
Nuclear	1.00
Joint with child's grandparents	1.05 (0.90- 3.93); 0.052
Joint without child's grandparents	0.95 (0.43- 2.08); 0.900
Feeding practices	
Diet quality	
Poor	1.00
Medium	1.44 (0.92- 2.55);0.109
Good	2.41 (1.24- 3.45); 0.011
Immunization status	
No immunization	1.0
Some immunization/incomplete	1.61 (0.56- 4.81); 0.373
Complete	1.65 (0.56- 4.81); 0.362
Interaction effects	
Maternal education* region	
No education* East	0.33 (0.13- 0.85); 0.021
Diet quality* region	
Good diet* Central-west	1.67 (1.07- 2.60); 0.024

WAZ: weight-for-age z score; OR: Odds Ratio; CI: Confidence Interval

[1.] Adjusted for maternal age, religion, age, gender and birth weight of index child

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

[3.]Type of household: Nuclear: Index child living with parents and siblings, Joint with grandparents: Index child living with parents, siblings, relatives including grandparents, Joint with grandparents: Index child living with parents, siblings and other relatives excluding grandparents

Table 4.8: Adjusted multivariable ordinal logistic regression for determinants of normal weight-for-height for children < 3 years

Variables	**Low WHZ (wasting) score vs. Normal[1] OR (95% CI); *p***
Maternal characteristics	
Education level	
No education	1.00
Primary	2.33 (0.59- 9.30); 0.229
Secondary	4.23 (0.66- 16.23); 0.342
Higher than Secondary	5.65 (0.57- 7.46); 0.122
Employed	
No	1.00
Yes	0.72 (0.54- 2.04); 0.121
Household characteristics	
Place of residence	
Urban	1.00
Rural	1.04 (0.90- 1.21); 0.563
Region[2]	
North	1.00
East	0.50 (0.33- 0.77); 0.001
North-east	1.06 (0.33- 0.77); 0.876
Central-west	0.67 (0.44- 1.01); 0.058
South	0.59 (0.39- 1.89); 0.120
Socio-economic status	
Poor	1.00
Middle	2.91 (0.59- 14.26); 0.189
High	5.24 (1.32- 20.79); 0.019
Type of household[3]	
Nuclear	1.00
Joint with child’s grandparents	0.98 (0.47- 2.03); 0.952
Joint without child’s grandparents	1.91 (0.70- 5.16); 0.205
Feeding practices	
Diet quality	
Poor	1.00
Medium	1.27 (0.37- 4.36); 0.699
Good	2.51 (1.38- 3.14); 0.033
Immunization status	
No immunization	1.00
Some immunization/incomplete	0.60 (0.31- 1.15); 0.125
Up-to-date immunization	0.76 (0.40- 1.46); 0.415
Interaction effects	
Diet quality*immunization status	
Poor diet*up-to-date immunization	2.17 (1.05- 4.50);0.037
Maternal education level* Household SES	
Primary education* high SES	0.19 (0.05- 0.76); 0.019

WHZ: weight-for-height z score; OR: Odds Ratio; CI: Confidence Interval

[1.] Adjusted for maternal age, religion, age, gender and birth weight of index child

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

[3.]Type of household: Nuclear: Index child living with parents and siblings, Joint with grandparents: Index child living with parents, siblings, relatives including grandparents, Joint with grandparents: Index child living with parents, siblings and other relatives excluding grandparents

Table 4.9: Adjusted multivariable ordinal logistic regression for determinants of normal hemoglobin level for children < 3 years

Variables	**Low Hb level (anemic) vs. Normal[1]** **OR (95% CI); *p***
Maternal characteristics	
Education level	
No education	1.00
Secondary	0.89 (0.76- 1.04); 0.146
Primary	0.66 (0.50- 0.87); 0.003
Higher than Secondary	0.61 (0.48- 0.82); 0.001
Employed	
Yes	1.00
No	0.95 (0.84- 1.07); 0.395
Household characteristics	
Place of residence	
Urban	1.00
Rural	1.05 (0.74- 1.49); 0.780
Region[2]	
North	1.00
East	1.41 (0.93- 2.14); 0.109
North-east	1.91 (0.94- 3.89); 0.072
Central-west	1.13 (0.81- 1.59); 0.465
South	1.41 (0.99- 2.01); 0.060
Socio-economic status	
Poor	1.00
Middle	1.08 (0.68- 1.72); 0.746
High	1.96 (1.31- 2.94); 0.001
Type of household[3]	
Nuclear	1.00
Joint with child's grandparents	1.12 (0.89- 1.40); 0.339
Joint without child's grandparents	1.01 (0.76- 1.33); 0.959
Feeding practices	
Diet quality	
Poor	1.00
Medium	0.25 (0.08- 0.78); 0.017
Good	2.54 (0.89- 3.11); 0.055
Immunization status	
No immunization	1.00
Some immunization/incomplete	0.66 (0.39- 1.13); 0.130
Up-to-date immunization	0.68 (0.40- 1.16); 0.161
Interaction effects	
Diet quality*immunization status	
Poor diet* up-to-date immunization	2.32 (1.01- 5.34); 0.047
Medium diet*some immunization	3.37 (1.19- 9.53); 0.022
Diet quality*household SES	

Medium diet* medium SES	1.92 (1.27- 2.88); 0.002
Diet quality* regions	
Poor diet* East region	1.71 (1.03- 2.84); 0.038

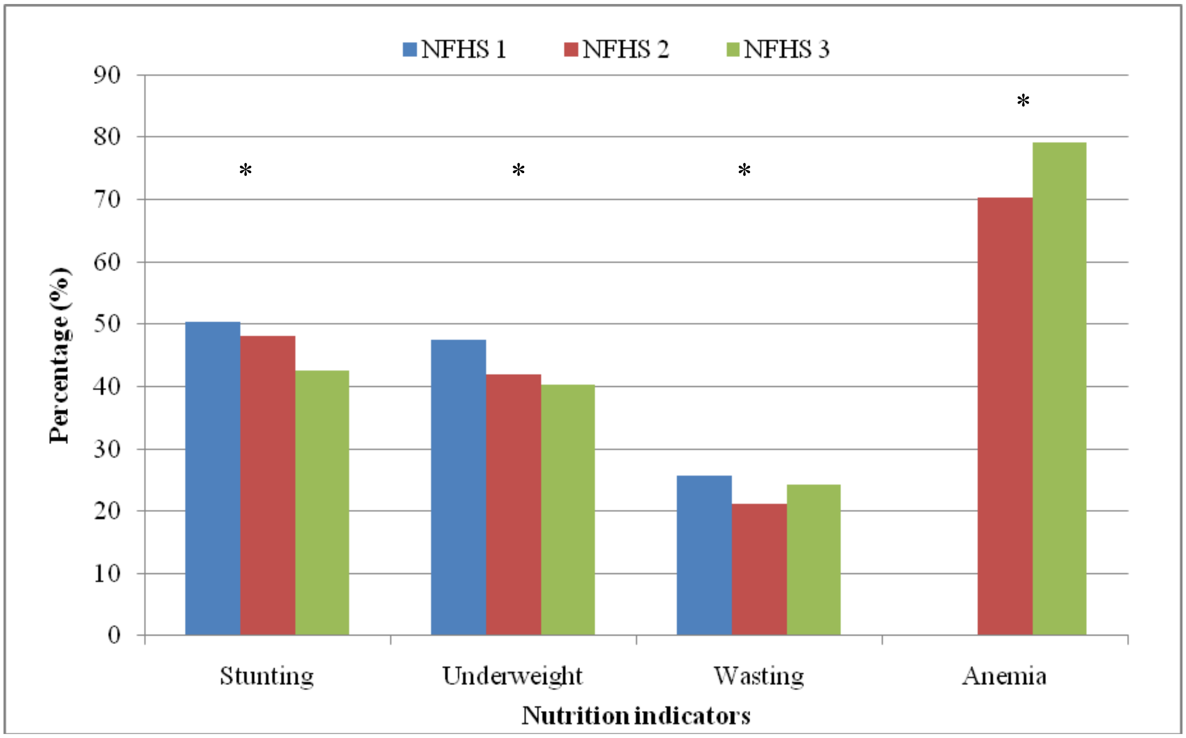
Hb: Hemoglobin; OR: Odds Ratio; CI: Confidence Interval

[1.] Adjusted for maternal age, religion, age, gender and birth weight of index child

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

[3.]Type of household: Nuclear: Index child living with parents and siblings, Joint with grandparents: Index child living with parents, siblings, relatives including grandparents, Joint with grandparents: Index child living with parents, siblings and other relatives excluding grandparents

Figure 4.1: Trend of child undernutrition prevalence over the years 1992- 2006



Hemoglobin levels were not collected in NFHS 1

*. Significant difference between undernutrition prevalence by survey waves, $p < 0.05$ (χ^2 test)

Figure 4.2 a: Mean HAZ score by place of residence

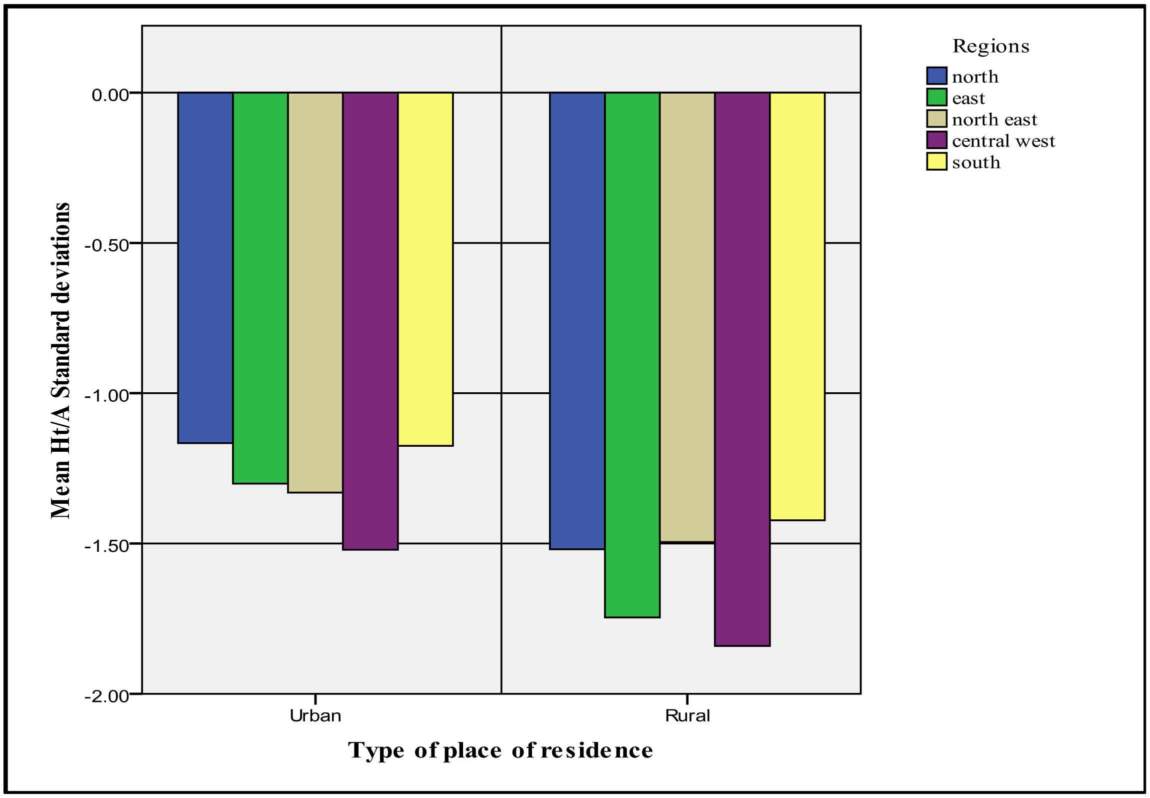


Figure 4.2 b: Mean WAZ score by place of residence

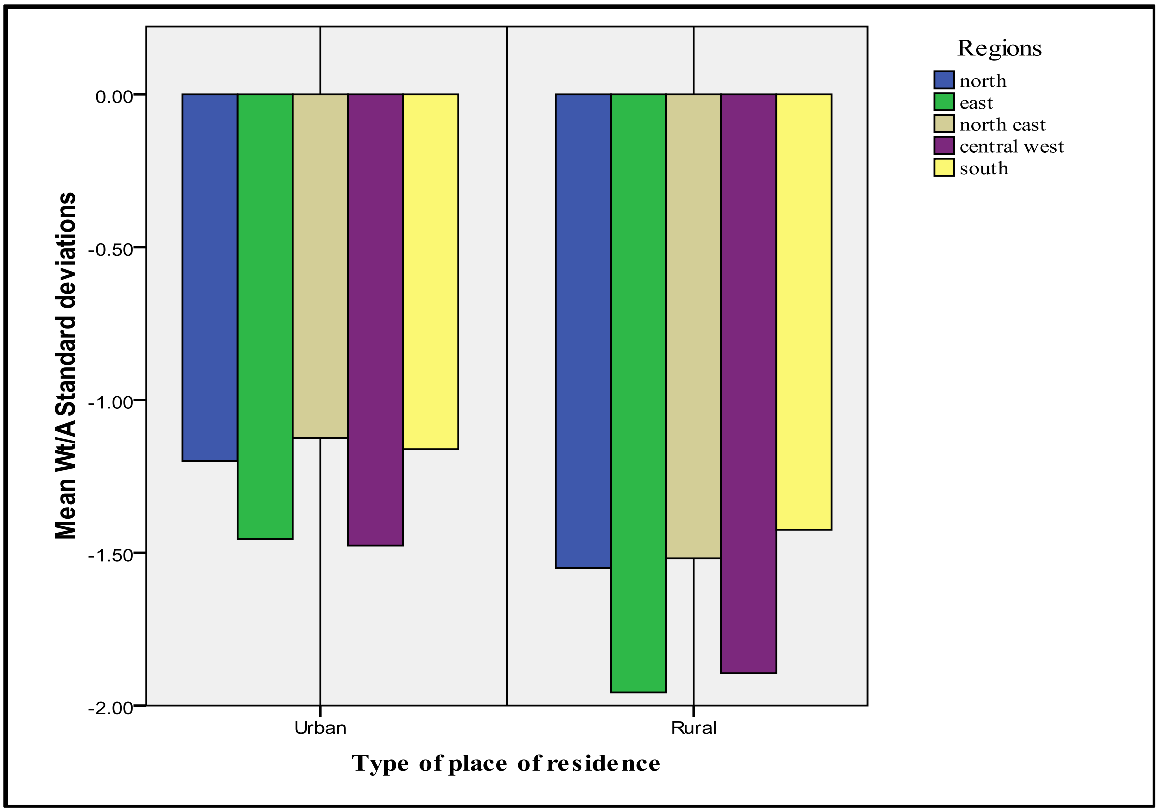


Figure 4.2 c: Mean WHZ score by place of residence

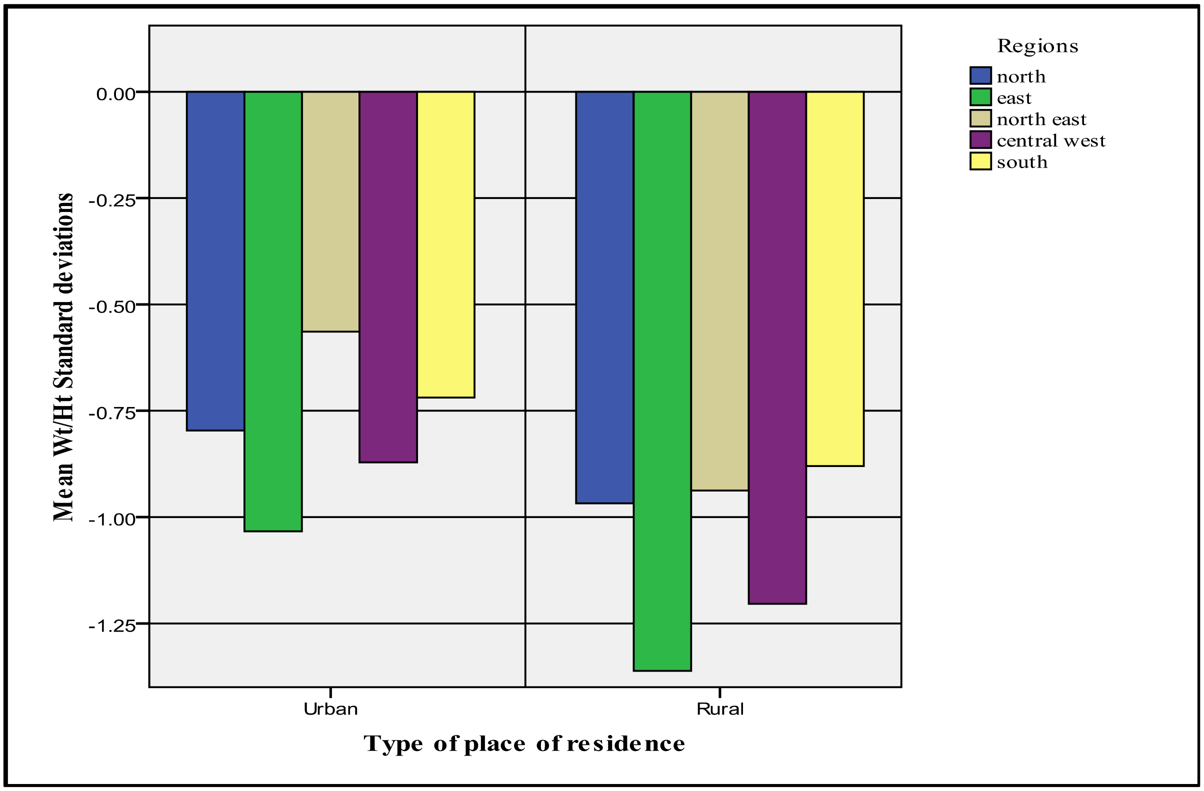


Figure 4.2 d: Mean hemoglobin level by place of residence

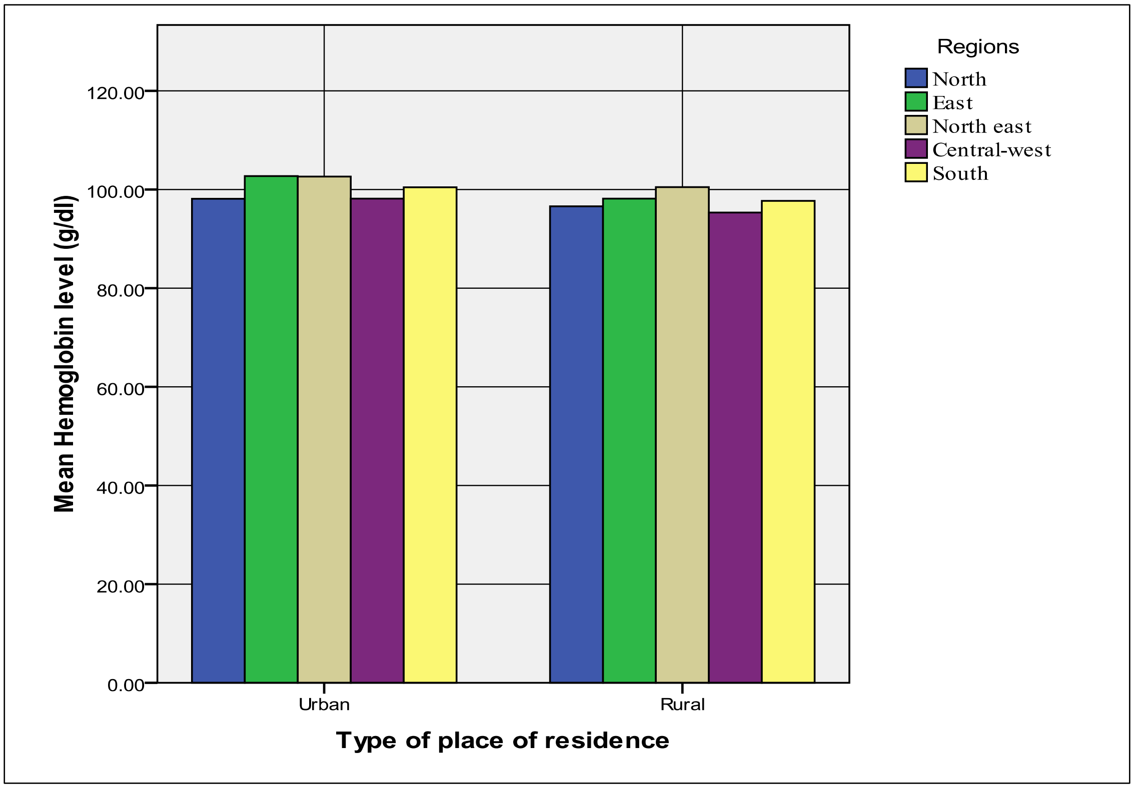
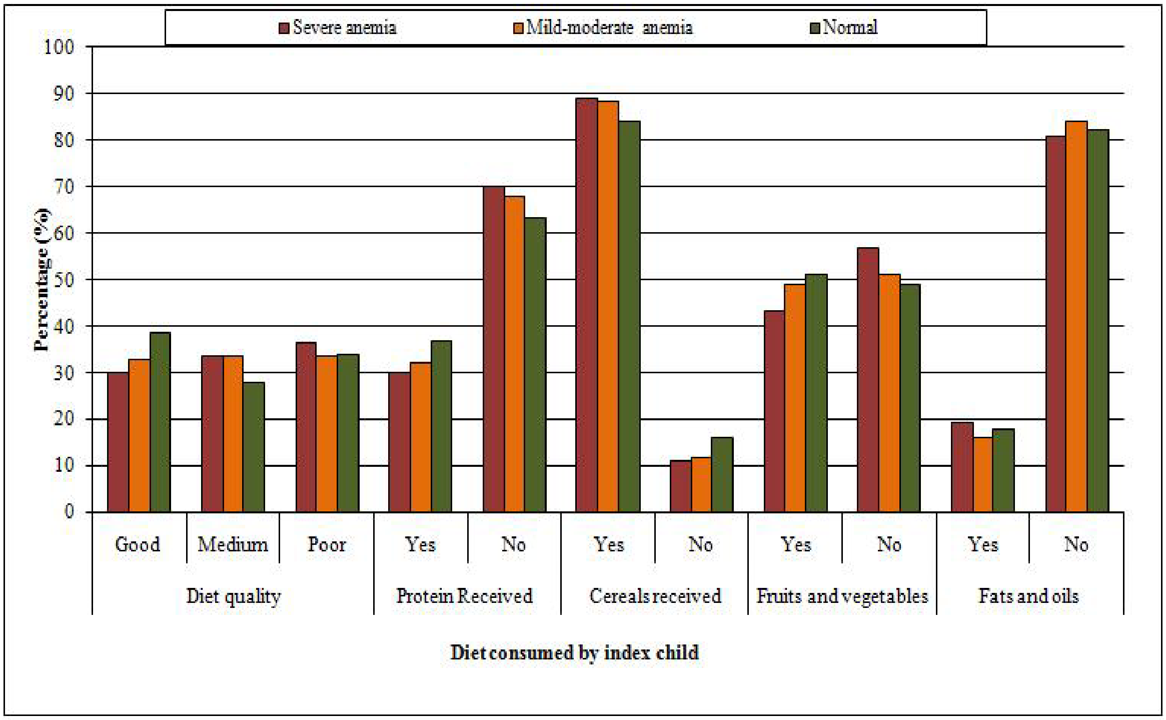
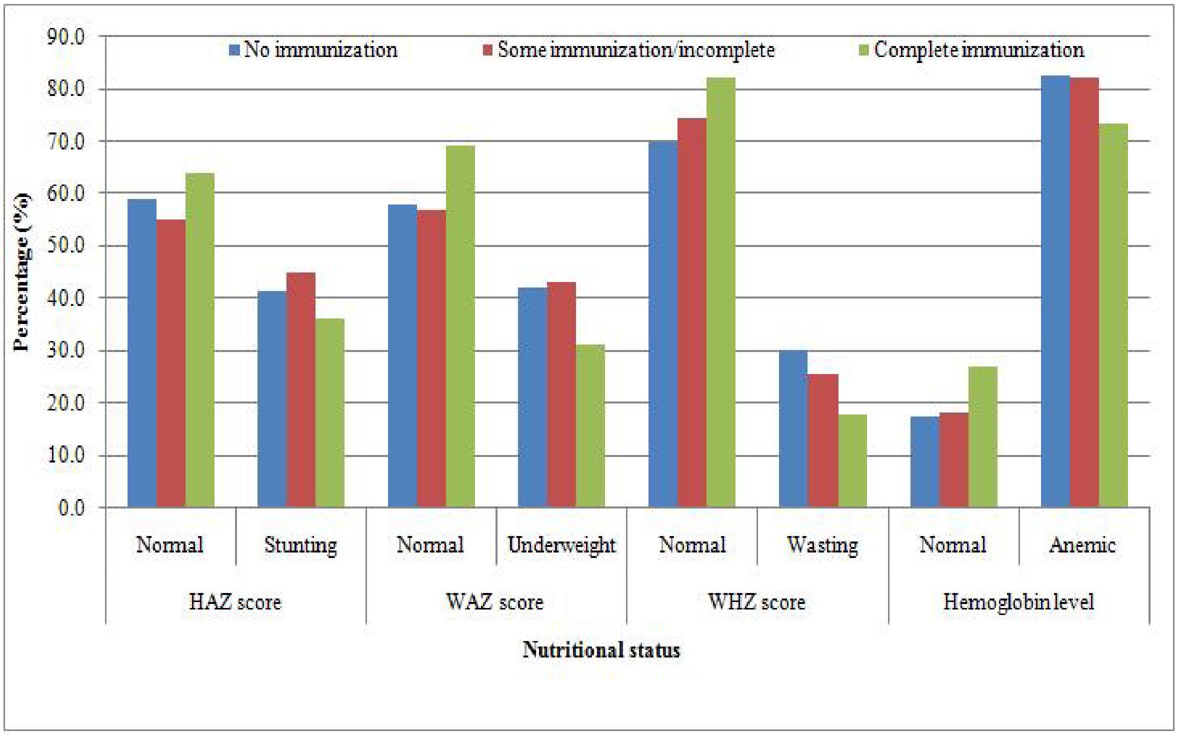


Figure 4.3: Hemoglobin status of children < 3 years by dietary practices



Results were significantly different between hemoglobin status by diet consumed by index child, $p < 0.05$, χ^2 test

Figure 4.4: Nutritional status of children < 3 by immunization status



Results were significantly different between nutrition indicators by immunization status of index child, $p < 0.05$, χ^2 test

CHAPTER 5

PREDICTORS OF OVERWEIGHT IN CHILDREN UNDER 5 YEARS IN INDIA[1]

[1] Chakraborty, P. and A. K. Anderson. 2010. *Current Research Journal of Social Science.* 2:138-146.

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Abstract

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

Introduction

The increasing prevalence of childhood overweight has become a growing concern for public health, as nearly one-third of overweight children grow up to become overweight or obese adults (1) with increased risks of chronic diseases (2, 3). Children from industrialized countries are at an increasing risk of being overweight where the prevalence has more than doubled in the past three decades (4). It is estimated that nearly 40% of school-age children will be overweight in America, Eastern Mediterranean and European regions in recent years (4). Consequently, studies conducted on preschool children from industrialized and developing countries provide evidence of an increasing trend of overweight prevalence in this age group (5- 7).

The cause of increasing childhood overweight in developing countries is attributed to the growing urbanization, transition towards a high fat Western diet and physical inactivity (8). The existence of chronic undernutrition (stunting) in early childhood also seems to magnify the risks of being overweight and increased adiposity in these children (9). With respect to increasing weight gain in early childhood, maternal socio-demographic characteristics such as education, employment and socio-economic status and genetic factors may predispose a child to the risks of being overweight (5, 9).

Similar to the observations in most developing countries, adaptation of a high caloric Western diet of refined cereals, fast foods and sedentary lifestyle in India are reported to be the primary causes of the increasing prevalence of overweight, insulin-resistance, metabolic syndromes and dyslipidemia in children (10- 12). While children and adolescents (aged 5 to 18 years) from the country's capital Delhi, were reported to consume energy dense fast foods nearly 4 times a week (12), a noticeable increase in overweight prevalence from 16.0% in 2002 to 24.0% in 2006-2007 was observed among this subpopulation (11). Previous studies conducted with urban school and preschool children document an overweight prevalence greater than 10.0% (12) and 4.5% respectively (13). Although the national prevalence of overweight among preschool children in India is similar to the estimated prevalence in developing countries (3.5% and 3.3% respectively), it is higher than the overall prevalence in Asia (2.9%) (14). In addition to this a noticeable increase in overweight and obesity prevalence among older children have been reported in India (12, 15). Simultaneously, with majority of Indian children < 5 years still suffering from underweight and stunting, others are more prone to becoming overweight, which has public health impact on the country. It is therefore imperative to understand and identify the underlying causes of the growing public health problem in this subpopulation. To the best of our knowledge, there is a dearth of literature on factors associated with overweight among Indian children < 5 years of age. The present study therefore examines the predictors of overweight in these children.

Methods

Study design and data

This study is a secondary data analysis of the most recent wave of India's National Family Health Survey (NFHS 3) conducted during 2005- 2006. This survey is periodically conducted by the Ministry of Health and Family Welfare, Government of India, with technical assistance from ORC Macro, USA (16). Sampling design of NFHS consisted of two-stage and three-stage stratifications in rural and urban areas respectively. The survey interviewed women aged 15-49 years and obtained information on demographic, socio-economic and health of 124,285 women. Details about survey procedure and sampling are reported elsewhere (17). To compare the regional differences in participants' characteristics and predictors of childhood overweight in the current study, we divided the country into 4 regions- namely: North, East-North East, South and Central-West regions (18).

Subjects

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

Dependent variable

Childhood overweight was assessed using the World Health Organization's (WHO) cut-off value of > 2.0 standard deviation for BAZ (19). This is a standardized variable that has been shown to predict overweight/obesity related complications in children (20). We used BAZ in the current study because of the lack of information on other reliable indicators of adiposity such as body composition and skin fold thickness measurements in the NFHS data sets.

Independent variables

Independent variables were grouped into different categories namely socio-demographic characteristics, place of residence and infant/child feeding practices. Variables of interest capturing the socio-demographic characteristics were age, employment, religion, education and economic status of the respondent together with age and gender of the index child. Socio-economic status of the respondents were based on the wealth index classifications of NFHS (17). Region and urban/rural area were variables capturing the respondent's place of residence.

The NFHS 3 obtained information on height and weight measurements of women aged 15 to 49 years and children born between January 2000 and 2001. These measurements were used as a proxy to assess the nutritional status of mothers and the index child. Long term nutritional status (stunting) of the index child was captured using height-for-age z score (HAZ) categorized as stunted (HAZ < -2.0) or normal (HAZ ≥ -2.0) (19). Maternal Body Mass Index (BMI) was used to classify mothers as underweight (< 18.5 kg/m^2), normal (18.5–24.9 kg/m^2), overweight (25.0- 29.9 kg/m^2) and obese (≥ 30.0 kg/m^2) based on WHO's recommendations (21).

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

Statistical Analysis

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

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

Results

Characteristics of participants

The socio-demographic characteristics of the participants from the four regions are presented in Table 5.1. Hinduism was the primary religion practiced across the country, along with Muslim, Christianity, Sikhism and other minor religions (Buddhism, Jainism Zoroastrian, Doni-polo) and no religion. Almost 98.0% of the participants were married in the four regions. Majority (> 60.0%) of the participants were aged between 20-29 years (26.7 ± 5.5 years). While there was a significant regional difference in education levels and employment status of participants, the highest illiteracy (48.0%) and unemployment (75.0%) rates were observed in the East-North East region (Table 5.1). Additionally, a greater proportion of rural women (35.2%) of the four regions were employed as compared to their urban counterparts (19.0%), with nearly 75.0% engaged in agricultural related activities. In contrast, the few employed urban women were professionals and of a higher socio-economic status (data not shown). With respect to socio-economic status, a greater percentage of participants (30.9%) from the poorest socio-economic category came from the East- North East region as compared to only 9.4% of the participants from the Southern region (Table 5.1). The mean age of the index child was 26.0 ± 16.4 months (range: 0 to 59 months). More than 50.0% of the children included in our analysis were males.

Distribution and characteristics of overweight children

Childhood overweight was widely prevalent in urban areas (3.5%) as compared to rural areas (2.1%). There was a significant (p<0.001) regional difference in overweight prevalence, with the highest observed in the Southern region (3.3%), followed by North (2.6%), Central-West (2.6%) and East-North East (1.8%) regions. Interestingly, overweight prevalence was similar in the urban areas of the four regions (North: 2.7% ; East North East: 3.3%; South: 3.5%; Central West: 3.9%). Childhood overweight was highest in rural parts of the Southern region (3.2%) compared to the other regions (North: 2.6%; East North East: 1.4%; Central west: 2.0%)

Table 5.2 presents the characteristics of children according to their weight status (normal weight vs. overweight). Compared to normal weight children, overweight children were likely to be 12.0 to 23.9 months of age (p<0.001; Table 5.2). Additionally, overweight children belonged to: Hindu and affluent households (high socio-economic status) (Table 5.2). There were significant differences between maternal characteristics for normal weight and overweight children (Table 5.2). Over 66.0% of the overweight children were also stunted compared to normal weight counterparts (p<0.001). There was no association between gender of the index child and overweight prevalence in the study population.

Predictors of childhood overweight

Results from the univariate logistic regression are presented in Table 5.3. Residing in the East- North East region had a protective effect on childhood overweight

(OR = 0.6; 95% CI: 0.5 to 0.8, $p = 0.004$; Table 5.3). Children from urban areas were nearly twice as likely to be overweight ($p<0.01$; Table 5.3) compared to rural counterpart. Index children from Christian (OR = 1.8; 95% CI: 1.2 to 2.9, $p = 0.005$) and other minor religion (OR = 2.5; 95% CI: 1.2 to 5.1, $p = 0.008$) households had greater risks of being overweight as compared to children from other religions (Hindu, Muslim, Sikh, Jain, Zoroastrian, Doni-polo and no religion). The odds of being overweight was almost doubled for children of mothers with either secondary or higher education compared to children of mothers with no formal education (Table 5.3). Other significant predictors of childhood overweight were maternal unemployment (OR= 1.4; 95% CI: 1.2 to 1.7, $p<0.001$), affluent households (OR= 1.8; 95% CI: 1.4 to 2.4, $p<0.001$) and maternal overweight (OR= 1.8; 95% CI: 1.4 to 2.5, $p<0.001$) and obesity (OR= 2.6; 95% CI: 1.6 to 4.2, $p<0.001$) (Table 5.3). Children aged > 24.0 months were less likely to be overweight compared to younger children. Stunted children were at a three-fold increased risk of being overweight compared to children with normal stature/height.

Results of the multivariate logistic regression analysis are presented in Table 5.4. In model 1 (Table 5.4), higher maternal BMI, residing in an urban area, maternal education level (secondary education) and unemployment, were significant independent predictors of childhood overweight, while residing in East-North East remained a protective factor (Table 5.4). In the second model stunting was the only independent predictor of childhood overweight, with an odds ratio of 2.9 (95% CI: 2.4 to 3.4, $p<0.001$; Table 5.4). The final model (Model 4; Table 5.4) examined the independent influence of all significant predictors from models 1-3. Stunting, maternal overweight/obesity, urban residence, maternal education and consumption of a high fat diet by the index child remained significant independent predictors of childhood overweight, after adjusting for important covariates (Table 5.4). Moreover, East- North East region had a protective effect on childhood overweight (Table 5.4).

Discussion

The current study presents the predictors of overweight among children < 5 years in India. The observation of an increased risk of childhood overweight in urban compared to rural areas in the present study is a confirmation of reports from previous studies conducted on preschool children from India (13) and other developing countries (14). Even in the less developed East- North East region, overweight prevalence remained significantly higher in the urban area, confirming the impact of urban lifestyle as observed previously (13, 14). With respect to household socio-economic status, our univariate logistic regression showed an increased risk for childhood overweight with higher wealth categories. This finding is similar to a previous study of 9-15 years old Indian children from three different socio-economic status (15). This observation is in contrast to observations reported from industrialized countries such as the US, where child food insecurity increased the risks of overweight in children aged 3 to 5 years (22). Low socioeconomic households in industrialized countries face the crisis of food insecurity, a factor associated with higher consumption of low cost calorie dense diets and physical inactivity, culminating in increased prevalence of childhood overweight (23, 24). These practices on the other hand are speculated to be profound amongst children from affluent households in India, thereby increasing the risks of overweight in this section of the population. This is also evident from findings of the present study and a previous report by Kaur et al. (2008) (12). According to the NFHS 3 report (17), 48.0%

of the urban population belonged to the highest socioeconomic households as compared to only 7.4% in the rural areas. This may have contributed to the insignificant association of socioeconomic status with overweight in the multivariate analysis in the presence of place of residence.

Our results also indicate a strong influence of maternal BMI on childhood overweight. Children of overweight/obese mothers were at an increased risk of being overweight compared to their counterparts of underweight/normal weight mothers, that is consistent with previous report by Bell et al. (2007). The authors reported a significant positive correlation between maternal BMI and child's BAZ, and observed an increase of 0.07 BAZ for every unit increase in maternal BMI (20). The influence of maternal adiposity on childhood overweight can be explained by genetic predisposition, as 50.0% of the variation in BMIs of twins reared apart was attributed to genes alone (25). Association between parental and childhood overweight is also attributed to familial similarities in dietary practice and environment, as reported by Fisher and Birch (1995) (26). Other researchers have observed fat consumption and adiposity in children aged 3 to 5 years to strongly correlate ($r = 0.75$, $p<0.01$) with parental adiposity (25). Our findings from the current study are also confirmed by a study from Germany which found preschool children (< 6 years) of overweight mothers to be at an increased risk of having higher BAZ (27).

Increased risk of overweight among children of mothers with secondary education observed in the present study is in agreement with findings by Martorell et al. (5). Our observation of maternal unemployment to be a risk factor for childhood overweight in the current study, although not significant in the multivariate analysis was surprising. This is in contrast to what has been reported by Takahasi et al. (1999) and Anderson et al.(2003) who studied children from Japan and US respectively (28, 29). Moreover, Armar-Klemesu et al. (2000) have documented an association between maternal employment and childhood overweight among advantaged households in Ghana, a developing country (30). In India, a higher proportion of educated and unemployed women were from urban affluent households (17), while working rural women with lower literacy rates were usually engaged in daily-labor or agriculture related activities belonged to lower socio-economic status (17). Thus, it can be speculated that unemployed urban mothers, with greater purchasing power, are possibly shifting towards a high calorie Western diet and sedentary lifestyle, thereby influencing the dietary practice and physical activity levels of their children. Transition to calorie dense diet comprising of fast foods and sweetened beverages and inadequate physical activity in children have been identified as leading causes of overweight in developing countries (10, 31). Further studies on lifestyle and physical activity pattern of urban children are essential to understand the underlying causes of the higher prevalence of overweight in children of educated, non-working mothers.

Another interesting finding from the present study was the increased risk of overweight among children from Christian and minor religious group (Buddhist, Jain, Zoroastrian, Doni-polo and no religion) compared to other religions (Hindu, Muslim and Sikh). This finding could be due to the diversity in socioeconomic standing, dietary practice and lifestyle/behavioral practices dictated by the different religious teachings. As evident in the NFHS 3 report, a greater proportion of Christian (31.1%) and Jain (87.0%) women were from higher socioeconomic household and had received more years of formal education (Christian: 23.5%; Jain: 52.0%) (17). A second reason for the increased risk of overweight in these groups could be the relatively small proportion of the sub-population belonging to Christianity and minor religious groups (3.0% and1.5% respectively) as compared to Hindus (81.6%) (17). However, in the presence of other socio-demographic characteristics, religion was no longer a significant predictor of childhood overweight, possibly due to its relationship with other maternal demographic and lifestyle characteristics.

Results from this study also show a strong relationship between childhood stunting and overweight, indicating the coexistence of under and over nutrition in this population. This finding is consistent with a previous study by Fernald and Neufeld (2007) that reports the dual prevalence of stunting and overweight in 10.0% of children aged 24 to 60 months in a rural community in Mexico (32). Similarly, Popkin et al. (1996) have reported a strong significant association between stunting and overweight in children from the Republic of South Africa and Russia (8). Stunted or undernourished children with reduced lean body mass and lower basal metabolic rate are at an increased risk of excess adipose tissue deposition, in the absence of nutrient dense foods required for linear growth (8). Additionally, 'early nutritional programming' may affect the potential for linear growth but not weight gain (8). Due to limited information in the data, the various biological and environmental factors that may affect stunting and thereby lead to the onset of overweight were not explored in the current study.

Decreased risk of childhood overweight in children > 2 years is an important finding of the study. Children > 2 years of age are less likely to be overweight possibly due to the decreased growth rate and stabilization of adipocytes after the first year of life

(33) that may influence their appetite and reduce food consumption. Children in this age group also develop feeding skills, dietary preferences and are more physically active, thereby expending more energy and reducing their risks of being overweight. In contrast, parental control of infant feeding practices and restricted physical movement during infancy may be a potential cause of rapid weight gain and adiposity (34). Additionally, accelerated weight gain or 'catch up growth' between birth to 2 years significantly increases the risks of overweight and central adiposity in children at 5 years (35), with a higher population attributable risk (15.7%) for rapid weight gain in infancy than in early childhood (11.7%) (36). Moreover, the prevalence of low birth weight deliveries in India is one of the highest (28.0%) among developing countries (15.0%) (37), which may explain a rapid catch-up growth in infancy that increase the risk of overweight in childhood and later adulthood. Our finding of higher risk of overweight for children < 2 years is also in line with observations made by Schroeder et al.(1995) (38). The study observed a rapid growth rate in height and weight of Guatemalan children below 2 years of age, in contrast to children beyond 2 years. It can therefore be speculated that prevalence of stunting in children < 2 years ('the critical period of life'), if severe may increase the risk of a child becoming overweight later in life. These findings also accentuate the need for future studies to examine the biological mechanism between growth rate, stunting and overweight in this population.

Our study also identified the intake of dietary fats as a potential predictor of childhood overweight. Although this is in accord with other studies of older children aged 6 to 11 years (39, 40), it is in contrast to studies of children aged below 5 years (41, 42). Assessment of fat intake in the current study was based on the mother's report of foods (containing fats and oil) consumed by the child within 24 hours prior to the survey. In the absence of the quantity of foods consumed, we were not able to analyze the food to estimate the fat content of such foods. On the other hand, studies reporting insignificant association between childhood overweight and fat intake in preschool children used the actual fat content of the diet in the assessment (41, 42). It is therefore difficult to interpret the association between fat intake and overweight in the study population.

Study limitations and significance

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

So far, the focus of existing health policies and nutrition programs in India has been on infectious diseases, undernutrition and mortality. Additionally, supplementary nutrition programs in developing countries including India, may be contributing to the increasing overweight prevalence being seen among previously undernourished population. Data from 19 Latin American countries reported that while 20.0% of the population received supplementary nutrition, only 12.0% of the population was undernourished (43) suggesting possible overfeeding of well nourished children. The two major food assistance programs in Latin America, the Chilean supplementary feeding program and the National Nursery Schools Council Program were associated with over nutrition among children < 6 years inspite of the reduction in undernutrition (44). Similarly in India children (< 5 years) from low SES receive supplementary nutrition through mid-day meal programs (in public schools) and the Integrated Child Development Scheme (ICDS) (45). It is plausible that these supplementary feeding programs while reducing the burden of undernutrition may be predisposing the same children overweight (excess weight gain). Therefore, nutrition programs need to be designed and well targeted to reduce the prevalence of undernutrition while preventing the onset of overweight in children < 5 years. These programs also need to target lifestyle modification, specifically for urban children from affluent households. Child feeding practices, focusing on the concepts of variety and moderation of the different food groups as well as adequate physical activity need to be integrated into health promotion programs. In conclusion, factors such as urban residency, socioeconomic status, maternal education and overweight/obesity, and childhood stunting identified as predictors of childhood overweight in our study population have significant public health implications in the fight against rising prevalence of overweight obesity worldwide. There is therefore a need for longitudinal studies to examine whether these predictors have actual causal relationships to childhood overweight in India.

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Table 5.1: Socio-demographic characteristics of women in NFHS 3 (2005-2006) by region of residence

	Regions[1]				
Characteristics	North n = 3222	East-North East n = 7103	South n = 4152	Central-West n = 9337	*p* value[2]
	(%)				
Religion					< 0.001
Hindu	76.8	73.5	80.5	83.0	
Muslim	12.0	21.8	13.1	14.6	
Christian	0.4	3.0	6.1	0.3	
Sikh	10.6	0.1	0.0	0.3	
Other[3]	0.0	1.6	0.3	2.0	
Maternal age (years)					< 0.001
15-19	4.4	9.0	5.4	5.4	
20-24	30.8	32.0	35.3	31.2	
25-29	36.4	31.4	36.7	34.0	
30-34	18.8	17.0	15.6	18.3	
35-39	6.5	7.1	5.3	8.3	
40-44	2.5	2.6	1.6	2.3	
45-49	0.6	0.9	0.1	0.5	
Education level of respondent					< 0.001
No education	47.1	48.0	26.9	47.2	
Primary	12.3	16.7	15.1	12.4	
Secondary	32.7	31.6	46.5	33.9	
Higher/college	8.0	3.7	11.5	6.5	
Respondent employed					< 0.001
Yes	33.6	25.1	35.0	32.3	
No	66.4	74.9	65.0	67.7	
Place of residence					< 0.001
Urban	28.8	17.7	38.1	29.5	
Rural	71.2	82.3	61.9	70.5	
Socio-economic status (wealth index)[4]					< 0.001
Poorest	12.8	30.9	9.4	22.9	
Poorer	13.1	26.2	15.8	21.0	
Middle	20.6	19.3	25.3	18.4	
Richer	24.4	14.5	26.7	18.7	

[1] North: Jammu & Kashmir, Himachal Pradesh, Haryana, Punjab, Delhi, Uttar Pradesh, Uttaranchal; East-North East: Bihar, Jharkhand, Chhattisgarh, West Bengal, Orissa, Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura;

South: Andhra Pradesh, Karnataka, Kerala, Tamil Nadu; Central-west: Maharashtra, Goa, Gujarat, Madhya Pradesh, Rajasthan.

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

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

[4]Wealth index: definition based on NFHS classification (17).

Table 5.2: Characteristics of normal weight vs. overweight children in NFHS 3 (2005-2006); (N = 23,814)

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

Obese	1.6	3.4	

BMI, Body Mass Index. HAZ, Height-for-age z-score

[1]Normal weight: -2.0 < BMI z-score ≤ 2.0; Overweight: BMI z-score > 2.0; Stunted: HAZ < -2.0; Normal: ≥ -2.0 (WHO, 2006).

[2] Significant difference between the normal weight and overweight children (χ^2 test)

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

[4]Wealth index: definition based on NFHS classification (17).

Table 5.3: Predictors of childhood overweight: Univariate logistic regression

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

Index child's HAZ		
Normal (HAZ ≥ -2.0)	1.0	
Stunted (HAZ < -2.0)	2.6 (2.0, 3.0)	< 0.001
Child feeding practices[5]		
Received carbohydrate rich foods		
No	1.0	
Yes	0.9 (0.7, 1.2)	NS
Received protein rich foods		
No	1.0	
Yes	1.1 (0.0,1.4)	0.100
Received fruits and vegetables		
No	1.0	
Yes	1.1 (0.8, 1.2)	NS
Received foods made from fats and oil		
No	1.0	
Yes	1.5 (1.1, 1.8)	0.020

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

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

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

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

[4] Wealth index: definition based on NFHS classification (17)

[5] Variables adjusted for age of the index child

Table 5.4: Logistic regression models of independent predictors of childhood overweight

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

Secondary	1.6 (1.3, 2.0)	< 0.001
Higher/college	1.5 (0.9, 2.2)	0.060
Maternal BMI (kg/m2)		
Underweight	1.0	
Normal	1.3 (1.0, 1.6)	0.020
Overweight	1.9 (1.3, 2.7)	0.001
Obese	2.5 (1.4, 4.6)	0.003
Index child's HAZ		
Normal (HAZ ≥ -2.0)	1.0	
Stunted (HAZ < -2.0)	4.0 (3.2, 5.0)	< 0.001
Received foods made from fats and oil		
No	1.0	
Yes	1.3 (1.0, 1. 8)	0.030

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

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

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

[3]Adjusted for age of the index child.

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

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

CHAPTER 6

CONCLUSION

Nutritional status of children is a world-wide concern, negatively or positively influenced by several factors at individual and household level. Poverty, lack of education of the mother, poor pregnancy outcome and poor dietary diversification of the child are among the important determinants of a child's nutritional status, in developing countries (1- 7). In a country like India, which is undergoing a rapid economic growth, prevalence of low birth weight and undernutrition in children < 5 years continue to be major public health issues (8, 9). Adding to this burden is the increasing prevalence of childhood overweight (10- 13).

Considering the nutrition scenario in India, the overarching goal of this dissertation was to examine the various factors at individual and household levels that influence the nutritional status of children aged below 5 years. The different parameters that were considered in this dissertation were 1) birth weight and birth size of children and related determinants, 2) determinants of undernutrition (stunting, underweight, wasting and anemia), and 3) determinants of childhood overweight.

The results of the first study presented in Chapter 3 indicate that prevalence of poor pregnancy outcome (measured as low birth weight and small birth size infants as reported by the mother) is high (20.0%) in India and is in accord with a recent UNICEF report (14). Maternal perception of the infant's birth size is significantly correlated ($r = 0.70$) with the infant's measured birth weight, which makes it a reliable indicator for assessing pregnancy outcome. Poor pregnancy outcome remained high in rural compared to urban areas. Within the country, we observed regional disparities in the prevalence of poor pregnancy outcome. These findings suggest that children from less developed regions and rural areas are more likely to be born low birth weight/small birth size.

In this dissertation research using data from India's NFHS, we observed maternal education, religion, age, household SES and regional location to be important predictors of pregnancy outcome. One of the most important maternal characteristic that independently predicted poor pregnancy outcome was low autonomy. This was also significantly associated with other factors such as maternal age, educational level, employment status, religion, utilization of prenatal care, nutritional status, household socio-economic status and place of residence. While few studies have examined the association between maternal autonomy and child's nutritional status (stunting) (15), results of this study fills the gap by showing the independent effect of maternal autonomy on pregnancy outcome.

Majority of the health reform programs in India are based on nutrition supplementation and nutrition and health education as strategies to combat the problem of low birth weight, overlooking the issues of women's status in the household. Therefore, our observation of maternal autonomy as a significant predictor of pregnancy outcome suggests that improving women's status in the household may be an important strategy to decreasing the prevalence of poor pregnancy outcome. Existing evidence suggests that women's mental health, influenced by her status/autonomy in the household (16, 17) is important for favorable pregnancy outcome (18, 20). Epidemiological studies with this population examining the mental health of women with low autonomy may be needed to understand the mechanism through which low maternal autonomy influences poor pregnancy outcome.

There was a significant positive correlation between birth weight of the index child and their height-for-age, weight-for-age, weight-for-height z scores and hemoglobin level that are in accord with findings from a previous study (21). These results indicate that children born low birth weight are at an increased risk for poor nutritional status (21). The second study which examined the prevalence and determinants of undernutrition observed childhood stunting, underweight, wasting and anemia to be considerably high in India. Consistent with previous reports (22, 23), rural children were more susceptible to be undernourished compared to their urban counterparts. We also observed a significant regional disparity in undernutrition prevalence reflective of the state of development by region.

As observed in our first study, maternal and household characteristics were important predictors of undernutrition. Low maternal education level, maternal employment, household SES and geographic location were among the important factors influencing child's nutritional status. In addition, dietary intake by the index child also had significant association with their nutritional status. One of the most important finding of this study was that joint households with grandparents attenuated the risks of undernutrition, specifically stunting in children receiving poor or medium quality diet. This observation therefore adds to the present body of evidence that presence of older adults and most importantly grandparents in the household enhances child care practices and influences the long term nutritional status of children. This evidence suggests that involving older adults/grandparents in nutrition intervention programs addressing undernutrition may enhance program outcome. In addition, our observation of a positive association of up-to-date immunization with nutritional status is also a confirmation of previous studies documenting this evidence. The study results add to the literature that children at risk of suffering from undernutrition (stunting, underweight, wasting and anemia), i.e. those belonging to low SES households, rural areas, having mothers with no education and receiving low quality diet need to be targeted through the Universal Immunization Program of India.

Due to the lack of information on composite nutrient intake, we were unable to examine the association between this variable and indicators of nutritional status. Future studies should therefore assess nutrient intake of children in this population and examine its association with the different nutritional indicators. Information on dietary intake of the child was collected through a 24-hour dietary recall that is not reflective of long-term dietary practices. Longitudinal studies are needed to understand the dietary pattern of children in this population accounting for regional food habits, seasonality and food availability.

Previous studies have shown a strong association between chronic undernutrition, i.e. stunting and childhood overweight (24, 25). In addition, India has been undergoing a nutrition transition, thereby exposing its population to the risk of overweight and obesity (26). Studies have reported an increased consumption of calorie dense foods and the prevalence of overweight in children aged 5-18 years (11). In the third study we therefore examined the predictors of childhood overweight, details of which have been presented in Chapter 5. Although the prevalence of overweight in children < 5 years have remained stable across 1992-2005 (27), we observed urban children to be at an increased risk of being overweight than their rural counterparts. In line with our previous findings (chapters 3 and 4), other important determinants of childhood overweight in this population were maternal education, overweight/obese status of the mother, religion, child's age, household SES and residing in more developed regions of the country specifically North, South and Central-west regions. Dietary fat intake of children, as assessed through the 24-hour dietary recall of the mother, also increased the risks of childhood overweight.

In addition, two major findings of this study were the association between stunting and maternal employment with childhood overweight. Stunted children were nearly three times at an increased risk of being overweight, suggesting the dual presence of under and over nutrition problems in this population. It therefore emphasizes the need to direct health and nutrition intervention programs to combat chronic undernutrition and thereby prevent the onset of childhood overweight in the country. Another interesting finding from this dissertation work is our observation of significant association between maternal unemployment and childhood overweight. This suggests that unemployed mothers, possibly from high SES households may be indulging their children in high calorie western diet and physical inactivity. It may therefore be of public health importance for health promotion programs to target urban affluent mothers as a means of addressing the emerging issue of childhood overweight in India.

The NFHS did not collect information on physical activity pattern of children and therefore, future epidemiological studies need to examine the association between physical activity among urban and rural children and overweight status. Furthermore, our finding suggests that children < 5 years, specifically from urban areas are vulnerable to the consequences of ongoing nutrition transition in the country. Therefore, in order to prevent the rise of childhood overweight in India, health programs should reconsider this emerging public health issue and incorporate relevant strategies to deal with the ongoing nutrition transition.

Overall, our results suggest that interventions need to have a holistic approach and consider both household and individual level factors. At the individual level mothers need to be aware of their nutritional needs and pregnancy care for better pregnancy outcome. In addition they need to be aware of the nutritional and health care requirements of their child. Awareness with respect to favorable practices for child's nutritional status needs to be present at the household level. Moreover, intervention strategies at these levels need to consider regional differences and cultural practices while developing and implementing such programs. In conclusion, results from the three studies confirm the importance of maternal and household characteristics as determinants of nutritional status of children in India. The study results therefore, call for an evaluation of current health programs in India and adoption of different strategies addressing these risk factors.

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APPENDICES

APPENDIX A: CHARACTERISTICS OF INDEX CHILDREN BY HEMOGLOBIN LEVEL-SUPPLEMENTAL TABLE FOR CHAPTER 4

Characteristics	**Hemoglobin level**			
	Normal n (%)	Mild- moderate anemia n (%)	Severe anemia n (%)	*p* value[1]
Age of index child (months)				
6-12	1409 (31.6)	3251 (28.2)	116 (19.5)	< 0.001
13-24	1572 (35.2)	5066 (43.9)	306 (51.4)	
25-35	1483 (33.2)	3231 (28.0)	173 (29.1)	
Gender of index child				
Male	2327 (52.1)	6321 (54.7)	368 (61.8)	< 0.001
Female	2136 (47.9)	5226 (45.3)	227 (38.2)	
Maternal age (years)				
15- 19	313 (7.0)	972 (8.4)	70 (11.8)	< 0.001
20-24	1645 (36.9)	4238 (36.7)	188 (31.6)	
25-29	1463 (32.8)	3676 (31.8)	178 (30.0)	
30-34	717 (16.1)	1733 (15.0)	106 (17.8)	
35-39	250 (5.6)	701 (6.1)	30 (5.1)	
40-44	64 (1.4)	181 (1.6)	17 (2.9)	
45-49	11 (0.2)	47 (0.4)	5 (0.8)	
Religion				
Hindu	3425 (76.8)	9111 (78.9)	491 (82.5)	< 0.001
Muslim	746 (16.7)	1907 (16.5)	76 (12.8)	
Christian	143 (3.2)	201 (1.7)	7 (1.2)	
Sikh	66 (1.5)	148 (1.3)	15 (2.5)	
Other[2]	82 (1.8)	181 (1.6)	6 (1.0)	
Education level				
No education	1671 (37.4)	5765 (49.9)	342 (57.6)	< 0.001
Primary	588 (13.2)	1618 (14.0)	84 (14.1)	
Secondary	1786 (40.0)	3613 (31.3)	146 (24.6)	
Higher	418 (9.4)	552 (4.8)	22 (3.7)	
Employed				
Yes	1214 (27.3)	3507 (30.4)	197 (33.2)	< 0.001
No	3241 (72.7)	8031 (69.6)	396 (66.8)	
Place of residence				
Urban	1495 (33.5)	2550 (22.1)	167 (28.1)	< 0.001
Rural	2968 (66.5)	8997 (77.9)	427 (71.9)	
Socio-economic status				

Poor	1599 (35.8)	5732 (49.6)	299 (50.3)	< 0.001
Middle	876 (19.6)	2226 (19.3)	141 (23.7)	
High	1989 (44.6)	3590 (31.1)	154 (25.9)	
Type of household[3]				
Nuclear	1833 (42.5)	5108 (45.6)	271 (48.0)	< 0.001
Joint with child's grandparents	1692 (39.2)	3797 (33.9)	174 (30.9)	
Joint without child's grandparents	788 (18.3)	2297 (20.5)	119 (21.1)	

1. *p* value for χ^2 test

2. Buddhist, Jain, Zoroastrian, Doni-polo or no religion

3. Type of household: Nuclear: Index child living with parents and siblings, Joint with grandparents: Index child living with parents, siblings, relatives including grandparents, Joint with grandparents: Index child living with parents, siblings and other relatives excluding grandparents

APPENDIX B: CLASSIFICATION OF Z-SCORES TO INTERPRET GROWTH INDICATOR

Z score	**Growth indicators**			
	Length/height-for age (HAZ)	**Weight-for-age (WAZ)**	**Weight-for-length/height (WHZ)**	**BMI-for-age (BMZ)**
> 3.0	Very tall	May have a growth problem	Obese	Obese
> 2.0		May have a growth problem	Overweight	Overweight
0.0 to 2.0				
< -1.0				
< -2.0	Stunted	Underweight	Wasted	Underweight
< -3.0	Severely stunted	Severely underweight	Severely wasted	Severely underweight

The shaded region indicates growth indicator within the normal range

(*Adapted from:* WHO Child growth standards)